EFFECT OF CONSTRUCTIVIST APPROACH ON THE ACADEMIC ACHIEVEMENT, EXPERIMENTAL SELF EFFICACY AND SCIENTIFICATTITUDE OF SECONDARY SCHOOL STUDENTS TAUGHT THROUGH VIRTUAL SCIENCE LABS.

Thesis Submitted for the Award of the Degree of

DOCTOR OF PHILOSOPHY

in

Education

By

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2024

DECLARATION

I Swastika hereby declare that the thesis entitled **Effect of Constructivist Approach on the Academic Achievement, Experimental Self Efficacy and Scientific Attitude of Secondary School Students Taught Through Virtual Science Labs.** submitted to Lovely Professional University for the award of Degree Doctor of Philosophy in Education, is my original research work and has been prepared by me in School of Education at Lovely Professional University under the supervision of Prof. (Dr.) Savita Gupta, Professor, Faculty of Education, Head - Dept. of Faculty Development, HRDC, Lovely Professional University. No part of this thesis has formed the basis for the award of any degree or fellowship previously.

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CERTIFICATE

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ABSTRACT

This study investigated the effect of constructivist approach on the academic achievement, experimental self-efficacy, and scientific attitude of secondary school students taught through virtual science labs. Through a comprehensive literature review, the role of virtual labs in enhancing academic achievement, fostering experimental self-efficacy, and cultivating a positive scientific attitude among secondary school students was examined. The research contributes to understanding of the potential of constructivist learning facilitated by virtual labs to influence students' learning experience, experimental self-efficacy, and perceptions of scientific inquiry.

The objectives of the study were to select the curriculum content and software for teaching science lab courses in virtual mode and physical mode; to develop instructional plans for teaching science lab courses in virtual mode and physical mode; to study the effect of constructivist approach on the academic achievement of secondary school students in teaching science lab courses taught through virtual and physical mode; to study the effect of constructivist approach on the experimental self-efficacy of secondary school students in teaching science lab courses taught through virtual and physical mode; and to study the effect of constructivist approach on the scientific attitude of secondary school students in teaching science lab courses taught through virtual and physical mode.

The investigation used a pre-test post-test quasi-experimental non-equivalent group design to assess the effectiveness of carrying out experiments in virtual science laboratory on the academic achievement, experimental self-efficacy, and scientific attitude of eleventh-grade secondary school students. In this study, constructivist approach was employed, and a group of 74 students from a secondary school participated in the research. These students were selected from a public school located in the Delhi region. The sample was divided evenly, with 37 students in the Control Group (CG) and 37 students in the Experimental Group (EG). The instructional plans for chemistry practicals were designed utilizing the 5E approach to promote a self-constructed learning atmosphere. A total of 40 plans were prepared, with 20

customized for the control group, where students got engaged in hands-on experiments, and another 20 for the experimental group, where students conducted virtual experiments. In this regard, the curriculum given by the Central Board of Secondary Education (CBSE) for class XI, was considered. The selected experiments of chemistry were classified in 3 categories: volumetric analysis, salt analysis & content based experiments. OLABS platform was used to carry out experiments by virtual mode. The other tools used in the study include a Chemistry Practical Achievement Test (CPAT), an experimental self-efficacy scale, and a scientific attitude scale.

The development and standardization of a chemistry practical achievement test was done with the specific purpose of evaluating the academic achievement of Class XI science students. This test was carefully crafted to align with the curriculum and learning objectives, allowing for a comprehensive assessment of the students' knowledge, understanding, application and skill in the subject of chemistry. The experimental self-efficacy scale created by Kolil et al. (2020) was used to gauge the students' level of self- efficacy in conducting experiments. To measure the scientific attitude of students, a scientific attitude scale developed by Khan and Siddiqui (2020) was used. Revalidation of both the tools was done to ensure its reliability in assessing experimental self-efficacy and scientific attitude among the students. The research process began with a pre-test conducted on both, the control group and experimental group students. The control groups students performed experiments in traditional chemistry laboratory while the experimental group students in virtual mode in a constructivist learning environment. Both the groups performed experiments as per the agreed-upon schedule. Thirty practical classes were conducted for both control group and experimental group each. Following the completion of the experimentation phase, a post-test was conducted on control and experimental group students to assess the changes in their academic achievement, experimental self-efficacy, and scientific attitude.

To observe the effect of a virtual mode experimentation on the academic performance, experimental self-efficacy, and scientific attitude of secondary school students in a constructivist learning setting, both independent and paired sample t-tests were employed.

The results of the study concluded that before the treatment, students of both the Control Group (CG) and Experimental Group (EG) demonstrated similar academic achievement levels in chemistry practical, experimental self-efficacy and scientific attitude. After the treatment, the mean chemistry practical achievement test scores of the experimental group were found to be higher than those of the control group. Based on the difference, it was concluded that the experimentation by virtual mode significantly enhanced the academic achievement of the students. It was also observed that 10.81% of students in the control group and 48.64 % students in experimental group transitioned from scores below 60% to above 60% after the intervention. This notable enhancement in academic achievement among students in the experimental group surpassed that of the control group, affirming the effectiveness of the virtual chemistry lab treatment. It was evident that students were more engaged and performed experiments with interest while working with the virtual laboratory, which contributed to their improved academic achievement.

Further, the experimental group exhibited a higher mean experimental self-efficacy (ESE) score in comparison to the control group's score. The study revealed that following the treatment, 8.1% of students in the control group and 70.2% of students in the experimental group progressed to the higher scorer category. This notable enhancement in experimental self-efficacy scores among students in the experimental group surpassed that of the control group, confirming the effectiveness of the virtual lab treatment. The results clearly indicate that the virtual lab environment had a positive impact on student's experimental self-efficacy. These favourable outcomes provide strong support for the adoption of virtual labs as valuable tools for enriching the learning process.

The results of statistical analysis further indicated that after the intervention the difference in the mean gain scores in scientific attitude between the experimental and control groups was negligible. It was also reported that after the treatment, the mean scientific attitude scores of the experimental group (1.41) were found to be almost

same as those of the control group (0.98). The study additionally noted a minimal proportion of students within both the control group (10.8%) and experimental group (8.1%) transitioning from the low scorer category to the high scorer after the treatment. These findings suggest that conducting experiments in virtual mode does not appear to influence the scientific attitude of students in a discernible manner.

To conclude, the results of the study indicated that the virtual lab environment had a positive effect on student academic achievement & experimental self- efficacy of students highlighting its potential as an effective educational tool though there was no change in the scientific attitude of students.

The findings of the study recommend integrating virtual lab into the curriculum, provide training to teachers, ensure easy access to virtual lab, implement a feedback mechanism for students, recognise and accommodate diverse learning styles within the realm of virtual lab.

Keywords: Academic Achievement, Experimental Self- Efficacy, Scientific Attitude, Virtual Laboratory, Constructivist Approach

ACKNOWLEDGEMENT

Foremost and above all, I extend my gratitude to the Almighty, the most beneficent and merciful, for providing me with this opportunity and bestowing upon me the ability to successfully undertake this endeavor. The completion of this thesis owes its existence to the invaluable contributions and guidance of numerous individuals, to whom I offer my sincere thanks.

It is a privilege to express my profound appreciation, deep respect, and heartfelt thanks to my esteemed and invaluable guide, Dr. Savita Gupta, Professor at the Faculty of Education and Head of the Department of Faculty Development at HRDC, Lovely Professional University. Her exemplary guidance, invaluable suggestions, constructive critique, unceasing encouragement, and unwavering supervision have been instrumental throughout this work.

I am deeply indebted to Dr. Harish Mittu for his generous support and expert guidance, particularly in statistical analysis and thesis composition across various stages.

I extend my gratitude to the esteemed faculty members of the Lovely Faculty of Education, with a special mention to Dr. P. P. Singh, for their unwavering support and motivation that propelled me to accomplish this work.

I am profoundly grateful to Ms. Anju Puri, Principal of DAV Public School, Vasant Kunj, for graciously permitting me to conduct my research on the school premises. I extend my heartfelt appreciation to the students of Class XI (2022-23) at the same school who wholeheartedly and voluntarily participated in the research, playing a pivotal role in its success.

I acknowledge with gratitude the guidance and assistance provided by Dr. R. K. Parashar and Dr. Anjni Koul from NCERT; Dr. Sunita Malhotra from IGNOU; Dr. Akhilesh Kumar from VMOU; Dr. Jasim Ahmed from Jamia Millia Islamia; Dr. Smriti Malhotra from Amity University; Dr. Renu Parashar from Delhi University; Dr. Meenakshi Joshi from Mewar Institute of Management; and Dr. Alok Chaturvedi from Ajmer University, for their expertise in shaping instructional plans and chemistry practical achievement tests.

I extend my sincere appreciation to Ms. Kanika Miglani, a Consultant at the Indian Council of Medical Research, for her valuable contributions to this work. My gratitude also goes to Mr. Sukriti Vishwas from LPU for providing expert guidance in crafting the graphical abstract. Furthermore, I would like to express my heartfelt thanks to Ms. Shalini Prakash, former Incharge & HOD English, for her assistance in refining the language and ensuring accuracy.

My heartfelt appreciation goes to my father, Dr. Jagdish Prasad Angrish, my mother-in-law, Mrs. Vanti Sharma, and my husband, Mr. Kush Sharma, for their unending love, assistance, constant inspiration, and encouragement, which have been pivotal in my academic pursuits. A special acknowledgement is reserved for my children, Ankan, Karina, Pratibha and Dr. Kartik, who have provided unwavering support throughout this journey.

I also extend my gratitude to my friends, those who provided support, assistance, and encouragement throughout the research process. Finally, I am deeply thankful to all those who selflessly stood by me whenever I required assistance.

While not all individuals can be mentioned, their contributions are certainly not forgotten.

Dated: 22.3.2024

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ACRONYMS

ACRONYMS	DISCRIPTION
CG	Control Group
EG	Experimental Group
PME	Physical Mode of Experimentation
VME	Virtual Mode of Experimentation
ESE	Experimental Self- Efficacy
CPAT	Chemistry Practical Achievement Test
SA	Scientific Attitude
w.r.t	with respect to
Df	Degrees of Freedom
CFA	Confirmatory Factor Analysis
SD	Standard Deviation
SE	Standard Error
CFI	Comparative Fit Index
AGFI	Adjusted Goodness Fit Index
RMSEA	Root Mean Square of Approximation
GFI	Goodness Fit Index
SRMR	Standardized Root Mean Square Residual
TLI	Tucker Lewis Index
SD	Standard Deviation
SK	Skewness
KU	Kurtosis
Sig.	Significance
SE_D	Standard Error of Difference between two treatment mean Values
CPRT	Control Group Pre- test

CPST	Control Group Post- test
EPRT	Experimental Group Pre- test
EPST	Experimental Group Post- test
&	And

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CHAPTER I

THEORETICAL ORIENTATION OF THE PROBLEM

1. INTRODUCTION

As the employment landscape and global ecosystem continue to evolve rapidly, students must acquire not just knowledge, but also the essential skill of "learning how to learn". In this context, education should shift away from a focus on content and instead emphasize developing problem-solving abilities, fostering critical and interdisciplinary thinking & cultivating the capacity to innovate, adapt, and absorb new information within a constantly changing educational ecosystem. This will help to prepare students to succeed in an uncertain and dynamic future.

In today's world, science has become ubiquitous and essential for daily living. Every individual must possess a basic understanding of science that is relevant to their lives. Furthermore, there is a need to acquire specific skills for effectively operating and maintaining the diverse array of scientific and technological devices that are becoming increasingly prevalent. Beyond acquiring knowledge and skills, the outcomes of science extend to shaping attitudes. The scientific approach reinforces an individual's commitment to open inquiry and the pursuit of truth. Developing a scientific temperament would not only facilitate personal growth but also contribute to social transformation.

As per the Kothari Commission (1964), the destiny of a nation is moulded within the confines of its educational institutions, encompassing classrooms and laboratories across schools, colleges, and universities. To truly grasp the essence of education, it is crucial to establish connections between school-based knowledge and the world beyond the classroom, ensuring that the study of science becomes an enjoyable and meaningful activity. The Kothari Education Commission also emphasized the integration of science into education at every level, from primary to university education. By encouraging technological advancements, education can aid in the development of various sectors such as agriculture, industry, and defence, contributing to the nation's prosperity.

The National Policy on Education (NPE) of 1986 highlights the significance of strengthening science education initiatives, placing a particular emphasis on cultivating well-defined abilities and values in children. These proficiencies and principles will empower learners to develop problem-solving skills, all while appreciating the role of science in various aspects of daily life, such as food, health, manufacturing, industry, and agriculture. Within the framework of the NPE, fostering a scientific mindset is identified as a pivotal element of the Core Curriculum, aimed at elevating the quality of life. To attain this objective, the learning of science needs to be extended beyond elucidating abstract concepts, but it should draw upon learner's contextual experiences.

Furthermore, offering students chances to interact with scientific instruments and actively participate in hands- on experiments is of utmost importance. This practical engagement reinforces theoretical comprehension through active demonstration and experimentation. Ensuring the availability of well-equipped laboratory demonstration facilities in all educational institutions is pivotal to support this approach.

To achieve successful advancements in science education, it is imperative to adequately motivate teachers. Merely supplying textbooks and laboratory equipment falls short if educators lack the essential skills and motivation. Science teachers must possess a robust foundational understanding of science, a familiarity with their surroundings, competencies and abilities to guide students, resource mobilization skills, equipment usage and maintenance proficiency, as well as effective communication capabilities.

The Yashpal Committee report 1993, titled "Learning without Burden," emphasized the importance of simplifying the complex scientific content and educational materials. The report raised awareness about the need to prioritize a deeper comprehension of subjects like mathematics and science, rather than simply focusing on rote learning and mechanical rules, to facilitate a more effective learning experience for students.

The Rashtriya Avishkar Abhiyan (RAA) was established by the Ministry of Education in 2015 with the primary goal of fostering innovation and integrating technology into the education system. This initiative offered a structured framework to cultivate learner's curiosity, creativity, and passion for Science and Mathematics, while also promoting the proficient use of technology. The RAA recognizes the significance of traditional classroom learning along with the aim to harness the potential of Science and Mathematics education beyond the confines of the classroom. The framework adopts a dual-track strategy to make Science, Mathematics, and Technology captivating for students both inside and outside the classroom. A core objective of the RAA is to empower children to enthusiastically engage with these subjects through hands-on experiences such as observation, experimentation, constructing inferences, building models, employing rational reasoning, and conducting testable activities. By fostering a culture of critical thinking, inventive exploration, experimentation, and practical application, the RAA endeavours to promote inquiry-based learning within educational institutions. In addition to nurturing curiosity and exploration, the RAA is dedicated to ensuring appropriate competency levels in Science and Mathematics for each grade level. This program is also committed to nurturing schools as hubs of innovation, encouraging them to cultivate an environment that supports and promotes innovative thinking.

To facilitate effective classroom instruction, the RAA recommends incorporating diverse teaching methods beyond traditional approaches. These methods include hands-on experimentation, interactive demonstrations, modelling, collaborative peer-to-peer learning, and utilization of online resources. By integrating these approaches, the RAA aims to create a dynamic and enriched learning experience that goes beyond conventional teaching methods.

To foster exploration and education, experimentation assumes an important role in the area of science learning. The process of unearthing novel ideas and comprehending concepts during the quest for knowledge goes beyond the realm of conventional instruction. Within the confines of school laboratories, students immerse themselves in hands-on experimentation, exploring various avenues and deciphering the intricacies of efficacy. This journey may lead them down pathways of trial and error, occasionally venturing into incorrect hypotheses. Yet, these encounters yield a deeper grasp of accurate principles.

Science laboratories stand as integral components of education across all tiers. They provide opportunities to students to actively participate in experiential learning, enabling them to apply scientific tenets to real-world contexts. Through the pursuit of experiments, students not only internalize scientific principles but also cultivate the faculties of critical analysis, problem-solving acumen, and collaborative teamwork. These competencies hold paramount importance in preparing students to navigate the dynamic contours of the contemporary global landscape. Hence, the provision of well-equipped science laboratories in schools emerges as imperative, ensuring unfettered access to essential resources and instruments for meaningful exploration and revelation.

In light of the requirements of the 21st century and the necessity to make meaningful contributions to the improvement of the world, an essential transformation in education is mandatory. By integrating and implementing the dynamic recommendations of policies with the same intent and spirit, learners can acquire essential skills that help students to work in different situations. The phrase "survival of the fittest" from Darwinian evolutionary theory is highly relevant when it comes to surviving in this changing world. As Darwin rightly said, "It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change."

The utility of training teachers and educators in the adoption of technology-based tools and resources for virtual mode experimentation cannot be neglected. It proposes the incorporation of technology-oriented modules within teacher training programs, encompassing the utilization of digital platforms for conducting virtual experiments and hands-on activities.

In the current situation, incorporating new technologies and practical activities in a safe and comfortable environment has become crucial. Modern laboratories equipped with advanced equipment can increase student motivation and enhance the teaching process (Ayesh, 2004). Nonetheless, geographical separations and resource constraints frequently impose restrictions on the feasibility of conducting experiments, particularly those demanding advanced apparatus. Furthermore, the task of locating suitably skilled educators can prove arduous. In response to these challenges, online courses leveraging web-based and video-centric approaches have been formulated. Web-facilitated experiments, capable of remote execution and observation, emerge as a means to kindle student inquisitiveness and foster ingenuity.

The significance of practical learning and experimentation in science education and recognizes virtual mode experimentation as a promising substitute for laboratory experiments. By advocating the adoption of technology-based platforms and tools, the research aims to create a participative and immersive experience of learning for students, ultimately enhancing the quality of science education.

1.1 VIRTUAL SCIENCE LABORATORY

The National Education Policy (NEP) 2020 recognizes the importance of experimentation and practical learning in science education. The introduction of Virtual Labs brings forth a reservoir of science and engineering wisdom, readily accessible to students in India. This comprehensive resource is ingeniously presented to captivate, immerse, and delight learners. By harnessing Virtual Labs, students gain the freedom to embark on journeys of exploration, uncovering new insights and acquiring knowledge on their own terms, irrespective of their location or schedule.

Virtual mode experimentation refers to the use of technology-based platforms that allow students to perform experiments and practical activities virtually. The NEP 2020 highlights the need to develop and promote online tools and resources that provide an immersive and interactive learning experience for students. Utilizing virtual mode experimentation aids in comprehending theoretical ideas and practical uses, enabling students to investigate and learn within a secure and regulated setting. However, due to the pandemic situation and the closure of schools and colleges, it became difficult to conduct practical classes and laboratory sessions in a physical mode. To address this issue, the NEP 2020 emphasized the use of technology and virtual modes of experimentation.

These platforms are designed to facilitate the acquisition of fundamental and advanced concepts through remote experimentation. Virtual labs establish an online educational environment that empowers students to cultivate essential laboratory skills. As a pivotal component of e-learning, virtual labs grant students the capacity to perform a wide array of experiments without any constraint of place or time, distinguishing them from conventional physical laboratories. These digital simulations, found in fields such as chemistry, biochemistry, physics, and biology, faithfully replicate the processes typically undertaken in physical labs, including the utilization of instruments, apparatus, tests, and protocols. Compared to physical labs, virtual labs are cost-effective and do not have limitations such as geographical location, making them accessible to more students. Virtual labs provide an access to lab-based courses to different groups of students and serving as contingency plans for disruptions such as natural disasters.

Virtual mode experimentation has several advantages, including the ability to replicate experiments multiple times and from different perspectives, the potential to utilize a variety of resources, and the ability to involve students in activity-based learning. Furthermore, virtual mode experimentation can provide access to quality education to students who may not have access to physical labs and equipment due to geographical or financial constraints.

The objective behind virtual labs is to establish a robust platform for performing laboratory experiments through the medium of computer simulations. These labs aim to complement traditional laboratory instruction by providing students with an interactive and engaging learning experience that can improve their understanding and retention of scientific concepts. Virtual labs are an essential tool that overcomes the limitations of physical labs, such as access constraints, safety concerns, and lack of resources. By providing students with a platform to conduct a wide range of laboratory experiments regardless of their location or the availability of physical resources, virtual labs can enhance the quality of science education. Moreover, it is safe to perform experiments in virtual labs as there is no risk of injury and no damage to equipment happens. Apart from providing access to laboratory experiments, virtual labs also promote innovation and research in scientific fields. By allowing students to explore and experiment with new ideas and technologies, virtual labs can develop a skilled workforce capable of driving scientific and technological advancement in India.

1.1.1 Objectives of Virtual Science Lab

In India, the establishment of these laboratories is guided by the following aims:

1. To extend the accessibility to laboratories across various domains of Science and Engineering. These virtual laboratories supplement to students at the undergraduate, postgraduate, and research scholar levels.

2. To ignite students' curiosity, motivating them to engage in experimental endeavours. This approach facilitates the acquisition of fundamental and high-level concepts through remote experimentation.

3. To furnish a learning management system centred around the virtual laboratories. This environment equips students with diverse learning tools, including supplementary web resources, videos and self-evaluation opportunities.

4. To democratize access to expensive equipment and resources, which would otherwise be constrained by limitations of time and geographical barriers for a limited user base?

Virtual laboratories serve as on-screen simulators, facilitating students in testing hypotheses and observing genuine outcomes. Leveraging sophisticated technology, learners conduct a series of experiments that yield authentic results. These laboratories offer flexibility, enabling students to access them conveniently at their own chosen times. Virtual labs provide instant feedback, and high-end equipment is available in them, which may not be available in physical labs. Finally, virtual labs are cost-effective, which makes them a great addition to the traditional lab setup.

Virtual Science Laboratories (VSLs) are software-based labs that replicate the real science lab environment. They allow users to move apparatus, glassware, appliances, and devices from one position to another, add chemicals to lab glassware, connect circuits in real time, and perform simulations from any place. VSLs are most suitable for observing microscopic objects and performing experiments with explosives and dangerous chemicals, which are not normally possible in physical labs. One of the key benefits of VSLs is their convenience and accessibility. Users can perform experiments and explore procedures without any hassle and develop their skills by changing variables. VSLs also provide a joyful learning environment that promotes conceptual clarity, comprehension, methodology, and interpretation of data. They are especially important during the current global health crisis, where there is a lack of proper infrastructure in educational institutes, non-availability of tools and equipment in schools, and a lack of time and funds. Traditional lab training can be dangerous, expensive, and limited in terms of access to physical laboratories. VSLs overcome these challenges by providing a safe and cost-effective alternative to physical labs. They allow learners to experiment with modern, advanced machines, even if they are out of budget. Additionally, crowded labs are no longer an issue in virtual lab, as every learner can conduct experiments first-hand.

Several studies have demonstrated the benefits of VSLs for learning outcomes. They have been found to increase motivation, academic performance, experimental self-efficacy, scientific attitude, science process skills, thinking ability, and concept clarity among students. However, several research findings highlight the continued significance of hands-on experiments within conventional laboratories in science education. These practical experiences not only contribute to boosting student motivation but also positively influence their perceived performance.

Overall, the use of VSLs in science education has the potential to make education more experiential, holistic, integrated, inquiry-driven, flexible, and enjoyable. It is a valuable tool for rediscovering pedagogy and improving the quality of science education.

1.1.2 Benefits of Using Virtual Labs in Education

While working in virtual lab, students develop capability to engage in experiments that could prove challenging or potentially hazardous within the confines of a conventional laboratory environment. This not only ensures their safety but also saves time and effort as they can use the lab at any time of convenience and from any place. Virtual labs have a significant impact on society by offering various advantages that save time and reduce costs for students and universities. By reducing the need for physical presence in real laboratories, virtual labs provide a convenient alternative for learning. They enable flexible learning opportunities, overcoming barriers related to time, pace, and location for learners in the community. Moreover, Hamed & Ghadeer (2020) observed that virtual experiments have proven especially valuable during emergency conditions, such as the pandemic, as they allow for physical distancing while ensuring continuous access to educational resources and experiences.

Additionally, virtual labs allow for the use of cutting-edge technologies, keeping students and teachers up to date with technological advancements in the digital age. Virtual labs facilitate better absorption of knowledge by facilitating the experimentation related to theory syllabus. Furthermore, virtual labs provide an enjoyable experience for students and enable them to repeat experiments, ensuring a thorough understanding of the concepts.

Virtual labs also eliminate the risks associated with handling toxic or radioactive chemicals and explosive devices, protecting students and teachers from hazards. Moreover, the convenience of changing input and transactional variables during the experiment without worrying about any dangerous effects is a significant advantage of virtual labs. Virtual labs also provide students with access to the internet, allowing them to explore and utilize gathered information while performing the experiment. Additionally, virtual labs enable students to record and share their results with others, encouraging collaboration and the exchange of ideas.

Virtual labs are also eco-friendly, eliminating environmental pollution and reducing the need to dispose of electronic waste produced in traditional laboratory settings. This makes virtual labs a sustainable and responsible choice for scientific education.

The core aim of this virtual laboratory is to elevate students' comprehension of the fundamental physical and chemical principles governing the intricate process of electrolysis. Through the application of a theoretical framework, the virtual lab seeks to surmount the inherent constraints posed by hands-on laboratory activities, such as limitations in manipulating operating variables like time, temperature, and cell quantity. Furthermore, this virtual platform equips students with real-world parameter values, empowering them to meticulously scrutinize and deliberate upon their gathered experimental outcomes.

In conclusion, virtual labs offer many advantages over traditional laboratory settings. From enhancing student safety and access to cutting-edge technology to providing an enjoyable and flexible learning experience, virtual labs promote scientific understanding and knowledge. The use of virtual labs can also help address societal, industrial, government, and environmental issues, making them a valuable addition to scientific education.

Davidsson & Verhagen (2017) suggested that simulations incorporated in virtual labs address and provide a solution for the complex situations present in real world.

1.1.3 Challenges of Using Virtual Labs

Creating a three-dimensional virtual lab with accurate simulations and full details requires computer devices with high specifications. The development of virtual labs also requires the expertise of professional programmers proficient in various programming languages. Moreover, a team of experts in the scientific material, teachers, and psychology specialists is necessary to create effective virtual labs.

Koehler (2021) employed a comprehensive survey, examining the Attitude Toward Chemistry Inventory to gauge students' perspectives. Additionally, interviews were conducted with a randomly selected subset of students. Statistical analyses were executed to contrast survey scores across five distinct aspects: emotional satisfaction obtained, anxiety created, intellectual IQ developed, interest generated and fear of non-performance. The results showed that there was no significant change in the students' attitudes after experiencing the virtual laboratory. However, a general reduction in students' perceptions concerning the enjoyment and practical applicability of chemistry was discerned. Notably, interview narratives unveiled that student relished the virtual lab experience and acknowledged the acquisition of a chemistry concept. Yet, the interviews did not reveal any noticeable alteration in the students' overall attitude towards the domain of chemistry.

Bauer (2008) created a new tool called the Attitude toward the Subject of Chemistry Inventory (ASCI) to measure student attitudes toward chemistry using a 20-item semantic differential assessment. This instrument can effectively evaluate student attitudes across various educational settings and is particularly beneficial for tracking changes over time or comparing different groups of students. Its application has been detailed, particularly in the context of an inquiry-based chemistry course designed for nonmajors.

One potential drawback of virtual mode experimentation is that they may reduce direct interaction between students and teachers. Most communication occurs electronically, which may limit the personal interaction and social skills development that typically occur in traditional laboratory settings.

1.1.4 Scope of Virtual Lab towards Societal Issues

Laboratory-based education has always been integral to engineering and scientific instruction. Yet, many institutions in developing nations like India confront significant hurdles, including the financial burden of establishing physical experiment setups, challenges in equipment upkeep, and a shortage of qualified educators. Recent strides in Information and Communication Technologies (ICT) have introduced innovative perspectives, harnessing, animations, simulations, and web-enabled remote laboratories within the curriculum. The rise of remote labs, enabling users to access authentic scientific data and control experiments from afar, has gained traction worldwide, resonating with both educators and students.

This mode of learning has demonstrated its prowess in kindling students' curiosity, affording them the chance to grasp concepts and engage in scientific practices through remote experimentation. Furthermore, remote labs have paved the way for personalized learning, ushering in a novel pedagogy that minimizes external intervention during classroom lectures. Various universities have successfully integrated remote labs into their educational frameworks, aligning with traditional classroom objectives. The implementation of virtual labs has proven particularly efficacious in fields like electrical engineering and various scientific domains. In nations like India, such platforms hold the potential to mitigate overarching and specific disparities in laboratory resources across institutions, addressing the challenge of inadequately equipped facilities.

However, the effectiveness of virtual laboratories, particularly in distance learning settings, hinges on several variables, encompassing students' behavioural intention, attitudes, perceived utility, and ease of use within the digital realm. Notably, virtual labs capable of recognizing users' gestures and movements, closely simulating real-life scenarios in educational settings, have showcased prowess in tasks such as solving chemical equations. These interactive virtual labs hold substantial promise for diverse stakeholders: engineering college students deprived of sufficient lab access, high school learners, whose curiosity is ignited across different institutes, fostering collaboration and resource sharing.

Moreover, simulations are not limited to school and college education. They are also helpful in the subjects of management, medicine, and teacher education to facilitate the learning of complex concepts and skills during different phases of knowledge development. By embracing virtual and remote labs, educational institutions can overcome many of the barriers to providing quality laboratory education and help students develop skills that are essential for their future careers.

In this study, students engaged in chemistry experiments within a conducive constructivist learning environment, utilizing both the physical chemistry laboratory and the virtual chemistry laboratory. It is essential to understand the role of constructivist pedagogical approach to teaching and learning.

1.2 CONSTRUCTIVIST APPROACH

The Constructivist approach represents a learning theory that places paramount importance on the dynamic process of learners actively constructing knowledge. At its core, this theory underscores the concept that individuals forge their understanding and wisdom by engaging in a reciprocal interchange between their preexisting knowledge and novel encounters or information they come across. Central to the Constructivist approach is the conviction that learning transpires as a constructive endeavour, a creative process where knowledge is assembled rather than passively assimilated. This transformative perspective emphasizes the learners' proactive involvement in the educational journey, veering away from the conventional model of mere information transmission from an instructor or written material.

According to the Constructivist approach, learning becomes most effective when it is collaborative, student-centred, and based on real-world problem-solving experiences. This approach focuses on the learner's needs, interests, and experiences, and encourages learners to explore, experiment, and question.

Ahmedi et al. (2023) observed that the implementation of a constructivist approach facilitated a shift from traditional teacher-centred to student-centred teaching methods. Interestingly, teachers displayed positive attitudes towards adopting this instructional approach. The significance ($p<0.05$) in context of teachers' attitudes to adapt the constructivist approach documented a pivotal role in determining the achievement of learning outcomes.

A fundamental tenet intrinsic to the Constructivist approach centres on the notion of "scaffolding." Scaffolding entails the provision of adept support and guidance, facilitated either by an educator or a more proficient peer, aimed at nurturing learners' comprehension and proficiencies. This scaffolding manifests through diverse means, including offering constructive feedback, demonstrating skills through modelling, and organizing learning tasks for optimal comprehension. Another pivotal element within the Constructivist framework is the concept of "authentic assessment." This form of assessment measures a learner's capacity to effectively employ acquired knowledge and competencies within real-life scenarios. This approach places a distinct emphasis on evaluating the learning process itself, rather than solely focusing on the outcome.

Underpinning the Constructivist perspective is the conception of learning as an ongoing process characterized by constant adaptation and refinement. This viewpoint envisions learning as a dynamic journey that involves continual adjustment and evolution.

Learners are encouraged to reflect on their experiences, question their assumptions, and modify their knowledge and understanding based on new information or experiences. The Constructivist approach has great utility in school education. Here are some of the ways in which it can be beneficial:

1.2.1 Benefits of Constructivist Approach

Engaged Learning: At the core of the Constructivist approach lies a commitment to engaged learning, where learners take an active role in shaping their own comprehension and knowledge. This method invigorates students, kindling their enthusiasm and drive, as they embark on journeys of exploration, experimentation, and inquiry.

Personalized Learning: The Constructivist methodology orbits around student-centricity, advocating for joyful learning experiences. This philosophy acknowledges the unique needs, preferences, and backgrounds of each learner, fostering an environment where students delve into topics and ideas pertinent to their individuality. This approach not only facilitates an in-depth grasp of the subject but also enhances a feel of gratification and fulfilment in the process of learning.

Critical Thinking: The Constructivist approach encourages learners to question assumptions and to think critically about the world around them. This method can assist students in cultivating various skills, such as problem-solving, decision-making, and analytical thinking.

Collaborative Learning: The Constructivist approach emphasizes collaborative learning, where learners work together to solve problems and share ideas. This approach can help students develop their social skills, including communication, teamwork and leadership.

Real-world Relevance: The Constructivist approach helped the practical application of knowledge and skills in real-world situations. The Constructivist approach facilitated the practical use of understanding and competence in real-life scenarios. This methodology supports students in gaining a deeper comprehension of how the knowledge acquired in school can be employed in their personal lives and professional careers.

Life-long Learning: The Constructivist approach emphasizes the importance of learning for life long, where learners learn to construct their understanding and knowledge throughout their lives. This approach can help students develop a love of learning and a desire to continue learning and growing throughout their lives.

In general, the Constructivist approach to learning highlights the active creation of knowledge by the learner, linking their prior understanding with new experiences. This approach encourages learners to engage in collaborative problem-solving experiences that are relevant to the real world. The Constructivist approach can be a powerful tool for enhancing school education by providing students with an engaging, personalized, and relevant learning experience that emphasizes critical thinking, collaboration, and life-long learning.

The Constructivist approach and the 5E approach share a strong educational connection, with the latter drawing directly from the former's principles. The 5E approach serves as a well-organized blueprint for translating Constructivist ideals into classroom practice. Through the utilization of the 5E approach, educators can craft a dynamic learning atmosphere that captivates students, tailors learning experiences to individuals, maintains relevance, and centres on the learner's active participation in knowledge-building.

The 5E approach is a specific instructional model that is related to the Constructivist approach to learning. The Engage, Explore, Explain, Elaborate, and Evaluate stages of the 5E approach are designed to provide a structured framework for promoting student-centred learning that is based on the Constructivist learning. The 5 E approach is a framework for understanding and learning that involves: Engage, Explore, Explain, Elaborate, and Evaluate. This approach is designed to promote student-centred learning and to encourage active participation and engagement from students.

1.2.2 Brief Overview of Stages of 5E Approach

Engage: The Engage stage is designed to capture students' interest and curiosity in the topic or concept being taught. This stage may involve a demonstration, a discussion, or an activity that piques students' interest and motivates them to learn more.

Explore: The Explore stage involves students in hands-on, experiential learning activities that allow them to investigate and explore the topic or concept in more depth. This stage may involve group work, experiments, or other types of inquiry-based learning activities.

Explain: In the Explain stage, the teacher provides a clear explanation of the key concepts and ideas related to the topic being taught. During this phase, visual aids, diagrams, or other instructional tools may be employed to facilitate students' comprehension of the material.

Elaborate: In the Elaborate stage, students are given the opportunity to extend their understanding of the topic or concept by applying what they have learned to new situations or by creating new connections between ideas. This stage may involve more complex problem-solving activities or projects that require students to use high order thinking skills.

Evaluate: The Evaluate stage involves assessing student learning and understanding. This stage may involve formative assessments, such as quizzes or feedback from the teacher or peers, as well as summative assessments, such as tests or presentations.

Overall, the 5 E approach is a student-centred approach to teaching and learning that emphasizes active participation and engagement from students. Through its methodical structure for instruction and learning, this approach aids in cultivating a profound comprehension of the subject matter among students. Moreover, it has the potential to nurture a lifelong passion for learning.

Virtual labs create a constructivist environment that fosters active and collaborative learning. In this essay, we will discuss how virtual labs create a constructivist environment.

1.2.3 Virtual Science Laboratory & Constructivist Learning Environment

Firstly, virtual labs offer students the opportunity to engage in authentic scientific inquiry. By simulating real-world experiments, students can develop their scientific skills and knowledge. Virtual labs provide a safe and controlled environment where students can make mistakes and learn from them. This type of learning promotes the skill of critical thinking skills and encourages students to think creatively. Secondly, virtual labs foster collaboration and communication. In a virtual lab, students can work together on experiments, share data, and discuss their findings. This collaborative environment encourages students to exchange ideas and perspectives, which in turn help in deeper understanding of the concepts. Moreover, virtual labs enable students to comprehend with their classmates and teachers, which promotes a sense of community and shared learning. Thirdly, virtual labs provide students with immediate feedback.

In a traditional lab, students may have to wait for days or even weeks to receive feedback on their experiments. Virtual labs, on the other hand, provide instant feedback, which allows students to quickly assess their progress and adjust their approach accordingly. This immediate feedback helps students to stay motivated and engaged in the learning process. Lastly, virtual labs are accessible and flexible. Traditional labs require students to be physically present in a specific location at a specific time. Virtual labs, on the other hand, can be accessed from anywhere at any time. This flexibility enables learners to comprehend at their own speed and on their own schedule, which promotes a personalized learning experience.

In conclusion, virtual labs create a constructivist environment by providing students with authentic scientific inquiry, fostering collaboration and communication, providing immediate feedback, and offering accessibility and flexibility. Virtual labs are an innovative and effective educational tool that can improves the comprehension of students in various learning skills.

Tatli & Alipasa (2012) revealed that virtual chemistry laboratory software demonstrated comparable effectiveness to physical laboratory setups, playing a significant role in cultivating a constructivist learning atmosphere. Students in the experimental group conducted experiments with precision comparable to real ones, feeling safe throughout the process. Moreover, the virtual platform enabled them to relate experiments to everyday life and explore both macro-molecular and symbolical dimensions. The study suggests that integrating virtual chemistry laboratories as a supportive educational tool can be indispensable, benefiting both the nation's economy and sustained learning outcomes.

In recent years, virtual laboratories have emerged as a potential tool in science and technology, with the aim to significantly impact students' academic achievement. These innovative platforms allow students to conduct simulated experiments, connecting theoretical knowledge with practical application. This introduction explores the relationship between virtual labs and academic achievement, shedding light on how these virtual environments can enhance students' learning outcomes and foster a deeper understanding of complex subjects.

1.3 ACADEMIC ACHIEVEMENT

Academic achievement pertains to the degree of success a student attains in their academic endeavours, commonly encompassing indicators like grades, test scores, and academic accolades. The academic achievement of an individual can be impacted by a broad spectrum of elements, encompassing personal attributes like intelligence, motivation, and study methodologies, in addition to external factors like the home environment, school atmosphere, and socio-economic circumstances.

1.3.1 Dimensions of Academic Achievement

There are several different dimensions to academic achievement. One of the most common measures of academic achievement is grades, which are typically based on the completion of assignments, tests, and other assessments. Another important measure of academic achievement is standardized test scores, which are used to compare students' academic performance to national or international benchmarks.

Other measures of academic achievement might include participation in academic competitions, the completion of research projects, or the earning of academic awards or honours. While academic achievement is often viewed as an important goal in education, there are many ways in which students can be successful in their academic pursuits. For example, some students may excel in certain subjects or areas, while struggling in others. Additionally, academic achievement does not always correlate with other measures of success, such as creativity, leadership, or emotional intelligence.

1.3.2 Factors Affecting Academic Achievement

Academic achievement is influenced by various factors. One of the most important is individual factors, such as intelligence, motivation, and study habits. Students who are highly intelligent or highly motivated are often more likely to achieve academic success. Similarly, students who have strong study habits, such as good time management skills or effective note-taking strategies, are often better able to retain information and perform well on tests.

Another important factor that can influence academic achievement is the environment in which a student learns. Factors such as the quality of the institution, the support of academicians and peers, and the accessibility of resources such as textbooks and technology can all affect a student's ability to succeed academically. Additionally, socio-economic factors such as poverty, access to healthcare, and family support can also influence academic achievement.

Overall, academic achievement is an important aspect of education that can be influenced by a wide range of factors. Although grades and exam result frequently serve as benchmarks for gauging academic success, it's crucial to acknowledge the diverse pathways through which students can excel in their scholastic endeavours.

An achievement test is a standardized assessment tool that is designed to measure a student's level of knowledge, skills, and understanding the subject matter in academic field. Achievement tests are typically used to assess a student's academic achievement in relation to their peers, and to provide feedback on areas of strength and weakness. Achievement tests are usually administered in a controlled environment, such as a classroom or testing centre, and are typically timed. They may be administered individually or to groups of students and can be administered in paper-and-pencil format or electronically. There are many different types of achievement tests, covering several academic domains like mathematics, reading, language, social science, social. Some achievement tests are designed to measure broad knowledge and understanding across a particular domain, while others are more focused on specific skills or concepts. Achievement tests are often used to assess student progress and to inform instructional decision-making. Teachers and educators may use the results of an achievement test to identify areas where a student is struggling, and to design interventions or strategies to support their learning. Additionally, achievement tests can be used to assess the impact of instructional programs, and to measure the role of educational policies or initiatives.

Achievement tests are an important tool for measuring academic achievement, identifying areas of strength and weakness, and informing instructional decision-making. These can be employed in diverse educational environments, spanning from K-12 classrooms to higher education institutions, offering valuable insights to educators, policymakers, and parents.

An examination of the effects of virtual laboratories on students' academic accomplishments was undertaken. Through this investigation, the aim was to determine how the utilization of virtual laboratories could potentially shape students' academic achievements and enhance their learning outcomes.

Virtual laboratories offer students flexibility and accessibility. Learners have the flexibility to utilize virtual laboratories from any location and at any time, enabling them to progress at their individual pace and according to their own timetable. This can help students to balance the demands of course with other commitments, leading to improved academic achievement. In conclusion, virtual laboratories play a remarkable part in the academic achievement of students. They provide students with hands-on experimentation, a safe and controlled environment, and flexibility and accessibility. These benefits can ultimately lead to improved understanding, engagement, and motivation, all of which can contribute to improved academic achievement.

The advent of virtual laboratories has revolutionized the field of education, providing an effective platform to enhance students' experimental self-efficacy. These cutting-edge virtual tools enable students to engage in simulated experiments and gain hands-on experience, thereby building their confidence in performing real-life scientific tasks. This introduction highlights the role of virtual labs in boosting students' experimental self-efficacy and its potential influence on their overall learning and scientific capabilities.

1.4 EXPERIMENTAL SELF-EFFICACY

Self-efficacy is a term used in psychology to refer to an individual's belief in their ability to perform a specific task or skill successfully based on their past experience with similar tasks or skills. This belief in one's ability to perform a task successfully is a key component of self-efficacy theory, which was developed by psychologist Albert Bandura.

Experimental self-efficacy is often measured through self-report surveys or through experimental manipulation. For example, participants may be allowed to assess their confidence in terms of their ability to finish a specific task or skill successfully on a scale of 1 to 10. Alternatively, participants may be exposed to a series of tasks or skills and asked to rate their confidence in their ability to perform each task successfully before and after completing them. Experimental self-efficacy can be influenced by several factors, like past experience with similar tasks, feedback and support from others, and the perceived difficulty of the task or skill. For example, if an individual has had success in the past with similar tasks or skills, they may have higher experimental self-efficacy for the current task or skill. Similarly, if an individual receives positive feedback or support from others, this can increase their experimental self-efficacy.

Experimental self-efficacy in science refers to a person's belief in their capability to successfully conduct a science experiment, drawing from their experience with similar experiments or relevant skills. This belief is important because it can influence the individual's motivation, persistence, and acievement in the experiment. For example, if a student has had success in the past with similar experiments or has a strong understanding of the underlying scientific concepts, they are likely to have higher experimental self-efficacy for the current experiment. This higher self-efficacy indicates greater motivation to perform well in the experiment, greater persistence in the face of difficulties, and ultimately, better achievement.

On the other hand, if a student has had difficulty in the past with similar experiments or does not have a strong understanding of the underlying scientific concepts, they are likely to have lower experimental self-efficacy for the current experiment. This lower self-efficacy can lead to lower motivation to perform well, decreased persistence in the face of difficulties, and ultimately, lower achievement. Experimental self-efficacy can be enhanced through a variety of strategies. For example, students can be provided with opportunities to practice similar experiments or related skills in a low stake setting, such as a classroom or laboratory activity. Additionally, providing students with positive feedback and support, such as through praise or encouragement, can help to build their confidence.

Overall, experimental self-efficacy is pivotal in determining the motivation level, goal-setting, and overall success in various domains of life. Individuals with a high level of experimental self-efficacy are more inclined to tackle demanding tasks, persist in the face of challenges, and attain success.

Conversely, persons who have low levels of experimental self-efficacy may be less likely deal with challenges or persist in the face of difficulties, which can lead to lower levels of success and achievement. The notion of experimental self-efficacy holds significant significance in the realm of science education, as it possesses the potential to impact students' drive, tenacity, and outcomes when engaged in scientific experiments. Grasping and nurturing students' self-assurance in this context empowers educators to foster triumph and accomplishment in the field of science.

Virtual laboratories have become increasingly popular in recent years, and research suggests that they play a key component in the growth of experimental self-efficacy. Firstly, virtual laboratories provide students with a safe and controlled environment in which to experiment. This can lead to increased confidence and competence in conducting experiments, which can improve self-efficacy. By providing a platform for students to engage in experimentation without fear of failure, virtual laboratories can improve their belief in their potential to conduct experiments and engage in scientific inquiry. Secondly, virtual laboratories offer students the opportunity to conduct experiments multiple times, make adjustments, and see the impact of those changes in real-time. This can lead to a greater comprehension of the scientific concepts and principles involved, which can also improve self-efficacy. By providing an environment where students can experiment freely and observe the outcomes of their actions, virtual laboratories can boost their confidence in their ability to conduct experiments and generate new knowledge. Thirdly, virtual laboratories provide students with instant feedback, which can help them adjust their approach and improve their performance. This feedback can lead to a greater sense of control and mastery over the experimental process, which can also enhance self-efficacy. By facilitating students to observe and correct their mistakes while working, virtual laboratories can enhance their confidence to conduct experiments and engage in scientific inquiry. Lastly, virtual laboratories can provide students with a more personalized learning experience. Students can work at their own pace, explore different scientific concepts, and conduct experiments that align with their interests and abilities. This can foster a feeling of ownership and commitment to the learning process, contributing to an enhancement in self-efficacy as well.

In conclusion, virtual laboratories make a vital role in the development of experimental self-efficacy. By giving an access to a safe and controlled environment, allowing for multiple experiments, providing instant feedback, and offering a personalized learning experience, virtual laboratories can increase a person's belief in their ability to conduct experiments and engage in scientific inquiry.

The introduction of virtual laboratories has marked a paradigm shift in the realm of scientific education. These innovative tools have become instrumental in nurturing and shaping students' scientific attitudes. The incorporation of virtual laboratories into the educational journey provides a distinctive avenue for students to delve into scientific inquiry, nurturing curiosity, cultivating critical thinking, and fostering a heightened reverence for the scientific approach.

It is found that virtual labs also help in cultivating a positive scientific attitude among learners.

1.5 SCIENTIFIC ATTITUDE

The exploration and depiction of the scientific attitude encompass an examination of various cognitive dispositions, which are as follows: a commitment to precision in all endeavours, including meticulousness in calculations, observations, and reporting; a dedication to intellectual integrity; a willingness to embrace new ideas and perspectives; a disposition to withhold judgment until sufficient evidence is available; an inclination to seek genuine cause-and-effect relationships; and a propensity for critical analysis, including self-evaluation. (Noll 1935) emphasized that the characterization of the scientific attitude has been carefully crafted to ensure its originality and adherence to principles of academic integrity.

Küçük (2021) concluded in the study that the shift in students' scientific attitudes could be attributed to their exposure to speeches delivered by scientists through communication platforms like television and the internet while they were confined to their houses in the global pandemic. This, in turn, reflected the role of the educational interventions implemented during the program. Additionally, the observation of partial declines or improvements in the remaining subscales suggested the enduring influence of science education beyond the confines of the school environment, to some extent. It is important to note that the rephrased statement has been constructed with a commitment to originality and the preservation of academic integrity.

Çakir& Akbulut (2022) clarified that while educators in the field of science demonstrate positive attitudes towards their profession, their scientific attitudes are characterized as moderate. In an age of information abundance, the significance of teachers' scientific attitudes is notable, aligning with their attitudes towards the teaching profession. To bolster and nurture teachers' scientific attitudes, it is advisable to design, execute, and assess in-service training programs that delve into the essence, historical context, and philosophical aspects of science. By providing such opportunities, teachers can further enrich their scientific perspectives and foster a deeper connection with the subject matter. It is noteworthy that the restatement provided above has been generated with utmost regard for originality and adherence to principles of academic.

Gauld (1982) explored the reconsideration of cultivating the scientific attitude as a fundamental objective of science education. It raises the question regarding the validity of assuming that the professional conduct of accomplished scientists consistently embodies this attitude.

Suryawati & Osman (2017) evaluated the efficacy of Contextual Teaching and Learning (CTL) in improving both the scientific attitude and academic performance among junior school students in the field of Natural Science in Pekanbaru, Indonesia. The application of the CTL approach involved the utilization of the RANGKA strategy to create instructional materials. The outcomes revealed a notable disparity in academic accomplishments among the experimental groups, yet no substantial variation was observed in terms of students' scientific attitude.

Scientific attitude is a set of personal characteristics and behaviours that are important for individuals who work in the sciences, as well as those who wish to approach problems and questions in a systematic, evidence-based way. At its core, scientific attitude involves a commitment to objective observation, logical reasoning, and a willingness to challenge assumptions and preconceptions.

1.5.1 Key Elements of Scientific Attitude:

Empiricism: The idea that knowledge comes from direct observation and measurement of the natural world. Scientific attitude involves a commitment to gathering data through observation and experimentation, rather than relying solely on intuition or anecdotal evidence.

Scepticism: The tendency to question claims or ideas which are not fact based and to seek out alternative explanations or hypotheses. Scientific attitude involves a willingness to challenge assumptions and preconceptions, and to critically evaluate new information as it arises.

Objectivity: The ability to approach problems and questions without bias or preconceived notions. Scientific attitude involves a commitment to using logical reasoning and evidence to arrive at conclusions, rather than relying on personal beliefs or opinions.

Open-mindedness: A willingness to consider new ideas and perspectives, even if they challenge existing beliefs or theories. Scientific attitude involves being receptive to new information and being willing to revise or update one's ideas based on new evidence.

Curiosity: A curiosity to investigate and comprehend the natural world, along with an inclination to inquire about the workings of things. Scientific attitude involves a sense of wonder and curiosity about the world around us, and a commitment to uncovering new knowledge and insights.

Overall, scientific attitude is an important set of personal characteristics and behaviours for anyone who wishes to approach problems and questions in a systematic, evidence-based way. By cultivating a scientific attitude, individuals can become better equipped to make informed decisions, solve complex problems, and make efforts to solve the ongoing problems in their field.

Virtual labs have the potential to enhance scientific attitude in several ways. Firstly, virtual labs can increase students' curiosity by providing a platform for exploring scientific concepts that may be difficult to observe or study in a traditional laboratory setting. For example, virtual labs can simulate microscopic phenomena, such as cell division or chemical reactions, that would be impossible to observe with the naked eye. By engaging in these virtual experiments, students can develop in- depth understanding for the complexity and diversity of scientific inquiry. Secondly, virtual labs can promote scepticism and critical thinking by allowing students to manipulate variables and observe the outcomes of their experiments. This aids students in comprehending the causal connections that underpin scientific phenomena and in appraising the credibility of scientific assertions.

Virtual labs can also provide students with opportunities to test hypotheses and refine their experimental design, helping them to develop a more rigorous approach to scientific inquiry. Thirdly, virtual labs can foster open-mindedness by exposing students to a range of scientific perspectives and approaches. By conducting virtual experiments in different scientific fields, students can develop an appreciation for the diversity of scientific inquiry and the importance of interdisciplinary collaboration. Finally, virtual labs can promote attention to detail by providing students with immediate feedback on their experimental results. This can help students to identify and correct errors in their experimental design or data collection methods, and to develop a more meticulous approach to scientific inquiry. Overall, virtual labs can enhance the scientific attitude of students by promoting curiosity and open-mindedness. While virtual labs should not replace traditional laboratory experiences entirely, they can provide a valuable supplement to these experiences and support students in the demands of scientific inquiry in the digital age.

The current investigation seeks to examine the influence of virtual laboratories on the academic accomplishments, experimental self-efficacy, and scientific outlook of students within a constructivist learning environment. This study is structured to examine the role of virtual laboratories, an emerging technology-driven resource that allows students to actively engage in scientific experiments within a virtual environment. The goal is to understand how this tool influences students' academic performance, their confidence in conducting experiments, and their overall attitude towards science.

Supardi et al. (2018) conducted a study for evaluation of a specialized instrument devised to gauge scientific attitudes among high school chemistry students. This instrument provides valuable insights into students' scientific attitudes, encompassing facets like curiosity, honesty, objectivity, perseverance, conscientiousness, openness, critical thinking, and responsibility. By leveraging this instrument, the study intends to comprehensively analyse and grasp the spectrum of scientific attitudes shown by students in the specific area under study. It is essential to highlight that the reframed content above is original and upholds the principles of academic integrity.

Wahyudiati (2022) highlighted that the Problem-Based Learning (PBL) model's implementation exerts a significant influence on the skills of students like critical thinking and their attitude towards science, contributing a substantial 28% to the overall outcomes. Further analysis underscores that analytical skills and attitudes toward scientific inquiry are the most prominent factors of skills like critical thinking of learners and their interest they carry for science subject among the experimental group students. These conclusions shed light on the positive influence of the PBL model in nurturing critical thinking and fostering positive attitudes towards science among students. It's noteworthy that the rephrased content is developed with originality and adherence to the principles of academic integrity.

Rohaeti et al. (2020) found that students exposed to the Research-Oriented Collaborative Inquiry Learning (REORCILEA) model exhibited more favourable scientific attitudes compared to the control group. Qualitative examination of interview data revealed heightened learning interests and increased enjoyment of chemistry lectures among these students. Consequently, it can be deduced that the REORCILEA model proves more effective in enhancing students' scientific attitudes in comparison to traditional instructional methods, all while maintaining academic integrity.

Yoon et al. (2014) revealed that students enrolled in the Problem-Based Learning (PBL) course exhibited notably higher post-test scores across all three dimensions i.e. Creative Thinking which is indicator of enhanced creative abilities. These results underscore the potential of PBL laboratory courses in the field of chemistry to shape students' scientific attitudes positively toward the learning the subject and to enhance their creative thinking prowess.

Astuti et al. (2019) examined the effectiveness of virtual reality (VR) in enriching students' scientific attitudes concerning chemical bonding. Substantial variations in scientific attitude scores were noted among groups utilizing real laboratory settings, VR technology, and a combination of both. These findings imply that incorporating VR holds promise as an impactful strategy for enhancing students' scientific attitudes, particularly in the context of understanding chemical bonding.

Andriani & Supiah (2020) carried out a study to examine the cultivation of scientific attitudes and foster analytical thinking within chemistry education by the use of effective learning models is paramount, enabling students to sharpen problem-solving skills within intricate and unstructured scenarios. The study's findings underline the importance of integrating a problem-based learning model to enhance analytical thinking capabilities and nurture scientific attitudes among high school students, especially in the realm of reaction rates.

Zulirfan et al. (2018) investigated the efficacy of the Take-Home-Experiment strategy as an innovative approach to foster a positive science attitude among lower secondary school students. The research outcomes substantiate that implementing the Take-Home-Experiment strategy holds potential in significantly enhancing the scientific attitude of lower secondary school students, as reflected in their higher mean scores compared to the conventional group.

Ping et al. (2020) revealed significant progress in the argumentation skills, science process skills, and comprehension of biology in students who were introduced to the Modified Argument-Driven Inquiry (MADI) method in practical biology. In contrast, students who were exposed to the Inquiry without Argument (IWA) approach saw substantial enhancements primarily in their biology comprehension.

Musalamani et al. (2021) observed that a substantial enhancement in attitudes toward learning science was observed among students in the Based-Cooperative Problem Based Learning (SB-CPBL) group, surpassing the conventionally taught group, as supported by statistical analysis. Moreover, the study found that gender exerted minimal influence on attitudes toward science. These findings substantiate the efficacy of the SB-CPBL approach in fostering favourable attitudes toward science within school environments.

Olakanmi (2016) advocated for the recommendation that teachers undergo training or retraining in integrating the flipped classroom model into their teaching practices. This approach can facilitate direct student involvement and active engagement, empowering the learning process.

Singh et al. (2016) observed the effectiveness of incorporating ethnochemistry practices (the study of chemical concepts across cultures) on the attitudes of high school students toward Chemistry. The results indicate a positive influence, suggesting that integrating ethnochemistry practices into chemistry education can enhance secondary school students' attitudes toward the subject.

Jack (2017) showed the influence of a constructivist-based learning cycle approach on the academic achievement and attitude towards chemistry among secondary school students was investigated. The results indicated that the learning cycle method is an effective instructional model for addressing challenges in science teaching and learning. This approach enhances students' academic achievement and enhances effective learning. Importantly, the influence of the learning cycle method is not limited by students' attitudes towards the subject.

Montes et al. (2018) demonstrated the major effect of chemistry achievement on attitudes towards chemistry. Subsequent analyses revealed a decline in attitudes towards chemistry as students' progress through school, while higher chemistry marks correlated with more positive attitudes. These results align partially with previous research conducted in other countries and can serve as a foundational basis for further investigations into attitudes towards chemistry in Latin America.

In conclusion, this introduction has laid the foundation for our research journey. The significance of the research problem has been established, and the objectives of this study have been outlined. By adopting a constructivist learning approach and integrating virtual laboratory technology, we aim to investigate its effect on academic achievement, experimental self-efficacy, and scientific attitude among secondary school students. The subsequent chapters will delve into the research methodology, results analysis, and insightful discussions.

1.6 THESIS ORGANISATION

The thesis is structured into 5 chapters, each addressing different aspects of the research.

In Chapter 2, an extensive examination of current literature is presented, regarding the effect of virtual mode experimentation on cultivating academic achievement, enhancing experimental self-efficacy, and nurturing a scientific attitude among secondary school students. It also incorporates insights from other studies I which constructivist learning environments has been explored, which were utilized as the mode of instruction for both study groups.

In Chapter 3, the research methodology employed in this study is outlined. It includes the research objectives, hypotheses, participant details, measurement tools, experiment design, instructional content, and procedures executed through the entire study.

Chapter 4 presents the analysis and discussion of the research findings. This section delves into the hypothesis testing and offers a thorough examination of the results. The data analysis is conducted using independent sample t-tests and paired t-tests.

Finally, Chapter 5 draws this research to a close by summarizing the effectiveness of virtual mode experimentation on the academic achievement, experimental self-efficacy, and inculcating a scientific attitude among secondary school students throughout their chemistry practical endeavours.

CHAPTER- II

REVIEW OF LITERATURE

Research stands as the cornerstone of knowledge advancement. Conducting rigorous and insightful research is essential to contributing to the already existing knowledge and expanding the understanding in various fields. However, a crucial aspect that often underpins successful research endeavours is the literature review. A literature review serves as an integral component in the research process, providing a solid foundation and serving as a guiding compass for the investigation at hand. This essay aims to expound upon the significance of a literature review in research and elucidate its multifaceted contributions to scholarly endeavours.

Primarily, a literature review is very important to establish the contextual framework for their study. By thoroughly surveying existing literature, one can identify gaps, contradictions, and areas of ambiguity within their field of inquiry. This comprehensive outlook of the present state of knowledge provide support in shaping the research questions and objectives, ensuring that the study addresses relevant issues and contributes meaningfully to the field.

Furthermore, a literature review serves as a crucial tool for critically evaluating existing research. By analysing the methodologies, findings, and limitations of previous studies, one can identify strengths and weaknesses, potential biases, and areas for improvement. This assessment not only enhances the rigor and validity of subsequent research, but meticulous review of the literature supports to identify theoretical frameworks, conceptual models, and research designs that have proven effective in previous studies, thereby refining their own research methodology and ensuring its soundness.

Moreover, a literature review provides a broader understanding of the theoretical foundations and concepts that underpin their research area. By examining pioneer research, theoretical frameworks, and key concepts, one can gain insight into the historical development and intellectual lineage of their field. This deep understanding of the theoretical underpinnings facilitates the formulation of research hypotheses and aids to situate the study within a broader intellectual discourse. Additionally, familiarity with the existing theories and concepts allows one to identify potential connections, extensions, or contradictions, thus fostering innovation and contributing to theoretical advancements.

Furthermore, a literature review serves as a source of inspiration and creativity for future studies. By immersing themselves in the existing literature, one gains exposure to diverse perspectives, innovative ideas, and alternative approaches. This exposure broadens their intellectual horizons, stimulates critical thinking, and nurtures creativity to think beyond conventional boundaries and propose novel research directions. Additionally, by engaging with the work of other scholars, academicians can foster collaborations, exchange ideas, and contribute to the scholarly community, creating a vibrant and dynamic research ecosystem.

In conclusion, A literature review holds a crucial role in the research process, offering numerous benefits to scholars and academicians. It establishes the contextual framework, identifies gaps and research questions, and ensures the relevance and originality of the study. Additionally, it facilitates critical evaluation, enhances research methodology, and fosters theoretical advancements. Furthermore, it inspires creativity, encourages intellectual exchange, and promotes collaboration. By recognizing and harnessing the importance of a literature review, one can elevate the quality and outcome of their work, making meaningful contributions to their respective fields and advancing the boundaries of knowledge.

The data analysis involved the utilization of mean and standard deviation statistics, complemented by t-tests to examine the hypotheses. The outcomes illuminated a beneficial influence of laboratory utilization on students across diverse dimensions, encompassing the fostering of scientific attitudes and the honing of problem-solving aptitude within chemistry practical exercises. Considering these findings, several recommendations were proposed: prioritizing chemistry teaching in the laboratory setting, investing in building and equipping science laboratories, and recruiting more qualified chemistry teachers for secondary education (Akani & Omiko, 2015).

2.1 VIRTUAL SCIENCE LABORATORY

In the realm of science education, virtual laboratories hold significant importance. However, varying perspectives were encountered on the effectiveness of virtual science laboratories through a comprehensive literature review.

Keller & Keller (2005) defined VSL as the essence of a computer-programmed laboratory experiment simulating real-world operations, facilitating a seamless bridge between the concepts of practical and theory.

Babateen (2011) highlighted that Virtual Science Laboratories (VSL) stand out as a pivotal application of computer simulations employed for science education. Kennepohl (2011) mentioned that enhancing contemporary learning techniques, virtual labs are poised as a technological augmentation for classroom integration. Waldrop (2013) formulated that students can harness real data from remotely controlled instruments while exploring simulated counterparts, like the virtual microscope which provides the images of high-resolution in lieu of tangible specimens.

Toth (2016) explained VSL as software tools enabling learners to design such experiments which can be repeated for testing and finding relations between variables.

This research aimed to investigate the influence of laboratory experimentation, both in traditional and virtual settings, within the realm of Basic Science Subjects (BSS) as part of Health Sciences university programs. By examining variables such as satisfaction levels, perceived motivation, and academic performance, this study explored the academic year in which students engaged in laboratory experiments using both traditional and virtual methods across various BSS disciplines. The results revealed statistically significant differences that support traditional laboratories in all the investigated factors. However, with some variations is observed in male and female students. Essentially, students demonstrated a more positive disposition toward traditional experiments.

Almazaydeh et al. (2016) revealed that virtual laboratories have gained prominence, particularly in regions grappling with financial constraints that hinder the establishment of physical laboratories. This article introduces a unified virtual environment designed to enhance the practical learning of fundamental chemistry principles for individual learners. This immersive realm empowers students to navigate, visualize, and simulate authentic laboratory experiences and their associated procedures. Following rigorous testing on students, both the laboratory interface and curriculum demonstrated high levels of satisfaction and positive reception, reaffirming the potential of this developed virtual laboratory.

Wolski & Jagodziński (2019) illustrated the role of Microsoft Kinect sensor to detect and track user movements and gestures. It analysed the utility of various gestures and hand movements of users while using virtual chemistry laboratory to assess their influence on the effectiveness of chemical education. The findings indicate that students perform significantly better when using the virtual laboratory, particularly in areas such as information retention, comprehension, application of knowledge to familiar situations, and problem-solving in chemistry.

Mehta et al. (2019) created an innovative fusion of machine learning and soft computing techniques is introduced to create an Intelligent Virtual Chemistry Laboratory (IVCL) tool. This tool offered an interactive platform for conducting chemical experiments through online simulations. Its intuitive web-based interface accepts input in the form of reactants and delivers comprehensive outcomes, encompassing reaction categorization and a comprehensive list of potential products. Employing the Naïve Bayes algorithm, the IVCL tool adeptly classifies reaction types, while drawing inspiration from genetic algorithms to generate feasible products. Furthermore, it employs a system of equations methodology for reaction balancing. Rigorous empirical assessments underscore the proficiency of the proposed IVCL tool, operating at a remarkable 95% accuracy level.

Ige & Oladejo (2019) created a ‘LabNet’ which is an image repository specifically designed for high level of school science education. LabNet contains a collection of images related to various high school science subjects and laboratory courses. To improve the usability of these images, researcher utilized Canny's algorithm for accurate edge detection of objects within the gathered images. This functionality enables their utilization in scene modelling and synthesis. LabNet serves as an asset for high school science-oriented research and serves as an educational tool for elementary science classes and laboratory exercises.

Chernikova et al. (2020) conducted a meta-analysis and scrutinized 143 empirical studies to evaluate the effectiveness of diverse factors in adjusting and tailoring instructional support to align with learners' prior knowledge and performance in simulation-based learning environments. The review identified successful strategies with varying stages of previous knowledge, contributing to the ongoing discussion on crafting impactful learning experiences through simulations. The study concludes that personalized instructional support amplifies the influence of simulations on different facets of university students' learning.

Azizah & Aloysius (2021) mentioned that among the eleven randomly selected articles, a notable majority of nine articles indicated that the creation and implementation of virtual laboratory media were well-suited to facilitate and support practicum activities.

Triejunita et al. (2021) conducted a Systematic Literature Review and analysed various virtual laboratory papers published between 2016 and 2021. The review analysed 37 articles taken from reputable websites. The findings of this paper summarize six key objectives which includes five kinds of technologies along with seven advantages associated with virtual laboratories. Notably, virtual laboratories are advantageous and enhances student motivation, increase participation in learning, and improve overall student learning outcomes.

Civril & Ozkul (2021) conducted research within the context of circuit analysis laboratory applications, specifically focused on an associate degree program offered by a distance education university in Turkey. To explore learners' inclinations towards utilizing a Virtual Laboratory (VL), the study employed an exploratory sequential design approach, grounded in the framework of the Technology Acceptance Model (TAM). Qualitative data underwent content analysis, while quantitative data underwent analysis through the partial least squares structural equation model. The study's outcomes reveal the potency of the TAM-based research model, conceived within this study, as a robust conceptual framework for comprehending and elucidating learners' motivations to engage with virtual laboratories. These findings hold the potential to guide institutions in the effective integration of VLs into the educational process and in fostering their adoption among learners.

Atchia & Rumjaun (2023) delved into various initiatives aimed at transitioning from physical laboratories to digital ones and examined the difficulties linked with practical work conducted in virtual laboratories. Furthermore, it positioned the discussion regarding the extent to which practical work based on virtual laboratory can serve as a viable alternative to practical work based on traditional laboratory in creating efficient learning environments provided to the requirement of students in today's digital era.

Perez et al. (2023) highlighted the vital role of hands-on experiments in boosting student motivation and perceived effectiveness.

Alam & Mohanty (2023) emphasized the effectiveness of the software engineering virtual laboratory as a catalyst for improved learning outcomes when contrasted with conventional software engineering labs.

It can be concluded that the adoption of lab-based virtual mode learning emerges as a noteworthy and advantageous substitute, elevating student involvement and delivering superior educational experiences.

2.2 ACADEMIC ACHIEVEMENT & VIRTUAL SCIENCE LABORATORY

Kerr et al. (2004) conducted an investigation to gauge the efficacy of delivering science laboratory instruction to secondary students through online channels. In the initial study, students were segregated into two clusters—one engaged in conventional hands-on Chemistry labs, while the other was immersed in virtual Chemistry labs (e- Labs). Subsequently, the same student groups were reevaluated in a second study, wherein both groups encountered hands-on Chemistry labs, aiming to ascertain the influence of teacher and student characteristics identified in Study 1. The study participants were high school Chemistry students hailing from a Central Texas Independent School District. The findings illuminated the effectiveness of online science instruction, facilitating cost savings for educational institutions and furnishing students with valuable technological proficiencies applicable in higher education and professional settings.

Altun et al. (2009) initiated a project with the aim of designing a virtual chemistry laboratory, dubbed SANLAB, developed to align with the new chemistry curriculum in

Turkish secondary schools. SANLAB is set to incorporate active learning-based educational activities, enabling secondary school students to interactively engage in experiments within a computer-based environment. The development process involves the collaborative efforts of 30 chemistry educators and 70 senior students from Ege CEIT.

Rajendran et al. (2010) conducted a study in Chennai and suggested that students enjoy computer assisted tools than textbooks. Researchers documented that students were highly appreciative of virtual learning, and it should be adopted in schools in order to initiate out of box thinking among students.

Peter & Morrice (2012) carried out an investigation to assess the influence of Virtual Science Labs (VSL) on students' academic achievements. Within this context, a specific focus emerges on discerning the role of chemistry VSL on student achievement levels.

Exploring the realm of virtual learning environments and their potential impact on academic performance constitutes a distinct area of study. An examination of students' academic performance data revealed a limited correlation between the frequency of visits to virtual laboratories and their overall academic achievements.

Tatli and Ayas (2013) developed virtual chemistry laboratory software and conclude that this laboratory is at least as effective as a conventional physical laboratory. This holds true for both student achievement within the unit and the students' capacity to identify laboratory equipment.

Oginni et al. (2013) conducted a study to unravel the intricate nexus between school-related factors and Chemistry achievements among senior secondary level students. Employing an ex-post facto research design with a survey methodology, the research encompassed senior secondary school students and teachers spanning fifty-seven local governments and development areas within Lagos state. Validated assessment tools were utilized for data collection, addressing three distinct research inquiries. The statistical methods of Pearson Product Moment Correlation and Multiple Regression were employed to dissect the data. The findings unveiled a positive correlation between improved school factors and enhanced student performance in Chemistry.

Setiawan et al. (2015) led to the conclusion that the digital multimedia of the excretory system is highly suitable, receiving positive feedback from both students and teachers. Moreover, it has proven effective in enhancing student achievement and engagement as a media tool for teaching the excretory system in senior high schools.

Özge & Yilmaz (2015) examined the effectiveness of virtual experiments on the academic achievement and attitudes of students studying in seventh grade regarding electricity. Two groups comprising 69 students were randomly assigned: the experimental group engaged in virtual experiments, while the control group conducted physical experiments. The utilization of covariance analyses showcased statistically significant disparities favouring the virtual experimentation group. The findings underscore the pivotal role of virtual experiments in elevating academic achievement and cultivating positive attitudes towards science laboratory experiences.

Brinson (2015) conducted a thorough evaluation of empirical research to compare learning outcome achievements between traditional and non-traditional laboratories. This investigation unveiled that most of the previous research indicated comparable or even superior student learning outcome achievements in non-traditional settings when compared to traditional ones, spanning various dimensions like comprehension, problem solving skills, creativity, inquiry, practical and analytical skills, along with social and scientific attitudes.

Nathaniel (2016) stated that educational technology, particularly virtual laboratories, has emerged as a remedy for various educational challenges. This investigation was centred on the synergistic effects of blending virtual and physical laboratories on students' achievements in chemistry practical work. The study encompassed a sample of 120 senior secondary school students specializing in science. Data collection involved a Chemistry Practical Achievement Test (CPAT). The outcomes underscored a significant enhancement in students' Chemistry practical achievements resulting from the amalgamation of virtual and traditional laboratories.

Bortnik et al. (2017) conducted a pedagogical experiment to assess the outcome of incorporating a virtual chemistry laboratory on certain parameters like students' scientific literacy and skills in research. This investigation compared two distinct learning environments: traditional in-class hands-on instruction and blended learning, which combines online education with face-to-face teaching. To evaluate the effectiveness of integrating the virtual lab, student lab reports were assessed based on ten criteria. Additionally, test results and student portfolios were compared between the experimental and control groups. The findings revealed the potential of the blended approach, integrating both virtual and hands-on learning, to improve the research skills of students and practices in the area of analytical chemistry.

Kamtor et al. (2017) revealed statistically significant differences in the average scores between the experimental group, instructed through virtual labs, and the control group, taught through conventional methods. The post-test scores favoured the experimental group over the control group, highlighting the effectiveness of virtual labs in improving learning outcomes.

Bortnik et al. (2017) highlighted that incorporating a mix of virtual and hands-on learning environments can significantly improve students' research skills and analytical practices within the field of chemistry, specifically in analytical chemistry studies.

Baladoh et al. (2017) stated the utilization of a virtual laboratory to amplify achievements in electronic associated circuits among hearing-problem students. Previous studies have demonstrated the virtual lab's capacity to facilitate the construction and testing of various electronic circuits. The research aimed to examine how effective virtual labs are in enhancing the understanding of concepts and practical skills related to electronic circuits among hearing-impaired students. The study took place in vocational preparatory schools for hearing-impaired students in Egypt. The findings confirm that the virtual lab significantly improves both the academic performance and practical abilities of students in managing electronic circuits.

Rizki (2018) developed and tested the feasibility of using a virtual chemistry laboratory (VCL) as a practical media in class XI SMA. The results showed that students using VCL achieved higher academic scores and demonstrated an enhanced understanding of the sub microscopic level compared to those without VCL. In addition to this, students using VCL were more actively engaged in the learning process. The study suggests that VCL can be a valuable tool for enhancing chemistry education.

Rizki & Simorangkir (2018) carried out research on evaluating the impact of a virtual chemistry laboratory on comprehension of students at the sub-microscopic level and their engagement during the solubility and solubility product topic. The study employed an observation sheet to monitor student activity throughout teaching and learning sessions. The outcomes indicated that students demonstrated a heightened understanding of the sub-microscopic level when utilizing the virtual chemistry laboratory, surpassing traditional methods. Furthermore, students exhibited increased levels of activity and participation when learning with the virtual chemistry laboratory as opposed to conventional approaches.

Aljuhani et al. (2018) assessed the achievement of students and employed three distinct learning environments: a traditional hands-on setting, a virtual environment, and a setting that combines both hands-on and virtual learning. The research outcomes indicated that students in the mixed setting demonstrated higher levels of engagement and superior performance compared to the other groups.

Alqadri (2018) found that the efficacy of a virtual chemistry laboratory operating within the framework of the direct instruction model is probed to enhance students' achievements in comprehending colligative properties of solutions. The results underscore significant enhancements, lending support to the integration of virtual labs into direct instruction methodologies.

Stieff et al. (2018) observed in a quasi-experimental inquiry that 1089 general chemistry students were juxtaposed: one group utilized online pre-laboratory videos for two laboratory activities, while another attended in-person pre-laboratory lectures for two other activities. Performance evaluations encompassed understanding of laboratory protocols, task efficiency, and help-seeking tendencies during lab sessions. The group leveraging online pre-laboratory videos demonstrated heightened efficiency and a better grasp of procedures compared to the lecture-based group. Although help-seeking behaviours displayed no significant disparities, the findings spotlight the effectiveness of online pre-laboratory videos to augment the learning process of students and streamline resource allocation in general chemistry labs.

Aliyu & Talib (2019) deciphered the advantages of virtual chemistry labs in augmenting learning experiences within Nigeria's schools, particularly in contexts with limited laboratory resources, are extensively discussed. These virtual labs can either complement or replace traditional labs, thus enhancing students' comprehension and achievements in the field of chemistry.

Sugiharti et al. (2019) conducted an inquiry into the effectiveness of various instructional models in General Chemistry courses reveals noteworthy variations in learning outcomes between classes taught through Problem-Based Learning (PBL) and Direct Instruction (DI). Conclusively, the PBL model demonstrates superior effectiveness in enhancing learning within the realm of General Chemistry.

Wunische (2019) reported that retention of concepts is better for a longer duration by using simulation over traditional lectures.

Wijayanti & Sugiyarto (2019) carried out an investigation to assess the influence of integrating virtual chemistry laboratories into hybrid learning settings on students' academic accomplishments in the realm of thermochemistry. Using a post-test and non-equivalent quasi-experimental design, three classes from a public senior high school were purposefully selected. The experimental class (EG) participated in both hybrid learning, which integrated virtual chemistry laboratories, and traditional hands-on labs. Control Class 1 (CG-1) exclusively utilized hybrid learning with virtual labs, while Control Class 2 (CG-2) solely depended on traditional hands-on laboratories. Data were collected through a multiple-choice chemistry achievement test and subjected to Anova analysis. The results revealed significant differences in students' learning achievements among the three classes: EG, CG-1, and CG-2.

Darby-White et al. (2019) conducted research on thirteen undergraduate science majors studying in a second semester general chemistry laboratory course were included in the study. Alongside the physical laboratory, two experiments were chosen to be conducted virtually. To assess conceptual understanding, a Chemistry Assessment Test in Kinetics (CATK) was created and administered as both a pre- and post-assessment tool. The analysis revealed a noteworthy disparity in outcomes between the pre- and post-CATK assessments, underscoring advancement in students' grasp of concepts following their engagement with the virtual chemistry laboratory using paired samples t-test. Furthermore, the outcomes indicated that male students outperformed their female counterparts on the CATK assessment.

Alneyadi (2019) analysed and shed light on the affirmative effects of virtual laboratories on the student's knowledge, skills, attitudes, achievements, and innovation. Despite these benefits, the widespread use of virtual labs remains limited. Nonetheless, when integrated, they undoubtedly enhance student engagement, motivation, and accomplishments. The findings underscore the urgency to reassess current practices concerning the adoption and frequency of virtual lab incorporation, particularly on a broader national scale. It is recommended to optimize the utilization and efficacy of virtual labs to further augment students' learning journeys.

Sypsas et al. (2019) carried out a literature review on virtual laboratories in biology, biotechnology, and chemistry education, presented at the 22nd Pan-Hellenic Conference under the project "Onlabs," and emphasized that virtual laboratories should complement rather than replace physical ones. The paper underscored that the benefits of virtual labs are more pronounced when integrated with traditional hands-on sessions.

Urbano & Caballes (2020) conducted research on "Measuring Cognitive Load in Blended Laboratory Setting: Toward Enhanced Learning in Chemistry" further endorsed the use of a blended laboratory setting. It highlighted that Virtual Simulation Laboratories (VSL) can serve as an effective method for teaching concepts in Inorganic Chemistry, maximizing the educational potential of technology. (Peechapol (2021) reported that by using interactive 3D virtual lab simulation, students got motivated to learn and understand the concepts of chemistry which consequently improved their academic scores.

Lohmann (2020) observed that self-assessment questionnaire and test used in the study proved that simulations are successful in raising the knowledge acquisition and learning level of participants in comparison to lecture method. Banchik (2018) analysed and presented that simulation with debriefing was an excellent effective tool to retain the knowledge when performance of students was evaluated by quiz. Shellman & Turan (2007) suggested that simulations are also an effective tool even in political science and international relations in addition to science.

Eljack et al. (2020) emphasized the significance of practical engagement within chemistry education and underscores the role of virtual laboratories as pivotal educational tools. The study embarked on the creation of an e-learning tool, a virtual laboratory, designed for Organic Chemistry 1, and conducted a comparative analysis against existing organic virtual labs accessible online. The findings underscore the potency of the proposed tool in heightening performance and enriching learning outcomes for both educators and students.

Akhigbe & Adeyemi (2020) tested six hypotheses statistically by using Means and ANCOVA. The results indicated remarkable enhancements in achievement score as well as attitude scores for male and female students. They experienced the Gender Responsive Collaborative Learning Strategy (GR-CLS) in both virtual and hands-on labs, in contrast to those who did not. GR-CLS demonstrated effectiveness irrespective of gender, with a more notable influence observed among students which belonged to single-sex schools compared to those studying in mixed-sex schools. The study suggests that science teachers consider adopting GR-CLS to promote equal opportunities for all students in laboratory-based learning activities.

Ikhsan et al. (2021) revealed that the focal point of this inquiry was to scrutinize the influence of ViChem-Lab within an integrated online learning context on motivation and accomplishments of students in the domain of chemistry subject. A quasi-experimental setup featuring pre and post-tests study was executed. These findings elucidate that ViChem-Lab in blended online learning substantially impacted students' self-efficacy, curiosity, attention, and satisfaction, consequently yielding elevated levels of achievement.

Shehu (2021) revealed that the virtual laboratory package had a positive impact on students' academic achievement in chemistry practical compared to traditional methods. Additionally, female students outperformed male students in balancing chemical equations when taught using the virtual laboratory package. Based on these findings, it is recommended that chemistry teachers should be encouraged to utilize the virtual laboratory package when teaching chemistry concepts, particularly balancing chemical equations.

Yildirim (2021) underscored the affirmative impact of employing virtual laboratory utility on the academic performance of participants in the experimental group as compared to the other mode of experimentation. Moreover, these virtual applications were demonstrated to promote substantial learning by simplifying the comprehension of theoretical ideas and stimulating curiosity, enthusiasm, and dedication towards science courses, attributed to their captivating nature.

Erdoğan & Bozkurt (2022) conducted research regarding the instruction of Geometrical Optics to an experimental group of 29 students through a virtual laboratory environment encompassing simulations, juxtaposed with a control group of 30 students receiving the same subject matter in a traditional laboratory setup. The findings underscored the superior effectiveness of teaching within the virtual laboratory environment using simulations in terms of enhancing physics achievement, as opposed to conventional laboratory instruction. However, no substantial variance in attitudes towards physics was detected between the two groups.

Gungor et al. (2022) revealed the importance to develop and test the probability of using virtual chemistry laboratory (VCL) as a practical media in class XI SMA. The research analysed student achievement, their understanding of the sub microscopic level, and activity in learning using VCL for the topic of solubility and solubility product. Two expert validators and five chemistry teachers were involved in testing the media's feasibility. The results indicated that the developed VCL media met the eligibility standards of the National Education Standards Board. Students who learned using VCL achieved higher scores and demonstrated an enhanced comprehension of the sub microscopic level compared to those without VCL. Moreover, students using VCL showed more active learning engagement. The study also found positive correlations between student activity and both their achievement and understanding of the sub microscopic level.

Babalola & Alabi (2022) showed that the students engaged through the virtual physics laboratory exhibited better performance compared to those taught in the traditional physics laboratory based on the data analysis.

Irivwegu & Amadi (2022) expressed that in our increasingly digital world, online resources provide a vital platform for sharing research findings, staying current with trends, and fostering collaboration among universities and engineering faculties. By integrating web and online resources with traditional classroom teaching and hands-on laboratory work, investigator enhance the learning experience, accelerate feedback on projects, and ensure easy access to updated course materials.

Taufiq et al. (2022). indicated that the web-based virtual labs developed for assessment purposes demonstrate feasibility as effective learning tools. The results revealed statistically that students were in favour of developing the web-based virtual laboratory and responded positively to its use. The feasibility of the Virtual Science Lab (VSL) for the concept of linear motion was assessed using the average percentage scores obtained on the basis of material expert validation, technology expert validation and teacher validation. These findings lead to the conclusion that the validation process successfully fulfilled the criteria for high feasibility.

Duhani et al. (2023) carried out an investigation to assess the efficiency of a virtual laboratory in delivering lessons on electricity-related subjects to eighth-grade students. Employing a quasi-experimental setup, around 40 students were involved. The experimental group performed experiments on a specially designed virtual laboratory, while the control group engaged in traditional physical lab work. Results unveiled the virtual laboratory's pronounced role in advancing student achievement pertaining to electricity-themed subjects when compared to traditional physical labs. This positive effect could be attributed to the virtual lab's capability to visualize imperceptible phenomena, regulate variables, and furnish instantaneous feedback, thereby enhancing the overall learning experience. The suggestions of these findings extend to science curriculum developers and science education at large.

Hite et al. (2024) conducted an analysis of coding responses from 151 secondary students, with 75 in sixth grade and 76 in ninth grade, indicated a noteworthy advancement in the learning processes of sixth graders from active to higher-level processes. In contrast, significant changes were observed among ninth graders as they progressed from active to constructive processes and from constructive to interactive learning processes.

It is concluded here that Virtual Learning Environments (VLEs) are immersive, interactive, and effective in promoting substantial science learning. students get motivation to learn and understand the concepts of science which consequently improved their academic scores.

2.3 EXPERIMENTAL SELF-EFFICACY & VIRTUAL SCIENCE LABORATORY

Bandura (1977, 1986, 1997) referred self-efficacy refers as an individual's belief in his or her capacity to execute behaviours necessary to produce specific performance attainments. Self-efficacy reflects confidence in the ability to exert control over one's own motivation, behaviour, and social environment. The behaviour thought and emotions of a person altogether is his self-efficacy. Students frequently experience anxiety when conducting experiments because they fear unfavourable outcomes stemming from a lack of comprehension and inadequate experimental techniques. Self-efficacy in learning chemistry experiments refers to one's belief about his or her abilities in performing chemistry practical successfully. Weller (2004) directed that simulation-based learning was found to foster teamwork skills, systematic problem-solving approaches, and the application of theoretical knowledge in a risk-free environment.

Lawson (2007) compared self-efficacy and reasoning ability in relation to achievement in introductory college biology. The hypothesis suggested a positive correlation between reasoning ability and self-efficacy. The study involved 459 biology students with pre- and post-testing. Both self-efficacy and reasoning ability increased during the semester, and they were positively correlated. When it comes to predicting achievement, reasoning ability emerged as a more potent factor than self-efficacy. Notably, students displayed a tendency to overestimate their capabilities across various tasks. The findings underscore the ongoing progression of intellectual development during college, with reasoning ability exerting influence over both self-efficacy and achievement. The introduction of challenging tasks at an early stage could potentially augment students' dedication, aptitude for reasoning, and overall achievement.

Kurbanoglu & Akin (2010) explored the relation between the anxiety caused in chemistry laboratory, attitude towards chemistry, and self-efficacy in performing experiments. Three scales were employed to measure Laboratory Anxiety, Attitudes towards chemistry, and the Self-efficacy in lab. The findings revealed negative correlations between chemistry laboratory anxiety and both chemistry attitudes and self-efficacy. Conversely, chemistry attitudes exhibited a positive correlation with self-efficacy. The study's path model highlighted the negative predictive influence of self-efficacy on chemistry laboratory anxiety, while also noting a direct positive influence on chemistry attitudes, ultimately contributing to the mitigation of chemistry laboratory anxiety. Furthermore, chemistry attitudes were found to be a negative predictor of chemistry laboratory anxiety.

Ghatty & Sundara (2013) assessed how well a virtual science laboratory could teach physics to students attending a Historically Black University College. The study involved 58 participants of science majors, all enrolled in a general physics lab course. The outcomes unveiled noteworthy advancements in students' self-efficacy, indicating a positive influence from the virtual science laboratory on bolstering their confidence and belief in their individual capabilities.

Çalık (2013) investigated the influence of scientific inquiry based on technology-embedded on self-efficacy among student teachers of science. The research cohort comprised 117 students' teachers who were studying in an environment based elective Chemistry course. Employing a quasi-experimental design, data collection involved the utilization of a technology-embedded scientific inquiry self-efficacy scale adapted from Ebenezer (2008). The outcomes underscored the efficacy and appropriateness of the proposed TESI model within the studied context. Furthermore, a positive interaction among the three components of the TESI model was observed, leading to an enhancement in SSSTs' self-efficacy.

Cheung (2014) defined self-efficacy for learning chemistry as an individual's belief in their ability to successfully perform specific tasks in the subject. A positive sense of self-efficacy is essential for students to excel in school chemistry. Research consistently shows that a student's self-efficacy influences their effort, persistence, resilience, academic achievement, and educational choices. Students develop their self-efficacy beliefs through four primary sources of information: their previous achievements, observing the experiences of others, receiving feedback and encouragement, and their own physiological and emotional conditions. These beliefs play a crucial role in shaping students' learning experiences and outcomes in the field of chemistry.

Cheung (2014) described the effectiveness of classroom teaching was established as a reinforcing factor for enhancing students' self-efficacy. Kolil et al. (2020) emphasized the importance of exposing students to virtual laboratories prior to experimentation in physical mode.

Husnaini et al. (2019) advocated that guided inquiry-based virtual laboratories were equally effective for simpler concepts but aids effectively for enhancing complex concepts. Diwakar et al. (2023) analysed the factors affecting student laboratory education, such as intrinsic and extrinsic motivation, laboratory performance scores, time spent on virtual lab experimentation, and teachers' perceptions, was undertaken to gain insights. Moreover, Makransky et al. (2016) indicated that even medical practitioners gained confidence in patient counselling through simulation in virtual laboratories, contributing to their understanding of disease mechanisms in clinical contexts.

Makransky et al. (2016) indicated that even medical practitioners felt confident in counselling a patient after using the simulation in virtual laboratory. This helps the future doctors in understanding the disease mechanism in the clinical situation. Weller (2004) found that simulation-based learning develops teamwork skill, systematic approach towards the problems and application of theoretical skills. It provides opportunity to students to learn new skills in risk free environment. In their 2021 review paper, Hussain et al. identified key factors contributing to low academic self-efficacy, highlighting that a lack of confidence, low self-esteem, and feelings of inferiority are significant contributors. In their 2021 review paper. Peechapol (2021) observed that a mobile educational app including the message of teacher and success, and failure of other students was found to improve the academic self-efficacy of students. The quasi-experimental study on first year undergraduate students demonstrated that virtual lab simulation had a positive influence on self-efficacy of students in learning of chemistry and the impact is further increased when it is integrated with traditional mode of learning.

Ibrahim et al. (2017) followed the Borg & Gall model and aims to create a virtual chemistry laboratory (VICH-LAB) on the acid-base topic. The study investigates the media's characteristics, quality, and its impact on students' self-efficacy. The VICH-LAB product was validated by experts, reviewed by peers and teachers, and tested with grade XI students. The results showed that the media is of excellent quality as an instructional tool, and students who used it experienced significantly higher improvements in self-efficacy compared to those who did not.

Nais et al. (2018) researched and delved into students' self-efficacy data, stratifying their scores into an exemplary rating classification. The outcomes elucidated that student who integrated virtual chem-lab as a complement or substitute for conventional hands-on laboratory experiences within hybrid learning showcased predominantly strong levels of self-efficacy. Conversely, participants in group virtual chem lab scored high with a moderate level of self-efficacy. These findings collectively underscore the affirmative effect of integrating virtual mode experimentation along with traditional mode in chemistry subject on the self-efficacy of students.

Solikhin et al. (2018) utilized a quasi-experimental design with a post-test methodology to compare three classes subjected to different treatments. One class followed a traditional laboratory format, another class adopted a hybrid learning approach integrating virtual labs, and the third class employed both methods. The dimensions of interest and self-efficacy were assessed using a 22-item questionnaire. Substantial variations in self-efficacy scores were noted between the class exclusively using the traditional laboratory and the class utilizing both the wet laboratory and the virtual laboratory as a supplementary tool. The outcome of the study favoured the use of virtual integration along with wet lab.

Husnaini et al. (2019) disclosed that the virtual laboratory proved to be as efficient as the physical laboratory in facilitating understanding of simple concepts, while exhibiting greater efficacy in enhancing comprehension of complex concepts and fostering scientific inquiry self-efficacy.

Chen (2020) explored into the efficiency of conducting experiments in virtual mode in chemistry and documented that experimental self-efficacy was necessitated by realising that strong self-efficacy is often associated with robust autonomous learning abilities.

Falade & Aladesusi (2020) observed the role of development of self-efficacy in using virtual laboratories for instructional delivery by biology teachers in Nigerian Secondary Schools. The findings showed that Biology teachers in Ilorin had a high level of self-efficacy in using virtual laboratories for instruction. There was no significant difference in self-efficacy between male and female teachers, nor based on years of experience. The study concluded that females are equally proficient in using ICT, and gender should not be a discriminating factor. The results suggest that gender differences in using ICT resources for research are diminishing, and the study strongly recommends promoting equal opportunities for both genders in utilizing virtual laboratories for teaching.

Falade & Aladesusi (2020) delved into the self-efficacy of Biology educators in Nigerian Secondary Schools with regards to employing virtual laboratories for instructional purposes. The outcomes revealed a substantial level of self-efficacy among Biology teachers in Ilorin when it came to utilizing virtual laboratories for teaching. The study found no significant disparity in self-efficacy based on gender or years of teaching experience. This helped to conclude that gender should not serve as a discriminatory factor, highlighting the equal proficiency of both male and female educators in using information and communication technology (ICT). The results underscored the diminishing gender-based discrepancies in utilizing ICT resources for instructional purposes, and the study vehemently advocates for equal opportunities in leveraging virtual laboratories for teaching across genders.

Setiawati et al. (2021) assessed the integration of 21st-century skills within virtual labs for senior high school chemistry education. The facets examined encompass: (1) Identifying obstacles to chemistry learning in high school; (2) Evaluating skills of 21st-century; (3) Scrutinizing the positive and negative effects of virtual labs; and (4) Unravelling the ramifications of virtual labs on 21st-century skills. Employing a descriptive qualitative approach, the study involves the analysis of both national and international literature pertinent to the incorporation of 21st-century skills within virtual labs for high school chemistry education. The findings underscore that virtual labs have the potential to assimilate skills of 21st-century, visualize abstract concepts, foster student-centred learning, alleviate apprehension in traditional laboratories, and elevate students' self-efficacy, rendering them invaluable tools in the chemistry learning journey.

Romika & Atun (2021) centred on the creation of a tool named Chemistry Student Virtual Laboratory Self-Efficacy, with the aim of gauging students' perceptions of their competencies within a virtual laboratory context. The study collected information through a questionnaire on self-efficacy. The experts validated content validity of the instrument, while the Rasch Model was used to see appropriateness of the tool in capturing students' self-efficacy concerning virtual laboratory experiences, specifically within the chemical equilibrium domain.

Peechapol (2021) carried out a quasi-experimental study involving first-year undergraduate students, the integration of virtual lab simulations with traditional learning methods positively influenced self-efficacy in learning chemistry.

Hussain et al. (2021) examined a review paper exploring the root causes of low academic self-efficacy identified factors such as lack of confidence, low self-esteem, and inferiority complex, and highlighted the efficacy of a mobile educational app in enhancing academic self-efficacy by including teacher messages and examples of student success and failure.

Youngblood et al. (2022) evaluated the role of at-home dissections through an online course on the outcomes of students: self-efficacy in the subject of anatomy, confidence in practical skills, support, and dissections. The results showed that students who participated in the at-home dissections gained self-efficacy and confidence in various practical skills. Based on students' feedback, they perceived that the at-home dissections contributed to these improvements. The findings suggested that hands-on laboratories at home are a suitable method for teaching practical skills on online platform. Science instructors are encouraged to consider implementing at-home laboratories, and the study provides recommendations for doing so successfully.

Okunuga & Okafor (2022) carried out a study in which experimental group used Virtual Chemistry Laboratory Software (VCLS) for practical activities, while the control group used the Conventional Laboratory Manual (CLM). Data were collected through the Chemistry Practical Skills Test (CPST) and analysed using descriptive statistics and ANOVA. The results indicated that students acquired practical skills with both VCLS and CLM. Additionally; female chemistry students demonstrated higher practical skills than their male counterparts. Based on these findings, the use of virtual laboratories is strongly recommended for conducting chemistry practical in secondary schools.

Lonez & Errabo (2022) conducted a study and sheds light on the characteristics of psychology students, revealing their intrinsic motivation, elevated self-efficacy, and robust self-regulation competencies. These students engage in actions driven by personal satisfaction and hold strong convictions in their ability to attain desired outcomes. The research accentuates notable variations in motivation, self-efficacy, and self-regulation levels among the student population. Additionally, the study underscores the robust connections between motivation and self-regulation, motivation and self-efficacy, and self-efficacy and self-regulation.

Shadbad et al. (2023) investigated the effectiveness of gamification in virtual labs to enhance learners' educational performance. Specifically, focussed on the use of leaderboards which is a motivational gamification mechanism to increase association and participation, ultimately leading to improved learning outcomes. By analysing a sample of students, it is found that the implementation of gamification in virtual labs results in higher performance, as indicated by increased task accomplishments, particularly with difficult tasks, and associated with higher self-efficacy. These findings provide convincing evidence of the positive impact of gamification in virtual lab learning environments.

Peters et al. (2023) observed that exclusive engagement in Kahoot game did not result in elevated self-efficacy scores. Nonetheless, a noteworthy association was identified between possessing an intelligence mindset and levels of self-efficacy, both prior to and following the virtual physics laboratory course.

Kolil et al. (2023) aimed to validate a novel Experimental Self-Efficacy (ESE) scale and explore its relationship with laboratory outcomes, considering gender and year of study as mediating variables. ESE refers to students' belief in their abilities to succeed in laboratory experiments. Strong ESE was found to have positive influence laboratory performance in students of both genders. It was related to factors like laboratory hazards, conceptual understanding, resource sufficiency, and procedural complexities. The study confirms the ESE-scale's validity and its relevance in various disciplines, such as chemistry, physics, and biology, as well as its association with students' academic outcomes in laboratories.

Duhani et al. (2024) investigated the impact of a web-based virtual laboratory on students' self-regulated learning (SRL). This quasi-experimental study involving 40 female students aged 14-15 found that a virtual laboratory significantly improved metacognitive self-regulation, effort regulation, peer learning, and overall self-regulated learning (SRL) compared to a traditional physical laboratory.

Now we can summarize that the flexibility of the virtual lab, allowing students to learn at their own pace and convenience, is attributed to these positive outcomes in context of experimental self- efficacy.

2.4 SCIENTIFIC ATTITUDE & VIRTUAL SCIENCE LABORATORY

Scientific attitude emerges as a paramount outcome of science education, serving as the bedrock for rational thinking. This amalgamation of qualities and virtues finds expression through an individual's conduct and deeds. The canvas of scientific attitude encompasses nine pivotal dimensions: critical-mindedness, reverence for evidence (reliance on facts), integrity, objectivity, receptiveness to altering viewpoints, openness, a spirit of inquiry, and an acceptance of ambiguity.

Çilenti (1988) Further stated the utilization of equipment, tools, and techniques within laboratory settings during the "learning by doing" process also contributes to personalized instruction. In parallel, the laboratory approach enhances students' engagement, nurtures critical thinking, fosters a scientific perspective, and hones problem-solving competencies.

Pyatt & Sims (2007) showed the shift towards simulations and virtual environments has unveiled the waning effectiveness of traditional physical laboratories in high-school and college-level science education. Tatli & Ayas (2010) mentioned that Virtual Laboratories (VLs) further intensify interaction both amongst students and between students and educators, bolstering dialogues and discussions. Such an enriched learning milieu, marked by heightened interaction and active student participation, augments attentiveness and motivation.

TÜYSÜZ (2010) observed the role of a virtual laboratory on students' accomplishments and perspectives within the realm of chemistry education. In light of constrained availability of physical lab resources, virtual experiments were conceived utilizing Information Technology. The results unveiled that the virtual laboratory wielded beneficial outcomes on both students' achievements and attitudes, outperforming the conventional pedagogical approach.

Cham & Fok (2015) conducted a survey included 50 engineering students, comprising 13 females and 37 males, with a majority of 46 local students. The data from Likert-type questions revealed that the virtual laboratories received positive feedback in general. However, the responses indicated that students perceived traditional labs as easier to operate, understand, and use flexibly in terms of time and place, and also found them more satisfying compared to virtual labs overall.

Chiu et al. (2015) conducted a study in which researcher utilized the Frame, a sensor-augmented virtual lab that incorporates sensors as physical inputs to control scientific simulations. A group of eighth-grade students (N = 45) participated in a Frame lab that specifically focused on exploring the properties of gases. The findings indicate that students who engaged with the Frame lab demonstrated notable progress in developing molecular-level explanations for gas behaviour. Furthermore, they showed improvement in refining their alternative and partial ideas, eventually converging towards normative ideas about gases. These results provide valuable insights into the design of augmented virtual labs, showcasing their potential to enhance science learning and promote the adoption of scientific practices, as advocated by the Next Generation Science Standards (NGSS).

Rasyida et al. (2015) investigated how virtual lab-based learning impacted critical thinking skills and scientific attitude of students regarding the concept of metagenesis in mosses and ferns. This quasi-experimental study with pre-test-post-test control group design, found a significant improvement in critical thinking skills among students in the experimental class as compared to the control class. However, there was no noteworthy difference in the scientific attitude of students between the two groups. This observation implies that virtual laboratories foster the development of critical thinking skills, albeit without yielding a substantial impact on students' scientific attitude.

Fahmidani & Rohaeti (2016) conducted a descriptive investigation aimed at elucidating the scientific attitude of students in the context of learning chemistry. To achieve this objective, a questionnaire comprising several statements pertaining to students' scientific attitude was administered. The study included the participation of 55 students from two high schools in Yogyakarta, Indonesia. The quantitative analysis of the questionnaire data involved calculating percentages and subsequently categorizing them as low, medium, or high. Researcher found that a significant majority of students exhibit scientific attitudes falling within the low and medium categories. This research provides valuable insights for educators and practitioners, serving as additional information to enhance students' scientific attitude, which, in turn, has a correlation with their academic achievement.

Irwanto (2017) found that the utilization of virtual laboratories resulted in improvements in various aspects of student learning, including problem-solving abilities, critical thinking skills, creativity, conceptual understanding, science process skills, lab skills, motivation, interest, perception, and overall learning outcomes. As a result, it is recommended for academicians to integrate virtual laboratories into their teaching strategies to enhance the quality of instruction and promote student learning.

Babaie (2017) mentioned that the transformation has been substantiated by research showing that the integration of virtual environments positively influences students' cognitive understanding and attitudes towards science.

Aşıksoy & Islek (2017) conducted research on essential laboratory sessions in two undergraduate subjects—microbiology and pharmaceutical toxicology for the University students of Southern Denmark, an additional program was implemented. The aim of this initiative was to evaluate the influence of virtual exercises on students' motivation and perspectives. The study involved a group of 73 students, and their response to the virtual exercises was analysed through the lens of motivational theories. The outcomes of the study indicated a noteworthy improvement in students' self-assurance and comfort in handling laboratory equipment subsequent to their engagement with virtual laboratory cases. Nonetheless, it was observed that the students' enthusiasm for virtual laboratories did not surpass their enthusiasm for traditional, hands-on laboratories. Remarkably, educators observed a higher level of engagement and participation in discussions from students who had used the program, in comparison to previous years when the program was not employed. In a similar vein, the utilization of virtual laboratory experiences exhibited a positive influence on students' attitudes, as per the findings of the study. Moreover, insights from semi-structured interviews illuminated the fact that students had favourable opinions about their encounters with the virtual physics laboratory.

Faour & Ayoubi (2018) observed the ramifications of integrating virtual labs on grade 10 students' comprehension of topic of direct current and electric circuits. Employing a quantitative and experimental study, 50 students from a secondary school participated. The experimental group utilized VL, specifically the kit of circuit construction Kit developed by Phet simulations, while the control group engaged with tangible laboratory equipment for interactive demonstrations. The analysis illuminated significant advancements in conceptual understanding for both cohorts, with the experimental group showcasing a notably elevated mean score. However, no noteworthy disparity surfaced in students' attitudes towards physics between the two groups after a 10-week instructional period.

Coleman & Smith (2018) conducted a study on the students one year after their participation in the simulation, and the findings exhibited a consistent pattern of responses. The virtual laboratory simulation proved to be instrumental in enhancing students' comprehension and knowledge in the realm of Health and Safety. Remarkably, even after the passage of one year, the simulation was still perceived as highly valuable, as it continued to contribute to students' confidence and understanding. This underscores the enduring impact of the simulation on student learning, highlighting its long-term efficacy and relevance.

Abou et al. (2018) suggested in the investigation that the impact of using Virtual Laboratories was analysed on the attitude of grade 10 students towards Physics. The study revealed that the mean gain score of the experimental group significantly exceeded that of the control group. However, no substantial disparity was observed in the attitudes of students between the two groups toward physics.

Ratanum & Osman (2018) showed the impact of Virtual Laboratory (VLab) and Physical Laboratory (PLab) on chemistry related attitude of students. The research encompassed Malaysian upper secondary four science stream students, totalling 147 participants. Employing a quasi-experimental design with pre-survey and post-survey measurements, the outcomes indicated that there existed no noteworthy disparity in students' chemistry attitudes between the VLab and PLab groups. Additionally, gender did not wield a significant influence on students' attitudes, and the interaction effect between group and gender was found to be negligible. suggesting the mutual independence of group-based and gender-based influences on attitude.

Ratamun & Osman (2018) conducted experiments to confirm the presence of anions and cations and then evaluated students' level of Science Process Skill mastery and found science process skills better when Physical Lab is used.

On the contrary, Ambusaid et al. (2018) conducted a study and recorded that there was no significant impact on students' academic achievement or their overall attitude towards science.

Penn & Ramnarain (2019) suggested that virtual simulations can serve as a valuable supplementary learning tool to enhance students' attitudes towards chemistry. Students perceive virtual simulations as helpful in visualizing abstract chemistry concepts. These findings hold particular significance for chemistry education in developing countries, like South Africa, where well-equipped laboratories are limited. By leveraging virtual simulations, educational institutions can bridge the resource gap and provide students with an effective means of learning chemistry.

Salame & Samson (2019) collected data and assessed the effects of implementing Excel, PhET interactive labs, and problem-solving sessions in General Chemistry I laboratory at The City College of New York. The results demonstrated a positive impact on students' attitudes towards chemistry, enhancing their learning experience and increasing engagement with the topics. These additions effectively complemented the traditional lab activities.

Koehler (2021) employed action research based on mixed- method; this study evaluated the shifts in high school chemistry students' attitudes toward chemistry prior to and subsequent to their engagement with a virtual laboratory. Surveying was conducted using the "Attitude toward the Subject of Chemistry Inventory" (Bauer, 2008), alongside targeted interviews with select participants. Although statistical analysis did not reveal significant alterations in student attitudes pre and post virtual laboratory exposure, a general decline in perceptions of chemistry's interest and utility was noted. Despite this, students expressed enjoyment and learning from the lab experience without substantial changes in their overall attitude toward chemistry. These findings underscore the necessity for continued assessment of virtual labs in chemistry education and their potential impact on student attitudes.

Yildirim (2021) showed the effects of incorporating virtual laboratory applications into science education on students' scholastic accomplishments and their perceptions of virtual labs. The study encompasses a group of 62 8th-grade students in Antalya and adopts a mixed-methods research design, amalgamating both qualitative and quantitative methodologies. Quantitative analysis involves a comparison between the control group and the experimental group on the basis of academic achievements, where virtual labs are employed for instruction. On the qualitative front, data are derived from interviews with the experimental group and observations during the application process. The findings suggest that the utilization of applications of virtual lab contributes to an enhanced academic performance among the experimental group. Furthermore, these applications foster meaningful learning, elucidate intricate concepts, and exert a positive influence on students' enthusiasm, intrigue, and motivation toward the domain of science.

Salame & Makki (2021) found that by use of PhET interactive simulations, students' attitudes and perceptions of learning got enhanced. These simulations also improved conceptual understanding, facilitate learning of abstract concepts, and provide unique learning opportunities. The results emphasized the need to update traditional chemistry laboratories with emerging technologies like PhET interactive simulations.

Larida et al. (2021) emphasized into the repercussions of integrating virtual laboratories (VLab) on the attitude and cognitive accomplishments of eleventh-grade STEM students. The outcomes underscored the positive impacts of both conventional and virtual laboratories on students' attitudes and average cognitive achievements. Notably, the virtual laboratory exhibited comparable effectiveness to its traditional counterpart, with a significant positive correlation between attitude and cognitive accomplishment. Students also articulated that the VLab facilitated swift experimentation, heightened interest, and personalized pacing.

Samosa (2021) underscored that the utilization of an inventive approach such as the mobile virtual laboratory in teaching chemistry engendered a robustly positive attitude and a conducive learning atmosphere among learners. Furthermore, the learners' achievements exhibited enhancement, as substantiated by markedly higher posttest scores when compared to their pretest scores. These findings bear significance for educational practitioners and augment the extant body of research concerning chemistry achievement, attitudes, and the learning environment.

Milhardi et al. (2022) mentioned the importance of online learning and its impact on students' scientific attitudes were examined in this study. The results emphasized the significance of motivation and a scientific attitude, which includes critical thinking, logical reasoning, curiosity, and consistency. The analysis of individual responses from 100 participants revealed the need to optimize material delivery and balance learning outcomes. Special attention should be given to the logical indicator in assessing students' scientific attitudes, as it forms the basis for effective problem-solving and decision-making in online learning.

Moreover, Kapici et al. (2022) underscored that the level of guidance provided to students holds paramount importance in their conceptual knowledge growth, while its effect on their acquisition of inquiry skills is comparatively modest. Notably, virtual labs are found to have equal potential as hands-on laboratories in fostering the advancement of conceptual knowledge and inquiry skills among middle school students.

Erdoğan & Bozkurt (2022) drew a comparison between the efficacy of imparting Geometrical Optics education through a virtual laboratory equipped with simulations and the conventional laboratory setup. The outcomes indicated an absence of substantial disparity in physics-related attitudes between the two cohorts.

Byukusenge (2022) presented and established a compelling case for the affirmative role of virtual laboratories on several key aspects of students' learning. These aspects encompass enhanced conceptual comprehension, refined laboratory proficiencies, practical aptitude, heightened motivation, and favourable attitudes towards the subject of biology. Drawing upon these substantial findings, seamless integration of virtual laboratories into pedagogical approaches is drawn. This integration is underpinned by the active involvement of students in scientific inquiry, which is facilitated by the utilization of virtual labs. This approach also ensures a secure learning environment while concurrently offering a cost-effective solution.

Ekawati et al. (2023) carried out research through a multifaceted approach encompassing observation, interviews, and self-assessment questionnaires, data were meticulously collected for this study. To ensure the robustness of the gathered data, the triangulation technique was employed. The outcomes of this case study elucidate that the incorporation of LCDS learning media and the Problem-Based Learning (PBL) paradigm into online physics education engenders a favourable influence on students' scientific attitudes, specifically nurturing attributes of curiosity and objectivity.

Ayasrah et al. (2024) compared lab simulation to traditional face-to-face instruction in teaching physics to UAE 11th-grade students. The topic of investigation was ‘Newton's Second Law’. The quasi-experimental research involved 90 students, utilizing the PhET interactive simulation. Results showed significant differences in students’ attitudes towards scientific inquiry, enjoyment of science lessons, and career interest in physics/science between the experimental and control groups. Males exhibited a more significant effect size than females in all three attitude scales.

Byukusenge et al. (2024) uncovered that before the implementation of teaching interventions, students found the topic of nerve cells to be abstract and intimidating. The visualization exercises proved beneficial in enhancing their comprehension, interest, and engagement with the subject. Nevertheless, no notable impact on gender was observed as a result of the treatment. The study suggests the utilization of virtual laboratories to teach challenging and abstract concepts, aiming to foster positive attitudes towards learning biology.

To summarize, the studies highlighted the potential of virtual laboratories to enhance students' readiness for practical laboratory work and positively impact their overall attitudes towards such experiences.

2.5 CONSTRUCTIVIST LEARNING ENVIRONMENT & VIRTUAL SCIENCE LABORATORY

Bruner (1961) uncovered an in-depth truth accessible for discovery. For Bruner, discovery encompasses any instance where an individual gains new knowledge autonomously, even if that knowledge has been previously acquired by others. Beyond permitting learners to construct knowledge, Bruner regarded the act of discovery as an intrinsic learning experience. He postulated that this process entails associated techniques and heuristics which cannot be imparted but are rather acquired through repetition and acquaintance with the art of exploration. Both perspectives on the construction of knowledge underline the significance of learner engagement in the process. Von Glasersfeld (1983) explained that contemplating one's actions contributes to shaping personal reality, while according to Bruner (1961), reflection plays a crucial role in honing inquiry and discovery skills. Importantly, aligned with constructivist theories, both agree that knowledge is a result of individual construction, not an external bestowment.

Von Glasersfeld (1983) also introduced objective constructivism, implying that learners shape their understanding and simultaneously shape their personal reality. Thus, objective facts independent of perception are absent; instead, there are ways when a learner comprehends and experiences the surroundings. Hence, a teacher’s role as a guide is established in this theory, since in the absence of an objective truth to dispense, the teacher aids students in navigating meaningful exploration and cultivating their distinct truths.

Von Glasersfeld (1987) defined Constructivism as a spectrum of learning theories rooted in the fundamental notion that knowledge is not transferred; instead, involves analyzing context, recognizing bias, and using critical thinking for meaningful understanding and future guidance. Yilmaz (2008) envisaged learning as an endeavor wherein the instructor undertakes the roles of both guide and facilitator, while learners delve into the exploration and organization of information. While every iteration of theories of constructivist learning emphasizes the individual as the central knowledge constructor, distinctions arise in how they consider contextual elements and their views on the kind of cognition.

The National Research Council (2012) mentioned the impact of constructivist learning theories on education, especially in science subjects when instructions are inquiry-based. This approach entails practices that immerse students in the scientific process to cultivate novel insight, a notion strongly impacted by Bruner's advocacy for students to undergo in the journey of knowledge construction.

Tatli & Alipasa (2012) found that the effectiveness of virtual chemistry laboratory software rivals that of real chemistry laboratories, fostering a conducive constructivist learning environment.

Sejzi & Aris (2012) expressed that traditional educational settings often fall short in providing the conditions for learners to autonomously construct knowledge. Hence, virtual universities supported by communication and information technologies (ICT) can adeptly implement constructivist strategies in the teaching and learning process.

Stoeckel (2020) expressed that it is challenging to implement constructivist learning theories in digital science education but is achievable. Teachers should consider instructional goals, incorporate mechanisms for students to express their processes, and ensure responsiveness to student ideas. While numerous lab experiences, both online and in-person, may not adhere to constructivist principles, a lab can function as a constructivist classroom by foregrounding student thinking, enabling scientific practices and inquiry, and fostering knowledge construction.

Rosli & Ishak (2022) mentioned the incorporation of virtual laboratories in teaching and learning to align with Sustainable Development Goal 4 (SDG4) of providing high-quality STEM education. The study has four main objectives: (i) to assess the difficulty level of learning topics from Secondary School Standard Curriculum (KSSM) Biology Form Four, (ii) to evaluate students' understanding of Biology concepts, (iii) to explore the implementation of teaching Biology, and (iv) to determine the level of readiness among Form Four students to use virtual laboratories in Biology learning. A combination of quantitative and qualitative approaches was utilized in this study, encompassing 107 students hailing from five national secondary schools situated in Kota Bharu, Kelantan. Moreover, interviews were conducted with three biology teachers to glean valuable perspectives on their instructional methodologies. The research incorporated an array of instruments, including questionnaires, diagnostic tests, teacher interviews, and readiness assessments. The outcomes illustrated that the domain of Nutrition and Human Digestive System emerged as a pivotal focal point for the creation of virtual laboratories in the realm of Biology. The diagnostic test results indicated a low level of understanding among students regarding the concept of nutrition and digestion. From the teacher interviews, five themes emerged. The study also found that students' readiness to use virtual laboratories was moderate, indicating potential for improving the biology teaching and learning process through the application of virtual laboratories.

Hence, we conclude that the constructivist approach is widely utilized in education, focusing on active, hands-on learning where students build their own understanding. It enhances critical thinking and problem-solving by encouraging exploration and inquiry-based activities. In classrooms, it supports collaborative projects and discussions, enabling students to construct knowledge through social interaction. This method is also applied in professional training to develop practical skills through experiential learning and reflection.

2.6 CONCLUSION:

The examination of existing literature revealed the significant role of the Virtual Mode of Experimentation (VME) on various aspects of student development when incorporated into a constructivist approach using the 5E strategy. Numerous studies highlighted the positive influence of virtual learning on academic achievement, while others underscored its role in fostering experimental self-efficacy. Furthermore, the utilization of VME was found to contribute to the enhancement of students' scientific attitudes.

Literature review serves as a foundation for the subsequent chapters, providing a solid understanding of the context and setting the stage for research methodology and analysis. The findings and insights from previous studies have informed the formulation of research objectives and hypotheses, helping to guide the design and implementation of the current study.

The literature review has been instrumental in shaping the direction and focus of the current research, providing a strong theoretical underpinning for the study. It has highlighted the importance of virtual laboratories in enhancing academic achievement, experimental self-efficacy, and scientific attitudes among secondary school students, paving the way for the subsequent chapters of the thesis.

2.7 RESEARCH GAP IDENTIFICATION

A review of literature on the efficiency of virtual science laboratories reveals significant opportunities for further in-depth research in this field. These research areas concerning virtual science labs should be explored within the context of the 'New Education Policy' (NEP) 2020 and the 'Digital India Program.' In India, there has been insufficient focus on inquiry-based learning and hands-on activities due to constraints in resources, funding, and infrastructure. Overcrowded classrooms, unenthusiastic students, and inadequately trained teachers have made teaching and learning, particularly in lab-based courses, challenging. The lack of a scientific mindset among students and poorly equipped laboratories have compounded issues related to science experiments. To address these challenges, there is a pressing need to develop virtual laboratories that are accessible to educators and students regardless of location, time, or cost. Additionally, during global health crises, online classes and virtual experimentation serve as effective alternatives to traditional schools and physical labs.

As per literature review, majority of studies have reported the beneficial impact of virtual laboratories on various aspects of learning and performance. These include the enhancement of science process mastery skills (Ratamun & Veilumuthu, 2018), improved academic performance (Gambari et al., 2013), and positive outcomes in e-learning (Rajendran et al., 2010; Ambusaidi et al., 2018). Furthermore, virtual labs have been shown to improve students' comprehension of experimental processes (Tatli et al., 2010), foster a preference for inquiry-based learning (Pyatt & Sims, 2007), and cultivate a constructivist learning environment (Tatli et al., 2012; Sejz et al., 2012). Additionally, studies have observed gains in learning outcomes (Brinson, 2015;

Falode & Onasanya, 2015), as well as an increase in the ability for multi-level thinking across macroscopic, symbolic, and sub-microscopic levels (Herga et al., 2016). Virtual labs also contribute to enhance students' performance in collaborative settings (Gambari et al., 2017).

Blended approach is advocated by (Bortnik et al.2017; Urbano et al.2020).

The virtual science lab is found flexible, accessible, and cost effective in open and distance learning. There is an increase in motivation level and academic performance of students by using virtual labs (Kamtor ET al.2017). Virtual Science Laboratories (VSLs) demonstrated efficacy in bolstering students' disposition toward science, their sense of enjoyment in scientific pursuits, motivation for engaging with science, self-perception within the realm of science, recognition of science's societal value, and alleviating apprehension related to science (Babaie, 2017). A positive relation was found in virtual labs and experimental self- efficacy developed in students (Kolil, et al.2020). Virtual labs and online courses are successful in creating constructivist learning environments if a suitable instruction strategy is employed (Jaber et al. 2018; Jang 2009; Stoeckel 2020).

While certain investigations indicated no notable contrast in mean achievement scores between students instructed through virtual physics laboratory packages and those subjected to conventional laboratory teaching (Falod et al., 2015; Ambusaidi et al., 2018) as well as a lack of observable shift in chemistry-related attitudes through virtual experimentation (Ratamun et al., 2018).

These findings from literature reviews prompted the necessity to delve into the influence of virtual laboratories on students' academic accomplishments, self-efficacy in experimentation, and scientific perspectives within a constructivist learning environment. The research is centered on secondary school students, specifically concentrating on the realm of chemistry, particularly within the practical aspect of the subject.

This study will help educators to make their teaching learning process effective specifically in lab-based courses which will further enhance the experimental self-efficacy, science process skills, clarity of concepts, inquisitiveness, and interest of students in constructivist learning environment. This research is totally in sync with

NEP (2020) and will help in implementing its reforms in classroom situation. The vision of Digital India program (2015) is to transform India into a digitally empowered society and knowledge economy. This study will aid this program in fulfilling its objectives.

2.8 SIGNIFICANCE OF THE PROBLEM

The problem of examining the "Effect of Constructivist Approach on the Academic Achievement, Experimental Self Efficacy, and Scientific Attitude of Secondary School Students Taught through Virtual Science Labs" holds significant importance in the field of education.

Initially, the research concentrates on the constructivist approach, an instructional technique emphasizing active learning, collaboration, and students' construction of knowledge. It's pivotal for educators and policymakers to grasp how this approach impacts secondary school students to enhance learning environments effectively.

Additionally, the study investigates the use of virtual science laboratories as a teaching tool. These labs offer a unique opportunity for students to engage in hands-on scientific exploration in a digital environment. By analyzing the effects of virtual labs, the research addresses the growing trend of integrating technology and innovative educational tools in classrooms.

Moreover, the research explores three key outcomes: academic achievement, experimental self-efficacy, and scientific attitude. Academic achievement reflects how the constructivist approach and virtual labs influence students' learning outcomes and performance in science. The Chemistry Practical Achievement Test (CPAT) scores were utilized to gauge the academic achievement of secondary school students.

Limited research has been undertaken concerning university students as well. (Ahmed et al., 2022; Sinadia & Jatmika, 2020; Tadese et al., Khan & Jamil, 2019; Smith & Karaman, 2019). Achievement tests in social science, health science, mathematics, social studies, and English have traditionally been crafted to assess theoretical concepts. However, there emerged a critical need to create an achievement test focusing on the practical aspects of science, especially in chemistry. This research aims to evaluate the knowledge, understanding, application, and skills gained through hands-on experiments in the chemistry laboratory.

Experimental self-efficacy encompasses students' conviction in their capacity to conduct scientific experiments, a pivotal element in nurturing their assurance and active participation in scientific exploration. Uzuntiryaki et al. (2009) devised a separate self- efficacy tool in chemistry for college students, stressing on the need of self-efficacy assessment in the domain of chemistry education. Kolil et al. (2020) employed a comprehensive 12-item scale to measure the efficacy of university students in the field.

By examining the unique challenges and factors that influence ESE specifically in the chemistry laboratory, this research contributes to a deeper understanding of students' self-efficacy and provides valuable insights into potential strategies to enhance ESE by using virtual laboratories.

Ultimately, scientific attitude encompasses students' outlook, fascination, and drive toward science, exerting enduring influences on their trajectory towards science-oriented professions and advanced learning. The study outcomes illuminated a constructive shift in students' science-related attitudes upon exposure to a virtual environment (Babaie, 2017; Pyatt et al., 2007). In a similar vein, this current study examines the effect of a virtual chemistry laboratory on students' scientific attitudes.

By investigating the effect of a constructivist approach in conjunction with virtual science labs, this study addresses the need to explore innovative teaching methodologies and tools for secondary school students. The findings from this research can throw light on the effect of virtual science labs in promoting academic achievement, enhancing students' self-efficacy in conducting experiments, and fostering a positive scientific attitude. Ultimately, this study has the potential to inform educational practices and guide the development of effective instructional strategies that enhance students' learning experiences in science education.

2.9 CONCEPTUAL MODEL & PROPOSED MODEL OF THE STUDY

A conceptual study model entails a theoretical framework or structured outline that elucidates the fundamental ideas, variables, connections, and assumptions that underlie a research project. Its purpose is to serve as a roadmap, assisting scholars in refining their thoughts, devising research methodologies, and interpreting their findings effectively.

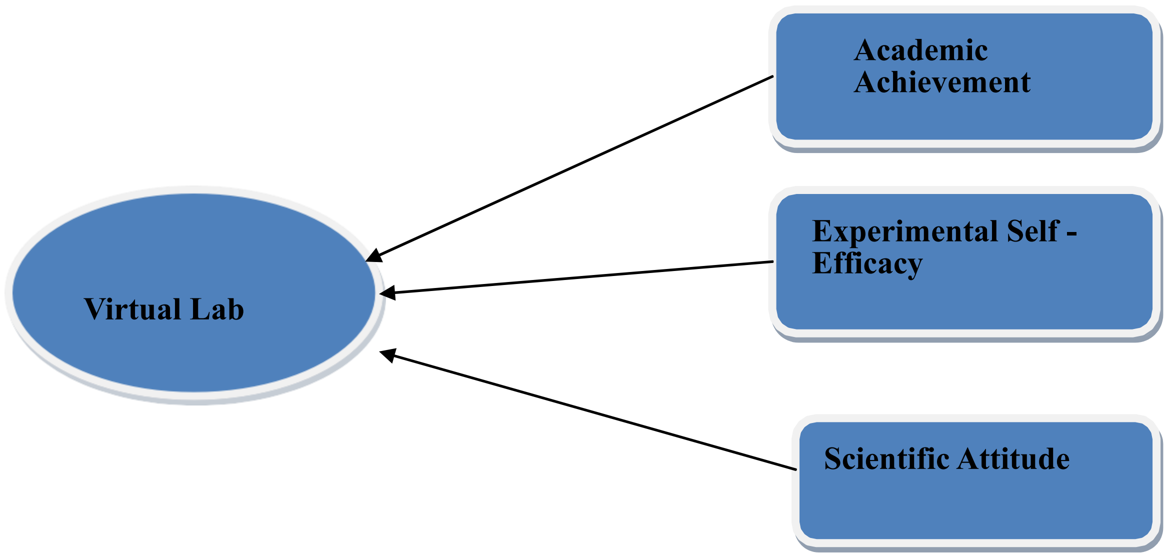


Figure 2.1: Theoretical Framework of The Study

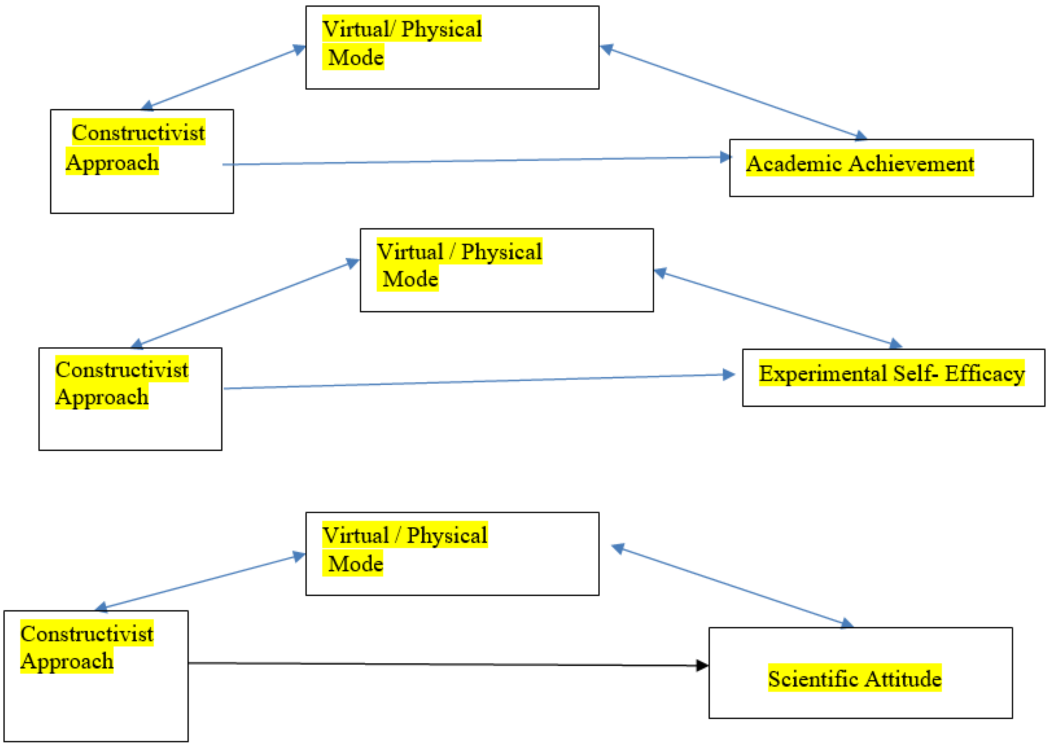


Figure 2.2: Proposed Model of the Study

2.10 STATEMENT OF THE PROBLEM

Deriving from the significance, the problem has been stated as follows,

EFFECT OF CONSTRUCTIVIST APPROACH ON THE ACADEMIC ACHIEVEMENT, EXPERIMENTAL SELF EFFICACY AND SCIENTIFIC ATTITUDE OF SECONDARY SCHOOL STUDENTS TAUGHT THROUGH VIRTUAL SCIENCE LABS.

2.11 OPERATIONAL DEFINITION OF THE TERMS

Academic Achievement

Academic achievement scores are considered as indicator of knowledge, understanding, application and skill. In this study, Chemistry Practical Achievement Test (CPAT) was used to measure the academic achievement of both control group and experimental group in chemistry practical within constructivist learning environment.

Experimental Self- Efficacy

It entails having confidence in one's capability to effectively carry out actions and observations within a controlled and simulated experimental setting, with the aim of attaining the intended result. The indicators of experimental self-efficacy in the study are comprehensive insight, laboratory hazards, procedural complexity, and sufficiency of resources. It is measured by Experimental Self- Efficacy (ESE) scores obtained by students in virtual mode experimentation within constructivist learning environment.

Scientific Attitude

Scientific attitude in the study is indicated by rationality, open mindedness, confidence in scientific methods, curiosity & aversion to superstition. The scientific attitude developed among students in virtual mode experimentation within constructivist learning environment is measured by Scientific Attitude (SA) scores.

Constructivist Approach (5E)

Constructivist approach is a type of constructivist learning environment which includes engaging, exploring, explaining, elaborate and evaluate. It embodies an inquiry-driven approach to science education, where learners actively build their own knowledge and comprehension. In the present research, a constructivist learning environment was established within both a physical and virtual chemistry laboratory setting.

Secondary School Students

The scope of this study encompasses secondary school students in Class XI level, which falls within the purview of the Central Board of Secondary Education (CBSE) in terms of curriculum and examination regulations for Classes IX to XII.

Virtual Science Lab

A virtual science lab refers to a digital platform or software that replicates the experience of conducting scientific experiments and investigations in a simulated, online environment. The study deals specifically with virtual mode of experimentation (VME) to observe its effect on academic achievement, experimental self-efficacy and scientific attitude developed among students.

2.12 OBJECTIVES OF THE STUDY

- To select the curriculum content and software for teaching science lab courses in virtual mode and physicalmode.
- To develop instructional plans for teaching science lab courses in virtual mode and physical mode. •
- To study the effect of constructivist approach on the academic achievement of secondary school students in teaching science lab courses taught through virtual and physical mode.
- To study the effect of constructivist approach on the experimental self-efficacy of secondary school students in teaching science lab courses taught through virtual and physical mode.
- To study the effect of constructivist approach on the scientific attitude of secondary school students in teaching science lab courses taught through virtual and physical mode.

2.13 HYPOTHESES OF THE STUDY

H01: There is no significant difference in academic achievement among secondary students in science who performed experiments with Virtual mode and without virtual mode in constructivist learning environment.

H01a: There is no significant difference in mean Chemistry Practical Achievement Test (CPAT) scores of Control Group (CG) & Experimental Group (EG) w.r.t. pre-test.

H01b: There is no significant difference in mean Chemistry Practical Achievement Test (CPAT) score of pre- and post- test w.r.t. control and experimental group.

H01c: There is no significant difference in mean Chemistry Practical Achievement Test (CPAT) scores of Control Group (CG) & Experimental Group (EG) w.r.t. post-test.

H01d: There is no significant difference in no of students of Control Group (CG) & Experimental Group (EG) in the pre- and post- test w.r.t. Chemistry Practical Achievement Test (CPAT) score.

H02: There is no significant difference in experimental self- efficacy of the students in science who performed experiments with virtual mode and without virtual mode in constructivist learning environment.

H02a: There is no significant difference in mean Experimental Self- Efficacy (ESE) scores of Control Group (CG) & Experimental Group (EG) w.r.t. pre- test.

H02b: There is no significant difference in mean Experimental Self- Efficacy (ESE) score of pre- and post- test w.r.t. control and experimental group.

H02c: There is no significant difference in mean Experimental Self- Efficacy (ESE) scores of Control Group (CG) & Experimental Group (EG) w.r.t. post-test.

H02d: There is no significant difference in no of students of Control Group (CG) & Experimental Group (EG) in the pre- and post- test w.r.t. Experimental Self- Efficacy (ESE) score.

H03: There is no significant difference in the scientific attitude of the students in science who performed experiments with Virtual mode and without virtual mode in constructivist learning environment.

H03a: There is no significant difference in mean Scientific Attitude (SA) scores of Control Group (CG) & Experimental Group (EG) w.r.t. pre- test.

H03b: There is no significant difference in mean Scientific Attitude (SA) score of pre- and post- test w.r.t. control and experimental group.

H03c: There is no significant difference in mean Scientific Attitude (SA) scores of Control Group (CG) & Experimental Group (EG) w.r.t. post-test.

H03d: There is no significant difference in no of students of Control Group (CG) & Experimental Group (EG) in the pre- and post- test w.r.t. Scientific Attitude (SA) score.

2.14 DELIMITATIONS OF THE STUDY

1. Due to time and resource limitations, this study was confined to schools in Delhi. This allowed for a more focused and feasible examination of the research objectives within a manageable scope.

2. It was conducted on science students of class XI and in chemistry subject.

CHAPTER III

METHODOLOGY

The study investigated the effect of virtual mode experimentation on the academic achievement, experimental self-efficacy, and scientific attitude of secondary stage students. To assess these, a constructivist learning environment was created using the 5E instructional technique in both physical and virtual chemistry labs. There is immense significance of laboratory experiments in science education. Lab experiments offer students an opportunity to apply theoretical concepts in a practical setting, provides opportunity to develop critical and creative thinking skills and problem-solving abilities. By conducting experiments, students can gain a integrated knowledge of the scientific method, learn how to collect, and analyse data, and draw conclusions based on evidence. Moreover, lab experiments help to visualize abstract concepts and provide a more engaging and interactive learning experience. Overall, lab experiments are an integral component of science education that can enrich students' understanding and appreciation of the subject.

The inclusion of both virtual and physical laboratory experiences is essential in comprehending the fundamental aspects of science, particularly within the realm of chemistry. By implementing a constructivist instructional strategy in the laboratory setting, the process of learning is greatly enhanced. Consequently, the study focused on a sample of class XI science students at the senior secondary level, making it a multi-level investigation.

The current chapter delves into various crucial aspects, including the selection of an appropriate online laboratory platform and curriculum. Furthermore, it addresses the development of Chemistry Practical Instructional Plans that align with the constructivist approach, the careful selection or preparation of suitable tools and resources, the rationale behind the chosen research methods and designs, the composition of the sample, the data collection procedures, as well as the statistical techniques employed for data analysis in the study.

It is noteworthy that the use of a constructivist instructional strategy in the laboratory setting holds immense potential for facilitating meaningful and engaging learning experiences. By employing suitable tools, incorporating appropriate curriculum materials, and adopting research methods aligned with the constructivist approach, the study seeks to establish a solid foundation for its investigation. The utilization of statistical techniques will allow for a comprehensive analysis of the collected data, yielding valuable findings and contributing to the existing body of scientific knowledge.

3.1 RESEARCH METHOD

The study utilized a pre-test post-test quasi-experimental non-equivalent group design to examine the effectiveness of Virtual Mode of Experimentation (VME) and Physical Mode of Experimentation (PME) on the academic achievement, experimental self-efficacy, and scientific attitude of secondary school students within a constructivist approach. It involved the collection and analysis of quantitative data obtained.

3.1.1 Criteria of selection of research design

The criteria for selecting the research design in this study are based on the nature of the problem and the practical feasibility of conducting a true experimental design. In this case, the chosen research design is a pretest-post-test quasi-experimental non-equivalent group design.

The quasi-experimental design is deemed appropriate when randomization of participants is not feasible or practical (W. Best, 2017). True experimental designs require strict control over variables, which may not be possible in certain situations, particularly in social science studies. In this study, several variables such as family background, parents' educational status, intelligence level, learning style, and the decision to take tuition classes cannot be controlled. Furthermore, there are inherent differences between two classes within a school, such as location, teachers, and students' attitudes towards their classmates, school, and society.

Due to these practical limitations, the quasi-experimental non-equivalent group design was chosen for the present study. This design allows for the comparison of two groups without random assignment, considering the existing differences between the groups. Although the quasi-experimental design does not provide the same level of control as a true experimental design, it still allows for valuable insights and conclusions to be drawn. It was the most suitable design given the practical considerations and the nature of the research problem under investigation. The proposed model of the study is the research design mentioned in figure 2.2.

3.2 SAMPLE

In the context of research, a sample denotes a specific group or subset of individuals, items, or data that is selected from a larger population. This selection is made with the intention of studying and drawing conclusions about the entire population. Utilizing a sample is a practical approach which helps to collect data, analyse patterns, and make informed inferences about the broader population without having to examine every single element within it. Prudent and suitable sampling techniques guarantee that the knowledge derived from the sample can be reasonably extrapolated or applied to the broader population.

3.2.1 Sampling Technique

Purposive sampling technique was used in the study. The purposive sampling technique is a non-probability sampling method that involves selecting participants relevant to the research study. This sampling technique is chosen to gather in-depth information from a particular population that have passed class X and opted for science subject in class XI. This approach allows for a more focused investigation and a deeper understanding of the objectives being studied. It helps the researcher to make the most out of a small population of interest and arrive at valuable research outcomes. Purposive sampling allows the researcher to gather qualitative responses, which leads to better insights and more precise research results.

The selection of participants for this study involved collecting a sample from secondary school students of a school in Delhi. The target group consisted specifically of science students of class XI. By focusing on XI class students in the NCR region, the study aimed to capture the perspectives and experiences of individuals who were at a specific stage of their academic journey and studying science subjects. To gather the sample, a systematic approach has been employed, such as contacting the school in Delhi region and requesting their cooperation in carrying out the research work.

To have an appropriate sample, only science students from class XI were included. This decision was made to focus specifically on students who were studying chemistry and were directly involved in chemistry practical.

3.2.2 SAMPLE SIZE

There existed two distinct science sections, namely XI A and XI B which were selected from DAV Public School in Vasant Kunj, New Delhi. The purposive sampling process was employed, resulting in a total sample size of 74 science students, encompassing 37 students from each of the XI A and XI B sections. The XI A group was designated as the Experimental Group (EG), while the XI B group assumed the role of the Control Group (CG). Students were assigned to two treatments viz., experimentation through physical laboratory mode (traditional mode) and experimentation through virtual laboratory mode. This categorization allowed for systematic and comparative analysis between the two groups, facilitating a comprehensive exploration of the study's objectives.

A sample size of 50 to 100 is found to be appropriate in experimental and quasi experimental studies. Review of literature of the experimental and quasi experimental studies support the selected sample size. The sample size is 37 students (Palloan et al. 2021) titled Student Self-Regulated in Remote Learning with the Implementation of Local Virtual Lab Based on Online Tutorial (LVL-BOT). The sample size is 32 students (Waluyo et al. 2021) in the study- The Effect of Using Proteus Software as A Virtual Laboratory on Student Learning Outcomes. The sample size is 95 (Peechapol, 2021) titled Investigating the Effect of Virtual Laboratory Simulation in Chemistry on Learning Achievement, Self-efficacy, and Learning Experience. The sample size is found to be 40 (Firmayanto et al. 2021) in -The Effectiveness of Content and Language Integrated Learning (CLIL) Online Assisted by Virtual Laboratory on Students' Science Process Skills in Acid-Base Materials. The sample size is 78 (Amalillah et al. 2021) regarding Application of the Virtual Laboratory Assisted Inquiry Learning Model for Understanding the Concept of Light Theory and Optical Instruments for Class VIII Students of SMPN 24 Bekasi. The sample size is 40 (Putri et al. 2021) which deals in - Enhancing Students' Scientific Literacy Using Virtual Lab Activity with Inquiry-Based Learning. The Sample size is fifty (Rajendran et al. 2010; Bortnik et al. 2017; Favor et al. 2018) and conducted study on A study on the effectiveness of virtual lab in E-learning, Effect of virtual analytical chemistry laboratory on enhancing student research skills and practices, respectively

Sample size is 90 (Hamed et al., 2020). The effectiveness of using virtual experiments on students' learning in the general physics lab. The Sample size is 70 students (El-Aziz El-Sabagh, 2011)- Enhance Science Learning with Virtual Labs: The Impact of a Web-based Virtual Lab on the Development of Students' Conceptual Understanding. Sample size is 77(Urbano et al. 2020); Sample size is 69 (Ambusaidi et al.2018; Muliawati1 et al. 2021); Conducted research on the impact of using virtual lab learning experiences on 9th grade students' achievement and their attitudes towards science and learning by virtual lab; The influence of quarted card and virtual laboratory media on students' critical thinking ability respectively. Sample size is 54 (Kamtor et al.2017); Sample size includes 24 physics teachers, 35 computer experts and 29 physics students (Falod et al. 2015); Sample size is 56 students (Babaie et al. 2017); Sample size is 109 (Herga et al. 2016); Sample size is 90 (Tatli et al. 2012) . Sample size is 102(Laila et al.2021) The Use of STEM-Based Virtual Laboratory (PhET) of Newton's Law to Improve Students' Problem-Solving Skills

The central limit theorem (CLT) states that "A minimum of 30 observations is sufficient to conduct significant statistics." A sample size of 30 and more gives normal distribution of the sample means.

3.3 TOOLS

The study utilized four distinct tools to assess different aspects of the participants' learning and attitudes. These tools include chemistry practical instructional plans, an achievement test, an experimental self-efficacy scale, and a scientific attitude scale.

The chemistry practical instructional plans were developed with the aim of facilitating knowledge transfer through a constructivist approach and fostering an environment of self-directed learning and hands-on experiences. By embracing the constructivist approach, the chemistry practical instructional plans were designed to go beyond traditional teacher-centred instruction and encourage active participation and engagement from the learners. The focus was on creating opportunities for students to construct their own knowledge and meaning through various interactive and experiential activities.

The achievement test prepared was specifically designed and further standardized to measure the academic achievement of science students in class XI. This test was carefully crafted to align with the curriculum and learning objectives, allowing for a comprehensive assessment of the students' knowledge, understanding, application and skill in the subject of study.

To measure the students' experimental self-efficacy, the research study employed the experimental self-efficacy scale which is developed by Kolil et al. (2020). This scale was selected due to its established validity and reliability in assessing students' perceived confidence and faith in their capability to carry out laboratory experiments successfully. Prior to its implementation in the current study, the scale was revalidated to ensure its applicability and suitability for the specific context.

Additionally, the study measured the students' scientific attitude using the scientific attitude scale developed by Khan and Siddiqui (2020). It underwent a revalidation process to ensure its appropriateness and reliability in capturing the development of a scientific attitude among the students. The scientific attitude scale focuses on assessing students' curiosity, respect for facts, critical thinking, attitude of discovery & creativity, open-mindedness, and attitude of persistence.

By incorporating these four distinct tools, the study aimed to gather comprehensive data on the academic achievement, experimental self-efficacy, and scientific attitude of the participants by teaching students in constructivist environment.

Considering these contexts, the following tools were selected/ developed:

1. Chemistry Practical Instructional Plans based on Constructivist approach (5E) for experimental & control group developed.
2. Chemistry Practical Achievement Test (CPAT) prepared and standardized
3. Experimental Self- Efficacy scale by Kolil et al., 2020 selected and revalidated
4. Scientific Attitude scale by Khan & Siddiqui, 2020 selected and revalidated

3.3.1 Construction of Tools

3.3.1.1 Development of Instructional Plans-

An instructional plan is a detailed outline or roadmap that educators use to guide the teaching and learning process. It serves as a blueprint for designing, implementing, and assessing instruction to meet specific learning objectives. Whether in a classroom setting, online environment, or any other educational context, instructional plans are essential tools for educators to effectively convey information and facilitate student learning. Following a thorough examination of the existing literature and in-depth discussions with experts, a meticulously crafted instructional plan was prepared.

3.3.1.2 Selection of Chemistry Practical Curriculum

To initiate the formulation of chemistry practical lesson plans, it is imperative to determine the curriculum pertaining to practical chemistry. In this regard, the curriculum of practical chemistry for the XI class, as prescribed by the Central Board of Secondary Education (CBSE), was carefully examined for the present study. The selection process entailed the inclusion of 75 to 80% of the total syllabus, ensuring a balanced representation.

Class XI chemistry practical syllabus under consideration (2022-23) is available at the following link.

https://cbseacademic.nic.in//web_material/CurriculumMain23/SrSec/Chemistry_SrSec_2022-23.pdf

Classification of class XI chemistry practical syllabus under consideration is given as below:

1. Volumetric Analysis
2. Salt Analysis
3. Content based experiments

It is further classified into experiments shown below.

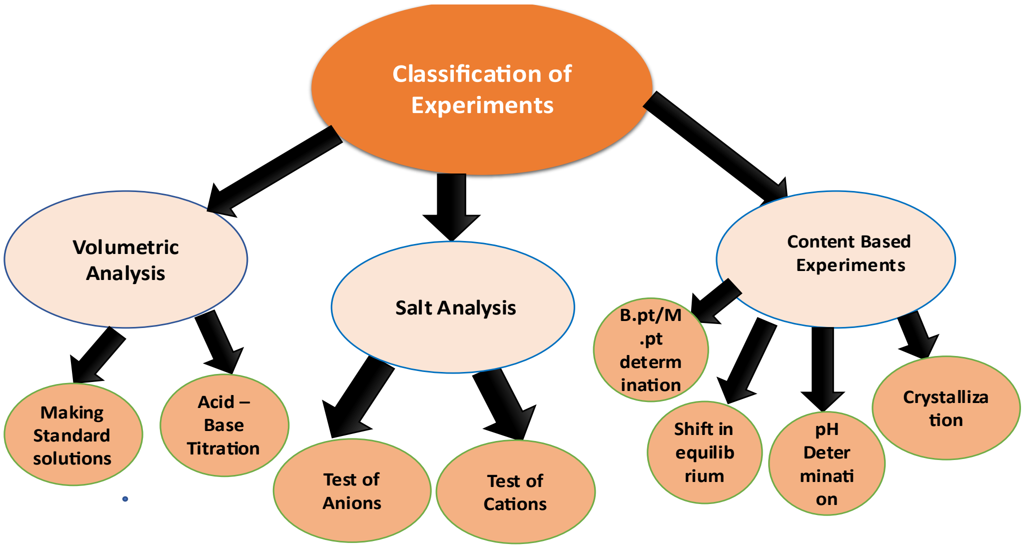


Figure: 3.1 Classification of Experiments Selected for the Study

Throughout the investigation, collaboration with distinguished experts in the fields of chemistry and education was taken through a combination of online and offline interactions. The valuable suggestions offered by these experts were meticulously integrated into the study's framework. The list of experts is mentioned in the appendix E. The selection criteria was based on the profound conceptual understanding of the topics, their practical applicability in real-world contexts, the potential for captivating students' engagement and interest, and the facilitation of skill development. In the initial draft, a comprehensive list of 31 experiments was chosen, which was subsequently edited to 25 in the second draft. Ultimately, the final draft consisted of a judicious selection of 20 experiments, ensuring a focused and purposeful investigation. The final list of 20 experiments are given below in table no. 3.1

Table 3.1: List of Selected Experiments

S. No.	Experiments	S. No.	Experiments
1	Study the shift in equilibrium between ferric ions and thiocyanate ions by increasing/decreasing the concentration of either of the ions.	11	Determination of nitrate anion in a given salt.
2	To determine the pH of the given sample using pH paper /Universal indicator	12	Determination of chloride anion in a given salt.
3	Determination of melting point of an organic compound.	13	Determination of bromide anion in a given salt.
4	Determination of boiling point of an organic compound.	14	Determination of sulphate anion in a given salt.
5	Preparation of standard solution of Sodium carbonate.	15	Determination of phosphate anion in a given salt.
6	Determination of strength of a given solution of hydrochloric acid by titrating it against standard Sodium Carbonate solution.	16	Determination of ammonium cation in a given salt.
7	Crystallization of impure sample of benzoic acid.	17	Determination of lead cation in a given salt.
8	Crystallization of impure sample of Copper Sulphate.	18	Determination of iron cation in a given salt.
9	Determination of cabonate anion in a given salt.	19	Determination of nickel in a given salt.
10	Determination of sulphide anion in a given salt.	20	Determination of barium, strontium & calcium cations by flame test in a given salt.

3.3.1.2 Selection of Software

Pre-test post-test quasi-experimental non-equivalent group design was employed for the study. Students were assigned to two treatments viz., experimentation through physical laboratory mode (traditional mode) and experimentation through virtual laboratory mode.

To facilitate virtual experimentation, various online laboratories were considered, such as OLabs, an initiative of the Ministry of Electronics & Information Technology, as well as ChemCollective's Virtual Labs and K12 Virtual Labs by Edutech. Among these options, OLabs stood out as an exceptional online platform for conducting virtual experiments due to its noteworthy features, making it the preferred choice.

OLABS offers a vast array of interactive simulations that effectively replicate real-world laboratory environments. It covers all the topics of chemistry practical of class XI. These simulations provide students with hands-on experience, enabling them to conduct experiments virtually and observe realistic outcomes. The platform's ability to accurately simulate various scientific phenomena and apparatus contributes to its superiority.

Moreover, OLabs incorporates a user-friendly interface and intuitive controls, ensuring a seamless and effortless experience for students. The platform is designed to be accessible and navigable, allowing users to easily manipulate variables, collect data, and analyze results. This user-centric approach enhances the overall learning experience and facilitates effective experimentation.

One of the most remarkable aspects of OLabs is its comprehensive coverage of diverse scientific disciplines. The platform encompasses experiments spanning subjects such as physics, chemistry, biology, and more. This broad range of experiments caters to the needs of students across different academic levels and promotes interdisciplinary learning.

Furthermore, OLabs provides extensive support materials and resources to supplement virtual experiments. These resources include detailed instructions, background theory, interactive quizzes, and comprehensive data analysis tools. By offering such supplementary materials, OLabs facilitates a holistic understanding of the experiments and encourages students to engage deeply with the scientific concepts involved.

In summary, OLabs distinguishes itself as a premier online experiment platform due to its realistic simulations, user-friendly interface, comprehensive subject coverage, extensive support materials, flexibility of access, and prioritization of safety. These attributes collectively contribute to an exceptional virtual laboratory experience, making OLabs the preferred choice for online experimentation.

3.3.1.3 Development of Chemistry Practical Instructional Plans with Constructivist Approach

Crafting a Chemistry Practical Lesson Plan involves a series of crucial steps to ensure the development of a well-structured and purposeful learning experience.

The instructional plans for chemistry practical, covering both virtual and physical modes of experimentation, were meticulously developed to provide students with rich and comprehensive learning experience. Each plan was thoughtfully organized into several key components to ensure clarity, engagement, and effective knowledge acquisition. The instructional plans for practical chemistry, covering both virtual and physical modes of experimentation, were systematically structured to encompass various crucial aspects. These plans were outlined under several key headings, including objectives, learning outcomes, curriculum framing questions incorporating essential and practical lesson content queries, and detailed lesson particulars, emphasizing prerequisite skills such as conceptual knowledge and language proficiency. Following this, the renowned 5E approach—Engagement, Exploration, Explanation, Elaboration, and Evaluation was implemented to guide the learning process comprehensively. Moreover, the instructional plans integrated resource links for further enrichment, alongside a practical summary, subject area identification, approximate time allocation, and objectives assigned for the contemporary needs of 21st-century students.

3.3.1.3.1 5E Approach

5E constructivist approach provided a well-structured instructional framework that fostered active learning, deep understanding, and the development of critical thinking skills. By engaging students in meaningful experiences, connecting concepts to real-life contexts, and promoting reflection and evaluation, rich learning environments were created that empowered students to become lifelong learners.

In total forty chemistry practical instructional plans were prepared based on chemistry practical of class XI. Twenty Chemistry Practical Instructional Plans were prepared for the students of the control group who performed experiments via physical mode and the rest twenty were prepared for the students of the experimental group who performed chemistry practical in virtual mode. A sample instructional plan of both virtual and physical mode is appended below in table 3.2 & 3.3 respectively.

Table 3.2: Instructional Plan of Experimentation in Virtual Laboratory

CLASS/ GRADE LEVEL - XI

PRACTICAL OVERVIEW

PRACTICAL_TITLE To determine the strength of a given solution of hydrochloric acid by titrating it against standard sodium carbonate solution.
PRACTICAL SUMMARY: Volumetric analysis, a key method in quantitative analysis, is widely employed in laboratories to ascertain the unknown concentration of a sample by measuring its volume. This technique, known as titration, involves reacting a solution of unknown concentration with one of known concentration. In this process, the solution in the burette is termed the titrant, while the solution in the conical flask is referred to as the analyte.
SUBJECT AREA: Chemistry & Education
APPROXIMATE TIME NEEDED: 40 minutes
FROM A UNIT PLAN OR CURRICULUM AREA
TARGETED CONTENT STANDARDS AND BENCHMARKS: Volumetric Analysis / Titration
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
OBJECTIVES: Enable the students to 1. Identify the acid, base, conjugate acid and conjugate base in a reaction. 2. Calculate the concentration of an unknown acid by using titration. 3. Determine the end point of the titration. 4. Build strong content knowledge. 5. Reason abstractly and quantitatively

6. Use appropriate experimental tools strategically.
7. Perform with precision.

LEARNING OUTCOMES:

1. Students will be made familiar with the apparatus used for titration.
2. Students will understand the terms: quantitative estimation, acid-base titrations, end point, standard solutions, molarity, molality, normality, and indicators.
3. Students will calculate the molarity and strength of a given acid or base using molarity or normality equations.
4. Students will acquire the skill to prepare the standard solution and to determine the end point.
5. Students will acquire the skill to select the indicators based on the nature of the solution.
6. Students will gain the skills necessary to perform titrations with sodium carbonate and hydrochloric acid in a real lab setting.

CURRICULUM FRAMING QUESTION

ESSENTIAL QUESTION:

1. Define neutralization titration.
2. What is the principle of volumetric analysis?
3. What is an indicator?

PRACTICAL LESSON CONTENT QUESTIONS:

1. What is the end point?
2. What is a standard solution?
3. What is the relation between the equivalent mass of a base/ acid and its molecular mass?

LESSON DETAILS:

PRE-REQUISITE SKILLS

CONCEPTUAL KNOWLEDGE:

Students should already be familiar with

- acidity and basicity,
- neutralization reactions,
- the pH scale.

  Students will be familiarized with
- relation between normality and molarity
- role of indicator

LANGUAGE SKILLS:

Students should have the basic skill of making notes, comprehending, and organizing the matter.

ENGAGEMENT:

Teachers will ask the students to identify acidic and basic substances in their daily life. Further she will probe the students regarding mixing of acids and bases. Students will be asked to recollect their previous knowledge and write the reaction of various acids and bases in the notebook.

EXPLORE:

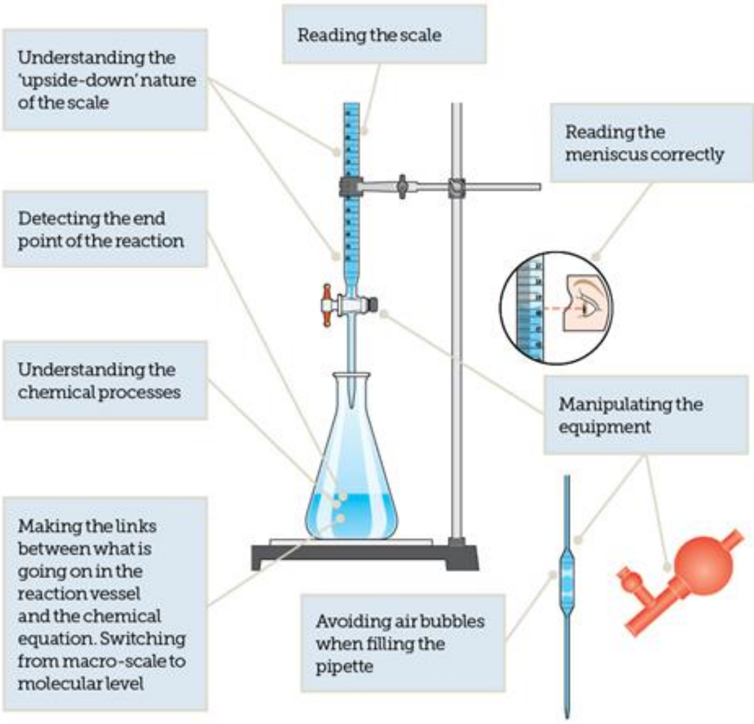
- Students will answer the queries, will observe keenly the part of the video of OLabs and classify acids and bases.
- They will observe the mixing of acid and base in the video and will try to understand the purpose of titration.
- They will be updated with the various terms used in the experiment viz titrant, analyte, end point, indicator etc.
- They will be made aware of the apparatus used in the experiment viz burette, pipette, burette stand etc.

EXPLAIN:

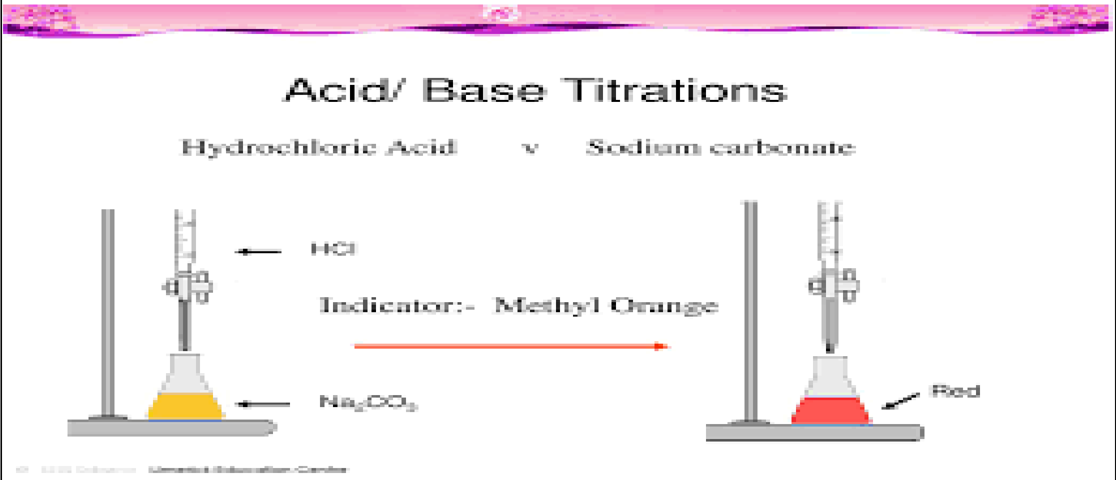
Students will be asked to observe the following activity.

- Take a burette and wash it with distilled water.

- Rinse and fill the burette with the given hydrochloric acid and set the initial burette reading as zero.
- Clamp it vertically to the burette stand.
- Rinse the pipette first with water and then with the given sodium carbonate solution.
- Pipette out 20ml of the given sodium hydroxide solution into a conical flask and add 1-2 drops of methyl orange into it.



- Titrate it against the hydrochloric acid taken in the burette till the colour of the solution in the conical flask changes from yellow to light red.



Now note down the final burette reading.

- Repeat the same procedure until concordant values are obtained.
- Students will be asked to perform the experiment by the icon 'Simulator given in the OLabs Platform. Here various options of type of titration, titrant, titrate, indicators are given.
- By carrying out multiple experiments via simulator, students develop expertise and become confident.

ELABORATE:

Students will be asked to record the observations in a tabular form as shown below.

Sl. No.	Initial Reading of Burette	Final Reading of Burette	Volume of HCl used (ml)
1			
2			

Calculation:

Students will be given normality equation.

$$N_1V_1= N_2V_2$$

They will be asked to write the reaction between the given acid and the base. Based on the reaction written they will come to know that 1 mole of sodium carbonate reacts with 2 moles of HCl

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

At this stage they will be able to derive molarity equation as

$$\mathbf{n_1 M_1V_1= n_2 M_2V_2}$$

Afterwards, they will be asked to substitute the values and calculate the molarity of HCl.

Molarity is expressed in moles per litre. Subsequently they will be asked to convert moles per litre into gram per litre. In this way they will be able to derive the formula of strength which is as follows:

Strength = Molarity * Molar mass

In this way they will be able to get the value of molarity and strength of HCl.

- Students will be asked to perform the titration with different concentration of same acid and base.
- Students will be asked to perform the titration between different acids and bases.

EVALUATE (Viva – Voce)

1. What is the type of reaction involved in acid-alkali titration?
2. What is the pH of the solution obtained by the reaction between a strong acid and a strong base?
3. What is the volume of conc. HCl required to prepare 250ml 5N HCl solution? (Normality of conc. HCl = 12)
4. The molar mass of H_2SO_4 is 98 g mol^{-1}. What is its equivalent mass?
5. What is the colour of methyl orange in acidic and basic solution?
6. Why should a titration flask not be rinsed?
7. Why do we read lower meniscus of a colourless solution and upper meniscus of a coloured solution?
8. Burette and pipette must not be rinsed with the solution with which they are filled, why?
9. Why must the last drop of solution not be blown out of a pipette?

RESOURCES:

http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=109&cnt=4

Table 3.3: Instructional Plan of Experimentation in Physical Mode

CLASS/ GRADE LEVEL - XI

PRACTICAL OVERVIEW

• **PRACTICAL-TITLE** To determine the strength of a given solution of hydrochloric acid by titrating it against standard sodium carbonate solution.
PRACTICAL SUMMARY: One of the important methods in Quantitative Analysis is Volumetric Analysis, a commonly used laboratory technique. It is used to determine the unknown concentration of a sample by measuring its volume. This process is also called titration. In a titration, a solution of unknown concentration is reacted with a solution of known concentration. The solution taken in the burette is called the titrant and the solution taken in the conical flask is called the analyte.
SUBJECT AREA: Chemistry & Education
APPROXIMATE TIME NEEDED: 40 minutes.
TARGETED CONTENT STANDARDS AND BENCHMARKS: Volumetric Analysis / Titration
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
OBJECTIVES: Enable the students to 1. Identify the acid and base in a reaction. 2. Calculate the concentration of an unknown acid by using titration. **LEARNING OUTCOMES**: 1. Students will understand the terms: quantitative estimation, acid-base titrations, end point, standard solutions, molarity, molality, normality, and indicators. 2. Students will calculate the strength of a given acid or base using molarity or normality equations. 3. Students will acquire the skill to prepare the standard solution and to determine the end point. 4. Students will acquire the skill to select the indicators based on the nature of the solution.

5. Students will be made familiar with the apparatus used for titration.
6. Students will acquire the skill to perform the titration using sodium carbonate and hydrochloric acid in the real lab with precision once they visualize the different steps.
7. Students will build theoretical and practical knowledge of volumetric analysis.
8. Take appropriate precautionary measures (do's and don'ts) while handling equipment, glass apparatus, chemicals during laboratory work.
9. Communicates the findings and conclusions effectively,

CURRICULUM FRAMING QUESTION

ESSENTIAL QUESTION:

1. Define neutralization titration.
2. What is the principle of volumetric analysis?
3. What is an indicator?

PRACTICAL LESSON CONTENT QUESTIONS:

1. What is end point?
2. What is a standard solution?
3. What is the relation between equivalent mass of a base/ acid and its molecular mass?

LESSON DETAILS:

PRE-REQUISITE SKILLS

CONCEPTUAL KNOWLEDGE:

Students should already be familiar with

- acidity and basicity,
- neutralization reactions,
- the pH scale.
- Students will be familiarized with relation between normality and molarity.
- role of indicator

LANGUAGE SKILLS:

Students should have the basic skill of making notes, comprehending, and organizing the matter.

ENGAGEMENT:

Teachers will ask the students to identify acidic and basic substances in their daily life. Further she will probe the students regarding mixing of acids and bases. Students will be asked to recollect their previous knowledge and write the reaction of various acids and bases in the notebook.

EXPLORE:

- Students will answer the queries, will observe keenly, and classify acids and bases.
- They will mix the given acid and base in a beaker and will try to find the neutralization point.
- As no colour change or precipitation or evolution of gas will happen, they will further investigate other method to find the point where reaction get completed.
- At this stage students will feel the need of some other chemical which may indicate the completion or end point, or neutralization point of the reaction.
- Students will be provided with methyl orange and will be asked to add it to acid and base and will observe their colour.

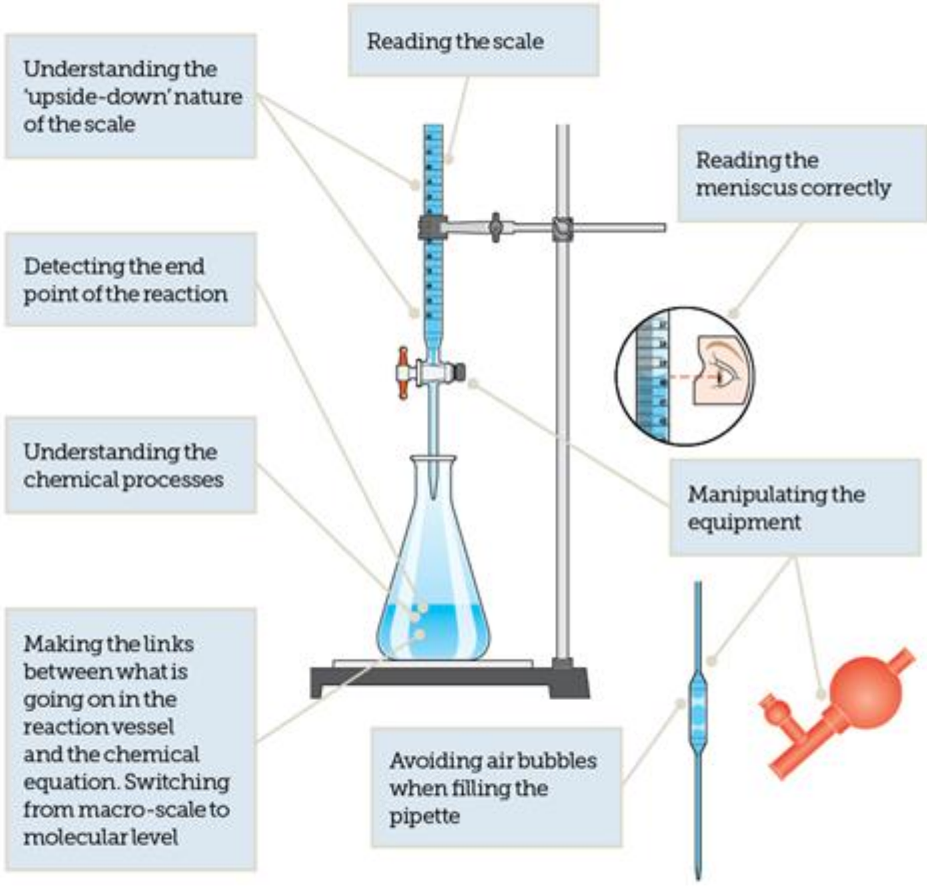
EXPLAIN:

Students will be asked to perform the following activity.

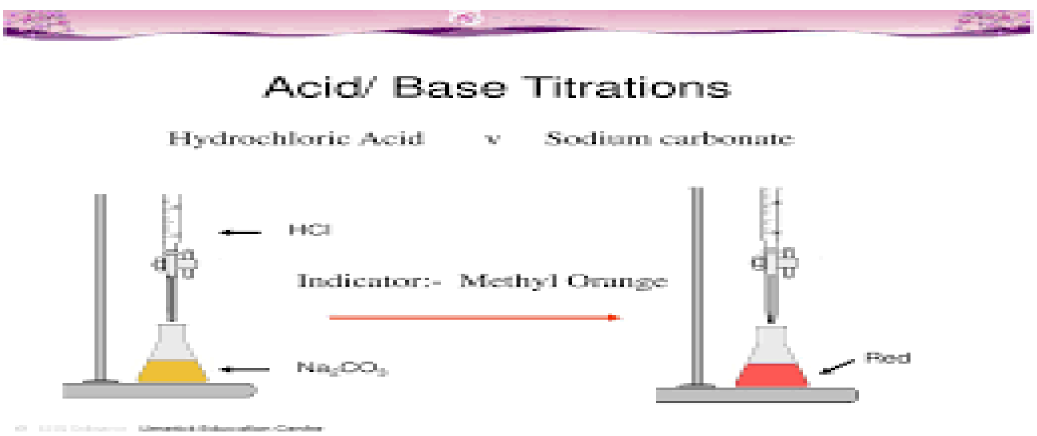
Take a burette and wash it with distilled water.

- Rinse and fill the burette with the given hydrochloric acid and set the initial burette reading as zero.

- Clamp it vertically to the burette stand.
- Rinse the pipette first with water and then with the given sodium carbonate solution.
- Pipette out 20ml of the given sodium hydroxide solution into a conical flask and add 1-2 drops of methyl orange into it.



- Titrate it against the hydrochloric acid taken in the burette till the colour of the solution in the conical flask changes from yellow to light red.



- Now note down the final burette reading.
- Repeat the same procedure until concordant values are obtained.

ELABORATE:

Students will be asked to record the observations in a tabular form as shown below.

Sl. No.	Initial Reading of Burette	Final Reading of Burette	Volume of HCl used (ml)
1			
2			

Calculation:

Students will be given normality equation.

$$N_1V_1 = N_2V_2$$

They will be asked to write the reaction between the given acid and the base. Based on the reaction written they will come to know that 1 mole of sodium carbonate reacts with 2 moles of HCl

$$\underset{\text{1 mole}}{Na_2CO_3} + \underset{\text{2 moles}}{2HCl} \rightarrow 2NaCl + H_2O + CO_2$$

At this stage they will be able to derive molarity equation as

$$\mathbf{n_1 M_1V_1 = n_2 M_2V_2}$$

Afterwards, they will be asked to substitute the values and calculate the molarity of HCl.

Molarity is expressed in moles per litre. Subsequently they will be asked to convert moles per litre into gram per litre. In this way they will be able to derive the formula of strength which is as follows:

Strength = Molarity * Molar mass

In this way they will be able to get the value of molarity and strength of HCl.

- Students will be asked to perform the titration with different concentration of same acid and base.
- Students will be asked to perform the titration between different acids and

bases.

EVALUATE (Viva – Voce)

1. What is the type of reaction involved in acid-alkali titration?
2. What is the pH of the solution obtained by the reaction between a strong acid and a strong base
3. What is the volume of conc. HCl required to prepare 250ml 5N HCl solution? (Normality of conc. HCl = 12)
4. The molar mass of H_2SO_4 is 98 g mol-1. What is its equivalent mass
5. What is the colour of methyl orange in acidic and basic solution?
6. Why a titration flask should not be rinsed?
7. Why do we read lower meniscus of a colourless solution and upper meniscus of a coloured solution?
8. Burette and pipette must not be rinsed with the solution with which they are filled, why?
9. Why the last drop of solution must not be blown out of a pipette?

RESOURCES:

- Laboratory Manual Chemistry for class XI - Published by NCERT

All chemistry practical instructional plans for virtual mode experimentation are available in Appendix A and the instructional plans for physical/ traditional mode of experimentation are available in appendix B.

3.3.1.4 Experimental Self- Efficacy Scale

To measure experimental self-efficacy, a standardized scale of experimental self-efficacy by Kolil et al. 2020 was used after revalidation, as revalidation of a tool is essential to ensure its continued reliability and validity in measuring the intended construct. Over time, factors such as changes in the population, cultural context, or research practices may impact the tool's performance. Therefore, revalidation helps to confirm that the tool still accurately measures what it intends to measure, providing confidence in its results and allowing for meaningful and accurate data collection and analysis.

3.3.1.4.1 Sample for ESE Scale

The revalidation process involved a sample of 90 students from six schools located in the Delhi National Capital Region (NCR). The participating schools were SB DAV School, Air Force Sr Sec School, Dronacharya Public School, Father Agnel School, SV (Co-education) Govt School, and Sarvodaya Kanya Vidyalya. All the students belonged to the science sections of class XI, with chemistry being their primary subject of study. The number of students who were studying in various schools and participated in the revalidation process of experimental self- efficacy scale are listed in the table 3.4 given below.

Table 3.4: List of Schools Selected for Validation of ESE Scale

Name of School	No. of Selected Students
SB DAV School	19
Air Force Sr Sec School	13
Dronacharya Public School	15
Father Agnel School	22
SV (Co-education) Govt School	11
Sarvodaya Kanya Vidyalya	10
Total	90

3.3.1.4.2 Procedure

The revalidation procedure for the Experimental Self-Efficacy Scale involved several distinct steps to ensure the reliability and validity of the tool. Firstly, a sample of participants, consisting of students from class XI science sections, was selected from six schools in the Delhi National Capital Region (NCR).

The selected students were provided with the scale and asked to respond to the items, indicating their level of experimental self-efficacy in conducting experiments. Data was collected using standardized procedures and appropriate ethical considerations.

The collected data was then subjected to statistical analyses to evaluate the psychometric properties of the scale. These analyses included examining internal consistency (Cronbach's alpha), inter-item correlations, and item-total correlations.

Confirmatory factor analysis (CFA) was also performed to assess the underlying factor structure of the scale.

The results of these analyses were carefully examined to determine the reliability and validity of the scale. By following the appropriate procedure, the revalidation of the Experimental Self-Efficacy Scale ensured that it maintained its reliability and validity, providing a robust and accurate measure of individuals' self-efficacy in conducting experiments. The statistical analysis table is mentioned here.

According to CFA findings, measurement model shows an acceptable fit to the data, $\chi2/df$ = 1.252 (<3), p value = .117 (> .05), GFI= .904 (>.90), AGFI= .838 (>.80), TLI= .985 (>.95), CFI = .990 (>.95), RMESA = .053 (<.08), SRMR= .0763 (<.08).

Table 3.5: Model Fit Indices of Experimental Self- Efficacy Scale

Measure	**CMIN/df ($\chi2$)**	**p-value**	**GFI**	**AGFI**	**TLI**	**CFI**	**RMESA**	**SRMR**
Calculated Values for	1.252	0.117	0.904	0.838	0.985	0.990	0.053	0.0763
Threshold Values	< 3	>0.05	>0.90	>0.80	>0.95	>0.95	<0.08	< 0.08

The experimental self-efficacy scale has been provided in the appendix labelled as Appendix C.

3.3.1.4.3 Scoring Norms of Experimental Self- Efficacy Scale

There are 12 items in the experimental self- efficacy scale. Each item was marked on a Likert scale which varies from 1 to 5 where 1 stands for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree and 5 for strongly agree. Based on this criteria, maximum score is 60 and minimum score is 12. The raw scores of all students who participated were collected and sorted into different categories based on the interpretation given by ESE scale (Table 3.6). Students were divided in high, average & low according to their achievement on the experimental self-efficacy questionnaire, as displayed in Table 3.6

Table 3.6: Scoring Norms of Experimental Self- Efficacy Scale

Raw Score	Level of Self- Efficacy
48- 60	High
24- 47	Average
12- 23	Low

3.3.1.5 Scientific Attitude Scale

The standardized and revalidated tool of scientific attitude by Khan & Siddiqui, 2020 was used to assess the scientific attitude of the students in the study. There are 39 statements in total. The scale contains both positive and negative polarity statements.

There are 15 negative polarity statements (5, 7, 8, 9, 12, 14, 15, 17, 21, 30, 34, 35, 36, 38 & 39) which are marked with asterisk sign in the scale shown in appendix D. The revalidation of the Scientific Attitude (SA) Scale was necessary to ensure its continued reliability, validity, and relevance in measuring individuals' attitudes towards science. Over time, various factors such as changes in the educational context, cultural shifts, and advancements in scientific knowledge may affect the achievement and applicability of the scale. Therefore, revalidation was essential to confirm that the scale still accurately captures the intended construct and produces meaningful and valid results.

3.3.1.5.1 Sample for SA Scale

The revalidation process encompassed a comprehensive sample of 398 students from 14 schools situated in the Delhi National Capital Region (NCR). The participating schools included SB DAV School, Air Force Sr Sec School, Dronacharya Public School, Father Agnel School, SV (Co-ed) Govt School, DPS Dwarka, Manav Sthali School, New Era Public School, KV Delhi Cantt no 1, KV Delhi Cantt no 2, Poorna Prajna Public School, Navyug School, Moti Bagh; Blooms Public School, Army Public School, Dhaula Kuan. All the students belonged to the science sections of class XI, with chemistry as their major subject of study. The inclusion of this diverse and representative sample ensured the robustness and generalizability of the revalidation process for the Scientific Attitude Scale.

The number of students who were studying in various schools and participated in the revalidation process of scientific attitude scale are listed in the table 3.7 given below.

Table 3.7: List of Schools Selected for Validation of SA Scale

Name of School	No. of Selected Students
SB DAV School	28
Air Force Sr Sec School	37
Dronacharya Public School	24
Father Agnel School	18
SV (Co-education) Govt School	24
DPS Dwarka	26
Manav Sthali School	16
New Era Public School	12
KV Delhi Cantt no 1	19
KV Delhi Cantt no 2	27
Poorna Prajna Public School	18
Navyug School, Moti Bagh	41
Blooms Public School	32
Army Public School, Dhaula Kuan	76
Total	398

3.3.1.5.2 Procedure

The revalidation procedure for Scientific Attitude Scale involved several distinct steps to ensure the reliability and validity of the tool. Firstly, a sample of participants, consisting of students from class XI science sections, was selected from fourteen schools in the Delhi National Capital Region (NCR).

The selected students were provided with the scale and asked to respond to the items, indicating their level of scientific attitude in conducting experiments. Data was collected using standardized procedures and appropriate ethical considerations.

The collected data was then subjected to statistical analyses to evaluate the psychometric properties of the scale. These analyses included examining internal consistency (Cronbach's alpha), inter-item correlations, and item-total correlations. Confirmatory factor analysis (CFA) was also performed to assess the underlying factor structure of the scale. The statistical analysis table is mentioned here.

According to CFA findings, measurement model shows an acceptable fit to the data, $\chi 2/df$ = 1.802 (<3), AGFI= .844 (>.80), TLI= .907 (>.90), CFI = .915 (>.90), RMESA = .045 (<.08), SRMR=.0426(<.08)

Table 3.8: Model Fit Indices of Scientific Attitude Scale

Measure	**chi-square**	**GFI**	**AGFI**	**TLI**	**CFI**	**RMESA**	**SRMR**
Calculated Values for							
	1.802	0.865	0.844	0.907	0.915	0.045	0.0426
Threshold Values	< 3	>0.90	>0.80	>0.90	>0.90	<0.08	< 0.08

The scientific attitude scale has been provided in the appendices section labelled as Appendix D.

3.3.1.5.3 Scoring Norms of Scientific Attitude Scale

There are 39 items in the scientific attitude scale. Each item was marked on a Likert scale which varies from 1 to 5, where 1 stands for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree and 5 for strongly agree. Based on this criteria, maximum score is 195 and minimum score is 39. The raw scores of all participating students were compiled and categorized into various levels based on the cut offs calculated by Q1 & Q3 w.r.t. the range of the scores. In our case, the scores less than 78 were considered in low scientific attitude, between 78-156 were in average scientific attitude and scores greater than 156 were in high scientific attitude as illustrated in Table 3.9.

Table 3.9: Scoring Norms of Scientific Attitude Scale

Raw Score	Level of SA
Above 156	High
78 - 156	Average
Less than 78	Low

3.3.1.6 Construction and standardization of Achievement Test of chemistry practical.

The Chemistry Practical Achievement Test (CPAT) was constructed to test the academic achievement of students. The process of creating a standardized achievement test involved several steps, including test planning, test construction, test administration, item analysis, and test standardization.

3.3.1.6.1 Test Planning

The initial and most vital stage in developing an achievement test is the planning process. Various factors such as the intended audience, the content to be assessed, the timing, and the methodology of measurement were taken into consideration while planning the test. This includes creating the test blueprint and making important decisions, such as the test's objectives, content, format, scoring method, measure of parameters, multiple types of options, duration, weighting of goals, time allocation, and marking procedures. The existing Chemistry-related achievement tests and consulted laboratory manuals were examined. The Chemistry practical syllabus secondary classes phase 2 as recommended by the Central Board of Secondary Education (C.B.S.E.) India was considered. Four types of questions were included in the test, namely multiple-choice, completion, true/false, and matching. The Achievement test features items that incorporate visual elements such as figures, diagrams, graphs, and tables. These items necessitate the application of advanced cognitive processes. Application-based items involve knowledge and concepts to solve real-world problems or situations. Few items test critical thinking skills which involve analysing, evaluating, and synthesizing information. A template was then developed using the learning objectives outlined in Bloom's Taxonomy of Educational Objectives as a guide.

3.3.1.6.1.1 Test Objectives

Certain behavioural aspects that relied on knowledge, learning, experimental demonstration, and proficiency were judged through achievement tests. The table 3.10 present the objectives in accordance with Bloom's Taxonomy and their weightages:

Table 3.10: Weightage to the Content as per Bloom's Taxonomy

Objectives	No of questions	% Weightage
Knowledge	21	17.07
Understanding	20	16.26
Application	48	39.02
Skill	34	27.6
Total	123	100

3.3.1.6.1.2 Content of the test

An essential aspect of designing an achievement test is the content analysis. This step involved reviewing material from six units of the Chemistry Practical syllabus mandated by the Central Board of Secondary Education (C.B.S.E.) for secondary classes students' phase 2 namely equilibrium, pH, melting and boiling point, volumetric analysis, crystallization, and salt analysis. Table 3.11 illustrates the weightage allocated to each unit.

Table 3.11: Topic Wise Weightage of the Content

S. No.	Content	Weightage	Percentage
1	Equilibrium	10	8.13
2	pH	11	8.94
3	Melting & boiling point	14	11.38
4	Volumetric Analysis	16	13.00
5	Crystallization	12	9.75
6	Salt Analysis	60	48.78
Total		123	100

3.3.1.6.1.3 Blueprint of the Test

The blueprint stage of test preparation is crucial as it establishes the framework for the development of test items for the initial draft. In this stage, a blueprint was created consisting of four types of questions and distributed them based on the cognitive abilities of the participants. Table 3.12 enumerates the 123 objective questions from the six units that comprise the blueprint.

Table 3.12: Achievement Test Framework (First Draft)

Sub Content	Knowledge	Understanding	Application	Skill	Total
Weightage	17.07%	16.26%	39.02 %	27.6%	100%
Equilibrium	2(2)	2(2)	4(4)	2(2)	10(10)
pH determination	3(3)	2(2)	4(4)	2(2)	11(11)
Melting point and boiling point determination	2(2)	6(6)	2(2)	4(4)	14(14)
Volumetric Analysis	3(3)	3(3)	6(6)	4(4)	16(16)
Crystallization	6(6)	1(1)	2(2)	3(3)	12(12)
Salt Analysis	5(5)	6(6)	30(30)	19(22)	60(63)
Total	21(21)	20(20)	48(48)	34(34)	123(126)

3.3.1.6.2 Test Construction

The process of creating test items involved three stages: Item-writing, expert review, and Item-editing. Initially, a rough draft was developed that included 123 questions addressing the teaching objectives of chemistry at the secondary level phase 2, specifically knowledge, comprehension, application, and skill. The distribution of questions across four objectives and six units of the curriculum is outlined in Table 3.13.

Table 3.13: Objective Wise Distribution of Items (123 Questions)

S. No.	Sub Content	Knowledge	Understanding	Application	Skill	Total
		17.07 %	**16.2 %**	**39.02 %**	**27.6 %**	**100%**

1	**Equilibrium**	2,7	1, 8	3, 4, 9, 10	5, 6	10
2	**pH determination**	11, 12, 17	14, 16	13, 15, 20, 21	18, 19	11
3	**Melting point and boiling point determination**	22, 32	23, 24, 26, 27, 29, 30	31, 34	25, 28, 33, 35	14
4	**Preparation of standard solution & titration**	40, 42, 48	45, 47, 51	37, 38, 39, 43, 44, 50	36, 41, 46, 49	16
5	**Crystallization**	52, 54, 55, 56, 60, 62	63	58, 59	53, 57, 61	12
6	**Salt Analysis**	65, 91, 92, 96, 100	72, 75, 94, 99, 106, 123	64, 67, 68, 69, 70, 71, 73, 74, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 103, 105, 107, 112, 113, 114, 116	66, 93, 95, 97, 98, 101, 102, 104, 108, 109, 110, 111, 115, 117,	60

					118, 119, 120, 121, 122	
	Total	21	20	48	34	123

The process of expert review entailed the thorough examination of each item under the guidance of six experts to ensure the absence of ambiguous wording or vague terminology in the format of the test items. The experts provided valuable feedback which resulted in the removal of five items (items 37, 55, 65, 66, and 119) and the revision of several others. Through this process, a second draft comprising 118 items was created.

3.3.1.6.3 Test Administration

3.3.1.6.3.1 Preliminary Try Out

Items to be tested were finalized and afterwards they were administered to a group of 50 senior secondary level students of Sarvodaya (Co-Ed) Vidyalya, Shakti Nagar. Adequate instructions were provided to the students on how to attempt the test. Afterwards, students marked their responses. The students were closely monitored to identify any areas of difficulty and language issues. The time spent by each student was recorded. Out of 118 items, 20 were found to be confusing and challenging by the students. These items (14, 21, 22, 52, 61, 67, 71, 74, 83, 86, 88, 89, 93, 95, 98, 100, 104, 106, 107, and 114) were subsequently removed from the draft. In light of the content and degree of difficulty, the third draft of the achievement test comprises 98 items.

3.3.1.6.3.2 Final try-out

For the final try out, 200 students of senior secondary level from 3 educational institutions (Sarvodaya (Co-Ed) Vidyalaya, Shakti Nagar; Heera Public School; SKV, East Vinod Nagar) participated (Table 3.14). The papers were collected and assessed using a designated scoring key. Correct responses were awarded marks while incorrect responses received no points.

Table 3.14: No of Students Participated in Final Try Out of Chemistry Practical Achievement Test

Name of the School	No. of Students Participated in Final Try Out
Sarvodaya(Co-Education) Vidyalaya, Shakti Nagar	50
Heera Public School, New Delhi	79
SKV, East Vinod Nagar	71
Total	200

3.3.1.6.4 Item Analysis

Item analysis was done after test items had been scored. It was done to evaluate the efficacy of various items by item analysis. Item analysis is a statistical science that is used to accept or reject test items based on the value of difficulty and discrimination power of the items. This serves the purpose of getting the test's most appropriate items. The steps in this process are as follows: orderly arrangement of the response sheets in descending order, calculation of Difficulty Value (DV) and Discrimination Power (DP) and finally rejection of items based on the values of DV and DP.

3.3.1.6.4.1 Difficulty Value

The percentage of students who successfully answered each question indicates the item's complexity. The value can be anywhere between 0% and 100%. The higher the value, the simpler the item is. A very easy item has a p value of 0.90 or higher, while a tough item has a DV value of 0.20 or lower. 0.5 difficulty value is ideal to create a distinction between high and low achievers. In general, moderately challenging products should be chosen over extremely easy or extremely difficult ones. The difficulty value is represented by P and the calculation of difficulty value is P= (Ru + Rl)/ T

Where, P= Difficulty Value

Ru = Number of students who answered correctly in upper group

RL= Number of students who answered correctly in lower group

T= Total number of students

The difficulty indices were evaluated based on the points as shown in the following table 3.15.

Table 3.15: Relation between Marks Range and Difficulty Level

Range	Difficulty Level
20 & below	Very Difficult
21- 40	Difficult
41- 60	Average
61 - 80	Easy
81 & above	Very Easy

The P value of an item supplied accurate evidence of how easy or difficult the item was for the respondent. It is documented that in a multiple-choice test consisting of four or more alternatives, the items lying in the range of 0.20 to 0.80 should be selected (Nunnally, 1972). All items found too easy or too difficult were excluded.

3.3.1.6.4.2 Discrimination Power

High and low scorers can be distinguished by the value of the Discrimination index. Out of all the students under consideration, the top 27% are categorized as high scorers and the bottom 27% are categorized as low scorers. An item is retained in the achievement test if it can distinguish between high and low scorers. Calculation of the Discrimination index is as follows:

D I = (Ru - RL) / T/2, Where

D I = Discrimination Index

Ru = Number of students who answered correctly in upper group

RL= Number of students who answered correctly in lower group

T= Total number of students

The selection of items in achievement tests were formalized based on Ebel's (1979) parameters and guidelines for categorizing discrimination power.

Ebel's Parameters on discrimination power (1979) are as follows:

If the value of Discriminating Power is 0.40 and above, the item is quite satisfactory.

If it is between 0.30-0.39, less or no revision is required in the item.

If it is between 0.20-0.29 item is marginal and need revision

If it is less than 0.19, The item should be eliminated or completely revised.

As per Ebel's parameters, 98 selected items are mentioned in the appendix F along with their Difficulty Value & Discriminating Power

3.3.1.6.4.3 Achievement Test (Final Draft)

The concluding draft was prepared based on item analysis. After choosing the items for the end draft, they were reassembled into the four categories established by Blooms: knowledge, understanding, application, and skill. There are 84 questions in the achievement test's final draft as given in Table 3.16.

Table 3.16: Achievement Test Framework (final draft)

S. No.	**Sub Content**	**Knowledge**	**Understanding**	**Application**	**Skill**	**Total**
		16.4 %	**23.5 %**	**35.2 %**	**24.7 %**	**100 %**
1	**Equilibrium**	-	8	4, 9, 10	5, 6	6
2	**pH determination**	11, 12, 17	14, 16	15, 20	18	8

3	**Melting point and boiling point determination**	29	21, 24, 26	27, 28, 30, 31, 32	22,25	11
4	**Preparation of standard solution & titration**	36, 44	43, 47	34, 35, 37, 40	33, 42, 45	11
5	**Crystallization**	48, 49, 50, 54	56	52, 53	51, 55	9
6	**Salt Analysis**	80, 82, 84, 85	62, 74, 75, 76, 77, 78,86, 87, 89, 90, 91	59, 60, 61, 63, 64, 66, 67, 68, 69, 70, 71, 72, 73,	79, 81, 83, 88, 92, 93, 94, 95, 96, 97, 98	39
	Total	14	20	30	21	84

Table 3.17 represent the 4 categories of objective type questions prepared in CPAT.

Table 3.17: Types of Objective Test-items in Final Draft of Achievement Test

S. No	Types of questions	NO. of questions	Marks
1	Multiple Choice	55	55
2	Complete the sentence	14	14
3	True False	14	14
4	Match the columns	1	1

3.3.1.6.5 Test Standardization

The final draft retained 84 items of the Achievement test after following standardization process. To carry out the standardization process, reliability and validity of the test was established.

3.3.1.6.5.1 Test Reliability

Reliability is one of the most significant features of any test and measuring instrument. The Split-half method was used to measure the reliability of the test. Split half is the method of splitting the test in two halves and finding the correlation. The responses of 200 students were used for the calculation. The scores of two halves were correlated and reliability of the test was found to be 0.96 (Pearson Coefficient) The reliability coefficient of full test was measured as rtt by the following formula:

rtt= 2r/1+r.

The reliability coefficient for the full test by Cronbach's Alpha statistic was .98. It concluded that the test has a high degree of reliability.

3.3.1.6.5.2 Test Validity

Validity means that the findings reflect what was intended to be measured. The reference of validity can be used to interpret the relevance of evidence of data and theory. Thus, absolute validity of the test cannot be established. However, the validity of scores is relevant for some uses or interpretations and not for others (29)

Validity of the Test was done while preparing the blueprint and item writing of the test. The views of experts in this field were duly noted and indispensable modifications were made in the achievement test as per their recommendations. Face validity and content validity of the test was assured by awarding adequate weightage to content and objectives.

The conclusive CPAT questionnaire has been included in the appendix labelled as Appendix G and appendix H contains the answer key for CPAT.

3.3.1.6.5.3 Scoring Norms of Chemistry Practical Achievement Test (CPAT)

The scoring norms of CPAT are established using z-scores, which are derived from the raw scores of all participating students. This statistical method allows for the normalization of scores, making it possible to compare individual marks against the overall distribution of scores. The z-score indicates how many standard deviations a student's raw score is from the mean score of the group. The following table 3.18 presents these scoring norms, showing the corresponding z-scores and their interpretation in terms of achievement levels.

Table 3.18: SCORING NORMS OF CHEMISTRY PRACTICAL ACHIEVEMENT TEST(CPAT)

Grade	Marks %	Raw Score	Z score
Excellent	90 % & above	76 & above	1.04 & above
A	75% & less than 90%	63 & less than 76	0.60 & less than 1.04
B	60 % & less than 75%	50 & less than 63	0.16 & less than 0.60
C	50% & less than 60%	42 & less than 50	-0.12 & less than 0.16
D	33% & less than 50%	28 & less than 42	-0.59 & less than -0.12
E	Below 33%	Below 28	Less than -0.59

3.4 Sample of Actual Experimentation

The study encompassed a population of science students in class XI from DAV Public School, located in Vas ant Kunj, Delhi, India. To ensure ethical compliance, proper permission was duly obtained from the head of the institution. Within the school, there are four sections for class XI, with two sections specifically designated for science students, namely XI A and XI B. The selection of science students was crucial as the study focused specifically on chemistry practical, with chemistry being their major subject of study.

To form a representative sample, a purposive sampling technique was employed, resulting in the participation of 37 students from each of the science sections, totalling 74 students across both XI A and XI B. This careful selection process aimed to ensure the inclusion of students who could provide valuable insights and contribute to the study's objectives.

By adopting this methodical approach and obtaining proper permission, the study successfully incorporated a targeted sample of science students from DAV Public School, Vasant Kunj, Delhi, facilitating a focused investigation into the chemistry practical domain.

3.5 Data Collection for Assessment of Academic Achievement, Experimental Self- Efficacy & Scientific Attitude

In this study a pre-test post-test study design was employed to examine the effect of Virtual Mode of Experimentation (VME) on 3 variables namely academic achievement, experimental self-efficacy and scientific attitude associated with the students. In this regard, a whatsapp group was created separately for both CG and EG group students. This was done to remain connected with students and update them for the schedule of pre-test, experimentation and post-test. Separate Google forms were made for both, control and experimental group students as per the requirement of the study. The research process began with a pre-test conducted online during which both teacher and students were physically present at the school and engaged with their respective computer systems. A set of 3 questionnaires were administered to the students in a computer lab setting. These questionnaires included the standardized CPAT, revalidated ESE scale, and revalidated SA scale. The students from both CG and EG participated in the questionnaire sessions on three different days. Again, they were instructed to answer honestly as the information is to be kept confidential and to be used only for research purpose. ESE scale and SA scale questionnaire were to be answered on a 5-point Likert Scale which varies from strongly agree (1) to strongly disagree (5). In CPAT, they were instructed to answer all the questions based on their knowledge, understanding, application and skill. In CPAT, one mark was allotted to each correct answer and zero mark to each incorrect answer. Scoring was done for all 3 tests (CPAT, ESE & SA) for both CG and EG students. Their responses were collected and recorded in a Google Excel sheet, allowing for analysis of the data across three variables and two groups. The data was tabulated for statistical analysis.

The pretest served as a baseline measurement, providing a starting point to determine the initial levels of academic achievement, experimental self-efficacy, and scientific attitude among the students. This allowed for a comparative analysis to be conducted following the intervention.

Afterward, a schedule was made for the experimentation phase in the laboratory. Mutually agreed upon day and time schedule was made in consultation with school authorities. The CG students received instruction in a traditional laboratory with a constructivist learning environment, while the EG students were taught in a virtual laboratory with a constructivist learning environment. Both groups performed a total of 20 experiments separately as per the agreed-upon schedule. Thirty classes were conducted for the CG group, and an equal number were conducted for the EG group. Each class had duration of 40 minutes.

The classes for the experimental group took place in the first half of the day whereas CG classes occurred in the second half of the day in the months of December, January and February. For the detailed schedule of the experimentation, please refer to appendix J. The students of CG did experiments in physical mode and students of Experimental Group (EG) in virtual mode.

In the very first class of the experimental group, students were introduced to the OLabs platform, which encompassed various components such as theory of experiment, procedure to perform practical, simulator and video incorporated in OLabs, viva voce, resources, and feedback. Additionally, the students were allotted extra time to delve into the simulator, enabling them to actively engage with the experiment by manipulating variables. The students found this interactive experience enjoyable and captivating.

Subsequently, in each class, the students of the Experimental Group (EG) embarked on new experiments using the OLabs platform. Most classes focused on conducting a distinct experiment, allowing the students to broaden their understanding and mastery of the subject matter. In certain cases, students were provided with more than one class to thoroughly explore and comprehend specific experiments. This approach provided them with ample time and opportunity to delve deeper into the intricacies of the experiments and enhance their comprehension.

Within the experimental group (EG), an **engaging** approach was implemented to foster student involvement. Initially, students were presented with relatable everyday objects and tasked with identifying them, assigning names, and discerning their positive and negative effects. Following this, the topic of the day's experiments was introduced, capturing their attention, and setting the stage for further exploration.

Next, students were provided with the necessary apparatus, glassware, and chemicals required for the experiment within the OLabs platform. They were encouraged to **explore** and actively participate by identifying and naming the materials. A concise overview of the theoretical aspects was provided, establishing a connection between the experiment, relevant theory chapters, and their prior knowledge.

During the **explanation** phase, students attentively viewed a video detailing the experiment's procedure and the reactions occurring within the test tubes, beakers, or conical flasks. At regular intervals, the video was paused, and students were prompted with questions related to the experiment. They were encouraged to predict the final product based on the chemical reactions explored during the earlier exploration phase. The identification of the product was often based on color changes and turbidity/ precipitation observed during the experimentation process.

In the **elaboration** step, students utilized the OLabs simulator to perform the experiment themselves. They had the opportunity to change the chemicals and their quantities, observing the resulting variations in colors or products formed. The students found great joy in both observing and actively participating in the experiments conducted through the OLabs platform. In fact, they continued to perform experiments online even after the class hours, demonstrating a strong desire to enhance their understanding of the concepts. They shared their knowledge with the teacher and were encouraged to apply their newly acquired knowledge and skills to other aspects of their lives.

To assess their understanding, the **evaluation** phase involved students tabulating their observations and drawing conclusions based on their findings. Additionally, interactive sessions comprising group and/or individual viva voce were conducted after each session. Students submitted their lab records to the teacher upon completion of the experiment. They were evaluated based on their completion of assigned tasks and their acevement in the viva voce questioning.

This holistic and interactive approach provided students in the experimental group with a comprehensive learning experience, allowing them to actively engage with the experiments, deepen their understanding, and showcase their knowledge and skills through evaluations and interactions with the teacher.

During the first class of the Control Group (CG), students were introduced to the physical chemistry laboratory setting, including the arrangement of chemicals and apparatus. They were familiarized with various components of the lab like water bath, precision balance, hot plate, test kits, centrifuge machine and burners. Furthermore, additional time was allotted for them to explore the other equipment and glassware. The students got the information to use this traditional lab in this interactive and collaborative process.

In subsequent classes, the students of the Control Group embarked on a series of new experiments using the Physical Chemistry Laboratory (PCL). Each class often presented a fresh experiment, allowing the students to expand their understanding and grasp of the subject matter. In some instances, certain experiments required more than one class for the students to fully explore and comprehend the intricacies involved. This approach provided them with ample time to delve deeper into the experiments and enhance their comprehension, ensuring a thorough grasp of the concepts being covered.

In the Control Group (CG), an interactive approach was implemented to **engage** the students right from the start. Initially, students were presented with everyday objects relevant to their lives and tasked with identifying and naming them, as well as determining their positive and negative effects. This exercise aimed to establish a connection between their daily experiences and the upcoming experiments.

Following this introductory phase, students were acquainted with the subject matter of the experiment scheduled for the day. They were then provided with the necessary apparatus, glassware, and chemicals required for the experiment. They were prompted to name the materials available with them as per the requirement of the experiment. A brief instruction on the theory behind the experiment was provided, enabling them to **explore** the relevance and significance of the specific experiment and make connections with theory chapters and their prior knowledge.

During the **explanation** phase, students were given a concise description of the experiment's process. They were then given the opportunity to perform the experiments themselves, drawing on their previous knowledge and concepts learned during theory classes. The identification of the final product was primarily based on attributes such as color, smell, and other sensory characteristics associated with the various chemicals and devices employed in the experimental process.

In the **elaboration** step, students were encouraged to extend their acquired knowledge and skills to other areas of their lives. They were asked to carefully tabulate their observations and ultimately draw conclusions from their findings. Upon completion of the experiment, students submitted their lab records to the teacher for evaluation. Their performance was assessed based on completed home assignments and through viva voce questioning, ensuring a comprehensive evaluation of their understanding and application of the concepts learned.

Following the completion of the experimentation phase, a post-test was conducted on both the Control Group (CG) and Experimental Group (EG) students to assess the changes in their academic achievement, experimental self-efficacy, and scientific attitude. To accomplish this, the students were once again presented with Chemistry Practical Achievement Test (CPAT), Experimental Self-Efficacy (ESE) scale, and Scientific Attitude (SA) scale. The questionnaires were administered to the sample in the computer lab of the school. They were instructed to answer honestly as the information is to be kept confidential and to be used only for research purposes. ESE scale and SA scale questionnaire were to be answered on a scale of 1 to 5 and in CPAT; they must answer all the questions based on their knowledge, understanding, application and skill gained in the process of experimentation by different modes. In CPAT, one mark was allotted to each correct answer and zero mark to each incorrect answer. Scoring was done for all 3 tests (CPAT, ESE & SA) for both CG and EG. The data was tabulated for statistical analysis.

3.6 STATISTICAL TECHNIQUES

To analyze the data with suitable statistical techniques, the following statistical procedure was adopted in the present study.

- To study the effect of academic achievement of secondary school students (Class XI), independent t-test and paired t-test were used.
- To study the effect of virtual laboratory and experimental self-efficacy of secondary school students, independent t- test and paired t- test were used.
- To study the effect of virtual labs on the scientific attitude developed among secondary school students, independent t- test and paired t-test was used.

CHAPTER IV

ANALYSIS OF DATA AND INTERPRETATION OF RESULTS

The present chapter delves into the analysis, interpretation, and discussion of the data. Data analysis, also known as statistical analysis, involves the examination of collected numbers or data to describe, combine, and draw inferences from them. This process encompasses not only numerical values but also the principles governing their arrangement.

The data obtained is analyzed statistically by categorizing them into the following parameters:

4.1 Effect of Constructivist Approach on the Academic Achievement of Secondary School Students in Teaching Science Lab Courses taught through Virtual and Physical Mode

4.2 Effect of Constructivist Approach on the Experimental Self- Efficacy of Secondary School Students in Teaching Science Lab Courses taught through Virtual and Physical Mode

4.3 Effect of Constructivist Approach on the Scientific Attitude of Secondary School Students in Teaching Science Lab Courses taught through Virtual and Physical Mode

It involves two distinct groups from the Science section of Class XI from a school located in Delhi. These groups are referred to as the Control Group (CG) and the Experimental Group (EG). Both groups received instruction based on a constructivist approach. The Control Group (CG) engaged in Physical Mode of Experimentation (PME) while the Experimental Group (EG) conducted their practical in Virtual Mode of Experimentation (VME) using OLabs platform.

The mode of experimentation to conduct chemistry practical (virtual chemistry laboratory and Physical Chemistry Laboratory) was the independent variable and constructivist approach was the instructional strategy. There were three dependent variables, namely, Academic Achievement, Experimental Self- Efficacy and Scientific Attitude.

Independent variable

In the present study, the modes of conducting chemistry experiments are Virtual Chemistry Laboratory and Physical Chemistry Laboratory. EG is exposed to Virtual Mode of Experimentation (VME) and CG is exposed to Physical Mode of Experimentation (PME).

Visual presentation of the same is given below:

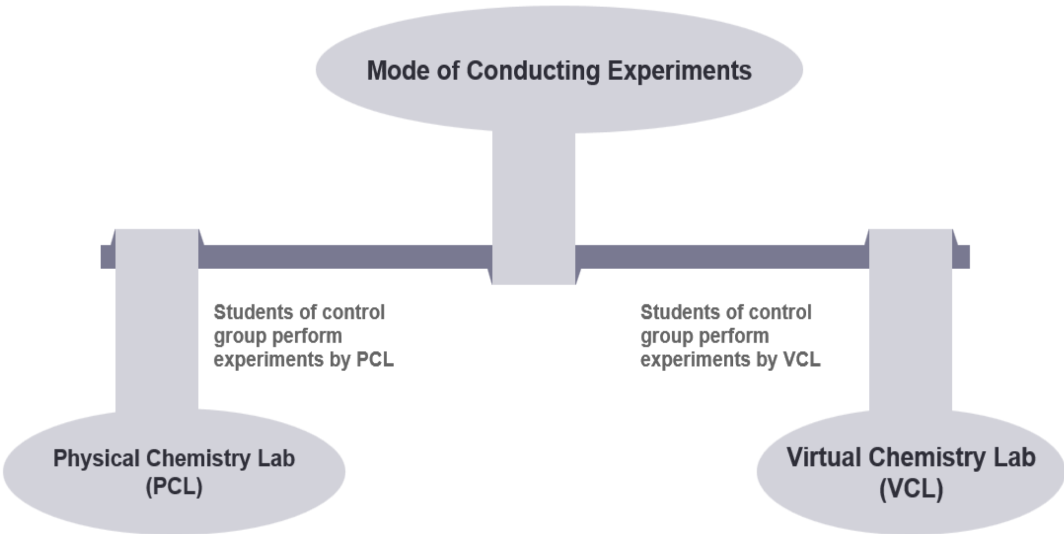


Figure 4.1: Classification of Mode of Conducting Experiments

Instructional Strategy: Constructivist Approach (5E)

Dependent variables are classified into three categories as shown in the figure below:

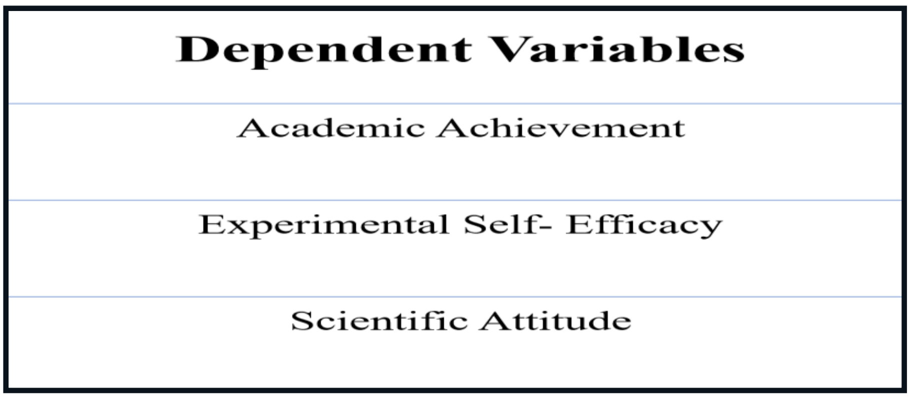


Figure 4.2: Classification of Dependent Variables

The objective wise detailed discussion is as follows.

4.1 EFFECT OF CONSTRUCTIVIST APPROACH ON THE ACADEMIC ACHIEVEMENT OF SECONDARY SCHOOL STUDENTS IN TEACHING SCIENCE LAB COURSES TAUGHT THROUGH VIRTUAL AND PHYSICAL MODE

The study aimed to investigate the effect of a constructivist approach on the academic achievement of secondary school students when learning science lab courses through both virtual and physical modes. The purpose of this objective is to assess the effect of virtual mode of experimentation on the academic achievement of secondary school students in the context of chemistry practical.

A null hypothesis is formulated based on literature review, which is stated as:

H_0: There is no significant difference in academic achievement among secondary students in science who performed experiments with Virtual mode and without virtual mode in constructivist learning environment.

The objective 4.1 is analysed under four subcategories:

- Difference in mean CPAT scores of CG & EG w.r.t. pre- test
- Difference in mean CPAT score of pre- and post- test w.r.t. control and experimental group.
- Difference in mean CPAT scores of CG & EG w.r.t. post test
- Comparison in no of students of CG & EG in the pre- and post- test w.r.t. CPAT score

4.1.1 Test for Normality of Chemistry Practical Achievement Test Data

Normality of Distribution: The assumption of normal distribution of the observation in the experimentally homogeneous sets was tested using descriptive statistics. The following table provides descriptive statistics for the Pre-test and Post-test Chemistry Practical Achievement Test scores of both the Control Group (CG) and the Experimental Group (EG).

Table 4.1: Descriptive Statistics for Pre-test and Post-test Chemistry Practical Achievement Test Scores of the Control Group (CG) and Experimental Group (EG)

Chemistry Practical Achievement Test Control Group (CG)	Treatment	N	Mean	Median	SD	SK	KU
	Pre-Test	37	46.51	44.00	13.07	.17	-.84
	Post-Test	37	49.84	50.00	15.73	.11	-1.00
Chemistry Practical Achievement Test of Experimental Group (EG)	Pre-Test	37	44.46	45.00	13.24	.54	1.12
	Post-Test	37	60.14	64.00	14.72	-.61	-.41

In the initial assessment (Pre-test), the Control Group had a mean score of 46.51, a median score of 44.00 and a standard deviation of 13.07. The value of skewness is .17 and kurtosis is -.84. After the intervention, the Post-test mean score for the Control Group was 49.84, with a median score of 50.00 and a standard deviation of 15.73. The value of skewness is .11 and kurtosis is -1.00 (Table 4.1)

For the experimental group, the Pre-test mean score was 44.46, with a median score of 45.00 and a standard deviation of 13.24. The value of skewness is .54 and kurtosis is 1.12. In the Post-test, the experimental group showed a significant improvement with a mean score of 60.14 and a median score of 64.00, along with a standard deviation of 14.72. The value of skewness is -.61 and kurtosis is -.41. (Table 4.1)

The values of skewness and kurtosis corresponding to pre- and post- tests scores for CG & EG as shown in table 4.1, lies in the range as advocated by Hair et al. (2010) and Bryne (2010) (skewness is between -2 to +2) and kurtosis is between (-7 to +7). It indicates that the present data is normal.

The visual representation of normality of data is given in following normality plots

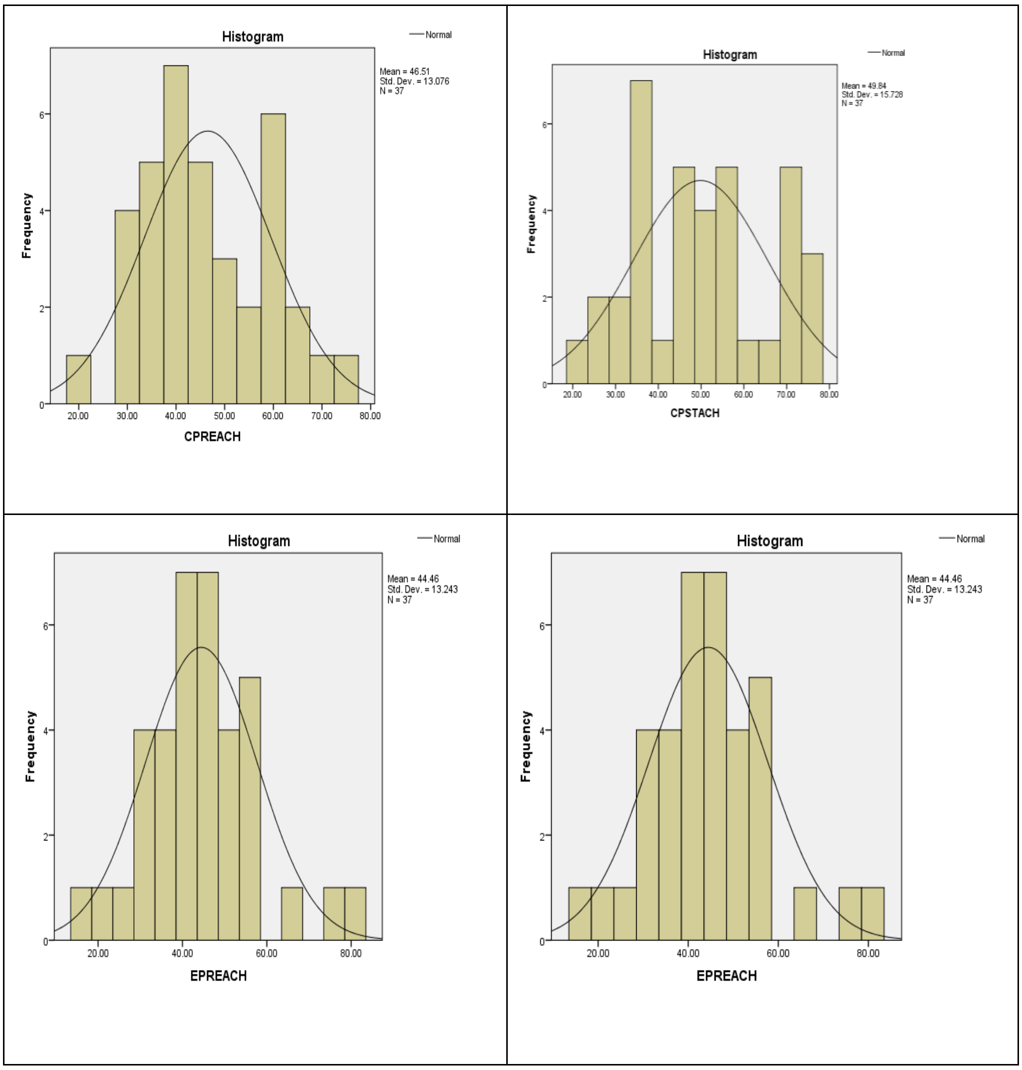


Figure 4.3: Normality Plots for Data Distribution (Academic Achievement)

The normality of chemistry practical achievement test data is also checked with normality test i.e. Shapiro-Wilk test ($N<50$) and the results are represented in the following table 4.2.

Table 4.2: Shapiro-Wilk Normality Test for pre and post-tests Scores of Control and Experimental Groups

Groups	**Statistic**	**N**	**Sig.**
Control Pre- Test	.970	37	.419
Control post-test	.955	37	.144
Experimental Pre-test	.968	37	.361
Experimental post-test	.946	37	.072

Table 4.2 present the results of the Shapiro-Wilk test, assessing the normality of data distribution in the control and experimental groups for both the Pre-Test and Post-Test conditions. The p-values obtained for the Pre-Test and Post-Test scores in the Control Group are .419 and .144, respectively, while in the experimental group, the p-values are .361 and .072, respectively. As all p-values are greater than .05, indicating statistical not significant, it can be concluded that the data in both groups' Pre-Test and Post-Test conditions follow a normal distribution based on the Shapiro-Wilk test.

4.1.2 Difference in Mean CPAT Scores of CG & EG w.r.t. Pre- Test

A pre- test was conducted to assess the difference in academic achievement of both the groups, CG & EG, prior to treatment i.e. physical mode and virtual mode.

An independent sample t-test was employed on the pre-test scores of the control and experimental groups, to find out the significant difference in academic achievement of students in chemistry practical. The results of the independent sample t-test are given in table 4.3.

H01a: There is no significant difference in mean CPAT scores of CG & EG w.r.t. pre-test.

Table 4.3 Difference in Mean Academic Achievement Scores of Control and Experimental Group Students In Chemistry Practical

Test	Group	N	M	SD	SE_D	t-value	p-value
Pre-test	Control	37	46.51	13.08	3.06	.67	.50
	Experimental	37	44.46	13.24			

**Significant at 0.05*

The table 4.3 present numbers of students, mean, standard deviation, standard error of difference, t- value and p- value corresponding to the pre-test Chemistry Practical Achievement Test scores of the control and experimental groups. The mean achievement score in chemistry practical for the pre- test of control group is 46.51 and for experimental group is 44.46. The corresponding standard deviation for two groups is 13.08 and 13.24 respectively. The standard error of the difference (SE_D) is calculated to be 3.06. The t-value for this groups is 0.67, and the corresponding p-value is 0.50 (>.05). It indicates that statistical difference is insignificant. Hence concluded that both the groups have same level of achievement before the treatment.

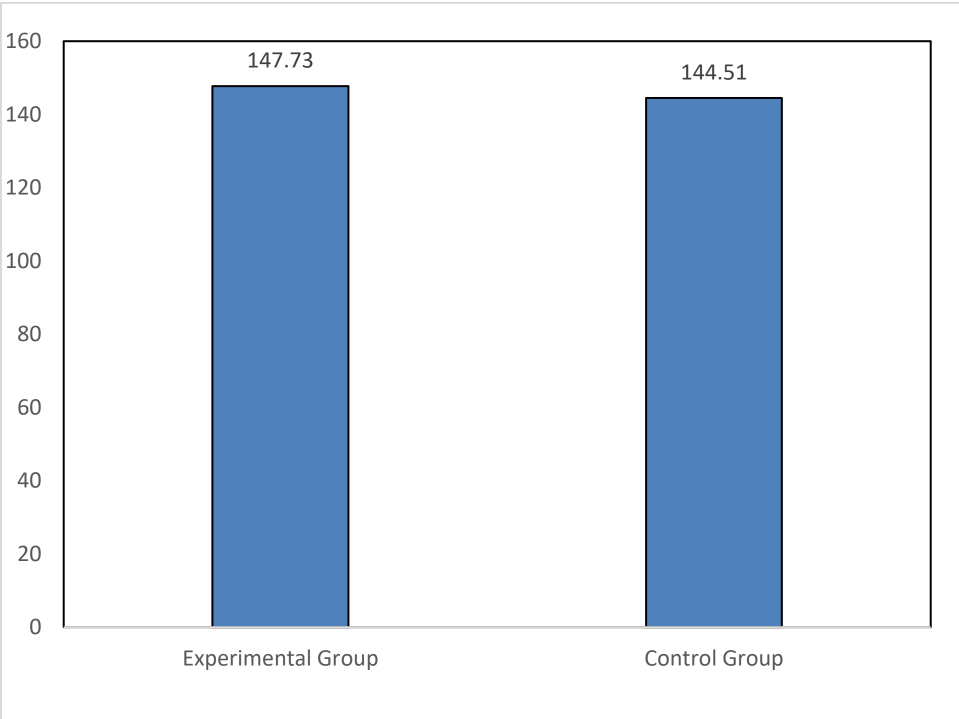


Figure 4.4 Graphical Representation of Mean Pre-test Scores of Achievement Test in Chemistry Practical of Control and Experimental Groups

4.1.3 Difference in mean CPAT score of pre- and post- test w.r.t. control and experimental group.

A paired t-test was employed to determine the significant difference between the mean CPAT scores of the pre-test and post-test conditions corresponding to Control group CG) and the Experimental Group (EG).

The results of paired t-test are given in the table 4.4.

H01b: There is no significant difference in mean CPAT score of pre- and post- test w.r.t. control and experimental group.

Table 4.4: Paired t-test Results for Mean Achievement Test Scores in the Control and Experimental Groups

Group	Test	N	M	SD	r	SE_D	t-value	p-value
Control	Pre-test	37	46.51	13.08	.007	3.35	.99	.328
	Post-test	37	49.84	15.73				
Experimental	Pre-test	37	44.46	13.24	.004	3.25	4.83	.000
	Post-test	37	60.14	14.72				

**Significant at 0.01

Table 4.4 present the mean Chemistry Practical Achievement Test (CPAT) scores in the pre-test and post-test for both the control group and the experimental group. In the control group, the mean CPAT score is 46.51 (SD = 13.08) in the pre-test and 49.84 (SD = 15.73) in the post-test. The paired sample t-test showed a t-value of .99 with 36 degrees of freedom (df), corresponding to a p-value of .328. Since the obtained p-value exceeded the value of 0.05, no statistical significant difference is observed in the mean CPAT scores between pre- and post- test scores of control group.

On the other hand, in the experimental group, the pre-test mean CPAT score is 44.46 (SD = 13.24), while the post-test mean CPAT score is 60.14 (SD = 14.72). The paired sample t-test yielded a t-value of 4.83 with 36 degrees of freedom (df) corresponding to a p-value of .000. This p-value is below the value of 0.05, indicating a statistical significant difference at both .01 & .05 level in the CPAT scores between the pre-test and post-test for the experimental group.

Further, table 4.4 revealed that the mean gain score in the control group is 3.31 (49.84 – 46.51) whereas the mean gain score in the experimental group is 15.68 (60.14 – 44.46). When the mean gain score of control group is compared with mean gain score of experimental groups, it is found that increase in mean gain score in experimental group is 12.37 (15.68 – 3.31) units more than the control group.

These findings suggest a significant improvement in the academic achievement in chemistry practical (measured by the CPAT scores) among students of experimental group as compared to control group.

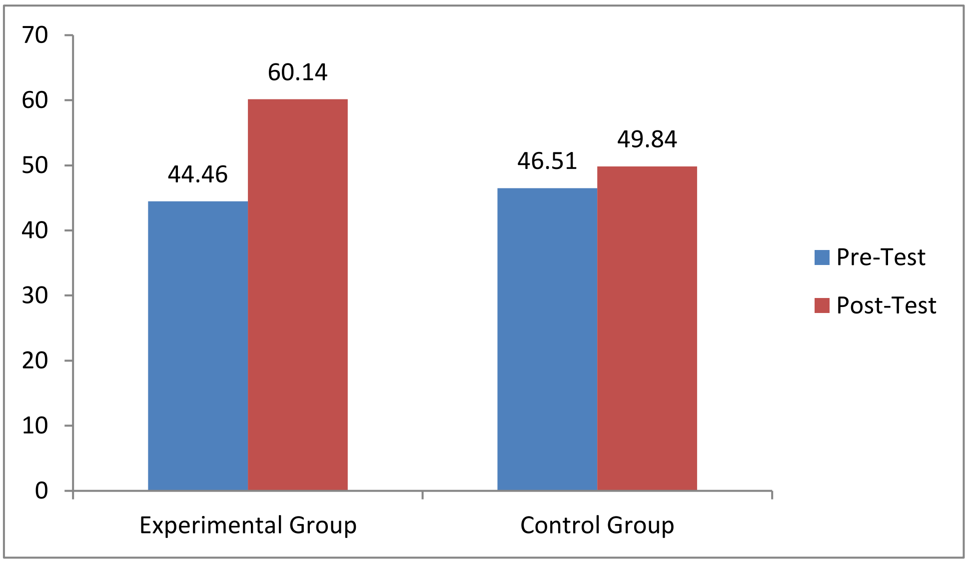


Figure 4.5 Comparison of Pre-Test and Post-Test Scores for Control and Experimental Groups

4.1.4 Difference in Mean CPAT Scores of CG & EG w.r.t. post test

After the treatment, a post- test was conducted to assess the difference in academic achievement of both the groups, CG & EG, i.e., physical mode and virtual mode.

An independent sample t-test was employed on the post-test scores of the control and experimental groups, to find out the significant difference in academic achievement of students in chemistry practical. The results of the independent sample t-test are given in table 4.5.

H01c: There is no significant difference in mean CPAT scores of CG & EG w.r.t. post-test.

Table 4.5: Difference in Mean academic achievement scores of control and experimental group students in chemistry practical

Test	Group	N	M	SD	SE_D	t-value	p-value
Post-test	Control	37	49.84	15.73	3.54	2.90	.005
	Experimental	37	60.14	14.72			

*Significant at 0.05

Table 4.5 provides valuable insights into the significance of the difference in mean Chemistry Practical Achievement Test (CPAT) scores between the control (M= 49.84, SD= 15.73) and experimental (M=60.14, SD= 14.72) groups in relation to their post-test results. The comparison between mean CPAT scores in post- tests of control and experimental group yielded a t-value of 2.90 corresponding to a p-value of .005 (<.05) revealed a statistical significant difference at .05 level of significance.

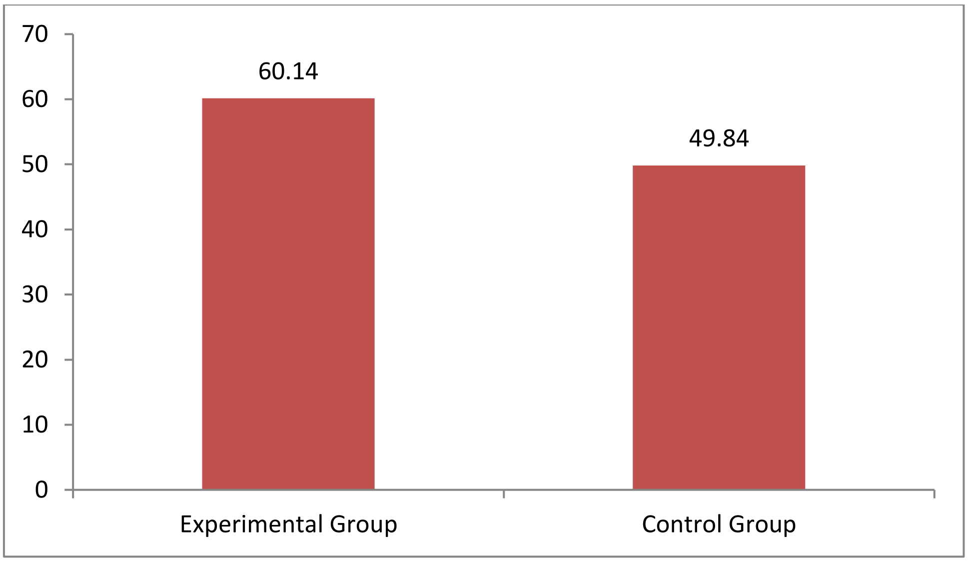


Figure 4.6: Graphical Representation of Mean Post- Test CPAT Scores of Control and Experimental Group

4.1.5 Comparison in no of students of CG & EG in the pre and post-test w.r.t. CPAT score

In order to compare the academic improvement of students who were exposed to physical and virtual modes of conducting chemistry practical, a change is observed in the number of students in the Control Group (CG) and Experimental Group (EG) who initially scored below 60% in the pre-test and later achieved a score of 60% or above in the post-test. This analysis aimed to determine the effect of the two modes i.e., physical and virtual, on students' academic achievement.

H01d: There is no significant difference in no of students of CG & EG in the pre- and post- test w.r.t. CPAT score.

Table 4.6: Distribution of Students Based on CPAT Scores in Pre-Test and Post-Test w.r.t. Control Group (CG) and Experimental Group (EG)

Marks %	**Raw Score**	CPRT	CPST	EPRT	EPST
≥60 %	≥50	15	19	11	29
<60%	<50	22	18	26	8

***CPRT**: Control group pre-test;* ***CPST**: control group post-test;* ***EPRT**: experimental group pre-test and* ***EPST:** experimental group post-test.*

The data presented in the table 4.6 highlights the classification of academic achievement into two distinct groups: Group 1 (< 60%) and Group 2 (≥ 60%). Within the control group, it was observed that 10.81% of students transitioned from Group 1 to Group 2 after participating in practical conducted in a conventional chemistry lab. In contrast, the experimental group exhibited a significantly higher improvement, with 48.64% of students moving from Group 1 to Group 2 after engaging in experiments conducted in a virtual chemistry lab.

This marked improvement in academic achievement among students in the experimental group surpassed that of the control group, thus confirming the effectiveness of the virtual chemistry lab treatment. The results indicated that the virtual lab environment positively influenced student achievement, demonstrating its potential as an impactful educational tool.

It is concluded that the null hypothesis H0 is rejected i.e., there is statistical significant difference in academic achievement among secondary students in science who performed experiments with Virtual mode and without virtual mode in constructivist learning environment.

These findings suggest that the implemented intervention or treatment positively influenced the CPAT scores of the experimental group, resulting in a notable improvement in their Academic Achievement. The studies by (Gamari et al. 2018; Kamtor et al.2017; James R. Brinson, 2015; Khulood Aljuhani et al. 2018; Rajendran et al. 2010; Athanasios Sypsas et al. 2019; Urbano & Caballes 2020; Lohmann, 2020; Banchik, 2018; Wunische, 2019; Darby- White et al., 2019; Wijayanti et al., 2018) are in sync with the findings of the present study which indicates that virtual mode learning improves the academic achievement of students.

4.2 EFFECT OF CONSTRUCTIVIST APPROACH ON THE EXPERIMENTAL SELF- EFFICACY OF SECONDARY SCHOOL STUDENTS IN TEACHING SCIENCE LAB COURSES TAUGHT THROUGH VIRTUAL AND PHYSICAL MODE

The study aimed to investigate how a constructivist approach influences the level of experimental self- efficacy among secondary school students participating in science lab courses taught through virtual and physical mode.

A null hypothesis is formulated based on literature review, which is stated as:

H0: There is no significant difference in experimental self- efficacy of the students in science who performed experiments with virtual mode and without virtual mode in constructivist learning environment.

The purpose of this objective was to assess the effect of virtual laboratory experiments on the students' experimental self-efficacy specifically in the context of chemistry practical.

The objective 4.2 is analysed under four subcategories:

- Difference in mean ESE scores of CG & EG w.r.t. pre- test
- Difference in mean ESE score of pre- and post- test w.r.t. control and experimental group.

- Difference in mean ESE scores of CG & EG w.r.t. post test
- Comparison in no of students of CG & EG in the pre- and post- test w.r.t. ESE score

Test for Normality of Experimental Self- Efficacy data

4.2.1 Normality of distribution: The assumption of normal distribution of the observation in the experimentally homogeneous sets was tested using descriptive statistics. The following tables depict the descriptive statistics for the Pre-test and Post-test experimental self-efficacy scores of both the Control Group (CG) and the Experimental Group (EG).

Table 4.7: Descriptive Statistics for Pre-Test and Post-Test Experimental Self-Efficacy Scores of The Control Group and Experimental Group

Experimental Self- Efficacy	**Treatment**	**N**	**Mean**	**Median**	**SD**	**SK**	**KU**
(Control Group)	Pre-Test	37	46.24	47.00	7.39	-.443	.402
	Post-Test	37	47.30	48.00	8.08	-.278	-.432
Experimental Self- Efficacy (Experimental Group)	Pre-Test	37	47.30	48.00	8.08	-.278	-.432
	Post-Test	37	50.95	51.00	6.35	-.189	-.900

In the Pre-test, the Control Group had a mean score of 46.24, a median score of 47.00 and a standard deviation of 7.39. The value of skewness is -.443 and kurtosis is .402. The Post-test mean score for the Control Group was 47.30, with a median score of 48.00 and a standard deviation of 8.08. The value of skewness is .278 and kurtosis is -.432 (Table 4.7)

For the Experimental Group, the Pre-test mean score was 47.30, with a median score of 48.00 and a standard deviation of 8.08. The value of skewness is .278 and kurtosis is -.432. The Post-test mean score of experimental group was 50.95 and a median score of 51.00, along with a standard deviation of 6.35. The value of skewness is -.189 and C is -.900 (Table 4.7)

The value of skewness and kurtosis corresponding to pre- and post- test scores for CG and EG as shown in table 4.7, lies in the range as advocated by Hair et al. (2010) and Bryne (2010) It indicated that the present data is normal.

The Visual representation of normality of data is given in following normality plots.

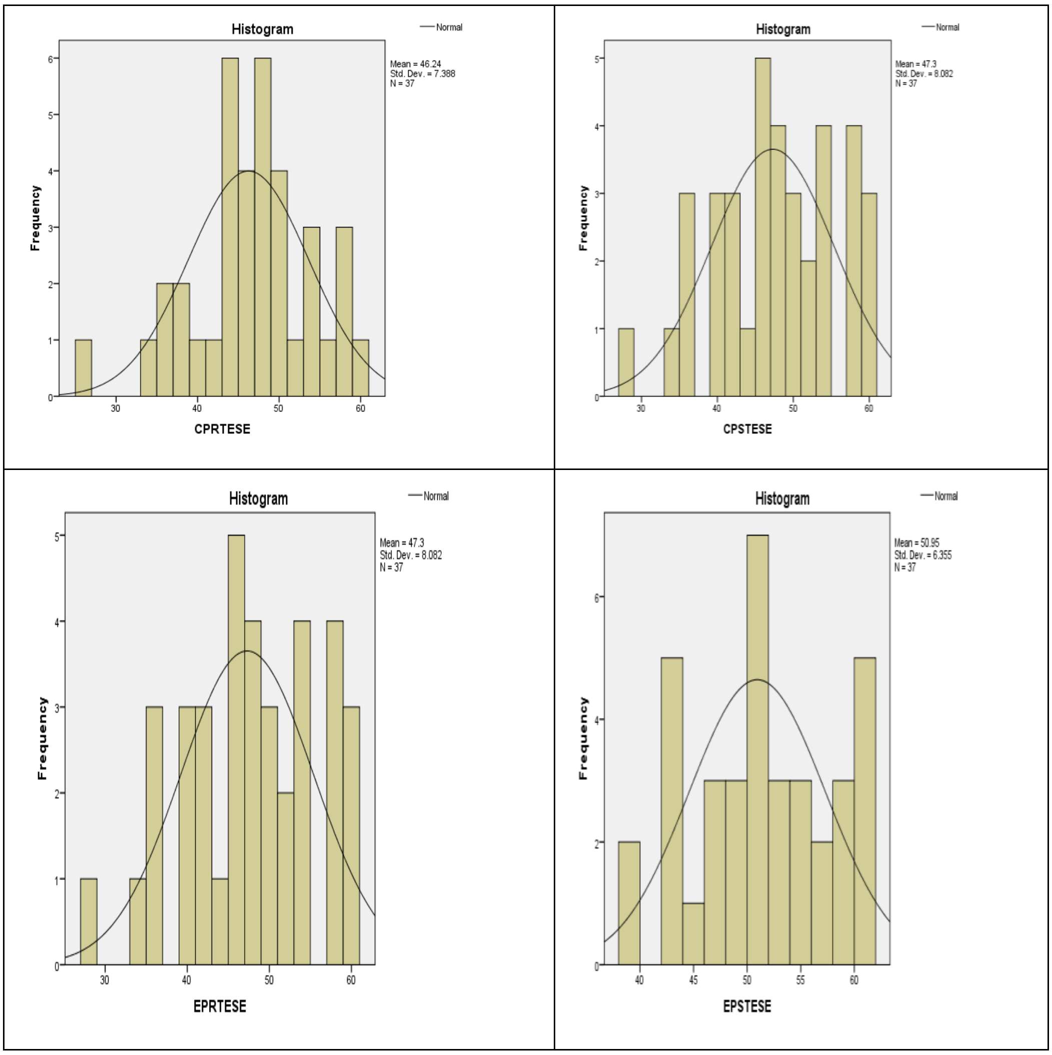


Figure 4.7: Normality Plots for Data Distribution (Experimental Self-Efficacy)

The normality of chemistry practical experimental self- efficacy data is also checked with normality test i.e. Shapiro-Wilk test (N<50) and the r represented in the following table 4.8.

Table 4.8: Shapiro-Wilk Normality Test for Pre and Post-Tests Scores of Control and Experimental Groups

Groups	Statistic	N	Sig.
Control Pre- Test	.974	37	.529
Control post-test	.972	37	.478
Experimental Pre- Test	.972	37	.478
Experimental post-test	.946	37	.070

The table 4.8 present the results of the Shapiro-Wilk test, assessing the normality of data distribution in the control and experimental groups for both the Pre-Test and Post-Test conditions. The p-values obtained for the Pre-Test and Post-Test scores in the Control Group are .529 and .478 respectively, while in the Experimental Group, the p-values are .478 and .070, respectively. As all p-values are greater than .05, indicating statistical not significant, it can be concluded that the data in both groups' Pre-Test and Post-Test conditions follow a normal distribution based on the Shapiro-Wilk test.

4.2.2 Difference in Mean CPAT Scores of CG & EG w.r.t. Pre-Test

A pre- test was conducted to assess the difference in experimental self- efficacy of both the groups, CG & EG, prior to treatment i.e., physical mode and virtual mode.

An independent sample t-test was employed on the pre-test scores of the control and experimental groups, to find out the significant difference in experimental self-efficacy of students in chemistry practical. The results of the independent sample t-test are given in table 4.9.

H02a: There is no significant difference in mean ESE scores of CG & EG w.r.t. pre-test.

Table 4.9 Difference in Mean Experimental Self- Efficacy Scores of Control and Experimental Group Students in Chemistry Practical

Test	Group	N	M	SD	SE_D	t-value	p-value
Pre-test	Control	37	46.24	7.39	1.33	1.99	.053
	Experimental	37	43.60	3.35			

*Significant at 0.05

The table 4.9 present the number of students, mean, standard deviation, standard error of difference, t- value and p- value corresponding to the pre-test experimental self-efficacy scores of the control and experimental groups. The mean experimental self-efficacy score in experimental self- efficacy for the pre- test of control group is 46.24 and for experimental group is 43.60. The corresponding standard deviation for two groups is 7.39 and 3.35 respectively. The Standard Error of the Difference (SED) is calculated which comes out to be 1.33. The t-value for this groups is 1.99 and the corresponding p-value is 0.53 (>.05). It indicates that it is statistical difference is insignificant. Hence concluded that both the groups have same level of experimental self-efficacy before the treatment.

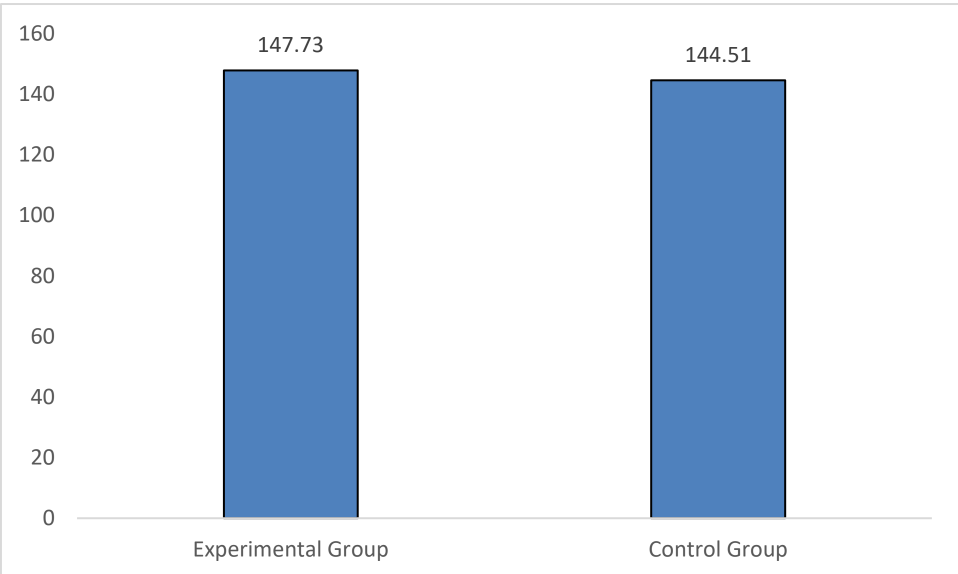


Figure 4.8 Graphical Representations of Mean Pre- Test Scores of Experimental Self- Efficacy Scores of Control & Experimental Group

4.2.3 Difference in mean ESE score of pre- and post- test w.r.t. control and experimental group

A paired t-test was employed to determine the significant difference between the mean ESE scores of the pre-test and post-test conditions corresponding to Control Group (CG) and the Experimental Group (EG).

The results of paired t- test are given in the table 4.10.

H02b: There is no significant difference in mean ESE score of pre- and post- test w.r.t. control and experimental group.

Table 4.10: Paired t-test Results for Mean Experimental Self- Efficacy Scores in the Control and Experimental Groups

Group	Test	N	M	SD	r	SED	t-value	p-value
Control	Pre-test	37	46.24	7.39	.46	1.33	.793	.433
	Post-test	37	47.30	8.08				
Experimental	Pre-test	37	43.60	3.35	.488	.91	8.05**	.000
	Post-test	37	50.95	6.36				

**Significant at 0.01

Table 4.10 present the mean Experimental Self -Efficacy (ESE) scores in the pre-test and post-test for both the control group and the experimental group. In the control group, the mean ESE score is 46.24 (SD = 7.38) in the pre- test and 47.30 (SD = 8.08) in the post test. The paired sample t-test showed a t-value of .793 with 36 degrees of freedom (df), corresponding to a p-value of .433. Since the obtained p-value exceeded the value of 0.05, no statistically significant difference is observed in the mean ESE scores between pre- and post- test scores of control group.

On the other hand, in experimental group, the pre- test mean ESE score is 43.60 (SD = 3.35) while the post- test mean ESE is 48.02 (SD = 4.48). The paired sample t-test yielded a t-value of 8.05 with 36 degrees of freedom (df) corresponding to a p-value of .000. This p-value is below the value of 0.05, indicating a statistically significant difference at both .01 & .05 level in the ESE scores between the pre-test and post-test for the experimental group.

Further, table 4.10 revealed that during the transition from the pre-test to the post-test, mean gain score in the control group is 1.06 (47.30 – 46.24) whereas the mean gain score in the experimental group is 3.65 (50.95 – 47.30). When mean gain score of control group is compared with mean gain score of experimental groups, it is found that increase in mean gain score in experimental group is 2.59 (3.65 – 1.06) units more than the control group.

These findings suggest a significant improvement in the experimental self- efficacy in chemistry practical (measured by ESE scores) among students of experimental group as compared to control group.

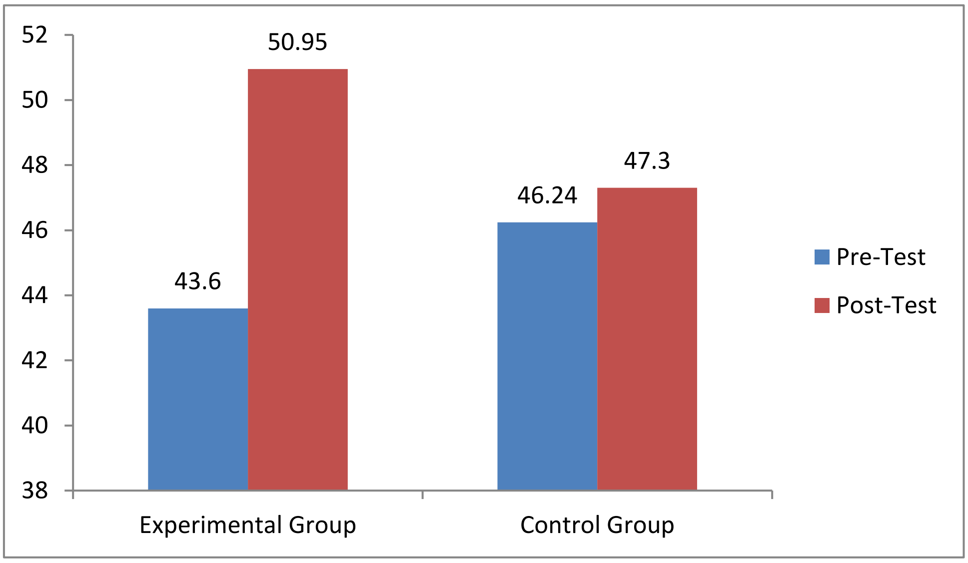


Figure 4.9: Comparison of Pre-Test and Post-Test Scores for Control and Experimental Groups

4.2.4 Difference in Mean ESE scores of CG & EG w.r.t. post test

After the treatment, a post- test was conducted to assess the difference in experimental self- efficacy of both the groups, CG & EG, i.e., physical mode and virtual mode.

An independent sample t-test was employed on the post-test scores of the control and experimental groups, to find out the significant difference in experimental self- efficacy of students in chemistry practical. The results of the independent sample t-test are given in table 4.11.

H02c: There is no significant difference in mean ESE scores of CG & EG w.r.t. post-test.

Table 4.11: Difference in Mean Experimental Self- Efficacy Scores of Control and Experimental Group Students in Chemistry Practical

Test	Group	N	M	SD	SED	t-value	p-value
Post-test	Control	37	47.30	8.08	1.69	2.16*	.034
	Experimental	37	50.95	6.36			

*Significant at 0.05

Table 4.11 provides valuable insights into the significance of the difference in mean Chemistry Practical Experimental Self- Efficacy (ESE) scores between the control (M= 47.30, SD= 8.08) and experimental (M=50.95, SD= 6.36) groups in relation to their post-test results. The comparison between mean SA scores in post-tests of control and experimental group yielded a t-value of 2.16 corresponding to a p-value of .034 (<.05) revealed a statistical significant difference at .05 level of significance.

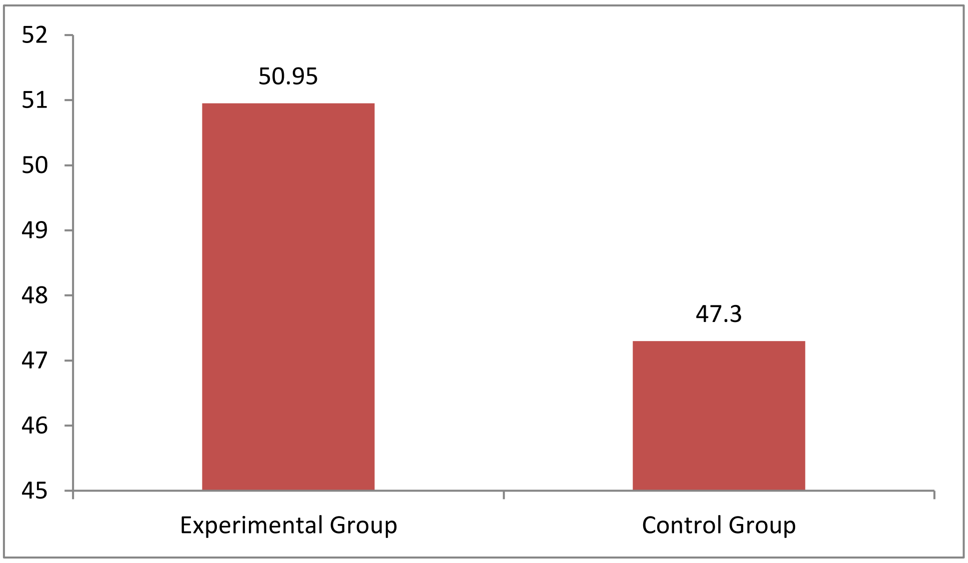


Figure 4.10: Graphical Representation of Mean Post- Test ESE Scores of Control and Experimental Group

4.2.5 Comparison in no of students of CG & EG in the pre- and post- test w.r.t. ESE score

To compare the experimental self-efficacy of students who were exposed to physical and virtual modes of conducting chemistry practical, the change was observed in the number of students in the Control Group (CG) and Experimental Group (EG) who initially scored average marks in the pre-test and later achieved a scored above average marks in the post-test. This analysis aimed to determine the effect of the two modes i.e., physical, and virtual, on students' experimental self-efficacy.

H02d: There is no significant difference in no of students of CG & EG in the pre- and post- test w.r.t. ESE score.

Table 4.12: Distribution of Students Based on ESE Scores in Pre-Test and Post-Test w.r.t. Control Group (CG) and Experimental Group (EG)

	No of Students = 37			
Level of ESE	**Control Group**		**Experimental Group**	
	CPRT	**CPST**	**EPRT**	**EPST**
Low	Nil	Nil	Nil	Nil
Average	24	21	37	11
High	13	16	Nil	26

CPRT*: Control group pre-test;* ***CPST****: control group post-test;* ***EPRT****: experimental group pre-test and* ***EPST:*** *experimental group post-test.*

Prior to conducting experiments by physical and virtual mode, an ESE test was administered to both the Control Group (CG) and the Experimental Group (EG). The results shown in table 4.12 indicates that in the pre-test, most students in both groups has average ESE scores (CG = 24 students, 65% and EG = 37 students, 100%), while only a small number of students has high ESE scores (CG = 13 students, 35% and EG = 0 students). Notably, a remarkable disparity in the scores of ESE is observed between the CG and EG. Within the CG, the number of students with average ESE scores decreased from 24 students (65%) to 21 students (57%), accompanied by an increase in the number of high-scoring students whereas, the EG exhibited a statistically significant increase in the number of students with high scores, rising from zero to 26 students (70%), while experiencing a decrease in ESE scores among the average-scoring students. The improvement in experimental group students was higher in comparison to control group students which proved the effectiveness of the virtual chemistry lab treatment in enhancing the experimental self-efficacy of students.

It is concluded that the Null Hypothesis H_0 is rejected i.e. There is significant difference in experimental self- efficacy among secondary students in science who performed experiments with Virtual mode and without virtual mode in constructivist learning environment.

These findings suggest that the implemented intervention or treatment positively influenced the ESE scores of the experimental group, resulting in a notable improvement in their experimental self- efficacy.

The studies by Ghatty et al. (2013), Dyrberg et al. (2017), Husnaini & Chen (2019), Kolil et al. (2020), Solikhin et al. (2018), Hussain et al. (2021), Lonez & Errabo (2022), Peters et al. (2023), Shadbad et al. (2023) found a significant difference in the experimental self-efficacy of students after performing experiments through virtual mode and supported the findings of the present study.

4.3 EFFECT OF CONSTRUCTIVIST APPROACH ON THE SCIENTIFIC ATTITUDE OF SECONDARY SCHOOL STUDENTS IN TEACHING SCIENCE LAB COURSES TAUGHT THROUGH VIRTUAL AND PHYSICAL MODE

The objective of the study is to study the effect of constructivist approach on the scientific attitude of secondary school students in teaching science lab courses taught through virtual and physical mode. The purpose this objective was to observe the effect of virtual laboratory experiments on scientific attitude of secondary school students in chemistry practical.

A null hypothesis is formulated Based on literature review, which is stated as:

H_0: There is no significant difference in scientific attitude among secondary students in science who performed experiments with Virtual mode and without virtual mode in constructivist learning environment.

The objective 4.3 is analysed under four subcategories:

- Difference in mean SA scores of CG & EG w.r.t. pre- test
- Difference in mean SA score of pre- and post- test w.r.t. control and experimental group.
- Difference in mean SA scores of CG & EG w.r.t. post test
- Comparison in no of students of CG & EG in the pre- and post- test w.r.t. SA score

4.3.1 Test of Normality of Scientific Attitude Data

Normality of Distribution: The assumption of normal distribution of the observation in the experimentally homogeneous sets was tested using descriptive statistics. The following tables provides descriptive statistics for the Pre-test and Post-test scientific attitude scores of both the Control Group (CG) and the Experimental Group (EG).

Table 4.13: Descriptive Statistics for Pre-test and Post-test scientific attitude Scores of the Control Group (CG) and Experimental Group (EG)

Scientific Attitude Test	Treatment	N	Mean	Median	SD	SK	KU
of Control Group (CG)	Pre-Test	37	144.51	143.00	11.78	-.218	.972
	Post-Test	37	145.49	147.00	13.93	-.063	-.579
Scientific Attitude Test of Experimental Group (EG)	Pre-Test	37	147.73	148.00	12.81	-.088	-.245
	Post-Test	37	149.14	148.00	15.11	-.207	-.140

In the pre-test, the Control Group had a mean score of 144.51, a median of 143.00 and a standard deviation of 11.78. The value of skewness (-0.218) and a high kurtosis (0.972). The post-test mean score for control group was 145.49, with a median of

147.00 and a standard deviation of 13.93. The skewness is -0.063 and kurtosis is -0.579. For the experimental group in the pre-test, the mean score is 147.73, with a median of 148.00 and a standard deviation of 12.81. The value of skewness is -0.088 and kurtosis is -0.245 (Table 4.13).

For the experimental group, the Pre-test mean score was 147.73, with a median score of 148.00 and a standard deviation of 12.81. The value of skewness is -.088 and kurtosis is -.088. In the Post-test, the experimental group showed a significant improvement with a mean score of 149.14 and a median score of 148.00, along with a standard deviation of 15.11. The value of skewness is -.207 and kurtosis is -.140. (Table 4.14)

The values of skewness and kurtosis corresponding to pre- and post- tests scores for CG & EG as shown in table 4.13, lies in the range as advocated by Hair et al. (2010) and Bryne (2010). It indicated that the present data is normal.

The visual representation of normality of data is given in following normality plots.

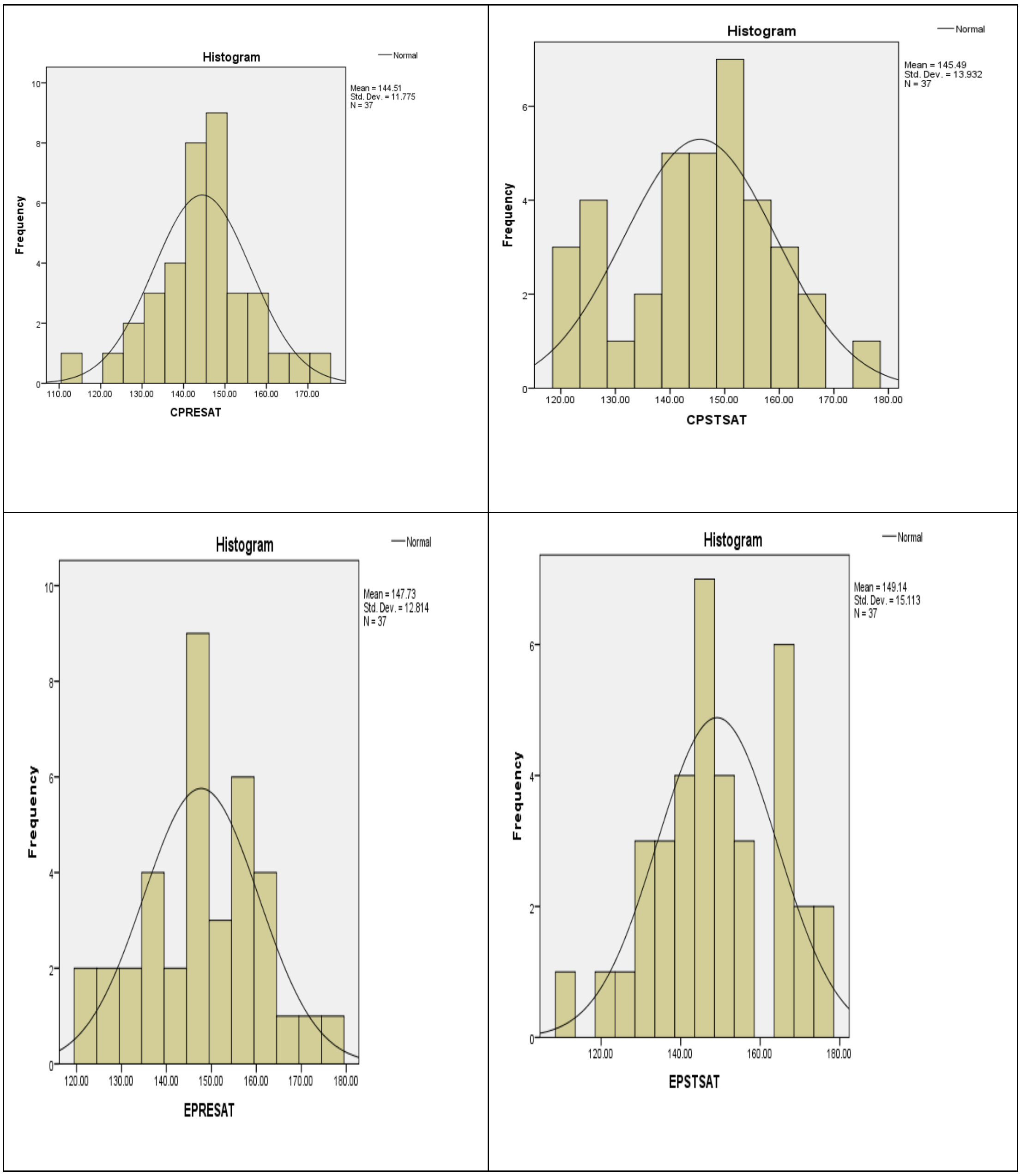


Figure 4.11: Normality Plots for Data Distribution (Scientific Attitude)

The normality of scientific attitude data is also checked with normality test i.e., Shapiro-Wilk test (N<50) and the results are represented in the following table 4.14.

Table 4.14: Statistical Tests for Normality of Data Distribution in Control and Experimental Groups

Groups	Statistic	N	Sig.
Control Pre-test	.974	37	.540

Control post-test	.974	37	.528
Experimental Pre-test	.980	37	.725
Experimental Post-test	.981	37	.773

This is a lower bound of the true significance, a Lilliefors Significance Correction

Table 4.14 present the results of the Shapiro-Wilk test, assessing the normality of data distribution in the Control and Experimental groups for both the Pre-Test and Post-Test conditions. The p-values obtained for the Pre-Test and Post-Test scores in the Control Group are .540 and .528, respectively, while in the experimental group, the p-values are .725 and .073, respectively. As all p-values are greater than .05, indicating statistical not significant, it can be concluded that the data in both groups' Pre-Test and Post-Test conditions follow a normal distribution based on the Shapiro-Wilk test.

4.3.2 Difference in mean SA scores of CG & EG w.r.t. pre- test

A pre- test was conducted to assess the difference in scientific attitude of both the groups, CG & EG, prior to treatment i.e. physical mode and virtual mode. An independent sample t-test was employed on the pre-test scores of the control and experimental groups, to determine the significant difference in scientific attitude of students in chemistry practical. The results of the independent sample t-test are given in table 4.15.

H03a: There is no significant difference in mean SA scores of CG & EG w.r.t. pre-test.

Table 4.15: Difference in Mean Scientific Attitude Scores of Control and Experimental Group Students in Chemistry Practical

Test	Group	N	M	SD	SE_D	t-value	p-value
Pre-test	Control	37	144.51	11.78	2.86	1.12	.265
	Experimental	37	147.73	12.81			

Significant at 0.05

The table 4.15 present number of students, mean, standard deviation, standard error of difference, t- value and p- value corresponding to the pre-test Chemistry Practical Achievement Test scores of the control and experimental groups. The mean scientific attitude scores in chemistry practical for pre-test scores of the Control group is 144.51 and for experimental group is 147.73. The corresponding 1.12, and the corresponding standard deviation for two groups is 11.78 and 12.81 respectively. The standard error of the difference (SE_D) is calculated to be 2.86. The t-value for the groups is 1.12 and the corresponding p-value is 0.265 (>.05). It indicates that it statistical difference is insignificant. Hence concluded that both the groups have same level of scientific attitude before the treatment.

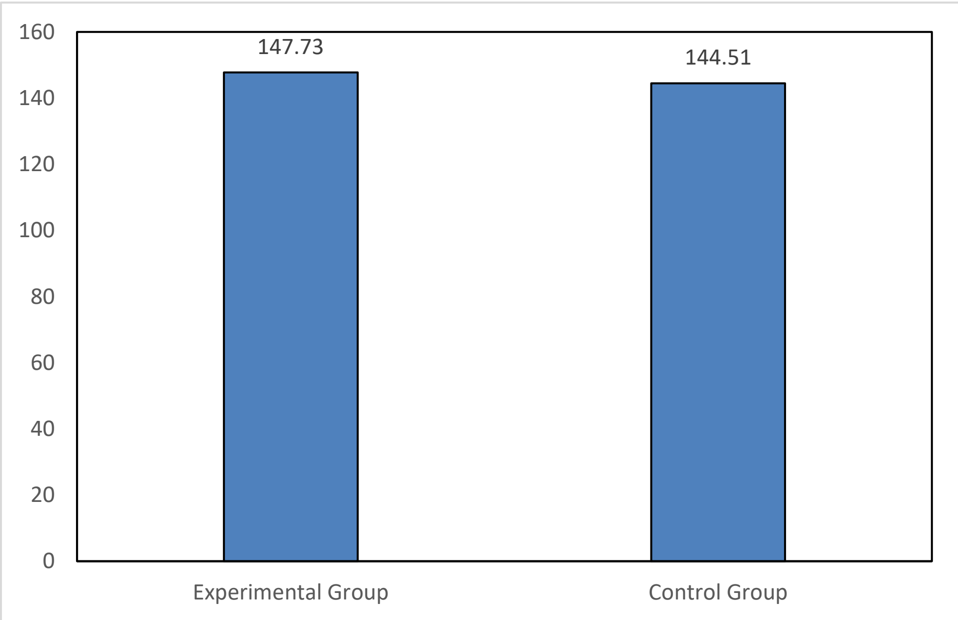


Figure 4.12: Graphical Representation of Mean Pre- Test Scores of Scientific Attitude of Control and Experimental Groups

4.3.3 Difference in mean SA score of pre- and post- test w.r.t. control and experimental group

A paired t-test was employed to determine the significant difference between the mean SA scores of the pre-test and post-test conditions corresponding to Control Group CG) and the Experimental Group (EG).

The results of paired t- test are given in the table 4.16.

H03b: There is no significant difference in mean SA score of pre- and post- test w.r.t. control and experimental group.

Table 4.16: Paired t-test Results for Mean Scientific Attitude Scores in the Control and Experimental Groups

Group	Test	N	M	SD	r	SED	t-value	p-value
Control	Pre-test	37	144.51	11.78	-.204	3.29	.296	.769
	Post-test	37	145.49	13.93				
Experimental	Pre-test	37	147.73	12.81	.581	2.13	.660	.513
	Post-test	37	149.14	15.11				

**Significant at 0.01

Table 4.16 present the mean Scientific Attitude (SA) scores in the pre-test and post-test for both the control group and the experimental group. In the control group, the mean SA score was 144.51(SD = 11.78) in the pre-test and 145.49 (SD = 13.93) in the post-test. The value of r between pre and post test scores for scientific attitude is -.204 (p=.226) which is not significant. The paired sample t-test showed a t-value of .296 with 36 degrees of freedom (df), corresponding to a p-value of .769. Since the obtained p-value exceeded the value of 0.05, so no statistical significant difference is observed between the mean SA scores of pre and post- tests of control group.

On the other hand, in the experimental group, the pre-test mean SA score is 147.73 (SD =12.81), while the post-test mean SA score is 149.14 (SD = 15.11). The value of r between pre and post test scores for scientific attitude is .581 (p=.000) which is significant. The paired sample t-test yielded a t-value of .660 with 36 degrees of freedom (df), corresponding to a p-value of .513. Since the obtained p-value exceeded the value of 0.05, so no statistical significant difference is observed between the mean SA scores of pre- and post- tests of experimental group.

Further, table 4.16 revealed that the mean gain score in the control group is 0.98 (145.49 – 144.51) whereas the mean gain score in the experimental group is 1.41 (149.14 – 147.73). When the mean gain score of control group is compared with mean gain score of experimental groups, it is found that increase in mean gain score in experimental group is only 0.43 (1.41– 0.98) units more than the control group.

These findings suggest insignificant improvement in the scientific attitude in chemistry practical (measured by the SA scores) among students of experimental group as compared to control group.

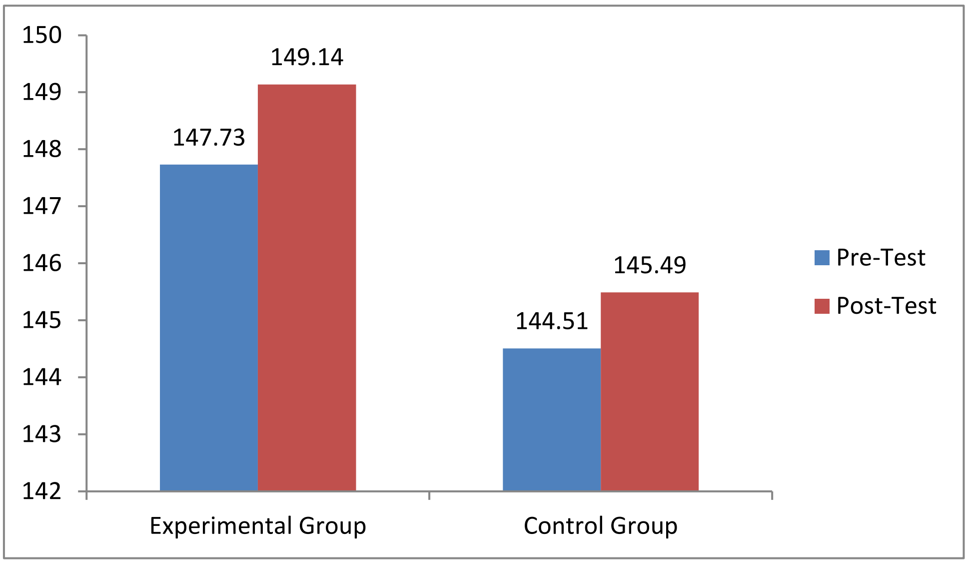


Figure 4.13: Comparison of Pre-Test and Post-Test Scores for Control and Experimental Groups

4.3.4 Difference in Mean SA scores of CG & EG w.r.t. post test

After the treatment, a post- test was conducted to assess the difference in scientific attitude of both the groups, CG & EG, i.e., physical mode and virtual mode.

An independent sample t-test was employed on the post-test scores of the control and experimental groups, to find out the significant difference in scientific attitude of students in chemistry practical. The results of the independent sample t-test are given in table 4.17.

H03c: There is no significant difference in mean SA scores of CG & EG w.r.t. post-test.

Table 4.17: Difference in Mean Post-Test Scores of Scientific Attitude of Control and Experimental Group

Test	Group	N	M	SD	SE_D	t-value	p-value
Post-test	Control	37	145.49	13.93	3.38	1.08	.284
	Experimental	37	149.14	15.11			

*Significant at 0.05

Table 4.17 provides valuable insights into the significance of the difference in mean Scientific Attitude (SA) scores between the control (M=145.49, SD= 13.93) and experimental (M= 149.14, SD= 15.11) groups in relation to their post-tests results. The comparison between mean SA scores in post- tests of control and experimental group yielded a t-value of 1.08 corresponding to a p-value of .284 (>.05) revealed no statistical significant difference at .05 level of significance.

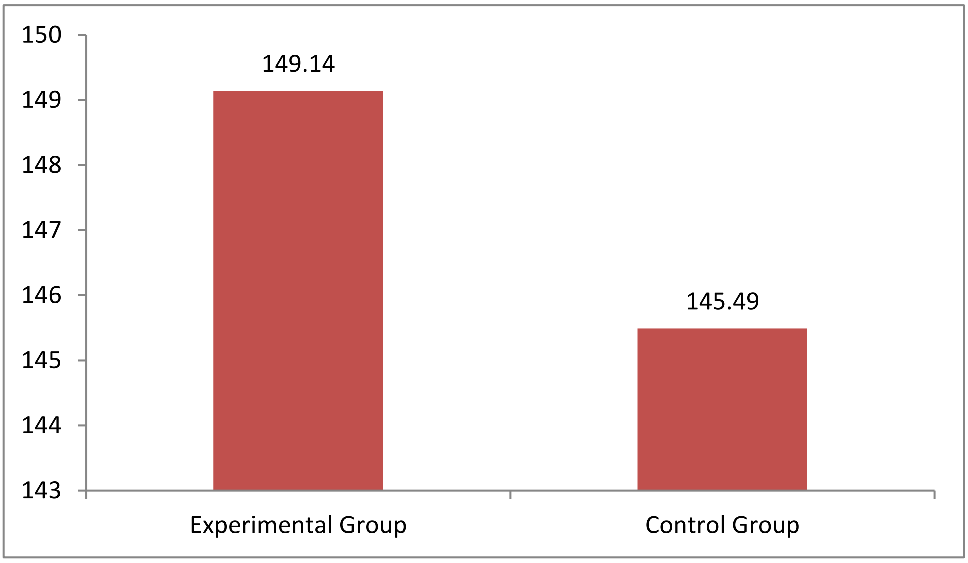


Figure 4.14: Graphical Representation of Mean Post- Test SA Scores of Control and Experimental Group

4.3.4 Comparison in no of students of CG & EG in the pre- and post- test w.r.t. SA score

In order to compare the scientific attitude of students who were exposed to physical and virtual modes of conducting chemistry practical, a change was observed in the number of students in the Control Group (CG) and Experimental Group (EG) who initially scored low (below 78, <40%) score in the pre-test and later achieved a score in average or high range (80%, 78- 156 or > 156) in the post-test. This analysis aimed to determine the effect of the two modes i.e., physical and virtual, on students' scientific attitude.

H03d: There is no significant difference in no of students of CG & EG in the pre- and post- test w.r.t. SA score.

Table 4.18: Distribution of Students Based on SA Scores in Pre-Test and Post-Test w.r.t. Control Group (CG) and Experimental Group (EG)

	No of Students = 37			
Level of SA	**Control Group**		**Experimental Group**	
	CPRT	**CPST**	**EPRT**	**EPST**
Low (<78)	Nil	Nil	Nil	Nil
Average (78- 156)	32	28	29	26
High (>156)	5	9	8	11

***CPRT**: Control group pre-test; **CPST**: control group post-test; **EPRT**: experimental group pre-test and **EPST:** experimental group post-test.*

Prior to conducting experiments by Physical Mode (PM) and Virtual Mode (VM), an SA test was administered to both the Control Group (CG) and the Experimental Group (EG). The results shown in table 4.18 indicates that in the pre-test, most students in both groups have average SA scores (CG = 32 students, 86.48% and EG = 29 students, 78.37 %), while only a small number of students has high ESE scores (CG = 5 students, 13.51 % and EG = 8 students, 21.6%). Within the CG, the number of students with high SA scores increased from 5 students (13.5 %) to 9 students (24.3%). Within experimental group, the number of students with high SA scores increased from 8 students (21.6 %) to 11 students (29.7 %). It is observed that there is no remarkable difference in the scientific attitude of students who performed experiments in virtual mode (3 students, 8.1%) and physical mode (4 students,10.8%). Within the Control Group (CG), the number of students with high SA scores increased from 5 students (13.5%) to 9 students (24.3%) after conducting experiments in the Physical Mode (PM). Similarly, within the Experimental Group (EG), the number of students with high SA scores increased from 8 students (21.6%) to 11 students (29.7%) following experiments in the Virtual Mode (VM). Notably, there is no significant difference observed in the scientific attitude of students taught in physical mode (4 students, 10.8%) and virtual mode (3 students, 8.1%). The results indicate that the virtual lab environment did not positively influence students' scientific attitude.

It is concluded that the null hypothesis H0 is accepted i.e., there is no statistically significant difference in scientific attitude among secondary students in science who performed experiments with Virtual mode and without virtual mode in constructivist learning environment.

These findings suggest that the implemented intervention or treatment did not influence the SA scores of the experimental group, resulting in insignificant increase in their scientific attitude.

The studies by Faour & Ayoubi (2018), Ratanum & Osman (2018), Falod et al. (2015), Ambusaidi et al. (2018), Chan et al. (2021), Koehler (2021), Larida et al. (2021), and Mihardi et al. (2022) are perfectly aligned with the findings of the present study.

Hence it is concluded that there is no effect of virtual mode of experimentation on students' scientific attitude as no significant difference is observed in the scientific attitude of students before and after engaging in virtual experimentation.

CHAPTER V

CONCLUSIONS, RECOEMENDATIONS, AND DIRECTIONS FOR FUTURE RESEARCH

This chapter provides a concise overview of the current research, outlines key findings, acknowledges constraints, offers practical recommendations, and proposes avenues for future exploration. The conclusion of a research study holds great importance as it serves as the final opportunity to summarize key findings, highlights their significance, and draw meaningful implications from the research.

The study titled 'the effect of the constructivist approach on the academic achievement, experimental self-efficacy, and scientific attitude of secondary school students taught through virtual science labs' holds significant importance and utility. Through investigating the role of the constructivist approach and virtual labs on students' learning experiences, this research aims to contribute valuable insights to the field of education. The study's findings can help educators, policymakers, and curriculum developers in making informed decisions to improve science education at the secondary school level.

A pivotal focus of this research involves investigating innovative teaching strategies, specifically the integration of virtual science labs into the learning environment. As technology becomes more prevalent in science education, virtual labs emerge as a promising method to enhance or even substitute traditional hands-on experiments. Understanding the effectiveness of virtual labs can open up new possibilities for engaging students in scientific exploration and experimentation, fostering their curiosity and interest in science subjects.

The constructivist approach places an emphasis on active learning, problem-solving and self-construction of knowledge. By investigating its effect on students' academic achievement, experimental self-efficacy, and scientific attitude, the study seeks to determine whether this student-centred teaching methodology can lead to more positive learning outcomes. Such insights are valuable for educators as they strive to create dynamic and motivating learning environments that satisfy the diverse problems and learning styles of secondary school learners.

Beyond the immediate implications for teaching and learning, the study holds relevance for science education policy and curriculum design. Additionally, the study's outcomes can influence the design of science curricula, encouraging the integration of constructivist principles and virtual labs to provide an enriching and more integrated learning engagement for students.

The utility of this study extends to teacher professional development programs. Educators can benefit from understanding the influence of the constructivist approach by using virtual labs on student outcomes, enabling them to adopt their instructional practices accordingly. Professional development initiatives can incorporate training on how to effectively implement constructivist teaching strategies and leverage virtual labs to enhance pupil involvement and active learning.

Furthermore, the research contributes to the advancement of knowledge in the field of science education. By contributing to the already investigated knowledge of research on constructivist learning and virtual labs, this study provides a foundation for future investigations and inquiries into effective educational practices. Based on these findings, the understanding of how to improve science education can deepen, leading to continuous enhancements in teaching and learning methodologies.

Finally, the study's impact reaches beyond individual classrooms and schools. Positive outcomes related to academic achievement, self-efficacy, and scientific attitude can have a significant effect on students' motivation to pursue further studies in science-related fields. Encouraging students to develop a positive attitude toward science and to believe in their abilities to engage in scientific inquiry can have lasting effects on their academic and career aspirations, potentially leading to a more scientifically literate society.

Moreover, virtual science labs offer practical advantages in terms of accessibility and cost-effectiveness. Especially for schools with limited resources or those in remote areas, virtual labs can provide a platform to students with access to experiments and in- depth learning experiences that might not otherwise be available. This aspect of the study highlights the potential of technology to bridge educational gaps and promote equitable access to quality science education.

The significance and utility of this study are not limited to specific geographical regions or educational systems. With advancements in technology, the insights gained from this research can be applied in various educational contexts worldwide, benefiting a diverse range of students and contributing to the global advancement of science education.

The statement articulated in the study is ‘Effect of constructivist approach on the academic achievement, experimental self-efficacy and scientific attitude of secondary school students taught through virtual science labs’.

5.1 CONCLUSIONS

Data analysis involved the use of independent sample t-tests and paired sample t-tests to identify any significant differences or improvements within and between the control and experimental groups. In the light of discussions and interpretations discussed in preceding chapter (chapter 4), the following conclusions are drawn:

Now, objective wise analysis is as follows:

There cannot be any conclusions drawn from objectives 1 & 2. Hence the conclusive analysis is presented for objectives 3, 4 & 5.

Objective 3: To study the effect of constructivist approach on the academic achievement of secondary school students in teaching science lab courses taught through virtual and physical mode.

1. Before the treatment, both the control group (CG) and Experimental Group (EG) students demonstrated similar academic achievement levels in chemistry practical, as measured by the Chemistry Practical Achievement Test (CPAT).
2. The mean gain score of the experimental group (15.68) was significantly higher than that of the control group (3.31). The experimental group's increase in mean gain score surpassed the control group by 12.37 scores. These findings highlight a remarkable improvement in academic achievement in chemistry practical, as measured by the CPAT scores, among students in the experimental group in comparison to the control group. These results are in sync with the findings by Davidsson & Verhagen, 2017; Ahmedi et al, 2023; Perez et al., 2023; Triejunita et al., 2021, Chernikova et al., 2020).

3. After the treatment, the mean chemistry practical achievement test scores of the experimental group (60.14) were found to be higher than those of the control group (49.84). This difference in scores was helpful in concluding that the utilization of the virtual chemistry lab significantly enhanced the academic achievement of students. This finding was further supported by the work of Tatli & Ayas (2013). It was evident that students exhibited elevated levels of focus and interest while working with the virtual chemistry laboratory, which contributed to their improved academic achievement (Yildirim, 2021; Azizah & Aloysius, 2021).

4. Prior to the intervention, 40.5% and 29.7% of students in the control and experimental groups, respectively, scored ≥ 60% in the pre-test. After the treatment, the percentage increase in experimental group (48.64%) is significantly higher than the increase in control group (10.81%). This notable enhancement in academic achievement among students in the experimental group surpassed that of the control group, affirming the efficacy of the virtual chemistry lab treatment. The results indicate that the virtual lab environment had a positive role on student achievement, highlighting its potential as an effective educational tool, as supported by (Gamari et al. 2018; Kamtor et al.2017; James R. Brinson, 2015; Khulood Aljuhani et al. 2018; Rajendran et al. 2010; Athanasios Sypsas et al. 2019; Urbano & Caballes 2020; Lohmann, 2020; Banchik, 2018; Wunische, 2019; Darby- White et al., 2019). However, one of the studies revealed that there is limited correlation between overall academic achievement and frequency of visits to virtual laboratories (Peter & Morrice, 2012).

The integration of virtual labs into educational curricula has been proved to do improvements in students' academic achievement. The interactive and engaging nature of virtual labs facilitates active learning, enabling students to explore scientific phenomena, manipulate variables, and observe outcomes in a controlled environment. This dynamic interaction fosters deeper understanding and retention of subject matter, as students can repeat experiments and observe various scenarios, promoting self-paced and personalized learning experiences. Therefore, students are strongly encouraged to utilize virtual modes of experimentation as a valuable supplement to traditional learning. Virtual labs offer flexible, engaging, and effective platforms for deepening scientific understanding and enhancing academic acievement.

Objective 4: To study the effect of constructivist approach on the experimental self-efficacy of secondary school students in teaching science lab courses taught through virtual and physical mode.

5. Similar level of experimental self-efficacy was observed in chemistry practical for both, the Control Group (CG) and Experimental Group (EG) students as measured by the experimental self-efficacy (ESE) scale.
6. During the transition from the pre-test to the post-test, the experimental group's mean gain score showed a notable increase of 2.59 units more than that of the control group. These findings indicate a significant improvement in the experimental self-efficacy in chemistry practical, as measured by ESE scores, among students in the experimental group compared to the control group.
7. Following the treatment, the experimental group exhibited a higher mean chemistry practical Experimental Self-Efficacy (ESE) score (50.95) in comparison to the control group's score (47.30). This significant difference in scores helped to conclude that the implementation of the virtual chemistry lab significantly enhanced students' experimental self-efficacy. This finding was further corroborated by the research of Kolil et al. (2020). Virtual laboratories showed remarkable improvements in conceptual understanding, procedural complexity, and reduced anxiety related to laboratory hazards and resource limitations. These positive outcomes support the adoption of virtual labs as valuable tools to enhance the learning experience.
8. After the treatment, the study observed a notable transition, with 8.1% of students in the control group and an impressive 70.2% of students in the experimental group advancing to the higher scorer category. This notable enhancement in experimental self-efficacy scores (62.1%) among students in the experimental group surpassed that of the control group, confirming the effectiveness of the virtual chemistry lab treatment. The results clearly indicate that the virtual lab environment had a positive effect on student’s experimental self-efficacy, showcasing its potential as an effective educational tool.

This observation is further supported by Ghatty et al. (2013), Dyrberg et al. (2017), Husnaini & Chen (2019), Kolil et al. (2020), Solikhin et al. (2018), Hussain et al. (2021), Lonez & Errabo (2022), Peters et al. (2023), and Shadbad et al. (2023).

The enhancement of experimental self-efficacy holds a pivotal role in elevating outcomes in laboratory education The utilization of a virtual laboratory (VL) platform contributes significantly to this advancement. The sophisticated simulations offered by VLs furnish a more holistic and lifelike comprehension of problems, surpassing the benefits of simple drawings. This proves particularly advantageous in the realm of science, particularly within chemistry laboratory work. The measurement of Experimental Self-Efficacy (ESE) involves assessing one's ability to gain conceptual understanding, navigate laboratory hazards, comprehend correct procedures, and manage laboratory resources effectively. The use of virtual labs plays a crucial role in pre-emptively acquainting students with these aspects, thereby contributing significantly to the augmentation of Experimental Self-Efficacy (ESE). Furthermore, the incorporation of VLs into the curriculum enhances students' problem-solving capabilities during physical experiments and bolsters their critical thinking skills. In the conventional approach, students grapple with comprehending both theoretical concepts and procedural intricacies, resulting in a heightened cognitive load that can impact their achievement in the laboratory. In contrast, this study demonstrates the seamless integration of theory and procedural guidance within the interactive VL platform, facilitating a more efficient and effective learning experience for students.

Based on the findings, it is evident that virtual laboratories significantly enhance students' experimental self-efficacy by providing conceptual clarity, procedural understanding, and safe exposure to laboratory environments. When used alongside traditional physical experiments, virtual labs help reduce cognitive load and better prepare students for hands-on tasks. This blended approach fosters critical thinking, problem-solving, and confidence in laboratory settings. Therefore, students should be encouraged to use virtual modes of experimentation as a complementary tool to enrich and reinforce physical lab experiences.

Objective 5: To study the effect of constructivist approach on the scientific attitude of secondary school students in teaching science lab courses taught through virtual and physical mode.

9. Before and after the treatment, both the Control Group (CG) and Experimental Group (EG) students demonstrated similar levels of scientific attitude in chemistry practical, as measured by the scientific attitude (SA) scores.

10. As per statistical analysis, after the intervention, the difference in the mean gain scores between the experimental and control groups was 0.43 units, indicating no significant increase in scientific attitude for both groups.

11. Also, the mean chemistry practical scientific attitude scores of the experimental group (149.14) were found to be almost same as those of the control group (145.49) after the treatment. This insignificant difference in scores guided to conclude that the utilization of the virtual chemistry lab did not enhance the scientific attitude of students.

12. Additionally, the study observed that 10.8% of students in the control group and 8.1% in the experimental group moved to the high scorer group after the intervention. This minimal change in the number of students suggests that the virtual lab environment had little influence on the scientific attitude of students. Consequently, the implemented intervention did not have significant role on the SA scores of the experimental group, resulting in an insignificant increase in their scientific attitude.

Based on these findings, it was concluded that there is no discernible effect of either the virtual chemistry lab or the physical chemistry lab on the scientific attitude of the students.

The findings of the present study are in alignment with the findings of several other studies: Bauer, 2018; Falod (2015); Faour & Ayoubi (2018), Ratanum & Osman (2018), Ambusaidi (2018), Chan (2021), Koehler (2021), Larida et al. (2021); Rasyida et al., (2015).and Mihardi et al. (2022). However, one of the studies observed significant differences in students' attitudes towards scientific inquiry, enjoyment of science lessons, and career interest in physics/science between the experimental and control groups by using PhET interactive simulation. (Ayasrah et al., 2024).

Based on the statistical analysis of the study, it was concluded that by using virtual laboratory in chemistry practical, there is negligible change in the scientific attitude of students.

Scientific attitude is influenced by a confluence of factors that collectively shape the mindset of individuals participating in scientific endeavours. Essential components include an inherent curiosity and enthusiasm for exploration, coupled with the capacity for critical thinking and the inclination to challenge assumptions. Receptiveness to new ideas and a healthy skepticism drive individuals to seek empirical proof and data, promoting a data-driven approach to comprehend the world. Cultivating effective observation skills, adept problem-solving capabilities, and a readiness to refine hypotheses based on emerging evidence are indicative of a scientific attitude.

Scientific thinking is characterized by a willingness to question assumptions, evaluate evidence objectively, and draw conclusions based on empirical observations. This multifaceted skill set is cultivated through continuous engagement with scientific literature, experimentation, and the assimilation of knowledge from various disciplines. Such a comprehensive understanding requires time for reflection, refinement of analytical skills, and the gradual internalization of the scientific method. Attempting to hasten the acquisition of a scientific attitude within a limited timeframe is challenging due to the depth and breadth of knowledge involved. Rushed efforts may compromise the depth of understanding and hinder the ability to apply scientific principles effectively. Therefore, a patient and systematic approach to learning, experimentation, and critical analysis remains essential for the enduring development of a robust scientific attitude. For all these reasons, negligible change in scientific attitude was observed among students during study period.

Overall, the scientific attitude is a dynamic interplay of personal attributes, educational exposures, and broader societal influences that empower individuals to meaningfully engage in exploration, discovery, and comprehension of the natural realm. Because of these reasons, it was concluded that scientific attitude change did not happen among students in the study period.

13. The null hypothesis stating that- There is no significant difference in academic achievement among secondary students in science who performed experiments with Virtual mode and without virtual mode in constructivist learning environment was rejected as it was found that there is significant difference in academic achievement of students who performed experiments with virtual mode in constructivist environment.

The rejection of the null hypothesis confirms that the use of virtual experimentation within a constructivist learning environment significantly improves students' academic achievement in science. This demonstrates the effectiveness of virtual labs in enhancing learning outcomes through interactive and immersive experiences. Therefore, incorporating virtual modes of experimentation is highly recommended to strengthen science education and support deeper conceptual understanding.

14. The null hypothesis stating that -There is no significant difference in experimental self- efficacy of the students in science who performed experiments with virtual mode and without virtual mode in constructivist learning environment was also rejected as it was found that there is significant increase in experimental self-efficacy of students who performed experiments in virtual mode in constructivist learning environment.

The rejection of the null hypothesis clearly indicates that students who engaged in virtual experimentation within a constructivist learning environment developed significantly higher experimental self-efficacy. This highlights the role of virtual labs in building students' confidence, procedural knowledge, and readiness for real-world laboratory tasks. Therefore, integrating virtual modes of experimentation is essential for fostering independent learning and enhancing students' practical science skills.

15. The null hypothesis stating that - There is no significant difference in scientific attitude of the students in science who performed experiments with virtual mode and without virtual mode in constructivist learning environment was accepted as it was found that there is no significant increase in experimental self-efficacy of students who performed experiments in virtual mode in constructivist learning environment.

5.2 LIMITATIONS

The study has provided valuable insights or contributions to the field, there are certain impediments mentioned below:

- Participants in virtual labs miss out on touch and smell which can limit the depth of data gathered and influence responses.
- Sometimes students face network and connectivity issues while working on online platform, OLabs.

Despite these limitations, virtual lab-related studies offer valuable research opportunities, especially when physical experimentation is not feasible or cost-effective. Virtual mode of experimentation is an excellent way of revision and remedy for weaker students. One should be aware of these limitations when designing and interpreting their studies to ensure the validity and reliability of their findings.

5.3 RECOMMENDATIONS

The most outstanding characteristic of any research is its contribution to the development of the concerned field. The study shall serve as a valuable resource for educators, students, or practitioners by providing comprehensive reviews, case studies, or teaching materials. In this regard, few recommendations are mentioned below:

1. Based on the findings of the study, the use of virtual laboratories has a positive impact on students' academic achievement in science practical subjects. Therefore, it is recommended to:

a) Acknowledge and incorporate constructivist learning environment to enhance learning process within the virtual science lab setting.

b) Offer animations and simulations for experiments and demonstrations mentioned in virtual laboratory to cater to a diverse group of students.

c) Use virtual lab to improve comprehension of concepts, foster their practical application, and aid in the development of skills in science practical.

2. The study reported that experimental self- efficacy of students is influenced positively by performing experiments in virtual labs. Virtual labs reduces the problems associated with laboratory hazards, procedural complexity, and limited resources. So, this is recommended to:

a) Provide the opportunity to students to use virtual labs more often to enhance their confidence to carry out the practical.

b) Encourage students to regularly access the virtual laboratory at times that suit them best. This flexibility can help the students in concept clarity.

3. The findings of the study indicated that the use of virtual lab improved scientific attitude of students but not significantly.

Cultivating a scientific attitude cannot be achieved quickly. To foster open-mindedness, curiosity, and rational thinking, it is recommended to:

a) Continuously expand and update the virtual chemistry laboratory's content and features to keep it engaging and aligned with the latest advancements in science education.

b) Train teachers on effectively utilizing the virtual laboratory. This will help them confidently incorporate the technology into their teaching methods and maximize its benefits for students.

c) Motivate students to perform experiments related to their theory topics which consequently will generate their interest in the science subjects.

By implementing these recommendations, schools can optimize the benefits of virtual chemistry laboratories and enhance the overall learning experience of their students in the subject of chemistry.

5.4 SUGGESTIONS FOR FURTHER RESEARCH WORK

Research is a continuous and on-going process and there is always space for further studies. The present research put forward following suggestions for the future studies:

- A longitudinal study can be Conducted to examine the long-term effect of the constructivist approach and virtual science labs on students' academic achievement, experimental self-efficacy, and scientific attitude throughout their secondary school education.
- A comparative analysis is suggested to observe the effectiveness of the constructivist approach with blended mode of experimentation on academic achievement, self-efficacy, and scientific attitude.
- In-depth qualitative research is suggested to gain deeper insights into students' perceptions, experiences, and challenges while learning through virtual science labs, which can provide valuable information for refining instructional strategies.
- Exploratory research to observe the effects of the constructivist approach and virtual science labs vary across diverse student populations, including students with different learning styles, abilities, and socioeconomic backgrounds is

suggested.

- The study has the potential for expansion into other scientific disciplines or even across diverse fields, aiming to explore whether the favorable outcomes of the constructivist approach and virtual labs remain consistent or are subject-specific.
- Furthermore, the study's scope can encompass all educational standards and classes, facilitating an investigation into the effect of virtual labs on different age cohorts.
- Investigative research to observe the effect of virtual labs on critical thinking, creativity and problem-solving attitude can be done.
- A study on the integration of additional technological tools, such as augmented reality or interactive simulations, to enhance the virtual science lab experience and further improve academic achievement, self-efficacy, and scientific attitude is suggested.
- The duration of the intervention period can be extended in further studies to assess the sustainability of the effects providing insights into the long-term impact on students' academic achievement, self-efficacy, and scientific attitude.
- It was observed that certain students, despite their introductory-level training, faced challenges due to unfamiliarity with the virtual platform, resulting in performance delays compared to their peers. Hence, meticulous preparation for all students before implementing new programs is imperative.

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APPENDICES

APPENDIX A

INSTRUCTIONAL PLAN VIRTUAL MODE

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 1

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To study the shift of equilibrium between ferric ions and thiocyanate ions by increasing the concentration of either of them.
Practical Summary: When the concentration of any of the reactants or products in a reaction at equilibrium is changed, the composition of the equilibrium mixture changes to minimize the effect of concentration changes.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Effect of concentration change on equilibrium.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives: To understand Le Chatelier's principle. To study the shift of equilibrium between ferric ions and thiocyanate ions by increasing the concentration of either of them. • To understand the law of equilibrium.
Learning Outcomes:

Learners will- • Understand the terms: chemical equilibrium, equilibrium constant.
• Understand the effect of change in concentration on the equilibrium of a reaction.
• Be able to write equilibrium constant for the reaction.
• Be familiarized with the ways of understanding chemical equilibrium in virtual laboratories.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is chemical equilibrium?
2. What is Le Chatelier's principle?
3. What is equilibrium constant?
Practical Lesson Content Questions:
1. What is the effect of concentration change on equilibrium?
2. What are the other factors affecting equilibrium?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• Laws of mass action.
• Meaning of 'equilibrium'.
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through

Google Meet link, they will be introduced with the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process. Wonder how a reaction will yield its product if it stays in equilibrium?
Also, where do you experience equilibrium in daily life and how does it affect you? Details of OLabs platform.
Apparatus & chemicals: Ferric chloride solution (0.1 M), Potassium thiocyanate solution (0.1 M), Potassium chloride solution (0.1 M), distilled water, beaker (250 mL), test tubes, test tubes stand and measuring cylinders.
EXPLORATION:
Students will be asked to gather information about the effect of concentration change on equilibrium reactions.
Then, they will be asked to work on 'Simulator' icon on the OLabs platform and to observe the shift in the equilibrium of the given reaction by their means.
Students will be provided with solutions of 0.1 M Ferric chloride, 0.1 M Potassium thiocyanate and 0.1 M Potassium Chloride virtually.
$Fe^{3+}(aq) + SCN^{-}(aq) \leftrightarrow [Fe(SCN)^{2+}]$
Based on this reaction, they will be asked to shift the equilibrium by changing the concentrations of reactants and report their findings in a tabular manner.
EXPLANATION:
Students will be shown a video demonstrating the concentration change on equilibrium. It will help the students to understand everything well and will give them clarity in all aspects.
• Take 10 ml of 0.1 M Ferric chloride solution in a measuring cylinder

and pour it into a clean beaker.

- To this, add 10 ml of 0.1 M Potassium thiocyanate using a measuring cylinder.
- A deep red colour is obtained due to the formation of the complex, [Fe (SCN)(H_2O)$_5$]$^{2+}$ (aq).

- Dilute the deep red solution by adding 50 ml of distilled water.
- Take four test tubes and label them as A, B, C and D.
- Add 10 ml of the deep red solution to each test tube using a measuring cylinder.
- Place the test tubes in the test tube stand.
- Add 5 ml of distilled water into test tube A; 5 ml of 0.1 M $FeCl_3$ solution to test tube B; 5 ml of 0.1 M KSCN solution to test tube C and 5 ml of 0.1 M KCl solution into the test tube D.
- Shake all the test tubes well.
- Now compare the intensity of the colours in the test tubes, B, C and D with the red colour in test tube A taken as the reference test tube.

ELABORATION:

Students will be asked to prepare a table in a word file and upload the file as a Google classroom assignment.

Test Tube	**Substance added at equilibrium**	**Change in Colour**	**Effect on the concentration of [Fe(SCN)(H_2O)$_5$]$^{2+}$**	**Shift of equilibrium**
A	5 mL of distilled	Reference Colour	-	-

	water			
B	5 mL of 0.1 M $FeCl_3$ solution			
C	5 mL of 0.1 M KCNS solution			
D	5 mL of 0.1 M KCl solution			

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

1. Explain the shift of equilibrium in the activity performed.
2. What are the other factors affecting equilibrium?
3. Give examples of equilibrium reactions observed in daily life.
4. Find out other such examples of a reaction which can be studied for concentration change.
5. What is the importance of studying equilibrium reactions?

HOME ASSIGNMENT:

1. Give examples of equilibrium phenomena taking place in your home surroundings.

RESOURCES:

Laboratory Manual NCERT Class XI

BOOKS:

NCERT Textbook Class XI

WEB RESOURCES:

http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

VIRTUAL MODE

PRACTICAL LESSON PLAN NUMBER - 2

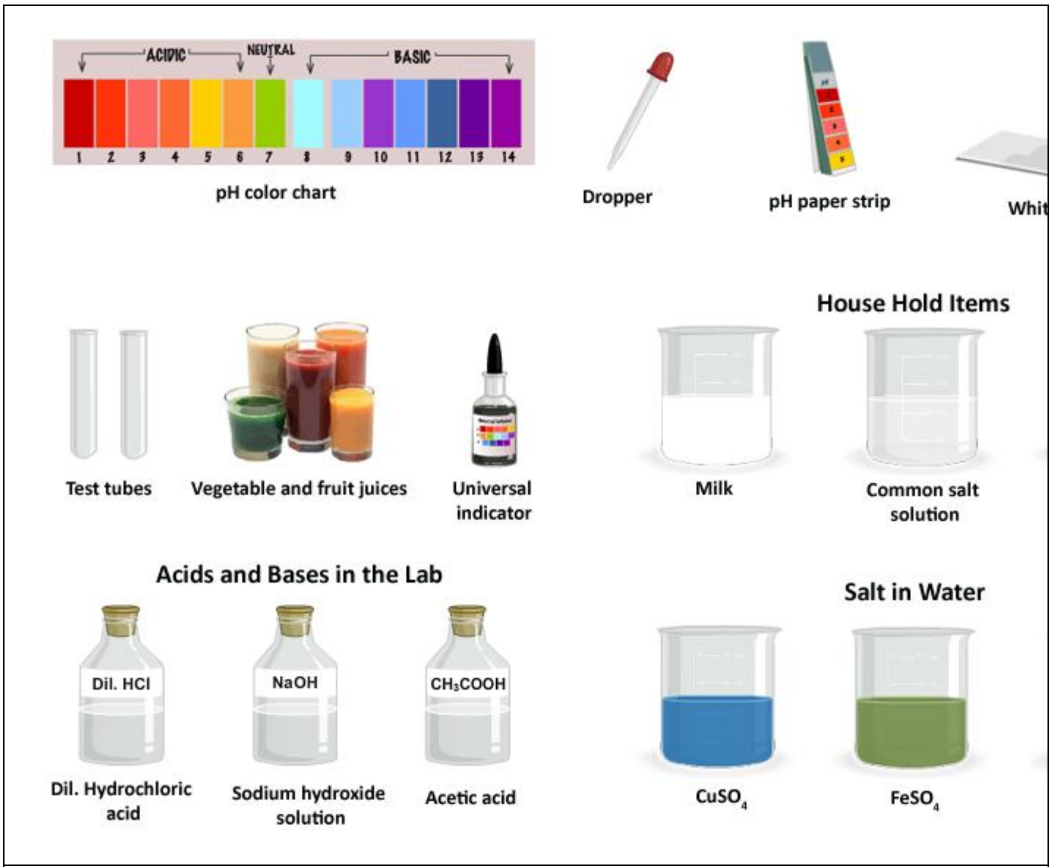
Class/ Grade Level - XI

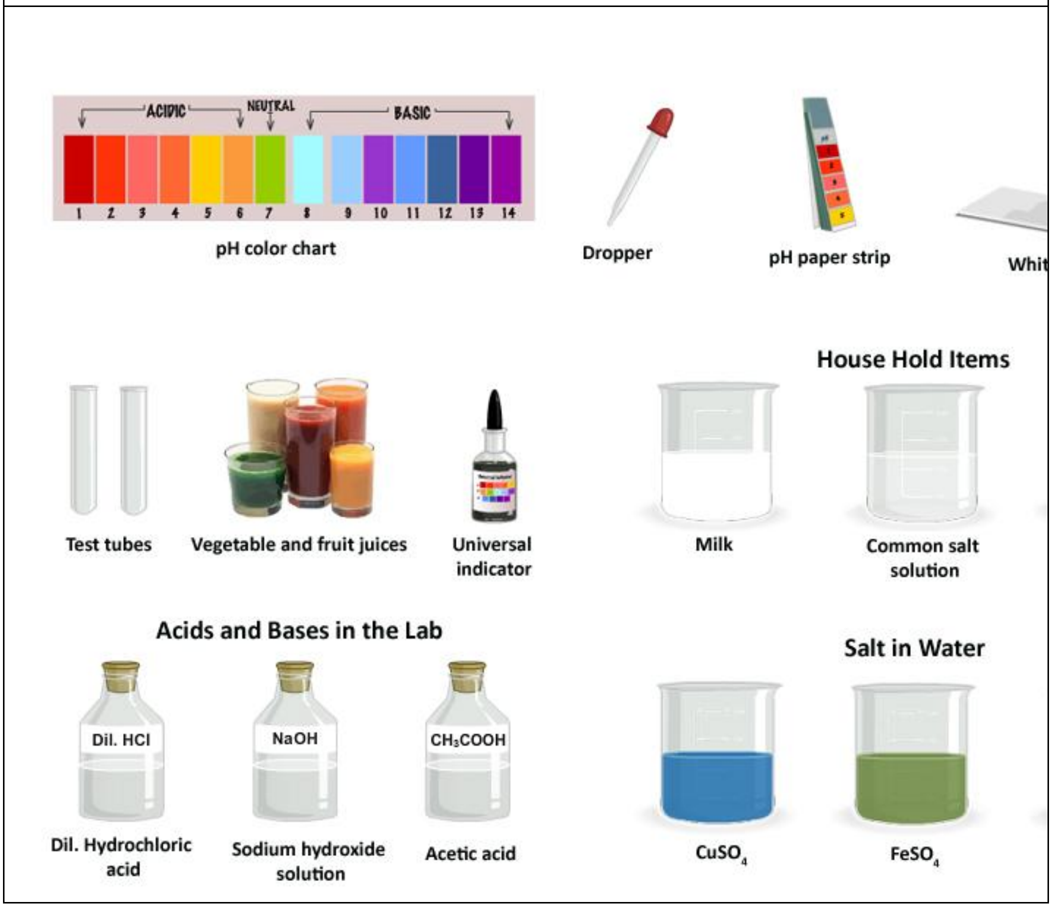
PRACTICAL OVERVIEW

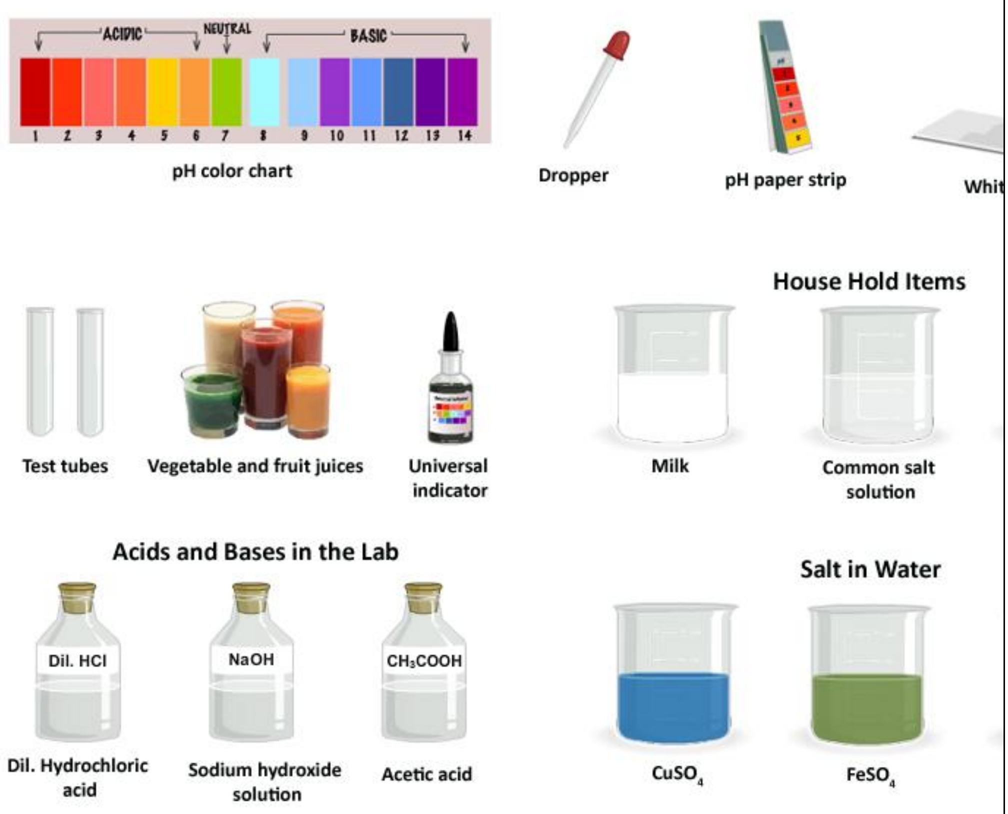
• **Practical Title**
To determine the pH of the given sample using pH paper/Universal indicator.
Practical Summary: All the chemical substances introduced in laboratories and home are either acidic, basic or neutral in nature. Acids produce free hydrogen ions (H^+) whereas bases produce hydroxyl ions (OH^-) when dissolved in water. pH of a solution is a measurement of acidic or basic properties of substances. It can be measured using pH indicators namely pH paper and universal indicators.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: pH of acids and bases
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To understand the role of pH paper and universal indicators.
• To determine the pH of given samples using pH paper and universal indicators.
• To classify the given samples into acids, bases and neutral based on their pH values.
Learning Outcomes:
Learner will-
• Understand the terms acids, bases, neutral solutions, pH and universal indicators.
• Determine the pH of different samples using pH indicators.

• Expertise the skills for classifying the substances as acidic, basic or neutral based on pH value.
• Be able to measure the pH of different substances using pH paper or universal indicator solution.
• Calculate the concentration of H^+ and OH^- ions present in different substances using the pH value of solution.
• Learn the importance of pH in everyday life.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are acids, bases and neutral substances?
2. Define pH of a solution?
3. What are different ways of measurement of pH of a solution?
Practical Lesson Content Questions:
1. What are pH paper and universal indicators?
2. What is the relation between pH and concentration of hydrogen ions?
3. What is the pH scale?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• Acids, bases, and neutral substances.
• Indicators.
• pH scale.
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:

Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced with the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked a number of questions to increase their participation in the learning process.
Students will be asked to list different acids, bases or neutral substances used in their daily life for different means. Then, they will be provided with different unknown samples and asked to identify them as acids, bases or neutral substances on the basis of their physical nature.
Further, they will be asked to recollect the knowledge of indicators for the identification of nature of different substances.
Apparatus and Chemicals required: pH colour chart, dropper, pH paper strip, white tile, test tubes, universal indicator, dil. HCl, NaOH, acetic acid, different samples etc.


ACIDIC
NEUTRAL
BASIC
1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH color chart
Dropper
pH paper strip
House Hold Items
Test tubes
Vegetable and fruit juices
Universal indicator
Milk
Common salt solution
Acids and Bases in the Lab
Salt in Water
Dil. HCl
NaOH
CH₃COOH
Dil. Hydrochloric acid
Sodium hydroxide solution
Acetic acid
CuSO4
FeSO4


ACIDIC
NEUTRAL
BASIC
1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH color chart
Dropper
pH paper strip
House Hold Items
Test tubes
Vegetable and fruit juices
Universal indicator
Milk
Common salt solution
Acids and Bases in the Lab
Salt in Water
Dil. HCl
NaOH
CH₃COOH
Dil. Hydrochloric acid
Sodium hydroxide solution
Acetic acid
CuSO4
FeSO4



EXPLORATION:

- Students will name different acids, bases or neutral substances used in their daily life.
- They will try to identify the given samples by visible colour appearances on the virtual platform.
- Above methods will not help them reach any conclusion and they will realize the need of an indicator.
- Then, they will be introduced to simulator icon available on OLabs to virtually perform the investigation.
- Students will be asked to explore the 'Simulator' icon on OLabs platform to figure out ways to determine pH.

EXPLANATION:

A video available on the OLabs platform will be shown to students in order to explain the method of identifying the pH of different substances. It will help students to understand all the necessary steps for identification of pH of given samples.

1. Determination of pH with the help of pH paper-
    - Take a pH paper strip and place it on a clean and dry white tile to clearly observe the colour change.
    - Pour a few drops of a given sample on the pH paper strip with a clean dropper.
    - Observe the colour change of the pH paper strip and compare the observed colour to the standard pH colour chart to obtain the pH value.
    - Record your observations in a tabular form.
    - Repeat the above steps to obtain the pH value for remaining given samples.
2. Determination of pH with the universal indicator solution-
    - Take a small amount of given sample in a clean, dry test tube using a dropper.
    - Pour a few drops of universal indicator solution in the same test tube using another dropper.
    - Shake the test tube well and observe the colour of the solution.
    - Compare the observed colour to the standard pH colour chart and obtain the pH value.
    - Record your observations in a tabular form.
    - Repeat the above steps to obtain the pH value for remaining given samples.

ELABORATION:

Students will be asked to prepare a table in a word file and upload the file as a Google classroom assignment.

S.No.	Sample	pH Paper Strip	Universal Indicator Solution

		Colour	pH	Colour	pH	
1.	A					
2.	B					
3.	C					
4.	D					
5.	E					
6.	F					
7.	G					

CALCULATION:

Based on the values of pH obtained by pH paper and universal indicators, students will be asked to classify the given samples into acids, bases or neutral substances.

Students will be asked for the equation of pH and the relation between the concentration of hydrogen ions and the pH value.

$$pH = -\log[H^+] \text{ OR } pH = \log\frac{1}{[H^+]}$$

Based on the above equation, they will be asked to calculate the concentration of hydrogen ions in the given samples.

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

1. What are pH indicators?
2. What are acids, bases, and neutral substances on the basis of pH?
3. What is the range of pH for acids and bases?
4. How will you calculate the concentration of hydrogen ions with the

help of pH?
5. What is the pH of water and blood?
6. What are the applications of pH?
7. Name some natural pH indicators.
HOME ASSIGNMENT:
1. Collect different vegetable and fruit juices at home and find out their pH with the same procedure mentioned in the activity.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 3

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the melting point of an organic compound.
Practical Summary: Melting point is one of the important physical properties of a compound which is also an indication of its purity. Melting point can be used to identify an unknown substance. For a material whose identity is known, an estimate of degree of purity can be made by comparing its melting point with that of a pure sample.

Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Determination of Melting point.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine the melting point of an organic compound.
• To understand the importance of melting point of a compound.
• To expertise the setup of apparatus used in determination of melting point.
Learning Outcomes:
Learners will-
• Understand the term 'Melting point'.
• Appreciate the importance of melting point in identification of an unknown compound.
• Realize the need of melting point in purity check of a compound.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is the melting point?
2. What is the importance of melting point?
Practical Lesson Content Questions:
1. How to determine the melting point of a compound?
2. What are the factors affecting the melting point of a compound?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:

• Physical properties of organic compounds.
• Factors affecting the physical properties.
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced with the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
Students will be asked about their understanding of the phenomenon of melting. They will be asked to give such examples in daily life. Why do different substances encounter in daily life melt at different temperatures?
Apparatus & chemicals: 100 mL beaker, Iron stand with clamp, wire gauze, tripod stand, Bunsen burner, thermometer, thin-walled capillary tube, thread, stirrer, spatula, crystalline substance, liquid paraffin.

EXPLORATION:
Students will be provided with an organic compound on a virtual OLabs platform and asked to think of ways to determine its melting point.
They may look for resources available on the internet and libraries to figure it out.
They will be introduced with a 'Simulator' icon to determine the melting point. They will be asked to explore the same icon in various possible ways.
They may try heating the compound directly but eventually they will realize the need for a proper setup.
EXPLANATION:
Students will be shown a video to explain the procedure of determination of melting point.
• First powder the crystalline substance.
• Take a capillary tube and seal one end by heating it or take a sealed

capillary.

- Fill the capillary tube with the compound by pushing one end of the tube on a heap of the powdered substance on the porous plate.
- Now tap the sealed end of the capillary tube on the porous plate gently. Fill the capillary tube up to 2-3 mm.
- Attach the capillary tube to a thermometer using a thread.
- Take liquid paraffin in a beaker and place it over a piece of wire gauze placed over a tripod stand.
- Clamp the thermometer carrying the test tube to an iron stand and immerse them in the bath of liquid paraffin.
- Heat the beaker slowly while constantly stirring the contents using a stirrer to maintain a uniform temperature throughout.
- Note the temperature (t1) when the substance starts melting.
- Again, note the temperature (t2) when the substance has completely melted.
- The average of the two readings gives the correct melting point of the substance.

ELABORATION:

Students will be asked to prepare a table in a word file and upload the file as a Google classroom assignment.

Students will be able to determine the melting point of the compound. They will also reason for the purity of a compound. They will also understand the different factors affecting the melting point.

Starts melting t_1(°C)	Has completely melted t_2 (°C)	Melting point of the given substance ($t_1 + t_2 / 2$ (°C)

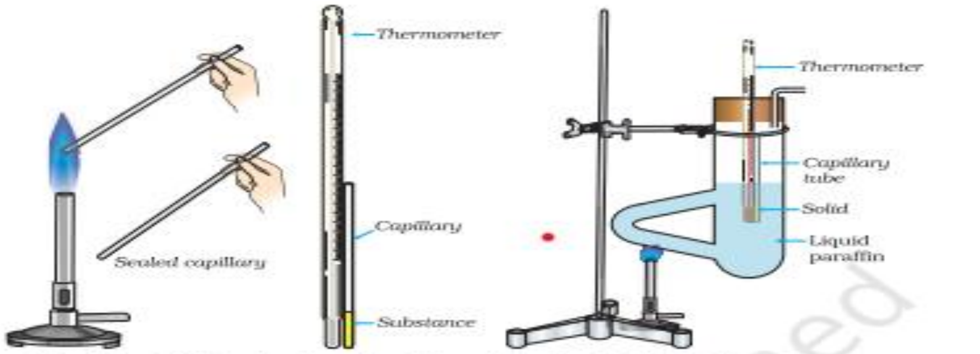


Fig. 3.1 : (a) Determination of melting point using Thiele's tube

Fig. 3.1 : (b) Different apparatus used for determining melting point

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

1. Define melting point.
2. How does impurity affect the melting point?
3. Why is the liquid bath stirred regularly during the determination of melting point?
4. What are the precautions taken during the determination of melting point?
5. What factors affect melting point?

HOME ASSIGNMENT:

1. Repeat the same experiment for an inorganic salt such as sodium chloride. Record your observations and discuss it with your teacher.

RESOURCES:

Laboratory Manual NCERT Class XI

BOOKS:

NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION (VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 4

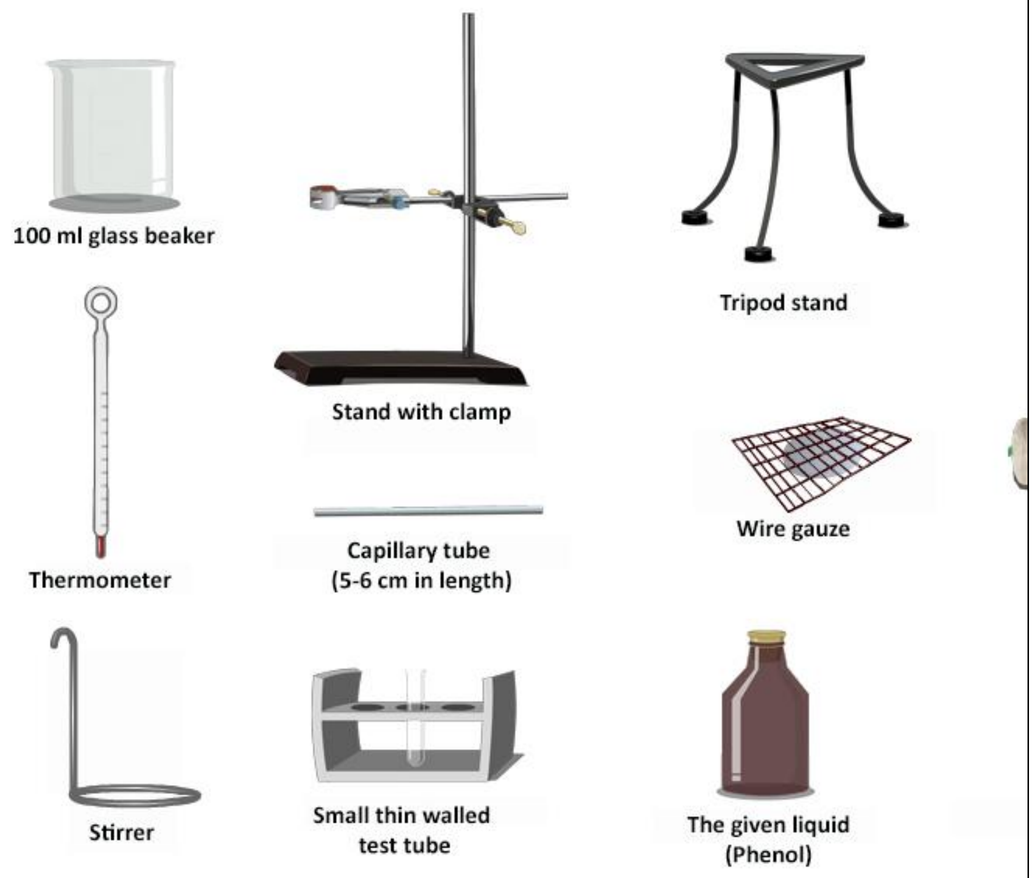
Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the boiling point of an organic compound.
Practical Summary: Boiling point of an organic compound gives important information about its physical and structural properties. A liquid boil when its vapour pressure is equal to the atmospheric pressure. Boiling point indicates the volatility of the compound. The Higher the boiling point, the less the volatility of the compound.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Determination of boiling point.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine the boiling point of an organic compound.
• To understand the importance of boiling point of a compound.
• To expertise the setup of apparatus used in determination of boiling point.

Learning Outcomes:
Learners will-
• Understand the term 'Boiling point'.
• Appreciate the importance of Boiling point in identification of an unknown compound.
• Understand the procedure of determination of boiling point in laboratories.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is the boiling point?
2. What is the importance of boiling point?
Practical Lesson Content Questions:
1. How to determine the boiling point of a compound?
2. What are the factors affecting the boiling point of a compound?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• Physical properties of organic compounds.
• Factors affecting the physical properties.
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced with the Olab platform. They will

be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos on YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
Students will be asked about their understanding of the phenomenon of boiling. They will be asked to give such examples in daily life. Why do different substances encounter in daily life boil at different temperatures?
They will be asked to ponder upon the fact that sanitizers dry faster than water… why?
Apparatus & chemicals: 100 mL beaker, iron stand with clamp, tripod stand, Bunsen burner, thermometer, capillary tube, wire gauze, thread, stirrer, small thin walled, given liquid and conc. Sulphuric acid.



EXPLORATION:

Students will be given an organic compound virtually and asked to study its physical properties first. Then they will be asked to discuss the ways to determine its boiling point using a simulator icon on the OLabs platform. Also, they will be asked to think about the factors affecting the boiling point.

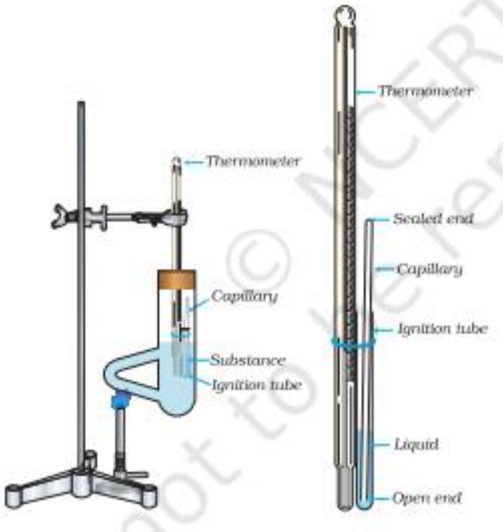
They will realize the need for a proper setup to determine the boiling point.

EXPLANATION:

Students will be shown a video explaining the setup and procedure of determining the boiling point.

- Fill ⅔ of a small test tube with the given organic compound.
- Place the test tube to a thermometer with a rubber band such that the bottom of the tube is at the middle of the thermometer bulb. The rubber band should not be dipped in the acid bath.

• Place a beaker over a wire gauze on a tripod stand and half fill the beaker with conc. Sulphuric acid.
• Clamp the thermometer carrying the test tube to an iron stand through a cork. Lower the thermometer along with the tube into the acid bath.
• Adjust the thermometer so its bulb is well under the acid and the open end of the tube with the rubber band is sufficiently outside the acid bath.
• Take a sealed capillary and place it in the test tube so that the sealed part of it stands in the liquid.
• Heat the acid bath slowly with gentle, continuous stirring.
• At first a bubble or two will be seen escaping at the end of the capillary tube dipped in the liquid, but soon a rapid and continuous stream of air bubbles escapes from it. At this stage the vapour pressure of the liquid just exceeds the atmospheric pressure.
• Note the temperature (t1) when a continuous stream of bubbles starts coming out.
• Remove from the flame and note the temperature (t2) when the evolution of bubbles from the end of the capillary tube just stops.
• The mean of these two temperatures gives the boiling point of the liquid.
• Allow the temperature to fall by 10oC and repeat the heating and again note the boiling point.
ELABORATION:
Students will be able to determine the boiling point of the organic compound virtually. They will also understand different factors affecting the boiling point.
Similarly, boiling point could be easily achieved by performing the above experiment in a Thiele's tube instead of a beaker as shown below.



EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What is the boiling point?
2. Why is the liquid bath stirred regularly during the determination of boiling point?
3. What are the precautions taken during the determination of boiling point?
4. What factors affect boiling point?
HOME ASSIGNMENT:
1. Perform the same experiment with a Thiele's tube. Compare the boiling point of different isomers of a same compound and try to account for the reason for any difference.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 5

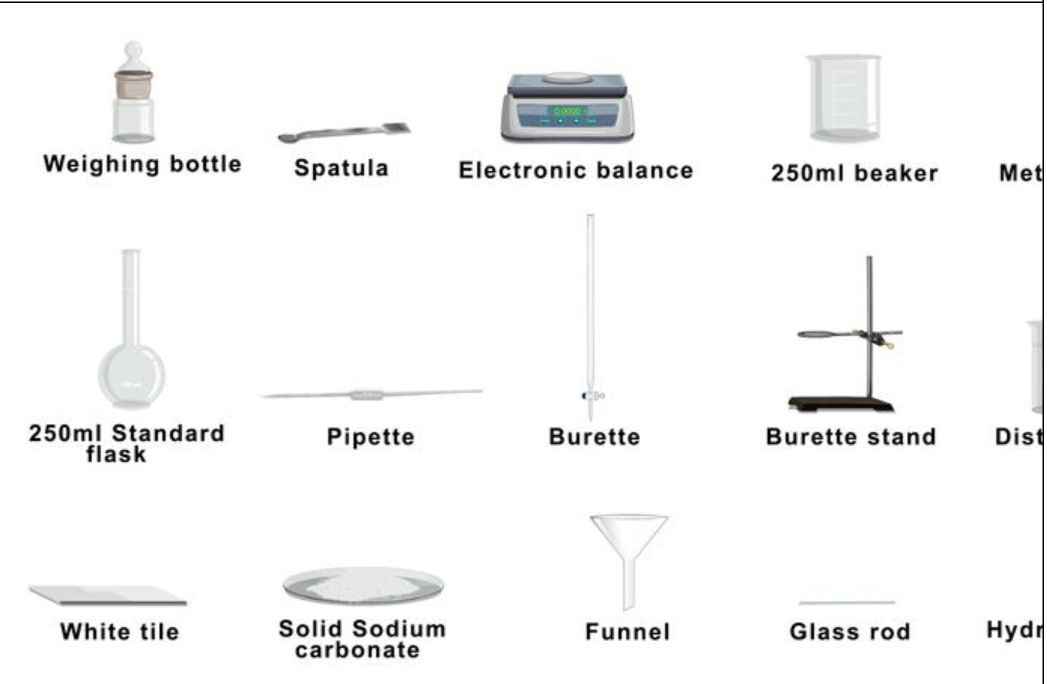
Class/ Grade Level - XI

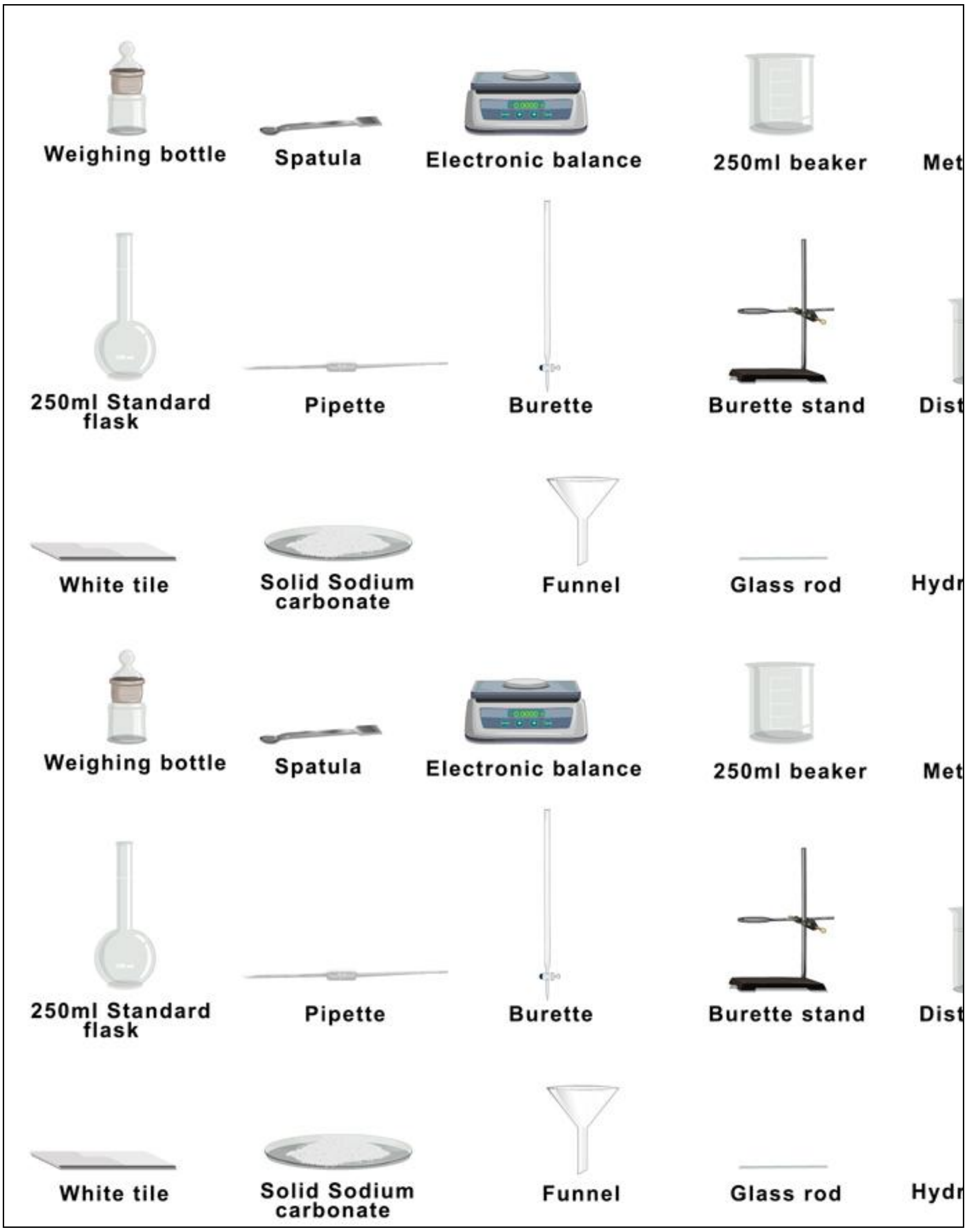
PRACTICAL OVERVIEW

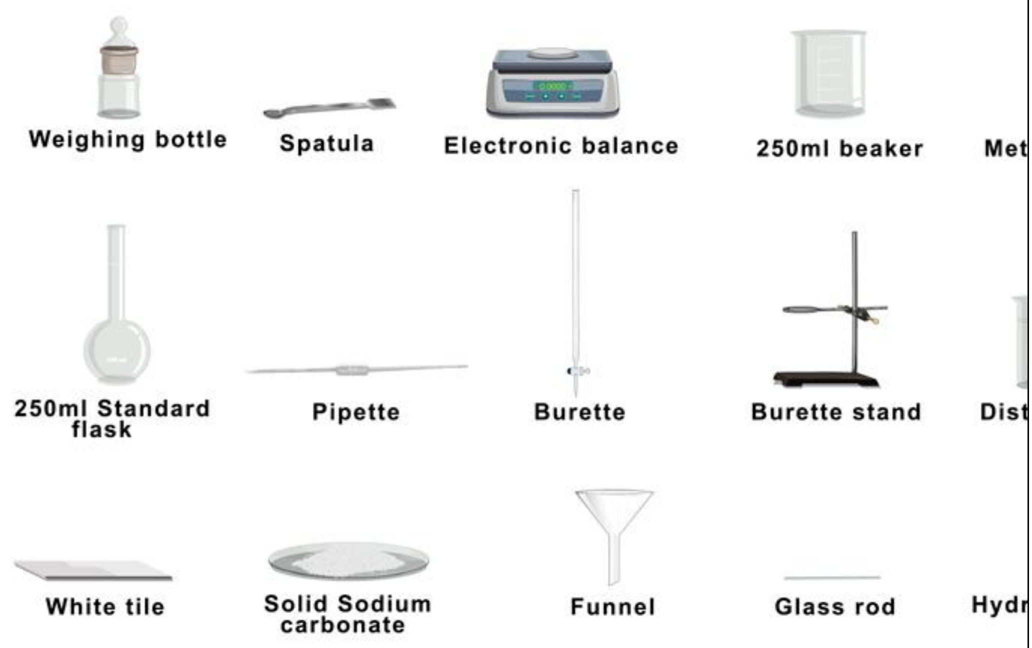
• **Practical Title**
To prepare a 250 mL standard solution of 0.1 M Sodium carbonate.
Practical Summary: Standard solutions are those solutions which have known concentration. It is prepared by dissolving a known amount of substance in a fixed volume of solvent. There are two types of standard solutions: primary and secondary. A standard solution is used to determine the unknown concentration of a solution of acid/base by volumetric analysis.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Preparation of standard solution of different concentration.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To prepare a 250 mL of 0.1 M standard solution of Sodium carbonate.
• To understand the preparation of different concentrations of standard solutions.
• To know the different ways of expressing the concentrations.
Learning Outcomes:
Learner will-
• Understand the terms: standard solution, molarity, normality, and molality.
• Learn to prepare different concentration solutions.

• Appreciate the use of standard solution in the determination of unknown concentration of analyte.
• Be able to express concentrations in different ways.
• Familiarize themself with the apparatus used in preparation of a solution.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is a standard solution?
2. What are different ways of expressing concentration?
Practical Lesson Content Questions:
1. What are the different apparatus used in the preparation of a standard solution?
2. What is the formula for calculating molarity, molality, and normality?
3. What precautions should be taken while preparing the standard solution?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• Calculation of molecular mass.
• Calculation of number of moles.
• Equivalent mass.
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google

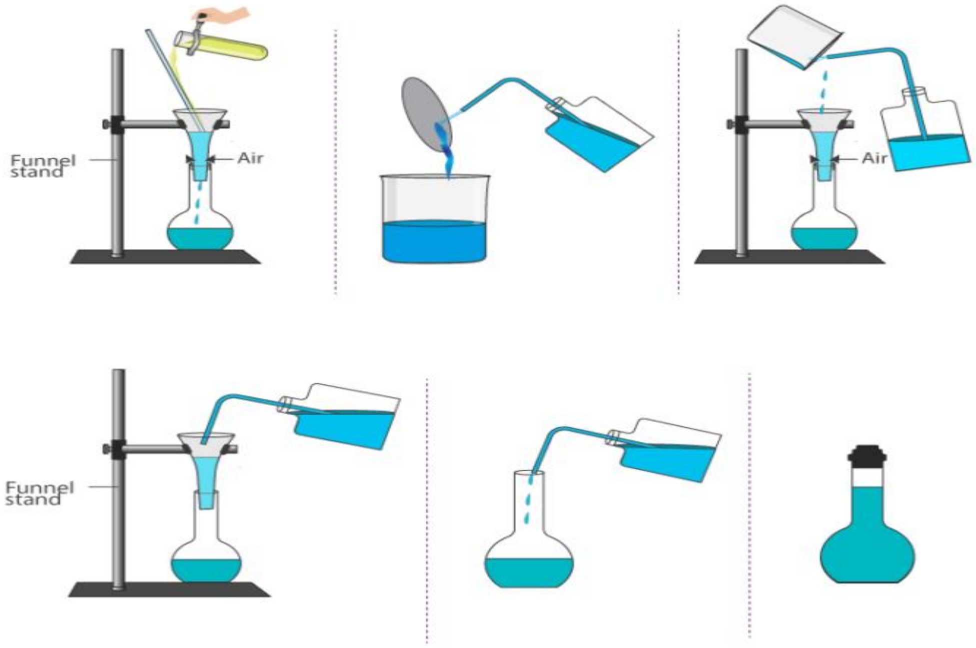
meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced with the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos on YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
Students will be asked the difference between dilute and concentrated solutions. They will be guided towards the amount of solute in a solvent. They will be asked what they understand by concentration in daily life and compare it to the different concentrations of solutions in a laboratory.
Apparatus and Chemicals required: Weighing bottle, spatula, electronic balance, 250 mL standard flask, pipette, funnel, funnel, solid sodium carbonate etc.




Weighing bottle
Spatula
Electronic balance
250ml beaker
250ml Standard flask
Pipette
Burette
Burette stand
White tile
Solid Sodium carbonate
Funnel
Glass rod
Weighing bottle
Spatula
Electronic balance
250ml beaker
250ml Standard flask
Pipette
Burette
Burette stand
White tile
Solid Sodium carbonate
Funnel
Glass rod



EXPLORATION:
• Students will have their own understanding of concentration.
• They will list various ways of expressing the concentrations, theoretically.
• Then, they will be asked to look for all possible apparatus to measure the volume accurately.
• They will try to calculate the amount of Sodium carbonate to be dissolved for the solution.



• At this point, they will realize the need for understanding the formula for molarity.
• Also, they will try to look for multiple virtual resources of information for the same.
EXPLANATION:
Video and animation available on the OLabs platform will be shown to students in order to familiarize them with the apparatus and explain the method to prepare the standard solution.
• Weigh 2.65 g of sodium carbonate in a weight bottle on a digital balance and transfer the content in a 250 mL beaker carefully.
• Wash the weighing bottle 2-3 times with distilled water and transfer the washings into the beaker.
• Dissolve the sodium carbonate into a minimum amount of water with a glass rod.
• When sodium carbonate dissolves completely, transfer the content in a 250 mL standard/volumetric flask using a funnel and glass rod.
• Wash the beaker 2-3 times with distilled water and again transfer the

contents into the volumetric flask carefully.
• Add distilled water to the volumetric flask so that the level is just below the calibration mark on it.
• Now, add distilled water to the volumetric flask with a pipette carefully and slowly so that the lower meniscus touches the calibration mark.
• Stopper the flask and shake gently to make the solution uniform.
ELABORATION:
Normality: It is defined as the number of gram equivalent of solute dissolved in one litre of the solution. It is denoted by the letter 'N'.
$\text{Normality} = \dfrac{\text{Number of gram equivalent of solute}}{\text{Volume of solution (in litre)}}$
Molarity: It is defined as the number of gram moles of solute dissolved in one litre of the solution. It is denoted by the letter 'M'.
$\text{Molarity} = \dfrac{\text{Number of gram moles of the solute}}{\text{Volume of the solution (in litre)}}$
Molality: It is defined as the number of moles of the solute dissolved in 1Kg of the solvent. It is denoted by the letter 'm'.
$\text{Molality} = \dfrac{\text{Number of moles of the solute}}{\text{Mass of the solvent (in Kg)}}$
CALCULATION:
Based on the formula of molarity, students will be asked to calculate the amount of Sodium carbonate required to dissolve in 250 mL of solvent.
In general, for preparing a solution of required molarity, the amount of substance to be weighed can be calculated by using the formula given below:
$\text{Molarity (M)} = \dfrac{\text{Mass of solute is grams} \times 1000}{\text{Molar mass of solute} \quad \text{(volume of solution to be prepared in mL)}}$
EVALUATION (Viva – Voce)

1. What is a molar solution?
2. What do you understand by 'weighing by transfer'?
3. Why are standard solutions prepared in volumetric flasks?
4. What is the need for standard solutions in volumetric analysis?
5. What is the need of adding distilled water while making a standard solution?
HOME ASSIGNMENT
1. Prepare 250 mL standard solution of 0.1 N sodium carbonate. Account for the difference between normality and molarity.
RESOURCES
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

VIRTUAL MODE

PRACTICAL LESSON PLAN NUMBER - 6

CLASS/ GRADE LEVEL – XI

PRACTICAL OVERVIEW

• **PRACTICAL_TITLE** To determine the strength of a given solution of hydrochloric acid by titrating it against standard sodium carbonate solution.
PRACTICAL SUMMARY: One of the important methods in Quantitative Analysis is Volumetric Analysis, a commonly used laboratory technique. It is used to determine the unknown concentration of a sample by measuring its volume. This process is also called titration. In a titration, a solution of unknown concentration is reacted with a solution of known concentration. The solution taken in the burette is called the titrant and the solution taken in the conical flask is called the analyte.
SUBJECT AREA: Chemistry & Education
APPROXIMATE TIME NEEDED: 40 minutes
FROM A UNIT PLAN OR CURRICULUM AREA
TARGETED CONTENT STANDARDS AND BENCHMARKS: Volumetric Analysis / Titration
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
OBJECTIVES: Enable the students to 1. Identify the acid, base, conjugate acid and conjugate base in a reaction. 2. Calculate the concentration of an unknown acid by using titration. 3. Determine the end point of the titration. 4. Build strong content knowledge. 5. Reason abstractly and quantitatively 6. Use appropriate experimental tools strategically.

7. Perform with precision.

LEARNING OUTCOMES:

1. Students will understand the terms: quantitative estimation, acid-base titrations, end point, standard solutions, molarity, molality, normality, and indicators.
2. Students will calculate the strength of a given acid or base using molarity or normality equations.
3. Students will acquire the skill to prepare the standard solution and to determine the end point.
4. Students will acquire the skill to select the indicators based on the nature of the solution.
5. Students will be made familiar with the apparatus used for titration.
6. Students will acquire the skill to perform the titration using sodium carbonate and hydrochloric acid in the real lab once they visualize the different steps.

CURRICULUM FRAMING QUESTION

ESSENTIAL QUESTION:

1. Define neutralization titration.
2. What is the principle of volumetric analysis?
3. What is an indicator?

PRACTICAL LESSON CONTENT QUESTIONS:

1. What is end point?
2. What is a standard solution?
3. What is the relation between equivalent mass of a base/ acid and its molecular mass?

LESSON DETAILS:

PRE-REQUISITE SKILLS

CONCEPTUAL KNOWLEDGE:

Students should already be familiar with

- acidity and basicity,

- neutralization reactions,
- the pH scale.

  Students will be familiarized with
- relation between normality and molarity
- role of indicator

LANGUAGE SKILLS:

Students should have the basic skill of making notes, comprehending, and organizing the matter.

ENGAGEMENT:

Teacher will ask the students to identify acidic and basic substances in their daily life. Further she will probe the students regarding mixing of acids and bases. Students will be asked to recollect their previous knowledge and write the reaction of various acids and bases in the notebook.

EXPLORE:

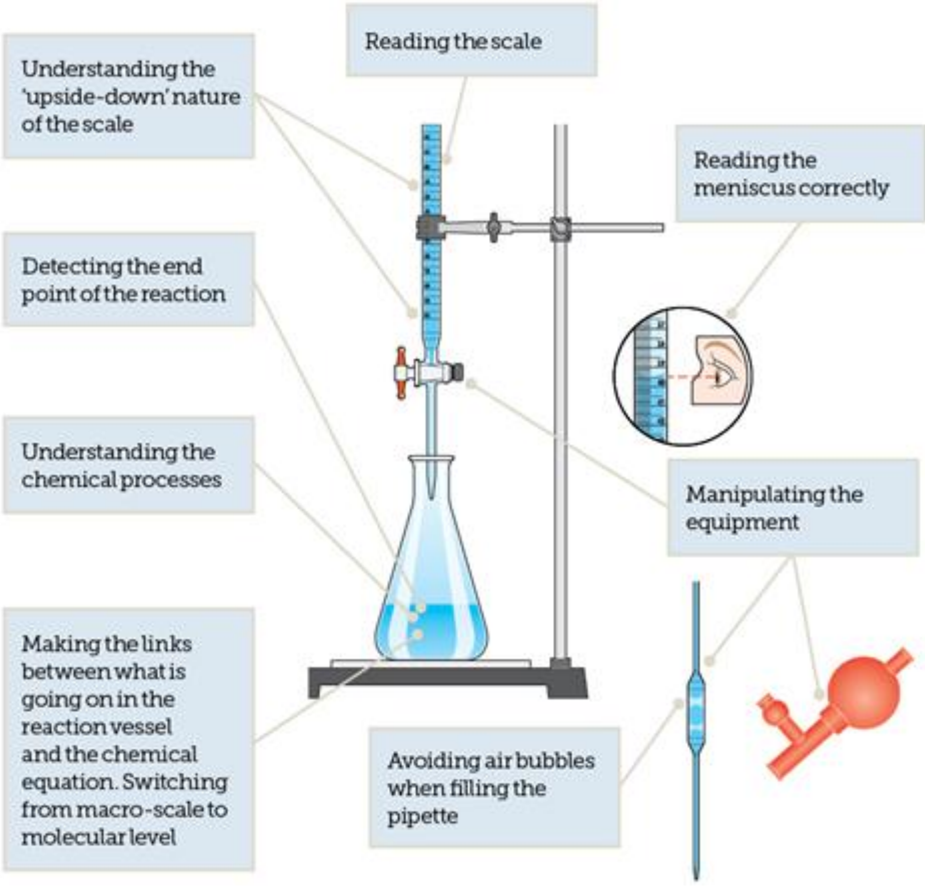
- Students will answer the queries, will observe keenly the part of the video of OLabs and classify acids and bases.
- They will observe the mixing of acid and base in the video and will try to the understand the purpose of titration.
- They will be updated with the various terms used in the experiment viz titrant, analyte, end point, indicator etc.
- They will be made aware of the apparatus used in the experiment viz burette, pipette, burette stand etc.

EXPLAIN:

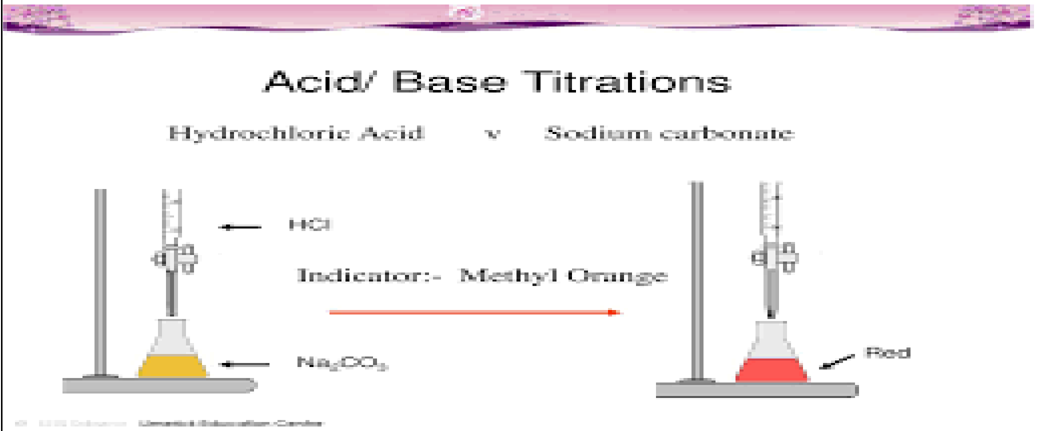
Students will be asked to observe the following activity.

- Take a burette and wash it with distilled water.

- Rinse and fill the burette with the given hydrochloric acid and set the initial burette reading as zero.
- Clamp it vertically to the burette stand.
- Rinse the pipette first with water and then with the given sodium carbonate solution.
- Pipette out 20ml of the given sodium hydroxide solution into a conical flask and add 1-2 drops of methyl orange into it.



- Titrate it against the hydrochloric acid taken in the burette till the colour of the solution in the conical flask changes from yellow to light red.



- Now note down the final burette reading.
- Repeat the same procedure until concordant values are obtained.
- Students will be asked to perform the experiment by the icon 'Simulator given in the OLabs Platform. Here various options of type of titration, titrant, titrate, indicators are given.
- By carrying out multiple experiments via simulator, students develop expertise and become confident.

ELABORATE:

Students will be asked to record the observations in a tabular form as shown below.

Sl. No.	Initial Reading of Burette	Final Reading of Burette	Volume of HCl used (ml)
1			
2			

Calculation:

Students will be given normality equation.

$$N_1V_1 = N_2V_2$$

They will be asked to write the reaction between the given acid and the base. Based on the reaction written they will come to know that 1 mole of sodium carbonate reacts with 2 moles of HCl

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$
1 mole 2 moles

At this stage they will be able to derive molarity equation as

$$n_1 M_1V_1 = n_2 M_2V_2$$

Afterwards, they will be asked to substitute the values and calculate the molarity of HCl.

Molarity is expressed in moles per litre. Subsequently they will be asked to convert moles per litre into gram per litre. In this way they will be able to derive the formula of strength which is as follows: Strength = Molarity * Molar mass

In this way they will be able to get the value of molarity and strength of HCl.

- Students will be asked to perform the titration with different concentration of same acid and base.
- Students will be asked to perform the titration between different acids and bases.

EVALUATE (Viva – Voce)

1. What is the type of reaction involved in acid-alkali titration?
2. What is the pH of the solution obtained by the reaction between a strong acid and a strong base?
3. What is the volume of conc. HCl required to prepare 250ml 5N HCl solution? (Normality of conc. HCl = 12)
4. The molar mass of H_2SO_4 is 98 g mol-1. What is its equivalent mass?
5. What is the colour of methyl orange in acidic and basic solution?
6. Why should a titration flask not be rinsed?
7. Why do we read lower meniscus of a colourless solution and upper meniscus of a coloured solution?
8. Burette and pipette must not be rinsed with the solution with which they are filled, why?
9. Why must the last drop of solution not be blown out of a pipette?

RESOURCES:

http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=109&cnt=4

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

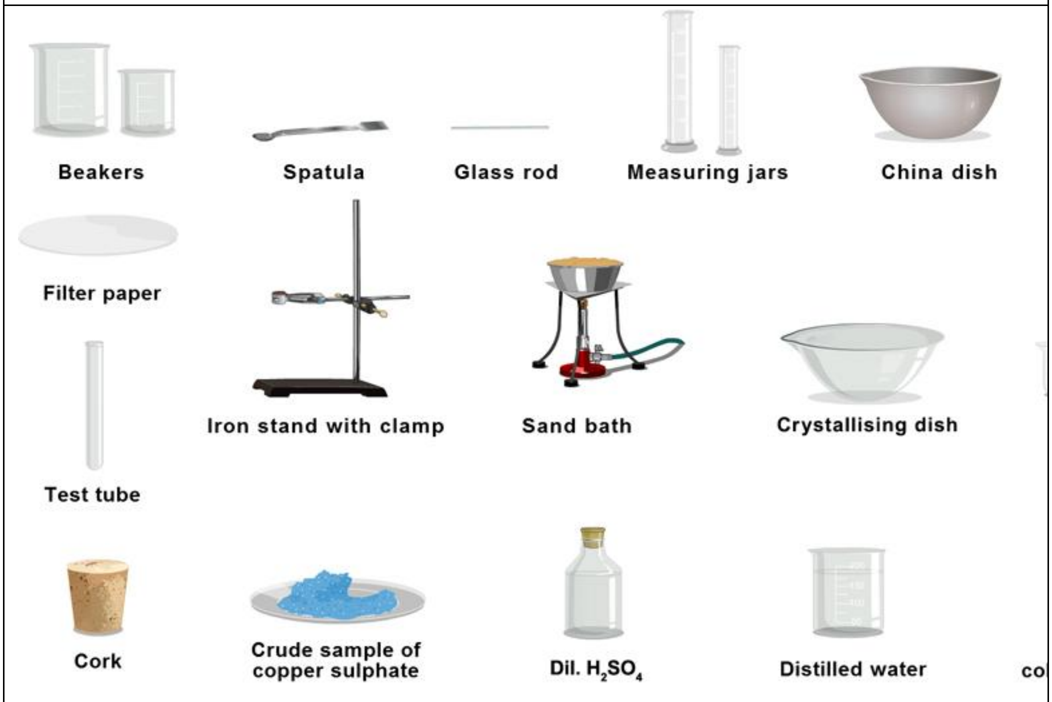
PRACTICAL LESSON PLAN NUMBER - 7

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To purify impure sample of benzoic acid by the process of crystallization.
Practical Summary: The substances used for chemical purposes should be free of any kind of impurities i.e., they should be pure. These impurities may or may not be soluble in the solvent in which the substance under consideration dissolves. There are multiple methods available for the purification of a substance, but they entirely depend on the nature of the impurity. Some examples of such methods are filtration, sedimentation, decantation, and crystallization. Crystallization is a separation technique to separate solids from a solution. Through this process, the atoms or molecules of a compound arrange themselves in a form of 3D lattice to minimize the energy of the system.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Purification using crystallization.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To prepare the crystals of benzoic acid from their impure samples through crystallization.
• To understand the procedure of crystallization in laboratories.
• To understand the principle of crystallization in purification

techniques.
Learning Outcomes:
Learners will-
• Understand the meaning of the term: 'crystallization'.
• Acquire the skills of performing the experiment.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is crystallization?
2. What is the principle behind crystallization?
3. Why do we need purification techniques?
Practical Lesson Content Questions:
1. How to perform crystallization?
2. What are the precautions while performing crystallization?
3. What is mother liquor?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What is solute?
• What is solvent?
• What is a saturated solution?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through

Google Meet link, they will be introduced with the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
Students will be asked about their understanding of crystals. We will ask them to collect some examples of crystalline solids. How do they think crystallization could be used to purify the substance?
They will be asked about the harvesting of salts, sugar crystals etc. to attract their attention towards the topic.
Apparatus and Chemicals required: Beakers, spatula, glass rod, measuring jars, china dish, funnel, filter paper, crystallizing dish, crude sample of benzoic acid, distilled water etc.



Beakers
Spatula
Glass rod
Measuring jars
China dish
Filter paper
Iron stand with clamp
Sand bath
Crystallising dish
Test tube
Cork
Crude sample of copper sulphate
Dil. H_2SO_4
Distilled water


Beakers
Spatula
Glass rod
Measuring jars
China dish
Filter paper
Iron stand with clamp
Sand bath
Crystallising dish
Test tube
Cork
Crude sample of copper sulphate
Dil. H_2SO_4
Distilled water

EXPLORATION:
Students will be provided with an impure sample of benzoic acid virtually. They will be asked to gather information about crystallization available on various resources. Based on their theoretical knowledge of crystallization, they will be asked to figure out a process to perform crystallization and purify the sample using a 'Simulator' icon on the OLabs platform.
EXPLANATION:
Students will be shown a video explaining crystallization. It will help them visualize all the steps and they will be able to perform the experiment themselves.
• Take around 150 mL of water in a beaker and boil it over a tripod stand.
• In another beaker, take 2-3 g of crude benzoic acid and gradually add a minimum amount of boiling water to it with stirring.
• Filter the solution immediately with a filter paper placed on a funnel.
• Let the filtered solution cool itself slowly and then cool it by placing it in a cold-water bath.
• Separate the crystals by filtration using funnel and filter paper. Then wash the crystals with water and dry them on a filter paper.

ELABORATION:
Students will understand the whole procedure of crystallization. They will follow the steps and purify the benzoic acid. They will also be asked to weigh the obtained crystals.

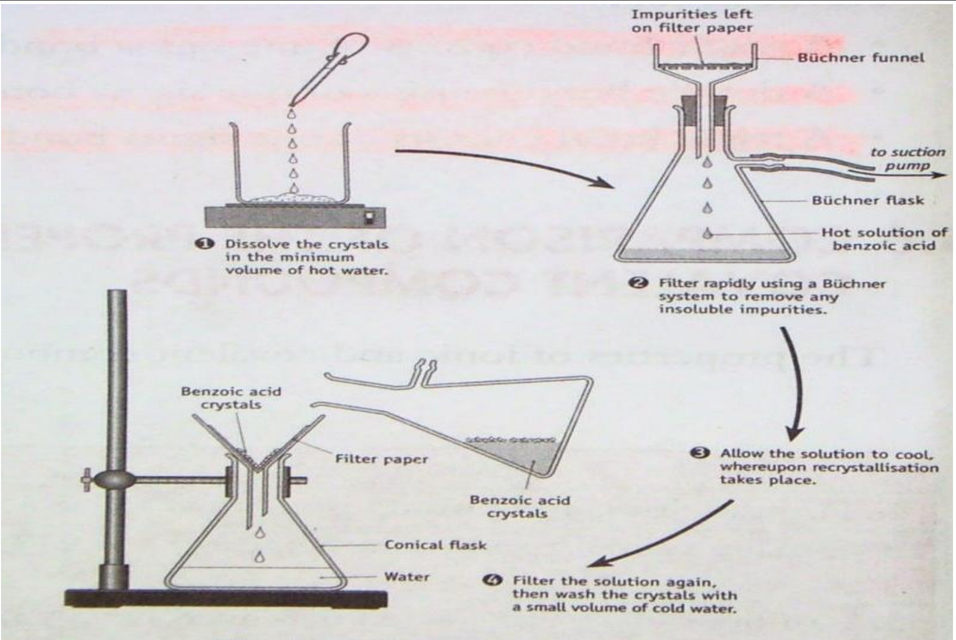
Alternate way to perform the recrystallization of benzoic acid-

EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What is solubility?
2. What is the application of crystallization?
3. Where do we observe crystallization in daily life?
4. What is mother liquor? What is its purpose?
5. What is the structure of benzoic acid?
HOME ASSIGNMENT
1. Try recrystallizing a substance available at home like sugar or salt. Compare the shape, colour, and size of the obtained crystals to that of benzoic acid crystals. Identify the reason behind the difference, if any.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS: NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

Fig. 5.6 Recrystallising benzoic acid using water as a solvent.

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 8

Class/ Grade Level - XI

PRACTICAL OVERVIEW

● **Practical Title**
To purify impure sample of copper sulphate by the process of crystallization.
Practical Summary: The substances used for chemical purposes should be free of any kind of impurities i.e., they should be pure. These impurities may or may not be soluble in the solvent in which the substance under consideration dissolves. There are multiple methods available for the purification of a substance, but they entirely depend on the nature of the impurity. Some examples of such methods are filtration, sedimentation, decantation, and crystallization. Crystallization is a separation technique to separate solids from a solution. Through this process, the atoms or molecules of a compound arrange themselves in the form of 3D lattice to minimize the energy of the system.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Purification using crystallization.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
● To prepare the crystals of copper sulphate from their impure samples through crystallization.
● To understand the procedure of crystallization in laboratories.
● To understand the principle of crystallization in purification techniques.
Learning Outcomes:
Learners will-
● Understand the meaning of the term: ‘crystallization’.

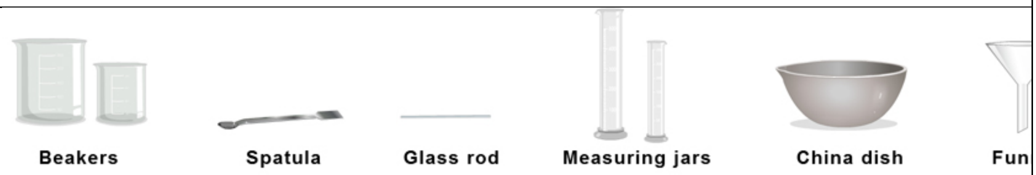
● Acquire the skills of performing the experiment.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is crystallization?
2. What is the principle behind crystallization?
3. Why do we need purification techniques?
Practical Lesson Content Questions:
1. How to perform crystallization?
2. What are the precautions while performing crystallization?
3. What is mother liquor?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
● What is solute?
● What is solvent?
● What is a saturated solution?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced with the Olab platform. They will be given the URL of Olabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos on youtube will be shown to students to generate their interest

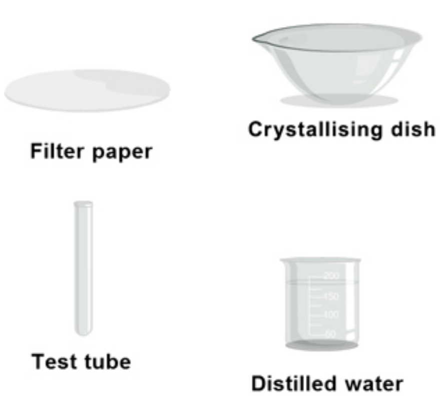
in the topic. They will be asked several questions to increase their participation in the learning process.

Students will be asked about their understanding of crystals. We will ask them to collect some examples of crystalline solids. How do they think crystallization could be used to purify the substance?

They will be asked about the harvesting of salts, sugar crystals etc. to attract their attention towards the topic.

Apparatus and Chemicals required: Beakers, spatula, glass rod, measuring jars, china dish, funnel, filter paper, crystallizing dish, crude sample of copper sulphate, dilute sulphuric acid, distilled water etc.





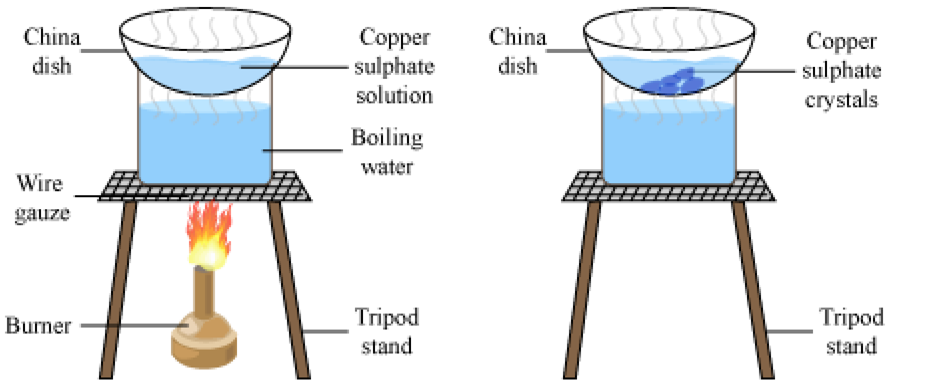
EXPLORATION:

Students will be provided with an impure sample of copper sulphate virtually. They will be asked to gather information about crystallization available on various resources. Based on their theoretical knowledge of crystallization, they will be asked to figure out a process to perform crystallization and purify the sample using a 'Simulator' icon on the OLab platform.

EXPLANATION:

Students will be shown a video explaining crystallization. It will help them visualize all the steps and they will be able to perform the experiment themselves.

● Add small quantities of crude copper sulphate to 25-30 mL of water in a beaker. Dissolve it completely.
● Add more copper sulphate to it and prepare a saturated solution. Add 2-3 mL of dilute sulphuric acid to make the solution clear.
● Filter the solution using a filter paper and funnel and collect in a china dish. Heat the contents of the china dish till the volume reaches one third at least with continuous stirring.
● Then, place the china dish on a water filled beaker and allow it to cool completely.
● Deep blue colored crystals will appear and in about half an hour, the crystallization is complete.
● Decant the mother liquor carefully and wash the crystals with ethyl alcohol containing a small amount of cold water.
● Transfer the filtered crystals on a filter paper and let it dry completely.



ELABORATION:

Students will understand the whole procedure of crystallization. They will follow the steps and purify the copper sulphate. They will also be asked to weigh the obtained crystals.

EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What is solubility?
2. What is the application of crystallization?
3. Where do we observe crystallization in daily life?
4. What is mother liquor? What is its purpose?
5. Why do we add dilute sulphuric acid while preparing the saturated solution of copper sulfate?
HOME ASSIGNMENT
1. Observe the phenomenon of recrystallization in your surroundings taking place naturally. List the examples and discuss it in your class.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.olabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION (VIRTUAL MODE)

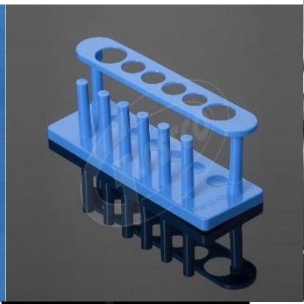
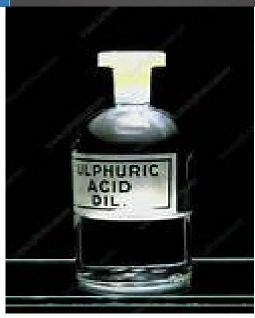
PRACTICAL LESSON PLAN NUMBER - 9

Class/ Grade Level - XI

PRACTICAL OVERVIEW
• **Practical Title**

To determine the carbonate ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out in order to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards And Benchmarks: Confirmation of carbonate ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
● To determine carbonate ion in the given salt.
● To understand the physical and chemical examination of anions.
● To understand the chemical reaction and their balanced equations that take place during the tests.
● To understand all the procedures of performing the test for identification of carbonate ions.
Learning Outcomes:
Learners will-
● Be able to determine carbonate ion in given salt.
● Understand all the chemical reactions taking place in various tests.
● Understand the physical and chemical tests for determination of ions.
● Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of carbonate ion salts?

2. What precautions to be taken while performing the chemical analysis of carbonate ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced to the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of youtube will be shown to students to generate their interest in the topic. They will be asked a number of questions to increase their participation in the learning process.
Students will be asked to list the carbonate salts used in daily life. What is the main purpose of using carbonate salts in daily life?
will be asked to ponder if all the carbonate salts will be harmless?
Apparatus and chemicals required: Test tubes, bunsen burner, dilute sulphuric acid, test tube holder, test tube stand, lime water, magnesium sulphate etc.

   
  
EXPLORATION:
Students will be provided a salt virtually on the oLab platform and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.
They may also try heating the salt.
They may collect information about the carbonate salts on the internet and find out ways to determine its presence on video resources.
Eventually, they will realize they need chemical analysis for the confirmation of

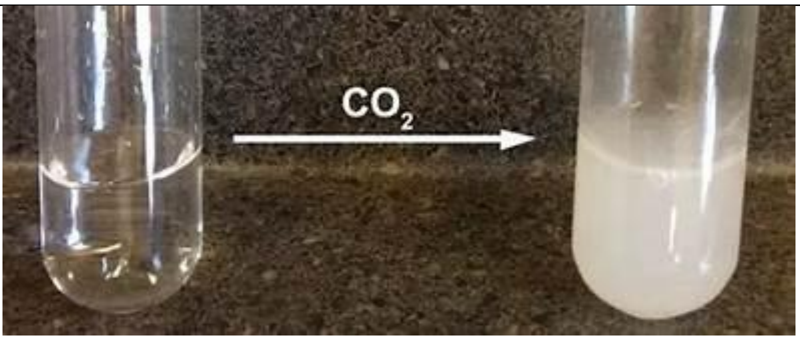
anion.

EXPLANATION:

Students will be asked to follow the procedure to determine carbonate ion in the salt or watch a video available on OLab platform showcasing the same.

- Take a small quantity of salt in a test tube. Add 2-3 mL dilute sulphuric acid to it. You will observe brisk effervescence if carbonate ion is present.
- For confirmation test,

Take a small quantity of salt in a test tube and add 2-3 mL of dilute sulphuric acid. Then, pass the evolved gas through lime water. If lime water turns milky, it confirms the presence of carbonate ion.



- Another test for confirmation: Add magnesium sulphate solution to the salt solution. The formation of white precipitate confirms the carbonate ion.

ELABORATION:

When dilute sulphuric acid is added to the salt, carbon dioxide gas evolves which leads to the appearance of effervescence.

In the confirmation tests,

Lime water turns milky as carbon dioxide gas reacts with lime water to form calcium carbonate which appears milky.

When magnesium sulphate is added, carbon dioxide gas evolves from the salt and reacts with it and forms magnesium carbonate which precipitates out.
Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.
EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What type of bond is present in an inorganic salt?
HOME ASSIGNMENT
1. Identify the carbonate salts in the items used in your households like shampoo, cleaner etc.
List at least 5 products and the role of carbonate in the products.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.olabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 10

Class/ Grade Level - XI

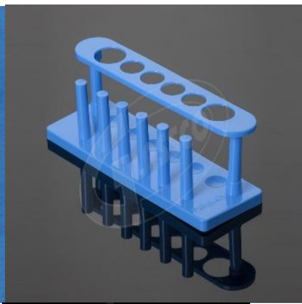
PRACTICAL OVERVIEW

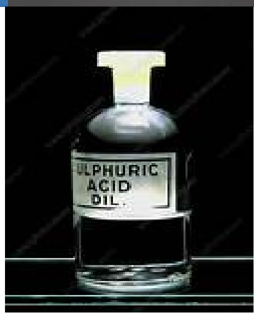
• **Practical Title**
To determine the sulphide ion in the given salt.

Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Determination of sulphide ion.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine sulphide ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of carbonate ions.
Learning Outcomes:
Learners will-
• Be able to determine sulphide ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?

Practical Lesson Content Questions:
1. What are the physical characteristics of carbonate ion salts?
2. What precautions to be taken while performing the chemical analysis of carbonate ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced with the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
Students will be asked to find out the products containing sulphide anion used in daily life along with their uses. Also, ponder if those products have any harmful effect on human health.
Apparatus and chemicals required: Test tubes, Bunsen burner, dilute

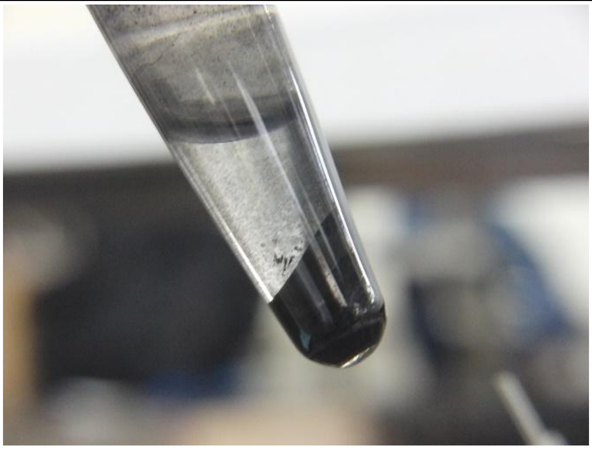
sulphuric acid, test tube holder, test tube stand, sodium nitroprusside, lead acetate, cadmium carbonate etc.





EXPLORATION:
Students will be provided a salt virtually on the OLabs platform and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.
They may also try heating the salt.
They may collect information about the sulphide salts on the internet and find out ways to determine its presence on video resources.
Eventually, they will realize they need chemical analysis for the confirmation of anion.
EXPLANATION:
Students will be asked to follow the procedure to determine sulphide ion in the salt or watch a video available on OLabs platform showcasing the same.
• Take a small quantity of salt in a test tube. Add 2-3 mL dilute sulphuric acid to it. If you observe rotten egg-like smell, sulphide ion may be present.
• For confirmation of the same, perform the following test.
1. Sodium nitroprusside test: Take a small amount of salt solution in a test tube and add a few drops of sodium nitroprusside solution. Purple or violet colour appearance confirms the presence of sulphide ion.

2. Lead acetate test: Take a small amount of salt solution in a test tube and add lead acetate solution to it. Appearance of black precipitate confirms the presence of sulphide ion.


3. Cadmium carbonate test: Take a small amount of salt solution, add a suspension of cadmium carbonate in water. Yellow precipitate confirms the presence of sulphide ion.

ELABORATION:
When dilute sulphuric acid is added to the salt, hydrogen sulphide gas evolves which leads to the smell of rotten eggs.
In the confirmation tests,
1. When sodium nitroprusside is added to the salt, the purple or violet colouration appears due to the complex formation with sulphide.
2. When lead acetate is added to the salt, black precipitate appears of PbS which confirms sulphide.
3. When cadmium carbonate is added to the salt, yellow precipitate of Cadmium sulphide is formed which confirms the presence of sulphide ion.
Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.

EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What is the complex formed in the nitroprusside test?
HOME ASSIGNMENT
1. Take different samples of disposed water from your kitchen, washroom, and school as well. Identify the presence of sulphide ion in the samples.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 11

Class/ Grade Level - XI

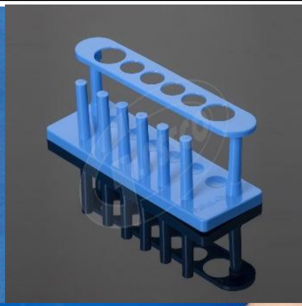
PRACTICAL OVERVIEW

• **Practical Title**
To determine the nitrate ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of

salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of nitrate ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine nitrate ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of nitrate ions.
Learning Outcomes:
Learners will-
• Be able to determine nitrate ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of nitrate ion salts?

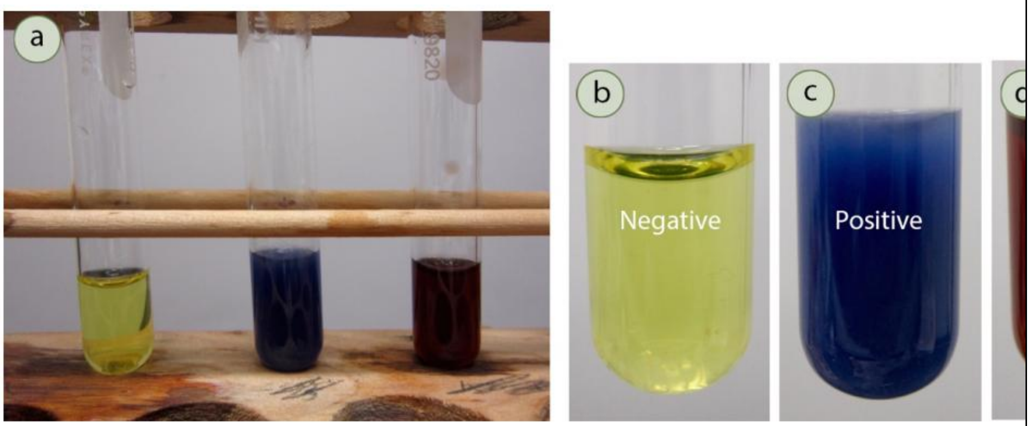
2. What precautions to be taken while performing the chemical analysis of nitrate ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced with the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
Nitrogen is an important part of the ecosystem. Nitrate anion plays a vital role in nitrogen fixation also. Read about the nitrogen cycle and the role of nitrate salts in it.
What do you think will happen if nitrate salts were not present?
Apparatus and chemicals required: Test tubes, Bunsen burner, conc. sulphuric acid, test tube holder, test tube stand, diphenylamine, copper chips,

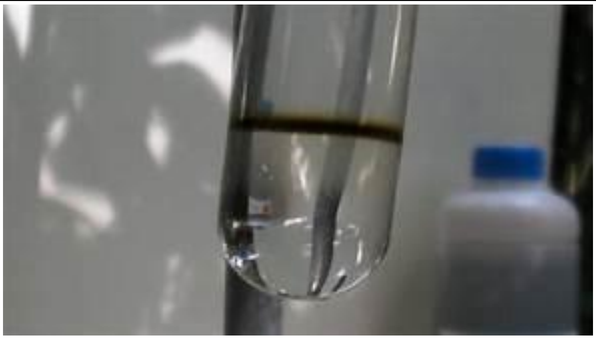
ferrous sulphate etc.



EXPLORATION:

Students will be provided a salt virtually on the OLabs platform and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.

They may also try heating the salt.
They may collect information about the nitrate salts on the internet and find out ways to determine its presence on video resources.
Eventually, they will realize they need chemical analysis for the confirmation of anion.
EXPLANATION:
Students will be asked to follow the procedure to determine nitrate ion in the salt or watch a video available on OLabs platform showcasing the same.
• Take a small quantity of the salt in a dry test tube and heat it. You may observe colored fumes which indicate the presence of nitrite/nitrate/chloride/iodide ions.
• Further, take a small quantity of salt in a test tube, add 1-2 mL of conc. sulphuric acid. You may observe the evolution of brown vapours of nitrogen peroxide if nitrate is present.
• For confirmation,
1. Diphenylamine test: Take a part of aqueous solution of the salt and add a few drops of diphenylamine. Appearance of deep blue colouration confirms the presence of nitrate ion.

2. Copper Chip test: Heat a small quantity of the original salt with concentrated sulphuric acid and a few copper chips. Evolution of dark brown fumes confirms the presence of nitrate ion.

3. Brown Ring test: Take a part of the aqueous solution and add a small quantity of freshly prepared solution of ferrous sulphate to it. Then, pour concentrated sulphuric acid slowly along the sides of the test tube. A dark brown ring is formed at the junction of the layers of the acid and the solution which confirms the presence of nitrate ion.

ELABORATION:
When conc. Sulphuric acid is added to the salt, evolution of brown vapours of nitrogen dioxide marks the presence of nitrate ion.
For confirmation,
1. Diphenylamine test: In the presence of nitrate diphenylamine gets oxidised, giving a blue colouration.
2. Copper Chip test: The reddish-brown fumes are due to the formation of NO2 gas.
3. Brown Ring test: The brown ring is due to the formation of a nitrosonium complex.
Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.
EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What is the chemical formula of the complex formed at brown ring?

HOME ASSIGNMENT
1. Different fruits and green leafy vegetables like spinach, beetroot, mustard green, radish, turnip etc. Extract their fresh juices and identify the presence of nitrate ion in the same.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 12

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the chloride ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.

Targeted Content Standards and Benchmarks: Confirmation of chloride ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine chloride ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of chloride ions.
Learning Outcomes:
Learners will-
• Be able to determine chloride ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of chloride ion salts?
2. What precautions to be taken while performing the chemical analysis of chloride ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic

knowledge of computers.

Conceptual Knowledge:

- What are salts?
- What physical skills are accounted for in physical examination of salts?

Language Skills:

Students should have the basic skills of making notes, comprehending, and organizing the matter.

ENGAGEMENT:

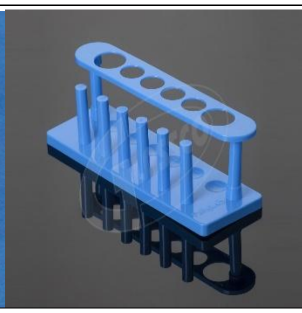
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced to the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.

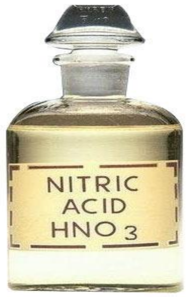
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.

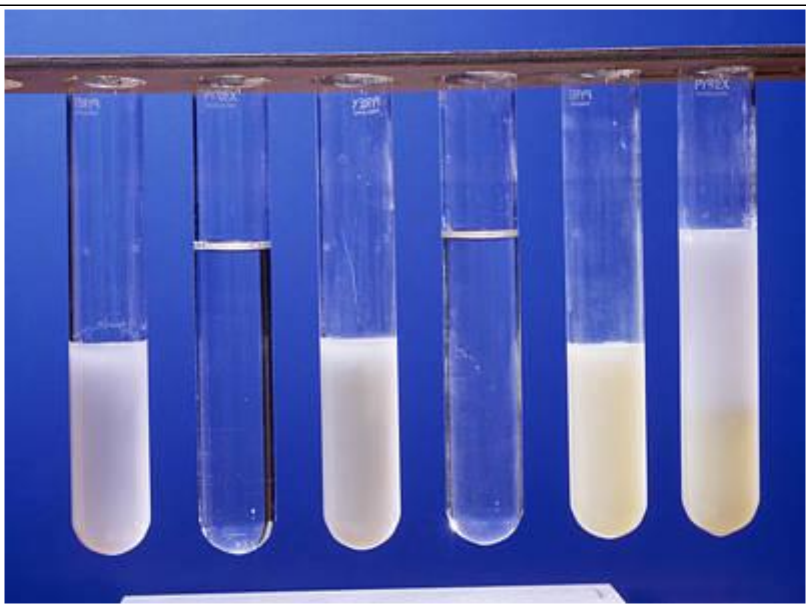
Students will be asked to understand the role of chloride ion in nature. In what areas chloride ions are in abundance?

What is the role of chloride ions in the human body? What will happen if the level of chloride is not maintained in the human body?

Apparatus and chemicals required: Test tubes, Bunsen burner, conc. sulphuric acid, test tube holder, test tube stand, silver nitrate, dilute nitric acid, potassium dichromate, acetic acid, lead acetate, etc.


    
EXPLORATION:
Students will be provided with salt virtually on the OLab platform and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like color, smell, density etc.
They may also try heating the salt.
They may collect information about the chloride salts on the internet and find

out ways to determine its presence on video resources.
Eventually, they will realize they need chemical analysis for the confirmation of anion.
EXPLANATION:
Students will be asked to follow the procedure to determine Chloride ion in the salt or watch a video available on OLabs platform showcasing the same.
• Take a small quantity of salt in a dry test tube and heat it. If you observe colourless fumes with a pungent smell, chloride may be present.
• Further, take a small quantity of salt in a test tube, add 1-2 mL of conc. sulphuric acid. You may observe colourless gas with a pungent smell, form white fumes with aqueous ammonia when a glass rod dipped in aqueous ammonia is shown over the mouth of the test tube.
• For confirmation,
1. Silver Nitrate test: Take a portion of aqueous solution and acidify it with dil. HNO_3. Boil it for some time, let it cool and then add silver nitrate solution to it. A white precipitate soluble in ammonium hydroxide confirms the presence of chloride.

2. Chromyl Chloride test: Mix a small quantity of the salt

with a small amount of powdered potassium dichromate. Take the mixture in a test tube and add conc. H_2SO_4.

Heat the test tube and pass the red vapours evolved into the gas detector containing NaOH solution. To the yellow solution thus obtained, add dil. CH_3COOH and lead acetate solution. A yellow precipitate confirms the presence of chloride ion.

ELABORATION:

When conc. Sulphuric acid is added to the salt, evolution of colourless vapours with a pungent smell of HCl gas marks the presence of chloride ion.

1. Silver nitrate test: A white precipitate of silver chloride is formed which dissolves in ammonium hydroxide forming a soluble complex.
2. Chromyl chloride test: The red fumes are due to the formation of chromyl chloride (CrO_2Cl_2).

CrO_2Cl_2 reacts with NaOH to form a yellow solution of sodium chromate (Na_2CrO_4). Na_2CrO_4 reacts with lead acetate in presence of dil. acetic acid to form yellow precipitate of lead chromate ($PbCrO_4$).

Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?

4. Write the chemical formula of a soluble complex formed in a silver nitrate test.
HOME ASSIGNMENT
1. Take three samples of water, home tap water, school tap water and distilled water. Identify the presence of chloride ion in the samples. Also, try to comment on the concentration of chloride ion in the samples with respect to the amount of the precipitate.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 13

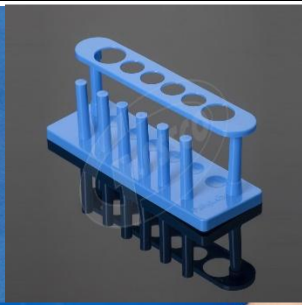
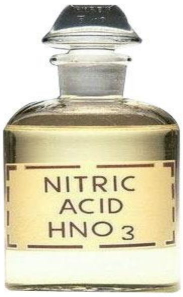
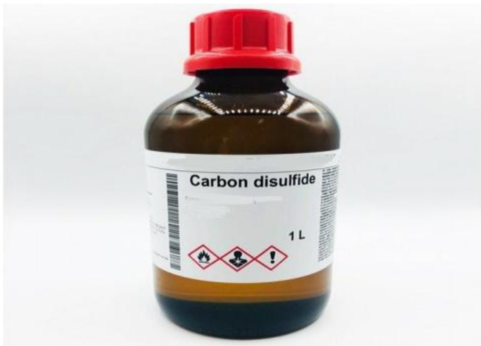
Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the bromide ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the

cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of bromide ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine bromide ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of bromide ions.
Learning Outcomes:
Learners will-
• Be able to determine bromide ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of bromide ion salts?
2. What precautions to be taken while performing the chemical analysis of bromide ion?
LESSON DETAILS

Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced to the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
In daily life, bromine is usually identified in pesticides and water treatment solutions. Students will be asked to find out the ways in which bromine is used in mentioned solutions. What salts are used? How do those salts work? What is the quantity used for such salts?
Also, find out if the human body needs bromine?
Apparatus and chemicals required: Test tubes, Bunsen burner, conc. sulphuric acid, test tube holder, test tube stand, silver nitrate, dilute nitric acid, Manganese dioxide, carbon disulphide, etc.

   
   
EXPLORATION:
Students will be provided a salt virtually on the OLabs platform and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like color, smell, density etc.
They may also try heating the salt.
They may collect information about the bromide salts on the internet and find

out ways to determine its presence on video resources.

Eventually, they will realize they need chemical analysis for the confirmation of anion.

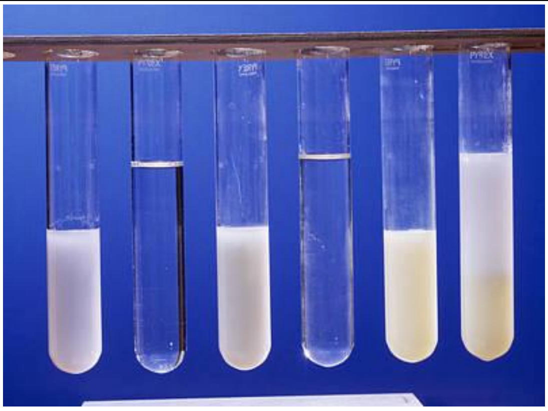
EXPLANATION:

Students will be asked to follow the procedure to determine bromide ion in the salt or watch a video available on OLabs platform showcasing the same.

- Take a small quantity of salt in a test tube, add 1-2 mL of conc. sulphuric acid. You may observe reddish brown gas with a pungent smell, which when brought near a starch paper, turns the paper yellow.

- For confirmation,

1. Silver Nitrate test: Take a portion of aqueous solution and acidify it with dil. HNO_3. Boil it for some time, let it cool and then add silver nitrate solution to it. A light-yellow precipitate partially soluble in ammonium hydroxide confirms the presence of bromide.



2.Manganese dioxide test: Heat a small quantity of the salt with solid MnO_4 and conc. H_2SO_4. Evolution of yellow brown vapour of bromine which turns starch paper yellow confirms the presence of bromide ions.

3. Chlorine water test: Take a portion of aqueous solution of salt and acidify it with dil. HCl. Add 1-2 mL of carbon disulphide and then chlorine water. Shake vigorously and allow it to stand. If the carbon disulphide layer acquires orange colouration, bromide ion is present.

ELABORATION:

When conc. Sulphuric acid is added to the salt, evolution of reddish-brown vapours with a pungent smell of Br_2 gas marks the presence of bromide ion.

1. Silver Nitrate test: A light yellow ppt. is obtained which is partially soluble in ammonium hydroxide.
2. Manganese dioxide test: Evolution of yellowish-brown vapours of bromine takes place, which turns the starch paper yellow.
3. Chlorine water test: Bromine liberated during the reaction being soluble in carbon disulphide (CS_2) imparts an orange colour to the CS_2 layer.

Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.

EVALUATION (Viva – Voce)

Students are asked to answer the following question based on the experiment-

1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. Write the chemical formula of a partially soluble complex formed in silver nitrate test.
5. How do you prepare chlorine water?

HOME ASSIGNMENT

1. Bromide ion is known to be present in sedative drugs. One of the commonly available sedative drugs is Xanax. You can identify the

presence of bromide ion in the drug.
2. Bromide is also added as a food additive in breads. Collect different samples of bread and identify the presence of ion in it. Also, find out the form in which bromide is added in the food.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

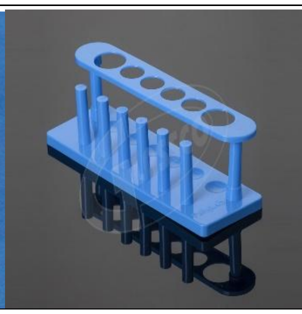
PRACTICAL LESSON PLAN NUMBER - 14

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the sulphate ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.

Targeted Content Standards and Benchmarks: Confirmation of sulphate ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine sulphate ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of sulphate ions.
Learning Outcomes:
Learners will-
• Be able to determine sulphate ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of sulphate ion salts?
2. What precautions to be taken while performing the chemical analysis of sulphate ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic

knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced to the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked a number of questions to increase their participation in the learning process.
Students will be asked to list at least three different sulphate salts and their uses in daily life. Also, try to identify the harmful effects of sulphate in nature.
Apparatus and chemicals required: Test tubes, bunsen burner, conc. sulphuric acid, test tube holder, test tube stand, Barium chloride, sodium carbonate, charcoal, sodium nitroprusside, china dish, lead acetate, ammonium acetate etc.
  


ACID
CONC


Danger
BARIUM
CHLORIDE


Sodium Carbonate

EXPLORATION:

Students will be provided a salt virtually on the OLabs platform and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like color, smell, density etc.

They may also try heating the salt.

They may collect information about the sulphate salts on the internet and find out ways to determine its presence on video resources.

Eventually, they will realize they need chemical analysis for the confirmation of anion.

EXPLANATION:

Students will be asked to follow the procedure to determine sulphate ion in the salt or watch a video available on OLabs platform showcasing the same.

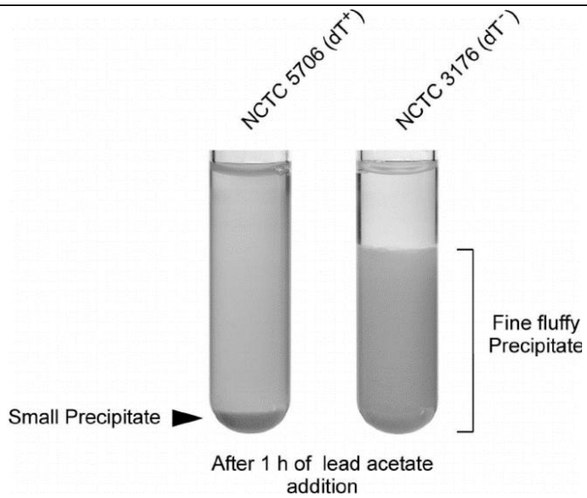
- Take a small amount of salt and boil it with dilute HCl in a test tube. Then, filter the solution and to the filtrate, add $BaCl_2$ solution. A white precipitate may indicate the presence of sulphate ions.

- For confirmation,

1. Barium Chloride test: To a part of aqueous solution of the salt add barium chloride solution. A white precipitate is observed. Add dil. HCl to it and shake. The white precipitate will be insoluble in HCl.

2. Matchstick test: Mix a small amount of the salt with sodium carbonate and a little powdered charcoal so as to get a paste. Take some of this paste on one end of a wooden splinter and heat in the reducing flame till the mass fuses. Dip the fused mass into a sodium nitroprusside solution taken in a China dish. Violet streaks mark the presence of sulphate ion.

3. Lead acetate test: Take a part of aqueous solution of salt and add lead acetate solution. A white precipitate is formed which is insoluble in excess of hot ammonium acetate solution confirms the presence of sulphate.



ELABORATION:

When Barium chloride is added to the acidified aqueous solution of salt, the white precipitate of barium sulphate indicates the presence of sulphate ion.

For confirmation,
1. Barium Chloride test: Insoluble precipitate of barium sulphate in dil. HCl is observed as the confirmation of sulphate ion.
2. Matchstick test: Violate streaks confirms the presence of sulphate ion.
3. Lead acetate test: The white precipitate is lead sulphate ($PbSO_4$) which is insoluble in excess of hot ammonium acetate. This confirms the presence of sulphate ion.
Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.
EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What are the uses of sulphate salts in daily life?
HOME ASSIGNMENT
1. Test for the presence of sulphate ion in different varieties of detergents. You may also test in shampoo.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 15

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the phosphate ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of phosphate ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine phosphate ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of phosphate ions.
Learning Outcomes:
Learners will-
• Be able to determine phosphate ion in given salt.
• Understand all the chemical reactions taking place in various tests.

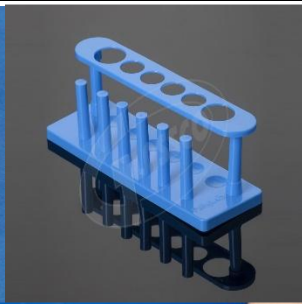
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of phosphate ion salts?
2. What precautions to be taken while performing the chemical analysis of phosphate ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced with the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.

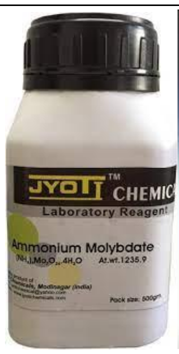
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.

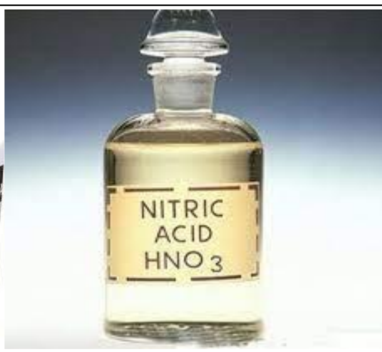
Students will be asked to ponder the biological importance of phosphate salts. They will be asked to understand the role of phosphate ions in the human body especially.

Also, what is the commercial importance of phosphate?

Apparatus and chemicals required: Test tubes, Bunsen burner, conc. sulphuric acid, test tube holder, test tube stand, ammonium molybdate, nitric acid, magnesia mixture etc.

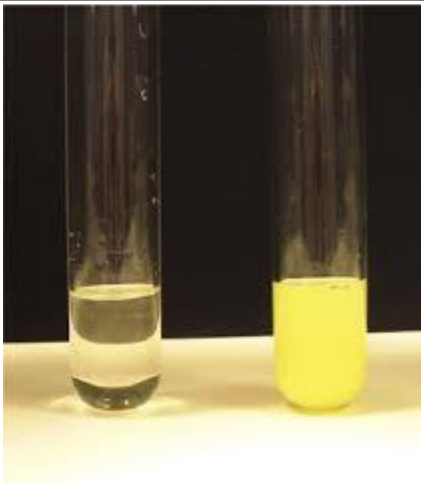



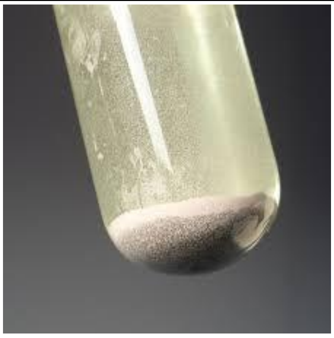




EXPLORATION:

Students will be provided a salt virtually on the OLabs platform and asked to

identify the anion present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.
They may also try heating the salt.
They may collect information about the phosphate salts on the internet and find out ways to determine its presence on video resources.
Eventually, they will realize they need chemical analysis for the confirmation of anion.
EXPLANATION:
Students will be asked to follow the procedure to determine phosphate ion in the salt or watch a video available on OLabs platform showcasing the same.
• Take a small amount of salt and boil it with dilute nitric acid in a test tube. Add a few drops of ammonium molybdate solution to it. A yellow precipitate may indicate the presence of phosphate ions.
• For confirmation,
1. Ammonium molybdate test: To the aqueous solution add concentrated nitric acid and boil. Add ammonium molybdate solution in excess and again boil. Yellow precipitate will confirm the presence of phosphate ion.

2. Magnesia mixture test: Take a small amount of aqueous solution of salt. Add magnesia mixture to it and allow to stand. The presence of white precipitate confirms the phosphate ion.



ELABORATION:

When ammonium molybdate is added to the acidified aqueous solution of salt, the yellow precipitate of ammonium phosphate molybdate indicates the presence of phosphate ion.

For confirmation,

1. Ammonium molybdate test: yellow precipitate of ammonium phosphate molybdate is observed as the confirmation of phosphate ion.
2. Magnesia mixture test: White precipitate of magnesium ammonium phosphate is observed as the confirmation of phosphate ion.

Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.

EVALUATION (Viva – Voce)

Students are asked to answer the following question based on the experiment-

1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What are the chemical formulas of ammonium phosphate molybdate and magnesium ammonium phosphate? Also, what is the oxidation state of phosphorus in both the chemical compounds?

OME ASSIGNMENT

1. Collect soil from a plant at your home and test for the presence of phosphate in the same.

RESOURCES:

Laboratory Manual NCERT Class XI

BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 16

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the ammonium ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes color, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of ammonium ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine ammonium ion in the given salt.
• To understand the physical and chemical examination of cations.
• To understand the chemical reaction and their balanced equations that

take place during the tests.
• To understand all the procedures of performing the test for identification of ammonium ions.
Learning Outcomes:
Learners will-
• Be able to determine ammonium ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of cation in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of ammonium ion salts?
2. What precautions to be taken while performing the chemical analysis of ammonium ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.

ENGAGEMENT:

Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced with the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.

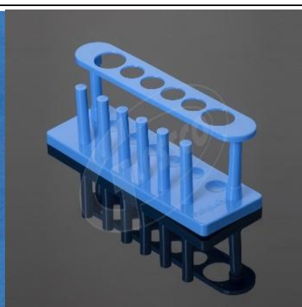
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.

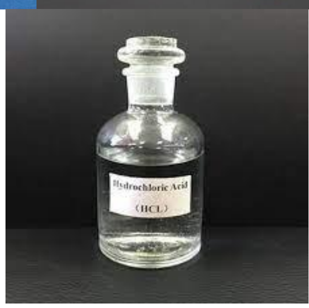
Ammonium salts are used as a rich source of nitrogen in fertilizers. What is the other biological importance of ammonium salts?

Ammonium salts are also an important component of medicines, and it also has other commercial uses.

Look for other uses and importance of the ammonium salts including its role in nitrogen cycle.

Apparatus and chemicals required: Test tubes, Bunsen burner, dil. hydrochloric acid, test tube holder, test tube stand, concentrated sodium hydroxide, Nessler's reagent etc.





EXPLORATION:

Students will be provided a salt virtually on the OLabs platform and asked to identify the cation present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.

They may also try heating the salt.

They may collect information about the ammonium salts on the internet and find out ways to determine its presence on video resources.

Eventually, they will realize they need chemical analysis for the confirmation of cation.

EXPLANATION:

Students will be asked to follow the procedure to determine ammonium ion in the salt or watch a video available on OLabs platform showcasing the same.

- Take a small amount of solid salt in a test tube. Add concentrated solution of sodium hydroxide to it and heat the contents. You may observe an ammoniacal smell if ammonium ion is present.
- For confirmation,

1. Take a small amount of solid salt in a test tube. Add concentrated solution of sodium hydroxide to it and heat the contents. Dip a glass rod in HCl and bring it near the mouth of the test tube. You will observe white fumes which confirm the presence of ammonium ion.

2. Nessler's reagent test: Pass the gas evolved in above test through Nessler's reagent taken in a test tube. Brown precipitate is formed which confirms the presence of ammonium ion.

ELABORATION:
When sodium hydroxide is added to the solid salt, ammonia gas is evolved as a preliminary examination of ammonium salt.
In the examination tests,
1. When a glass rod dipped in dil. HCl is brought near the mouth of the test tube, a gas evolved is ammonia which gives white fumes with HCl due to the formation of NH_4Cl.
2. When the gas evolved in the above test is passed through Nessler's reagent, brown precipitate is observed due to formation of a complex $H_2N.HgO.HgI$. It confirms the presence of ammonium ion.
Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.

EVALUATION (Viva – Voce)
Students are asked to answer the following question based on the experiment-
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What is Nessler's reagent?
5. What is the complex formed with Nessler's reagent?
6. How do pass the gas evolved through the Nessler's reagent?
HOME ASSIGNMENT
1. Collect soil from a plant at your home and test for the presence of ammonium ion in the same.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 17

Class/ Grade Level - XI

PRACTICAL OVERVIEW

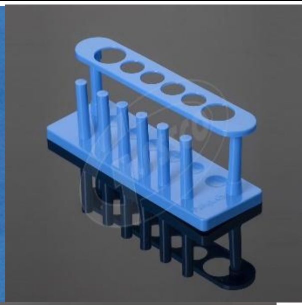
• **Practical Title**

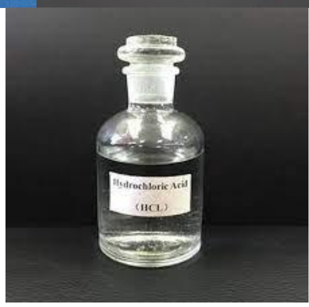
To determine the lead ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of lead ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine lead ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of lead ions.
Learning Outcomes:
Learners will-
• Be able to determine lead ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of cation in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?

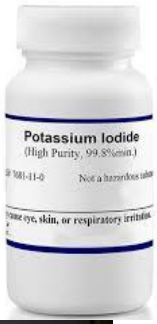
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of lead ion salts?
2. What precautions to be taken while performing the chemical analysis of lead ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced with the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
Lead is known as a toxic metal. Find out the lethal dose of lead for a human body?
What will be the repercussions if lead is thrown in a water body?

How do you think lead can be extracted from water? Try reading recent research articles on lead pollution and its measures.

Apparatus and chemicals required: Test tubes, Bunsen burner, dil. hydrochloric acid, test tube holder, test tube stand, potassium iodide, potassium chromate etc.

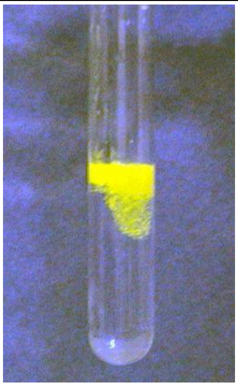


EXPLORATION:
Students will be provided a salt virtually on the OLabs platform and asked to identify the cation present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.
They may also try heating the salt.
They may collect information about the lead salts on the internet and find out ways to determine its presence on video resources.
Eventually, they will realize they need chemical analysis for the confirmation of cation.
EXPLANATION:
Students will be asked to follow the procedure to determine lead ion in the salt or watch a video available on OLabs platform showcasing the same.
• Take a small amount of salt solution and add dilute HCl to it. Then, centrifuge the content and wash the precipitate. Presence of white precipitate indicates the lead cation in salt.
• For confirmation,
Boil the white precipitate with 5-10 mL of water. Precipitate will dissolve. $PbCl_2$ is soluble in hot water. Then, divide the solution into three parts.
1. Cool the first part. White crystalline precipitate of $PbCl_2$ will be observed as the confirmation of lead ion.

2. Potassium iodide test: To the second part of the solution, add potassium iodide solution. Yellow precipitate due to the formation of PbI_2 will be observed as the confirmation of lead ion.

3. Potassium chromate test: To the third part of the solution, add potassium chromate solution. Yellow precipitate due to the formation of $PbCrO_4$ will be observed as the confirmation of lead ion.



ELABORATION:

When HCl is added to the salt solution, precipitate of $PbCl_2$ is observed indicating the presence of lead cation.

When the white ppt. is boiled with water, the precipitate dissolves because the $PbCl_2$ is soluble in hot water.

When potassium iodide is added, yellow precipitate of PbI_2 is observed whereas when potassium chromate is added, yellow precipitate of $PbCrO_4$ is observed. Both serve as confirmation for the presence of lead cation.

Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

1. What physical features did you observe in the given salt?

2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What is a lethal dose?
5. What are the other cations present in the same group as lead?
HOME ASSIGNMENT
1. It is well known that paint contains lead. Collect a few samples of different varieties of paints and identify the presence of lead in them.
You may also take samples of lead free paints and confirm the same.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 18

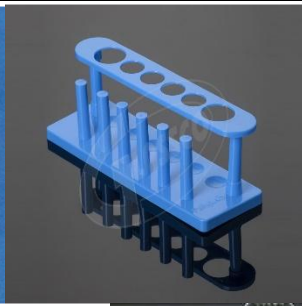
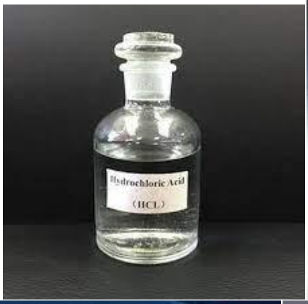
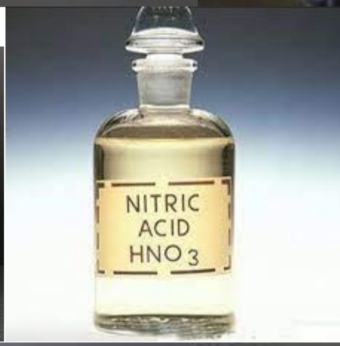
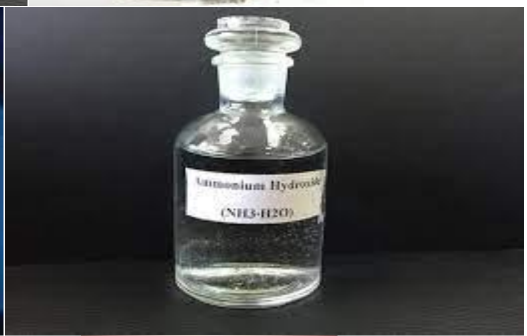
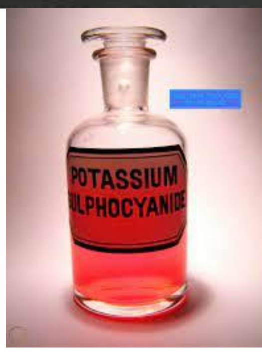
Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the ferrous ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical

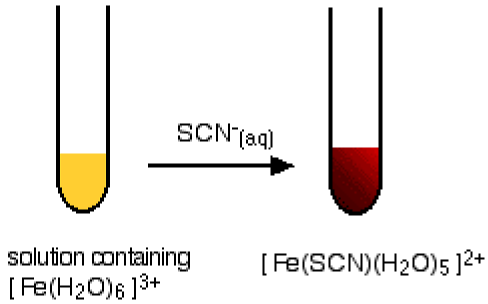
analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of ferrous ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine ferrous ion in the given salt.
• To understand the physical and chemical examination of cation.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of ferrous ions.
Learning Outcomes:
Learners will-
• Be able to determine ferrous ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of cation in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of ferrous ion salts?
2. What precautions to be taken while performing the chemical analysis of ferrous ion?

LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced to the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
Iron is an important element in biological as well as commercial aspects. Students will be asked to list five important commercial uses of Iron and five important biological uses of Iron.
What disease is caused by deficiency of iron in the human body? What is the optimum level of iron in the human body?
Which vegetables and fruits are the rich source of iron?
Apparatus and chemicals required: Test tubes, Bunsen burner, conc. Nitric acid, test tube holder, test tube stand, ammonium chloride, ammonium

hydroxide, potassium ferrocyanide, potassium sulphocyanide etc.
        
EXPLORATION:
Students will be provided a salt virtually on the OLabs platform and asked to identify the cation present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.
They may also try heating the salt.
They may collect information about the Iron salts on the internet and find out

ways to determine its presence on video resources.
Eventually, they will realize they need chemical analysis for the confirmation of cation.
EXPLAIN:
Students will be asked to follow the procedure to determine ferrous ion in the salt or watch a video available on OLabs platform showcasing the same.
• Take about 5 ml of salt solution in a test tube and add 4-5 drops of conc. HNO_3. Boil the solution for some time. Add to it about 2 g of solid NH_4Cl and boil again.
Cool the solution and add excess ammonium hydroxide to it and shake. Reddish brown precipitate indicates the presence of ferrous ion.
• For confirmation,
Dissolve the reddish-brown ppt. in dilute HCl and divide the solution into two parts.
1. Potassium ferrocyanide test: To the first part of the solution, add potassium ferrocyanide solution. Prussian blue colour is observed as confirmation of ferrous ion.

2. Potassium sulphocyanide test: To the second part of the solution, add a little potassium sulphocyanide solution. Blood red colouration is observed as confirmation of ferrous ion.



ELABORATION:
Reddish brown precipitate is observed due to the formation of ferric hydroxide in the preliminary test of the salt indicating the presence of ferrous ion.
In the confirmation test,
1. When potassium ferrocyanide is added, the Prussian blue colour is observed as confirmation of ferrous ion due to the formation of ferric ferrocyanide, $Fe_4[Fe(CN)_6]_3$.
2. When potassium sulphocyanide is added, the Blood red colouration is observed as confirmation of ferrous ion due to the formation of Ferric sulphocyanide, $Fe(CNS)_3$.
Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.
EVALUATION (Viva – Voce)
Students are asked to answer the following question based on the experiment-
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What are the other cations present in the same group as ferrous?
5. What type of bonding is present in the complexes observed in the confirmatory tests?
HOME ASSIGNMENT
1. An open slice of apple oxidizes easily when left open. Take fresh apple juice and confirm the presence of iron in the juice.

Take a packed apple juice as well and identify the presence of iron in it.
Compare the result obtained from fresh juice and packed juice.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

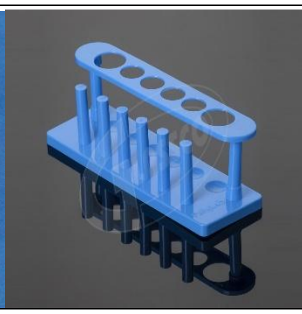
PRACTICAL LESSON PLAN NUMBER - 19

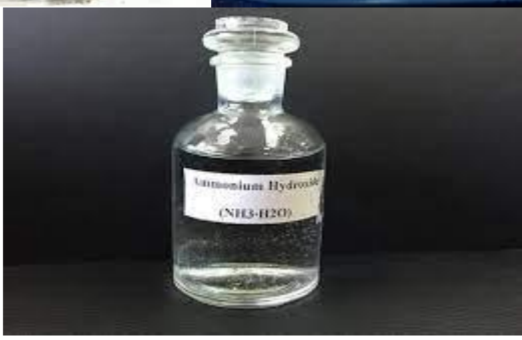
Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the nickel ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of Nickel ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine nickel ion in the given salt.

• To understand the physical and chemical examination of cation.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of nickel ions.
Learning Outcomes:
Learners will-
• Be able to determine nickel ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of cation in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of nickel ion salts?
2. What precautions to be taken while performing the chemical analysis of nickel ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:

Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced to the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
Nickel is often used in making alloys. What properties of nickel help the same?
What are the electronic properties of nickel?
Nickel also has many other commercial uses like in making coins. List some other important uses of nickel?
Is nickel important in biological functions also? Analyse your findings about nickel ion.
Apparatus and chemicals required: Test tubes, Bunsen burner, dil. hydrochloric acid, test tube holder, test tube stand, ammonium chloride, ammonium hydroxide, H_2S gas, dimethylglyoxime solution, Bromine water etc.
  



EXPLORATION:
Students will be provided a salt virtually on the OLabs platform and asked to identify the cation present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.
They may also try heating the salt.

They may collect information about the nickel salts on the internet and find out ways to determine its presence on video resources.
Eventually, they will realize they need chemical analysis for the confirmation of cation.
EXPLANATION:
Students will be asked to follow the procedure to determine nickel ion in the salt or watch a video available on the OLabs platform showcasing the same.
• Take about 5 ml of salt solution in a test tube and add 4-5 drops of conc. HNO_3. Boil the solution for some time. Add to it about 2 g of solid NH_4Cl and boil again.
Cool the solution and add excess ammonium hydroxide to it and shake. Then, pass H_2S gas through the ammoniacal solution. If you observe black precipitate, nickel or cobalt may be present.
• If the initial salt is greenish in colour, proceed with the confirmation of nickel ion.
• For confirmation,
1. Dimethylglyoxime test: Take around 5 mL of original salt solution in a test tube. Add ammonium hydroxide to it followed by the addition of a few drops of dimethyl glyoxime. Bright rose red precipitate is obtained as the confirmation of nickel ion.


	2. Sodium hydroxide - Br_2 test: Take around 5 mL of original salt solution in a test tube and add sodium hydroxide in excess. Green precipitate will be observed. Add bromine water to the same content and boil. A black precipitate is observed as the confirmation of nickel ion.

ELABORATION:
When H_2S gas is passed through the ammoniacal solution, black precipitate of NiS is observed as an indication of nickel ion.
In the confirmation test,
1. The bright red colour is due to the formation of Ni–dimethylglyoxime complex; $Ni(dmgH)_2$. It confirms the presence of nickel ion.
2. The green precipitate is due to the formation of $Ni(OH)_2$.The black precipitate is due to the formation of nickelic hydroxide, $Ni(OH)_3$. It confirms the presence of nickel ion.
Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.
EVALUATION (Viva – Voce)
Students are asked to answer the following question based on the experiment-
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?

4. What is the structure of the Nickel DMG complex?
HOME ASSIGNMENT
1. Why do nickel salts appear coloured?
2. What precautions must be taken while handling H_2S gas?
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(VIRTUAL MODE)

PRACTICAL LESSON PLAN NUMBER - 20

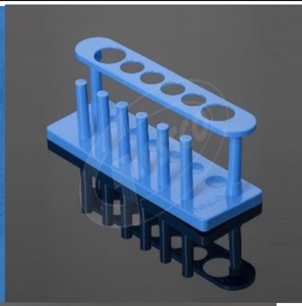
Class/ Grade Level - XI

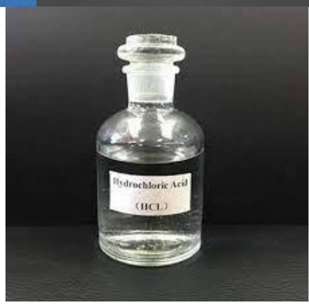
PRACTICAL OVERVIEW

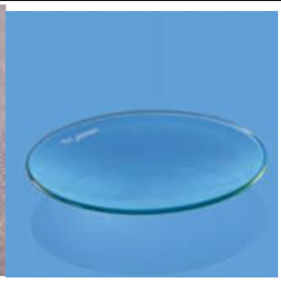
• **Practical Title**
To determine the barium, calcium, and strontium ion in the given salt with the help of flame test.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education

Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of Ba, Ca and Sr ion in salt with flame test.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine Ba, Ca and Sr ions in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the theoretical aspect of flame test.
• To understand all the procedures of performing the test for identification of Ba, Ca and Sr ions.
Learning Outcomes:
Learners will-
• Be able to determine Ba, Ca and Sr ions in given salt.
• Understand the flame test.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of cation in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of Ba, Ca and Sr ion salts?
2. What precautions to be taken while performing the chemical analysis of Ba, Ca and Sr ions?
3. What is a flame test?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring,

predicting, experimenting, communicating, handling apparatus and basic knowledge of computers.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
• What is a flame?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to join the practical class by virtual mode via Google meet link. A link will be shared with the students. When they join through Google Meet link, they will be introduced to the Olab platform. They will be given the URL of OLabs to facilitate the learning process. Then they will be familiarized with the various icons present in the OLabs such as theory, procedure, animation, simulator, video, viva voce, resources & important vocabulary words.
Suitable videos of YouTube will be shown to students to generate their interest in the topic. They will be asked several questions to increase their participation in the learning process.
We often use the physical and chemical characteristics of a salt to determine the cations and anions present in the same. Have you ever wondered if electronic properties could be used for the same?
Find out ways in which the electronic properties could be used for the identification of cations?
Apparatus and chemicals required: Test tubes, Bunsen burner, conc. hydrochloric acid, test tube holder, test tube stand, platinum wire, watch glass etc.



EXPLORATION:

Students will be provided with a salt virtually on the OLabs platform and asked to identify the cation present in it. They will be asked to judge the physical characteristics of salt like colour, smell, density etc.

They may also try heating the salt.

They may collect information about the Calcium, Barium and Strontium salts on the internet and find out ways to determine its presence on video resources.

Eventually, they will realize they need chemical analysis for the confirmation of cation.

EXPLANATION:

Students will be asked to perform the flame test following the procedure mentioned here or watch a video on the OLabs platform explaining the determination of Ca, Ba and Sr ion in the given salts-

- Take conc. HCl in a watch glass and clean platinum wire by dipping in it. Then, heat the wire strongly in the flame. Repeat the process till the platinum rod imparts no colour to the flame.

- Prepare a paste of the given salts individually with conc. HCl on a clean watch glass. Make a loop on one end of the platinum wire and place some amount of paste on the loop. Introduce the paste on the loop to the flame and observe the colour it imparts to the flame.

1. For Calcium: The flame appears non-persistent brick red.

2. For Strontium: The flame appears persistent crimson red.

3. For barium: The flame appears grassy green after prolonged heating.

ELABORATION:

When salts are heated in a flame, the electrons in a metal ion gain energy and

excite to a higher energy level from a lower energy level. Ions are not stable at a higher energy level, hence return to the ground with the release of energy. This energy released corresponds to the visible region and imparts colour which varies from one metal ion to another. Hence, each metal has its characteristic change of colour when it is heated.
Students will be asked to prepare their observations in a table in a word file and upload the file as a Google classroom assignment.
EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation test?
3. What are the limitations of flame tests?
4. Why do metal ions impart colour to the flame?
5. Why is hydrochloric acid used in the flame test?
6. What is the range of wavelengths for visible region?
7. What mandatory precautions should be taken for flame tests?
HOME ASSIGNMENT
1. Take different samples of water from your home, school, distilled water etc. Perform the identification tests of Ca, Ba and Sr in those samples and compare your results.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

APPENDIX B

Instructional Plan of Experimentation

(Physical Mode)

Practical Lesson Plan Number - 21

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To study the shift of equilibrium between ferric ions and thiocyanate ions by increasing the concentration of either of them.
Practical Summary: When the concentration of any of the reactants or products in a reaction at equilibrium is changed, the composition of the equilibrium mixture changes so as to minimize the effect of concentration changes.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Effect of concentration change on equilibrium.
21^{st} CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To understand Le Chatelier's principle.
• To study the shift of equilibrium between ferric ions and thiocyanate ions by increasing the concentration of either of them.
• To understand the law of equilibrium.
Learning Outcomes:
Learners will-
• Understand the terms: chemical equilibrium, equilibrium constant.
• Understand the effect of change in concentration on the equilibrium of

a reaction.
• Be able to write equilibrium constant for the reaction.
• Be familiarized with the ways of understanding chemical equilibrium in laboratories.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is chemical equilibrium?
2. What is Le Chatelier's principle?
3. What is equilibrium constant?
Practical Lesson Content Questions:
1. What is the effect of concentration change on equilibrium?
2. What are the other factors affecting equilibrium?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• Laws of mass action.
• Meaning of 'equilibrium'.
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked about their understanding of equilibrium. They will be probed by several questions related to their day today experiences,
Wonder how a reaction will yield its product if it stays in equilibrium?
How does drying of clothes happen in the summer and rainy season?
They will be asked to write 5 situations of equilibrium in daily life.
Apparatus & chemicals: Ferric chloride solution (0.1 M), Potassium

thiocyanate solution (0.1 M), Potassium chloride solution (0.1 M), distilled water, beaker (250 mL), test tubes, test tubes stand and measuring cylinders.
EXPLORATION:
Students will be provided with solutions of 0.1 M Ferric chloride, 0.1 M Potassium thiocyanate and 0.1 M Potassium Chloride.
$Fe^{3+}(aq) + SCN^{-}(aq) \leftrightarrow [Fe(SCN)^{2+}]$
Based on this reaction, they will be asked to observe the shift in equilibrium by changing the concentrations of reactants and observe the colour change.
EXPLANATION:
Students will be asked to perform the following activity-
• Take 10 ml of 0.1 M Ferric chloride solution in a measuring cylinder and pour it into a clean beaker.
• To this, add 10 ml of 0.1 M Potassium thiocyanate using a measuring cylinder.
• A deep red colour is obtained due to the formation of the complex, $[Fe(SCN)(H_2O)_5]^{2+}$ (aq).

• Dilute the deep red solution by adding 50 ml of distilled water.
• Take four test tubes and label them as A, B, C and D.
• Add 10 ml of the deep red solution to each test tube using a measuring cylinder.
• Place the test tubes in the test tube stand.
• Add 5 ml of distilled water into test tube A; 5 ml of 0.1 M $FeCl_3$ solution to test tube B; 5 ml of 0.1 M KSCN solution to test tube C and 5 ml of 0.1 M KCl solution into the test tube D.

- Shake all the test tubes well.
- Now compare the intensity of the colours in the test tubes, B, C and D with the red colour in test tube A taken as the reference test tube.

ELABORATION:

Students will be asked to observe the colour change carefully and report their observation in the table given below:

Table 3.3.1: Observation of Colour change & Shift in Equibrium in the reaction

Test Tube	**Substance added at equilibrium**	**Change in Colour**	**Effect on the concentration of $[Fe(SCN)(H_2O)_5]^{2+}$**	**Shift of equilibrium**
A	5 mL of distilled water	Reference Colour	-	-
B	5 mL of 0.1 M $FeCl_3$ solution			
C	5 mL of 0.1 M KCNS solution			
D	5 mL of 0.1 M KCl solution			

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

6. Explain the shift of equilibrium in the activity performed.
7. What are the other factors affecting equilibrium?
8. Give examples of equilibrium reactions observed in daily life.
9. Find out other such examples of a reaction which can be studied for

concentration change.
10. What is the importance of studying equilibrium reactions?
HOME ASSIGNMENT:
1. Give examples of equilibrium phenomena taking place in your home surroundings.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 22

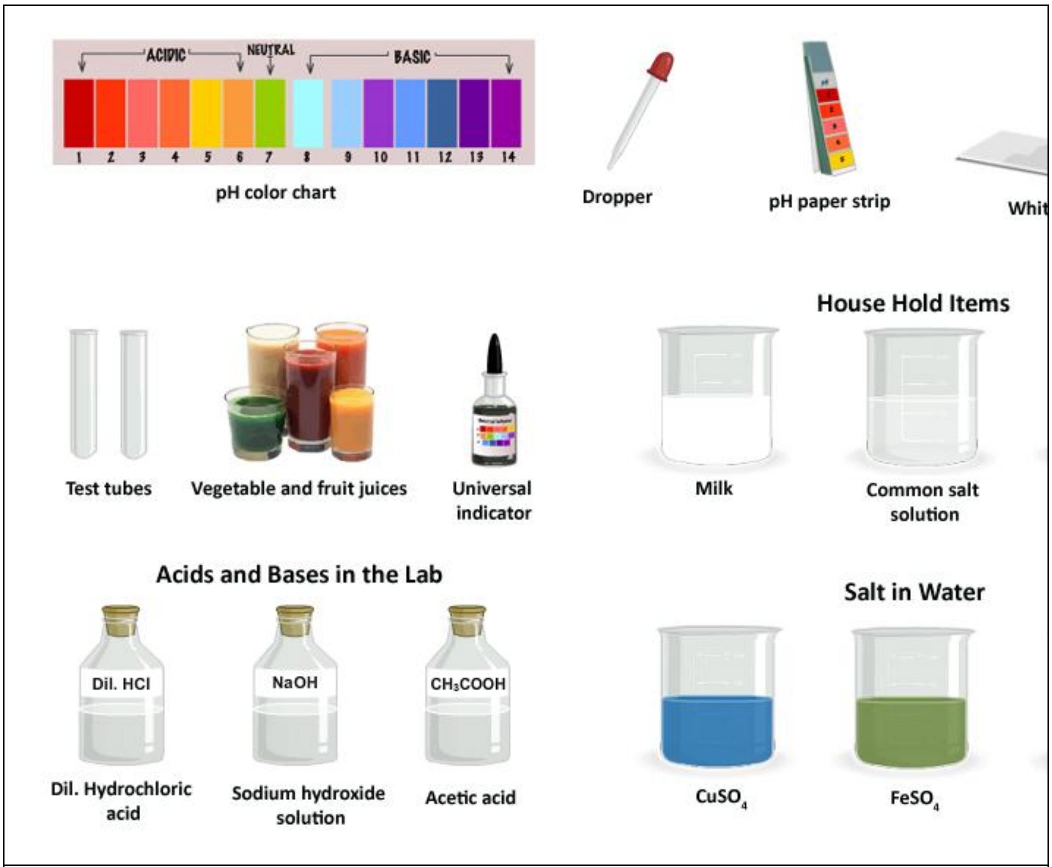
Class/ Grade Level - XI

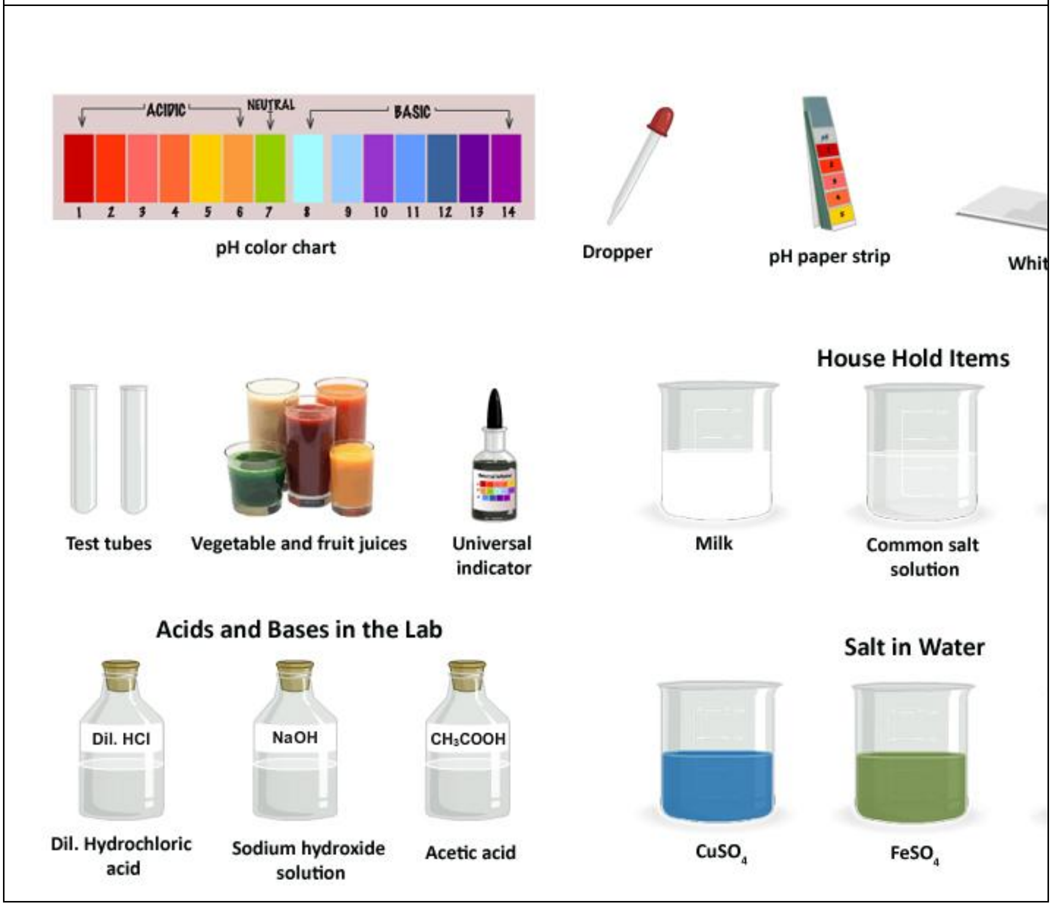
PRACTICAL OVERVIEW

• **Practical Title** To determine the pH of the given sample using pH paper/Universal indicator.
Practical Summary: All the chemical substances introduced in laboratories and homes are either acidic, basic, or neutral in nature. Acids produce free hydrogen ions (H^+) whereas bases produce hydroxyl ions (OH^-) when dissolved in water. pH of a solution is a measurement of acidic or basic properties of substances. It can be measured using pH indicators namely pH

paper and universal indicators.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: pH of acids and bases
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To understand the role of pH paper and universal indicators.
• To determine the pH of given samples using pH paper and universal indicators.
• To classify the given samples into acids, bases and neutral based on their pH values.
Learning Outcomes:
Learner will-
• Understand the terms acids, bases, neutral solutions, pH and universal indicators.
• Determine the pH of different samples using pH indicators.
• Expertise the skills for classifying the substances as acidic, basic or neutral based on pH value.
• Be able to measure the pH of different substances using pH paper or universal indicator solution.
• Calculate the concentration of H^+ and OH^- ions present in different substances using the pH value of solution.
• Learn the importance of pH in everyday life.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are acids, bases, and neutral substances?
2. Define pH of a solution?
3. What are different ways of measurement of pH of a solution?
Practical Lesson Content Questions:

1. What is pH paper and universal indicator?
2. What is the relation between pH and concentration of hydrogen ions?
3. What is the pH scale?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• Acids, bases, and neutral substances.
• Indicators.
• pH scale.
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to list different acids, bases or neutral substances used in their daily life for different means. Then, they will be provided with different unknown samples and asked to identify them as acids, bases, or neutral substances based on their physical nature.
Further, they will be asked to recollect the knowledge of indicators for the identification of nature of different substances.
Apparatus and Chemicals required: pH colour chart, dropper, pH paper strip, white tile, test tubes, universal indicator, dil. HCl, NaOH, acetic acid, different samples etc.


ACIDIC
NEUTRAL
BASIC
1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH color chart
Dropper
pH paper strip
Whit
House Hold Items
Test tubes
Vegetable and fruit juices
Universal indicator
Milk
Common salt solution
Acids and Bases in the Lab
Salt in Water
Dil. HCl
NaOH
CH₃COOH
Dil. Hydrochloric acid
Sodium hydroxide solution
Acetic acid
$CuSO_4$
$FeSO_4$


ACIDIC
NEUTRAL
BASIC
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pH color chart
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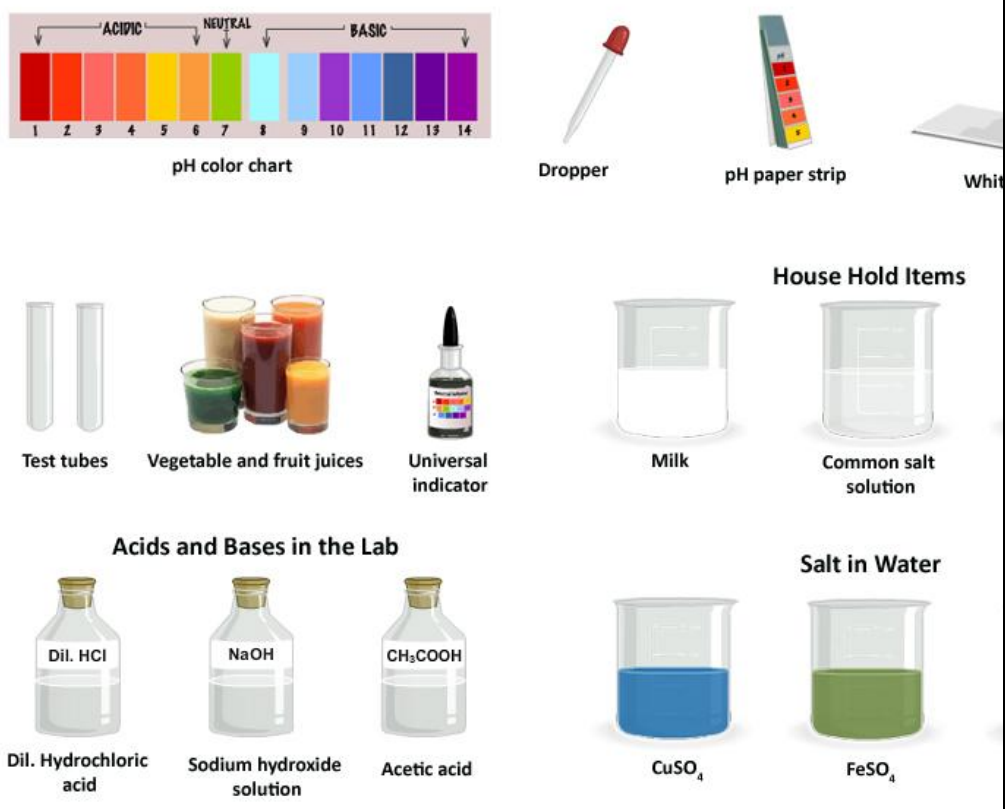
$CuSO_4$
$FeSO_4$



EXPLORATION:

- Students will name different acids, bases or neutral substances used in their daily life.
- They will try to identify the given samples by different ways like smelling, touching or any visible colour appearances. (They will be strictly restricted from ingesting the substances)
- Above methods will not help them reach any conclusion and they will realize the need of an indicator.
- At this point, they will be provided with pH paper strips, universal indicator and pH colour chart for further investigation.

EXPLANATION:

Students will be asked to perform the following activity.

1. Determination of pH with the help of pH paper-
    - Take a pH paper strip and place it on a clean and dry white tile

to clearly observe the colour change.

- Pour a few drops of a given sample on the pH paper strip with a clean dropper.
- Observe the colour change of the pH paper strip and compare the observed colour to the standard pH colour chart to obtain the pH value.
- Record your observations in a tabular form.
- Repeat the above steps to obtain the pH value for remaining given samples.

2. Determination of pH with the universal indicator solution-

- Take a small amount of given sample in a clean, dry test tube using a dropper.
- Pour a few drops of universal indicator solution in the same test tube using another dropper.
- Shake the test tube well and observe the colour of the solution.
- Compare the observed colour with the standard pH colour chart and obtain the pH value.
- Record your observations in a tabular form.
- Repeat the above steps to obtain the pH value for remaining given samples.

ELABORATION:

Students will be asked to record their observations in the tabular form as shown below-

S. No.	Sample	pH Paper Strip		Universal Indicator Solution	
		Colour	pH	Colour	pH
1.	A				
2.	B				

3.	C				
4.	D				
5.	E				
6.	F				
7.	G				

CALCULATION:

Based on the values of pH obtained by pH paper and universal indicators, students will be asked to classify the given samples into acids, bases or neutral substances.

Students will be asked to write the equation of pH and the relation between the concentration of hydrogen ions and the pH value.

$pH = -\log[H^+]$ OR $pH = \log\frac{1}{[H^+]}$

Based on the above equation, they will be asked to calculate the concentration of hydrogen ions in the given samples.

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

1. What are pH indicators?
2. What are acids, bases and neutral substances on the basis of pH?
3. What is the range of pH for acids and bases?
4. How will you calculate the concentration of hydrogen ions with the help of pH?
5. What is the pH of water and blood?
6. What are the applications of pH?
7. Name some natural pH indicators.

HOME ASSIGNMENT

1. Collect different vegetable and fruit juices at home and find out their pH with the same procedure mentioned in the activity.
RESOURCES
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 23

Class/ Grade Level - XI

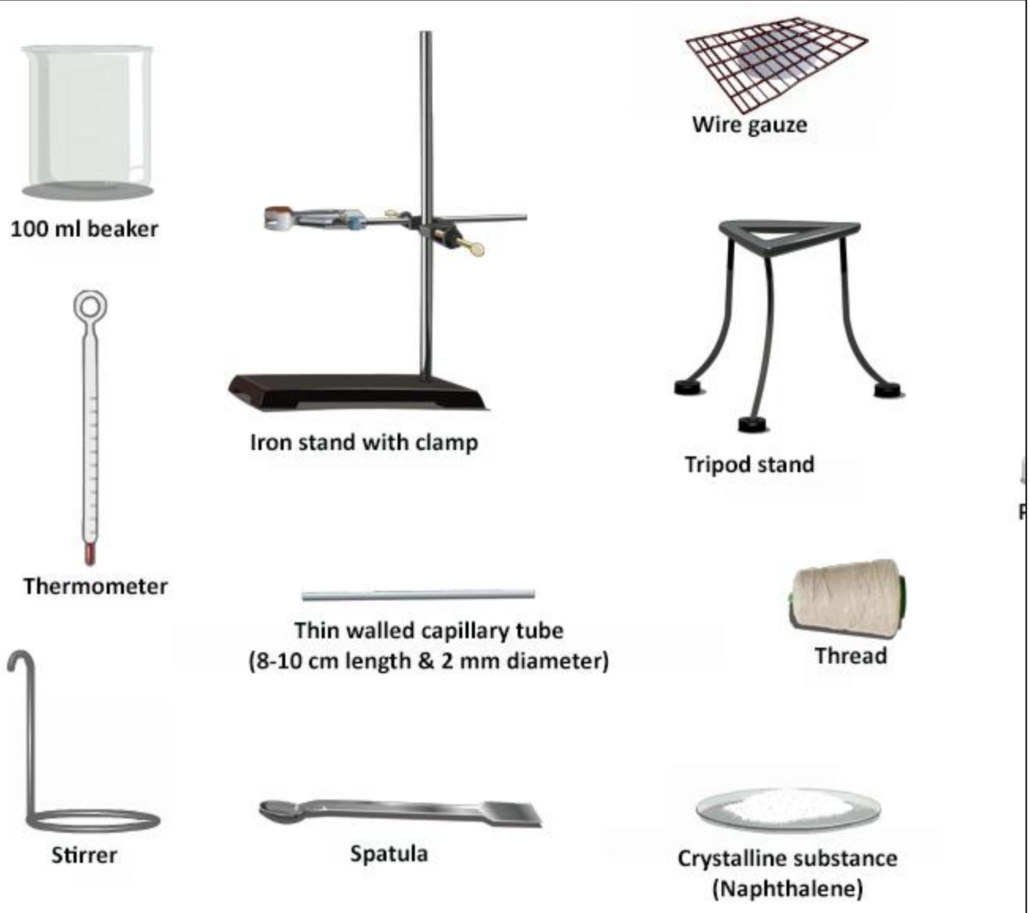
PRACTICAL OVERVIEW

• **Practical Title**
To determine the melting point of an organic compound.
Practical Summary: Melting point is one of the important physical properties of a compound which is also an indication of its purity. Melting point can be used to identify an unknown substance. For a material whose identity is known, an estimate of degree of purity can be made by comparing its melting point with that of a pure sample.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Determination of Melting point.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES

Objectives:
• To determine the melting point of an organic compound.
• To understand the importance of melting point of a compound.
• To expertise the setup of apparatus used in determination of melting point.
Learning Outcomes:
Learners will-
• Understand the term 'Melting point'.
• Appreciate the importance of melting point in identification of an unknown compound.
• Realize the need of melting point in purity check of a compound.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is the melting point?
2. What is the importance of melting point?
Practical Lesson Content Questions:
1. How to determine the melting point of a compound?
2. What are the factors affecting the melting point of a compound?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• Physical properties of organic compounds.
• Factors affecting the physical properties.
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:

Students will be asked about their understanding of the phenomenon of melting. They will be asked to give such examples in daily life. Why do different substances encounter in daily life melt at different temperatures?

Apparatus & chemicals: 100 mL beaker, Iron stand with clamp, wire gauze, tripod stand, bunsen burner, thermometer, thin-walled capillary tube, thread, stirrer, spatula, crystalline substance, liquid paraffin.



EXPLORATION:

Students will be provided with an organic compound and asked to think of ways to determine its melting point. They may try heating the compound directly but eventually they will realize the need for a proper setup.

EXPLANATION:

Students will be asked to follow the procedure-

- First powder the crystalline substance.

- Take a capillary tube and seal one end by heating it or take a sealed capillary.
- Fill the capillary tube with the compound by pushing one end of the tube on a heap of the powdered substance on the porous plate.
- Now tap the sealed end of the capillary tube on the porous plate gently. Fill the capillary tube up to 2-3 mm.
- Attach the capillary tube to a thermometer using a thread.
- Take liquid paraffin in a beaker and place it over a piece of wire gauze placed over a tripod stand.
- Clamp the thermometer carrying the test tube to an iron stand and immerse them in the bath of liquid paraffin.
- Heat the beaker slowly while constantly stirring the contents using a stirrer to maintain a uniform temperature throughout.
- Note the temperature (t1) when the substance starts melting.
- Again, note the temperature (t2) when the substance has completely melted.
- The average of the two readings gives the correct melting point of the substance.

ELABORATION:

Students will be able to determine the melting point of the compound. They will also reason on the purity of a compound. They will also understand the different factors affecting the melting point.

Students will be asked to observe the compound carefully and report their observation in the table given below:

Starts melting t_1(°C)	Has completely melted t_2 (°C)	Melting point of the given substance (t_1 + t 2 (°C)

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

1. Define melting point.

2. How does impurity affect the melting point?
3. Why is the liquid bath stirred regularly during the determination of melting point?
4. What are the precautions taken during the determination of melting point?
5. What factors affect melting point?
HOME ASSIGNMENT:
1. Repeat the same experiment for an inorganic salt such as sodium chloride. Record your observations and discuss it with your teacher.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 24

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the boiling point of an organic compound.
Practical Summary: Boiling point of an organic compound gives important information about its physical and structural properties. A liquid boil when its

vapour pressure is equal to the atmospheric pressure. Boiling point indicates the volatility of the compound. The Higher the boiling point, the less the volatility of the compound.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Determination of boiling point.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine the boiling point of an organic compound.
• To understand the importance of boiling point of a compound.
• To expertise the setup of apparatus used in determination of boiling point.
Learning Outcomes:
Learners will-
• Understand the term 'Boiling point'.
• Appreciate the importance of Boiling point in identification of an unknown compound.
• Understand the procedure of determination of boiling point in laboratories.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is the boiling point?
2. What is the importance of boiling point?
Practical Lesson Content Questions:
1. How to determine the boiling point of a compound?
2. What are the factors affecting the boiling point of a compound?
LESSON DETAILS
Pre-Requisite Skills-

Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• Physical properties of organic compounds.
• Factors affecting the physical properties.
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked about their understanding of the phenomenon of boiling. They will be asked to give various examples of evaporation/ volatility in daily life. Why do different substances encounter in daily life boil at different temperatures?
They will be asked to ponder upon the fact that sanitizers dry faster than water.
Apparatus & chemicals: 100 mL beaker, iron stand with clamp, tripod stand, bunsen burner, thermometer, capillary tube, wire gauze, thread, stirrer, small thin walled, given liquid and conc. Sulphuric acid.

EXPLORATION:

Students will be given an organic compound and asked to study its physical properties first. Then they will be asked to discuss the ways to determine its boiling point. Also, they will be asked to think about the factors affecting the boiling point.

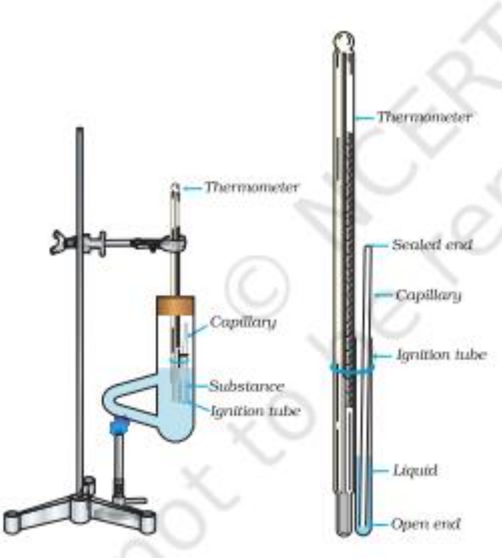
They will realize the need for a proper setup to determine the boiling point.

EXPLANATION:

Students will be asked to perform the following activity-

- Fill ⅔ of a small test tube with the given organic compound.
- Place the test tube to a thermometer with a rubber band such that the bottom of the tube is at the middle of the thermometer bulb. The rubber band should not be dipped in the acid bath.
- Place a beaker over a wire gauze on a tripod stand and half fill the

beaker with conc. Sulphuric acid.
• Clamp the thermometer carrying the test tube to an iron stand through a cork. Lower the thermometer along with the tube into the acid bath.
• Adjust the thermometer so its bulb is well under the acid and the open end of the tube with the rubber band is sufficiently outside the acid bath.
• Take a sealed capillary and place it in the test tube so that the sealed part of it stands in the liquid.
• Heat the acid bath slowly with gentle, continuous stirring.
• At first a bubble or two will be seen escaping at the end of the capillary tube dipped in the liquid, but soon a rapid and continuous stream of air bubbles escapes from it. At this stage the vapour pressure of the liquid just exceeds the atmospheric pressure.
• Note the temperature (t1) when a continuous stream of bubbles starts coming out.
• Remove from the flame and note the temperature (t2) when the evolution of bubbles from the end of the capillary tube just stops.
• The mean of these two temperatures gives the boiling point of the liquid.
• Allow the temperature to fall by 10oC and repeat the heating and again note the boiling point.
ELABORATION:
Students will be able to determine the boiling point of the organic compound. They will also understand different factors affecting the boiling point.
Similarly, boiling point could be easily achieved by performing the above experiment in a Thiele's tube instead of a beaker as shown below.



EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

1. What is the boiling point?
2. Why is the liquid bath stirred regularly during the determination of boiling point?
3. What are the precautions taken during the determination of boiling point?
4. What factors affect boiling point?

HOME ASSIGNMENT:

1. Perform the same experiment with a Thiele's tube. Compare the boiling point of different isomers of a same compound and try to account for the reason for any difference.

RESOURCES:

Laboratory Manual NCERT Class XI

BOOKS:

NCERT Textbook Class XI

WEB RESOURCES:

http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 25

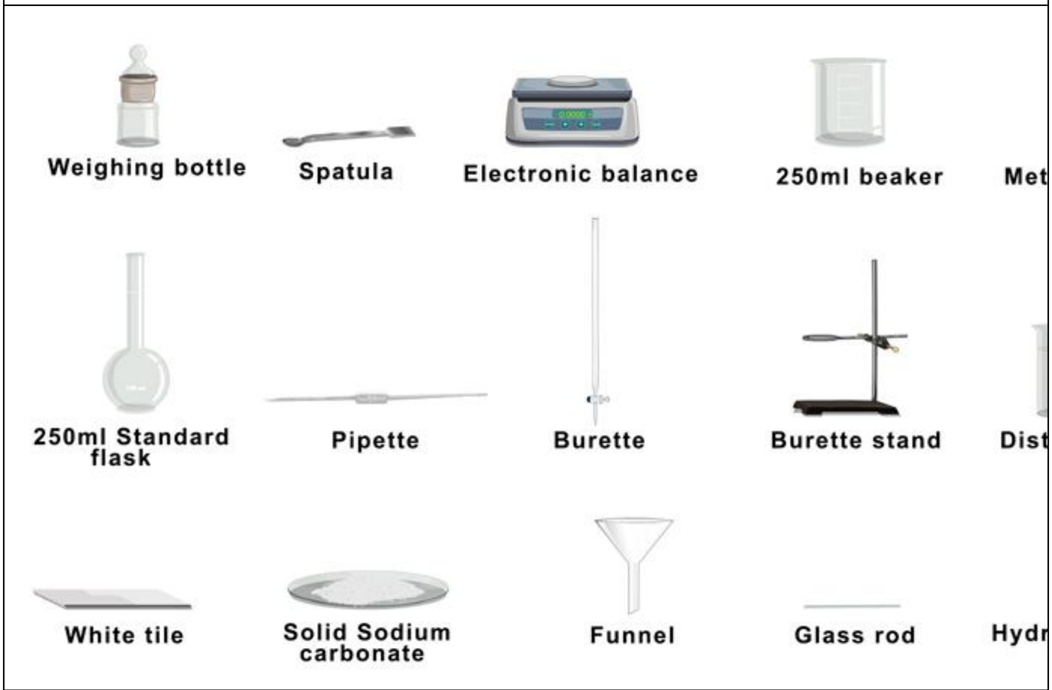
Class/ Grade Level - XI

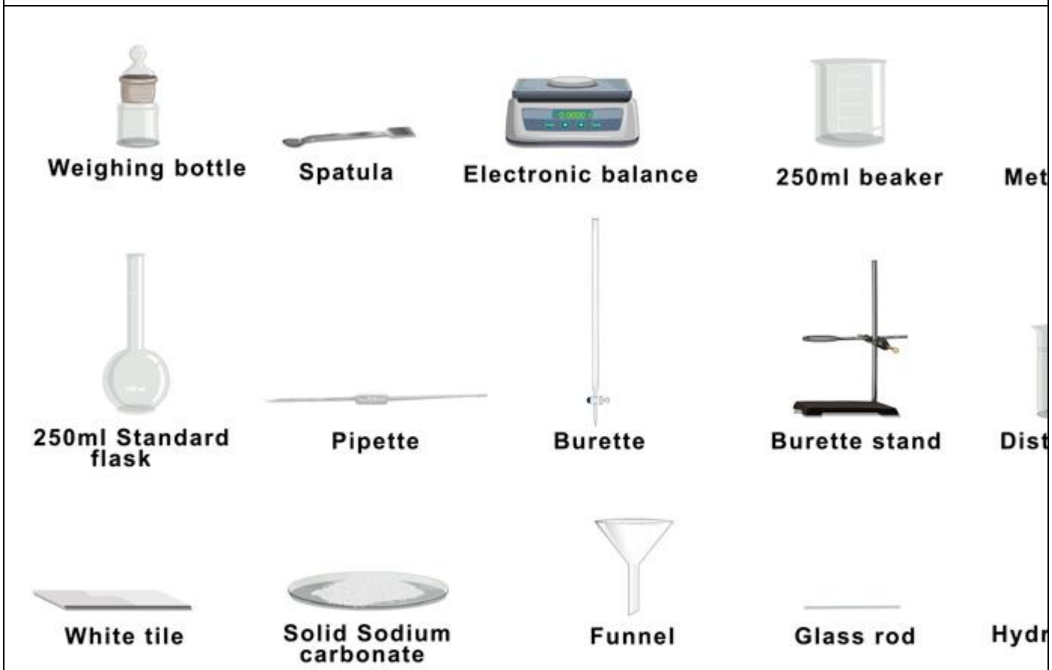
PRACTICAL OVERVIEW

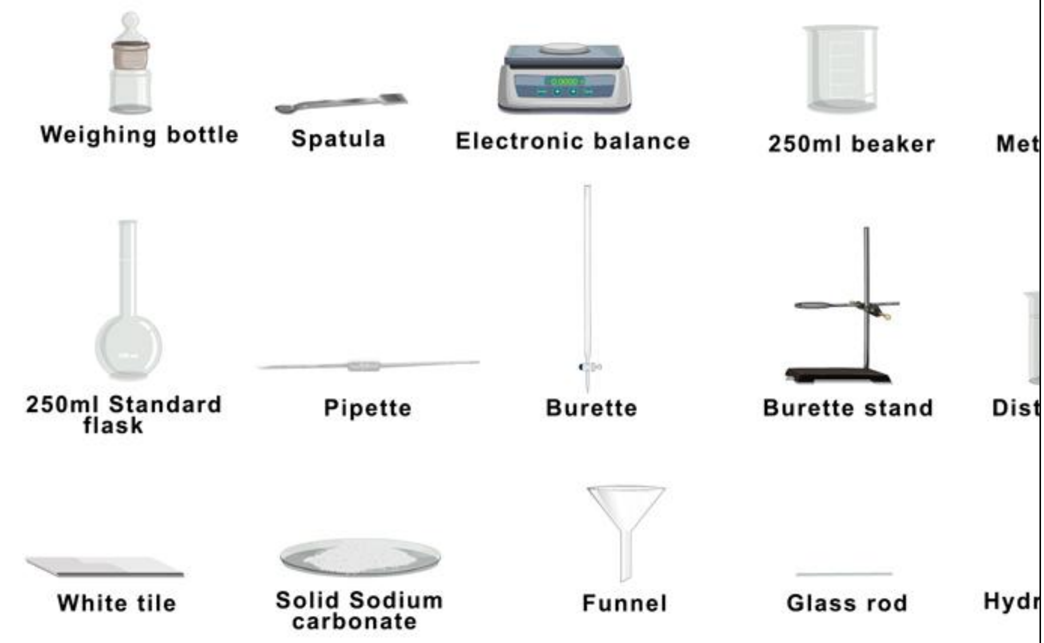
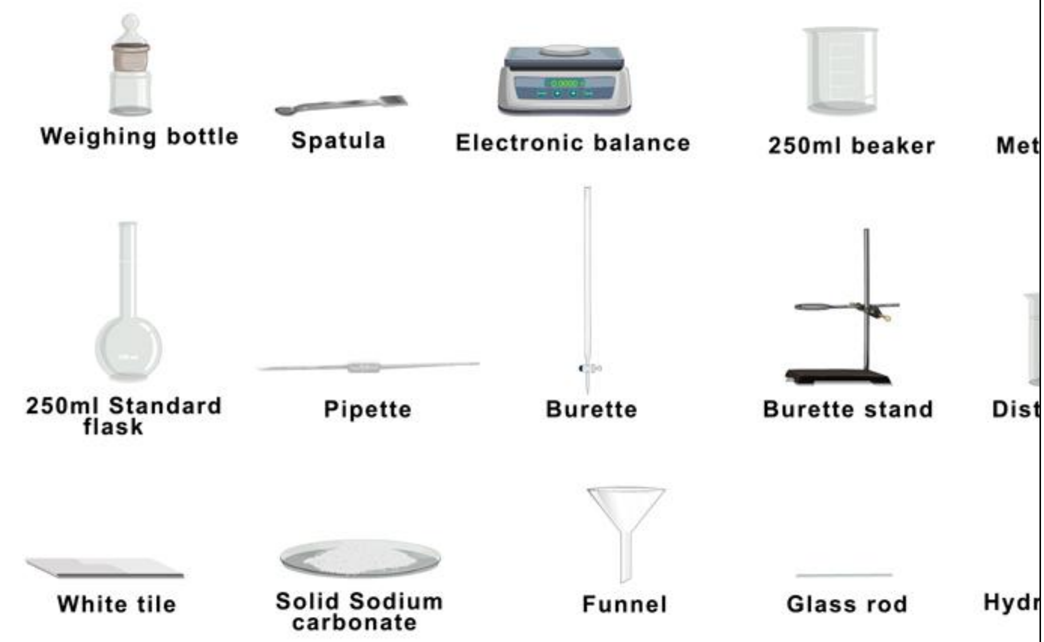
• **Practical Title**
To prepare a 250 mL standard solution of 0.1 M Sodium carbonate.
Practical Summary: Standard solutions are those solutions which have known concentration. It is prepared by dissolving a known amount of substance in a fixed volume of solvent. There are two types of standard solutions: primary and secondary. A standard solution is used to determine the unknown concentration of a solution of acid/base by volumetric analysis.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Preparation of standard solution of different concentration.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To prepare a 250 mL of 0.1 M standard solution of Sodium carbonate.
• To understand the preparation of different concentrations of standard solutions.
• To know the different ways of expressing the concentrations.
Learning Outcomes:
Learner will-
• Understand the terms: standard solution, molarity, normality, and molality.
• Learn to prepare different concentration solutions.
• Appreciate the use of standard solution in the determination of unknown concentration of analyte.

• Be able to express concentrations in different ways.
• Familiarize themself with the apparatus used in preparation of a solution.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is a standard solution?
2. What are different ways of expressing concentration?
Practical Lesson Content Questions:
1. What are the different apparatus used in the preparation of a standard solution?
2. What is the formula for calculating molarity, normality and molality.
3. What precautions should be taken while preparing the standard solution?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• Calculation of molecular mass.
• Calculation of number of moles.
• Equivalent mass.
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to differentiate between dilute and concentrated solutions. They will be guided towards the amount of solute in a solvent. They will be asked what they understand by concentration in daily life and compare it to the different concentrations of solutions in a laboratory.

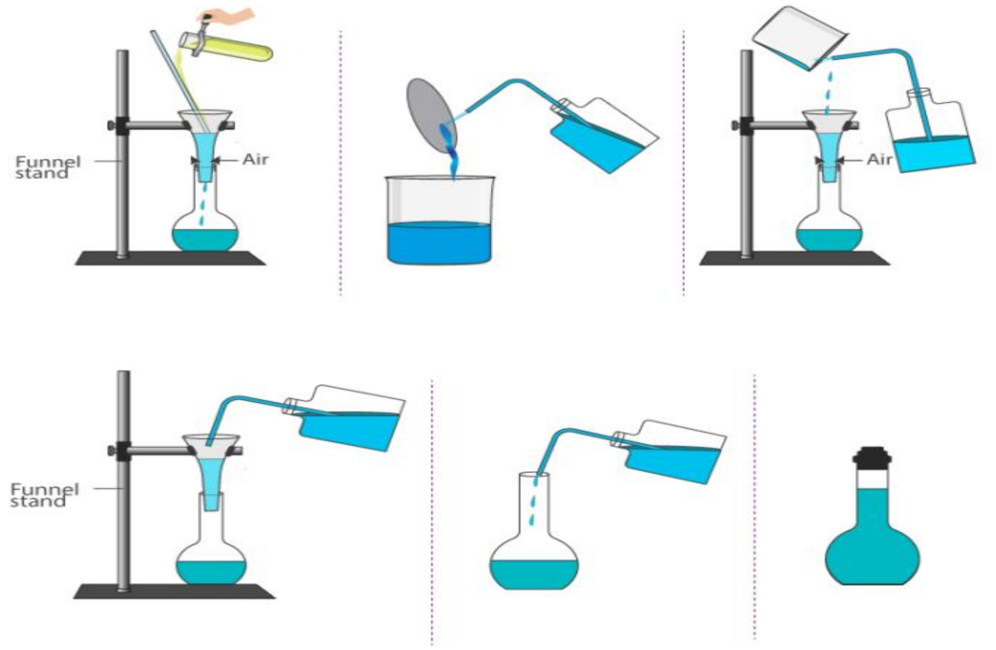
Apparatus and Chemicals required: Weighing bottle, spatula, electronic balance, 250 mL standard flask, pipette, funnel, funnel, solid sodium carbonate etc.





 
EXPLORATION:
• Students will have their own understanding of concentration.
• They will list various ways of expressing the concentrations, theoretically.
• Then, they will be asked to look for all possible apparatus to measure the volume accurately.
• They will try to calculate the amount of Sodium carbonate to be

dissolved for the solution.



- At this point, they will realize the need for understanding the formula for molarity.
- Also, they will try to figure out multiple apparatus for the accurate measurement of volume in a physical laboratory.

EXPLANATION:

Students will be asked to follow the following procedure-

- Weigh 2.65 g of sodium carbonate in a weight bottle on a digital balance and transfer the content in a 250 mL beaker carefully.
- Wash the weighing bottle 2-3 times with distilled water and transfer the washings into the beaker.
- Dissolve the sodium carbonate into a minimum amount of water with a glass rod.
- When sodium carbonate dissolves completely, transfer the content in a 250 mL standard/volumetric flask using a funnel and glass rod.
- Wash the beaker 2-3 times with distilled water and again transfer the contents into the volumetric flask carefully.

• Add distilled water to the volumetric flask so that the level is just below the calibration mark on it.
• Now, add distilled water to the volumetric flask with a pipette carefully and slowly so that the lower meniscus touches the calibration mark.
• Stopper the flask and shake gently to make the solution uniform.
ELABORATION:
Normality: It is defined as the number of gram equivalent of solute dissolved in one litre of the solution. It is denoted by the letter 'N'.
$\text{Normality} = \frac{\text{Number of gram equivalent of solute}}{\text{Volume of solution (in litre)}}$
Molarity: It is defined as the number of gram moles of solute dissolved in one litre of the solution. It is denoted by the letter 'M'.
$\text{Molarity} = \frac{\text{Number of gram moles of the solute}}{\text{Volume of the solution (in litre)}}$
Molality: It is defined as the number of moles of the solute dissolved in 1Kg of the solvent. It is denoted by the letter 'm'.
$\text{Molality} = \frac{\text{Number of moles of the solute}}{\text{Mass of the solvent (in Kg)}}$
CALCULATION:
Based on the formula of molarity, students will be asked to calculate the amount of Sodium carbonate required to dissolve in 250 mL of solvent.
In general, for preparing a solution of required molarity, the amount of substance to be weighed can be calculated by using the formula given below:
$\text{Molarity (M)} = \frac{\text{Mass of solute is grams} \times 1000}{\text{Molar mass of solute} \quad \text{(volume of solution to be prepared in mL)}}$
EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What is a molar solution?

2. What do you understand by 'weighing by transfer'?
3. Why are standard solutions prepared in volumetric flasks?
4. What is the need for standard solutions in volumetric analysis?
5. What is the need of adding distilled water while making a standard solution?
HOME ASSIGNMENT
1. Prepare 250 mL standard solution of 0.1 N sodium carbonate. Account for the difference between normality and molarity.
RESOURCES
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 26

Class/ Grade Level - XI

PRACTICAL OVERVIEW

PRACTICAL-TITLE To determine the strength of a given solution of hydrochloric acid by titrating it against standard sodium carbonate solution.
PRACTICAL SUMMARY: One of the important methods in Quantitative Analysis is Volumetric Analysis, a commonly used laboratory technique. It is used to determine the unknown concentration of a sample by measuring its volume. This process is also

called titration. In a titration, a solution of unknown concentration is reacted with a solution of known concentration. The solution taken in the burette is called the titrant and the solution taken in the conical flask is called the analyte.

SUBJECT AREA: Chemistry & Education

APPROXIMATE TIME NEEDED: 40 minutes

TARGETED CONTENT STANDARDS AND BENCHMARKS: Volumetric Analysis / Titration

21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES

OBJECTIVES: Enable the students to

1. Identify the acid and base in a reaction.
2. Calculate the concentration of an unknown acid by using titration.

LEARNING OUTCOMES:

Students will

1. understand the terms: quantitative estimation, acid-base titrations, end point, standard solutions, molarity, molality, normality, and indicators.
2. Students will calculate the strength of a given acid or base using molarity or normality equations.
3. Students will acquire the skill to prepare the standard solution and to determine the end point.
4. Students will acquire the skill to select the indicators based on the nature of the solution.
5. Students will be made familiar with the apparatus used for titration.
6. Students will acquire the skill to perform the titration using sodium carbonate and hydrochloric acid in the real lab with precision once they visualize the different steps.
7. Students will build theoretical and practical knowledge of volumetric analysis.
8. Take appropriate precautionary measures (do's and don'ts) while handling equipment, glass apparatus, chemicals during laboratory work.
9. Communicates the findings and conclusions effectively,

CURRICULUM FRAMING QUESTION

ESSENTIAL QUESTION:

1. Define neutralization titration.
2. What is the principle of volumetric analysis?
3. What is an indicator?

PRACTICAL LESSON CONTENT QUESTIONS:

1. What is end point?
2. What is a standard solution?
3. What is the relation between equivalent mass of a base/ acid and its molecular mass?

LESSON DETAILS:

PRE-REQUISITE SKILLS

CONCEPTUAL KNOWLEDGE:

Students should already be familiar with

- acidity and basicity,
- neutralization reactions,
- the pH scale
- Students will be familiarized with relation between normality and molarity
- role of indicator

LANGUAGE SKILLS:

Students should have the basic skill of making notes, comprehending, and organizing the matter.

ENGAGEMENT:

Teachers will ask the students to identify acidic and basic substances in their daily life. Further she will probe the students regarding mixing of acids and bases. Students will be asked to recollect their previous knowledge and write the reaction of various acids and bases in the notebook.

EXPLORE:

- Students will answer the queries, will observe keenly, and classify acids and bases.
- They will mix the given acid and base in a beaker and will try to find the

neutralization point.

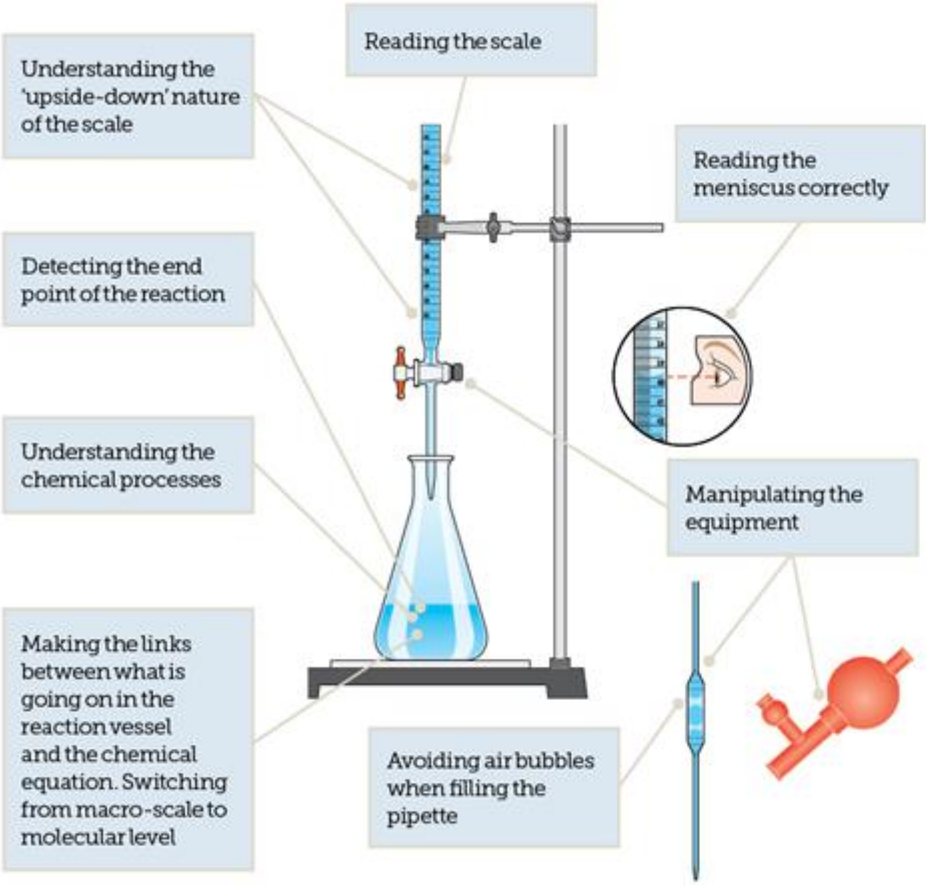
- As no colour change or precipitation or evolution of gas will happen, they will further investigate other method to find the point where reaction get completed.
- At this stage students will feel the need of some other chemical which may indicate the completion or end point, or neutralization point of the reaction.
- Students will be provided with methyl orange and will be asked to add it to acid and base and will observe their colour.

EXPLAIN:

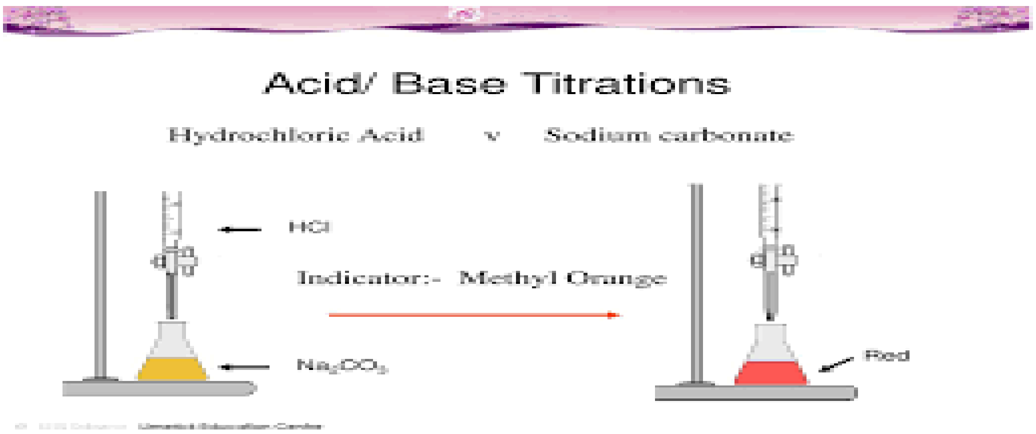
Students will be asked to perform the following activity.

- Take a burette and wash it with distilled water.

- Rinse and fill the burette with the given hydrochloric acid and set the initial burette reading as zero.
- Clamp it vertically to the burette stand.
- Rinse the pipette first with water and then with the given sodium carbonate solution.
- Pipette out 20ml of the given sodium hydroxide solution into a conical flask and add 1-2 drops of methyl orange into it.



- Titrate it against the hydrochloric acid taken in the burette till the colour of the solution in the conical flask changes from yellow to light red.



- Now note down the final burette reading.
- Repeat the same procedure until concordant values are obtained.

ELABORATE:

Students will be asked to record the observations in a tabular form as shown below

Sl. No.	Initial Reading of Burette	Final Reading of Burette	Volume of HCl used (ml)
1			
2			

Calculation:

Students will be given normality equation.

$$N_1V_1 = N_2V_2$$

They will be asked to write the reaction between the given acid and the base. Based on the reaction written they will come to know that 1 mole of sodium carbonate reacts with 2 moles of HCl

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

1 mole 2 moles

At this stage they will be able to derive molarity equation as

$$\mathbf{n_1 M_1V_1 = n_2 M_2V_2}$$

Afterwards, they will be asked to substitute the values and calculate the molarity of HCl.

Molarity is expressed in moles per litre. Subsequently they will be asked to convert moles per litre into gram per litre. In this way they will be able to derive the formula of strength which is as follows:

Strength = Molarity * Molar mass

In this way they will be able to get the value of molarity and strength of HCl.

- Students will be asked to perform the titration with different concentration of same acid and base.
- Students will be asked to perform the titration between different acids and bases.

EVALUATE (Viva – Voce)

1. What is the type of reaction involved in acid-alkali titration?

2. What is the pH of the solution obtained by the reaction between a strong acid and a strong base?
3. What is the volume of conc. HCl required to prepare 250ml 5N HCl solution? (Normality of conc. HCl = 12)
4. The molar mass of H_2SO_4 is 98 g mol-1. What is its equivalent mass
5. What is the colour of methyl orange in acidic and basic solution?
6. Why a titration flask should not be rinsed?
7. Why do we read lower meniscus of a colourless solution and upper meniscus of a coloured solution?
8. Burette and pipette must not be rinsed with the solution with which they are filled, Why?
9. Why the last drop of solution must not be blown out of a pipette?

RESOURCES:

- Laboratory Manual Chemistry for class XI - Published by NCERT

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 27

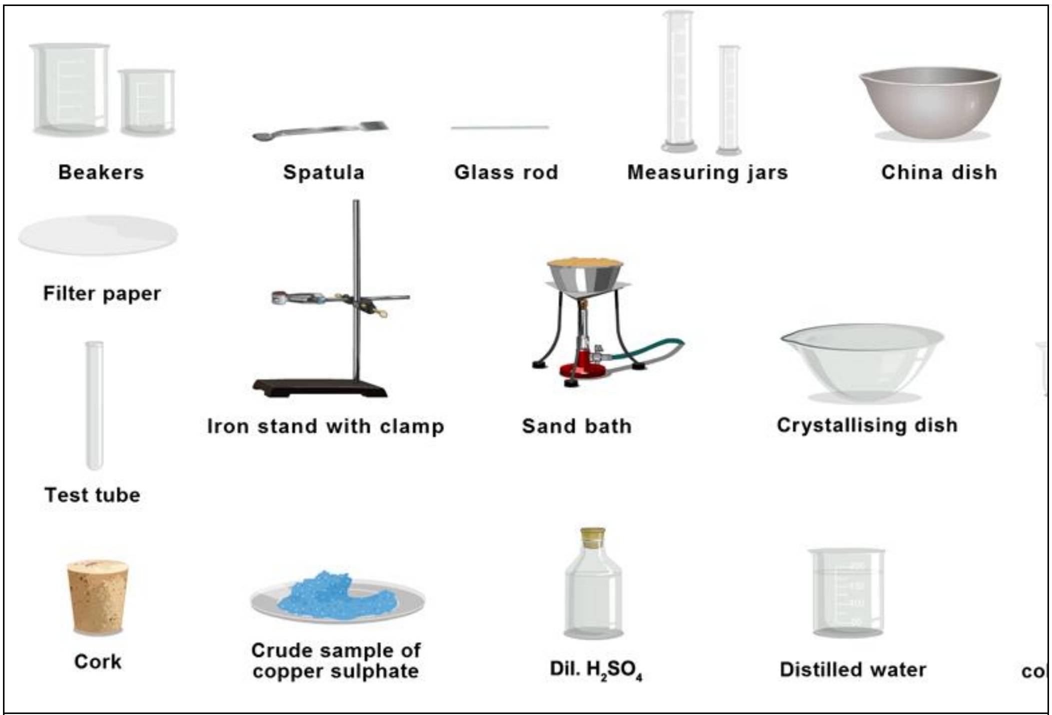
Class/ Grade Level - XI

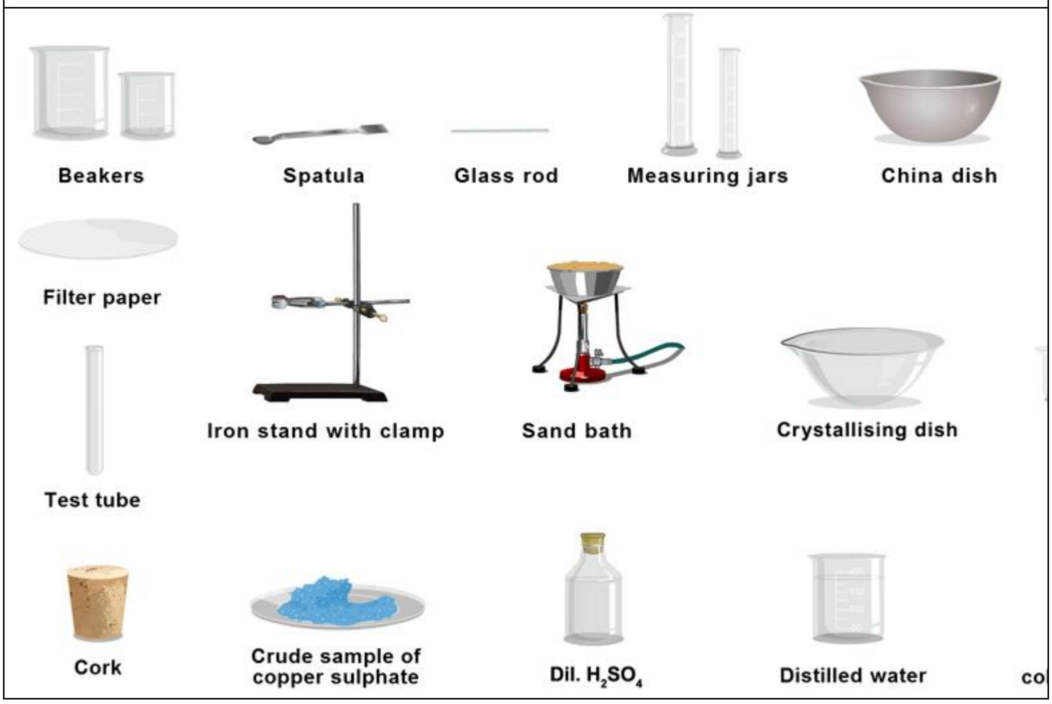
PRACTICAL OVERVIEW

• **Practical Title**
To purify impure sample of benzoic acid by the process of crystallization.
Practical Summary: The substances used for chemical purposes should be free of any kind of impurities i.e., they should be pure. These impurities may or may not be soluble in the solvent in which the substance under consideration dissolves. There are multiple methods available for the

purification of a substance, but they entirely depend on the nature of the impurity. Some examples of such methods are filtration, sedimentation, decantation, and crystallization. Crystallization is a separation technique to separate solids from a solution. Through this process, the atoms or molecules of a compound arrange themselves in a form of 3D lattice to minimize the energy of the system.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Purification using crystallization.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To prepare the crystals of benzoic acid from their impure samples through crystallization.
• To understand the procedure of crystallization in laboratories.
• To understand the principle of crystallization in purification techniques.
Learning Outcomes:
Learners will-
• Understand the meaning of the term: 'crystallization'.
• Acquire the skills of performing the experiment.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is crystallization?
2. What is the principle behind crystallization?
3. Why do we need purification techniques?
Practical Lesson Content Questions:
1. How to perform crystallization?
2. What are the precautions while performing crystallization?

3. What is mother liquor?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What is solute?
• What is solvent?
• What is a saturated solution?
Language Skills:
Students should have the basic skills of making notes, comprehending and organizing the matter.
ENGAGEMENT:
Students will be asked about their understanding of crystals. We will ask them to collect some examples of crystalline solids. How do they think crystallization could be used to purify the substance?
They will be asked about the harvesting of salts, sugar crystals etc. to attract their attention towards the topic.
Apparatus and Chemicals required: Beakers, spatula, glass rod, measuring jars, china dish, funnel, filter paper, crystallizing dish, crude sample of benzoic acid, distilled water etc.


Beakers
Spatula
Glass rod
Measuring jars
China dish
Filter paper
Iron stand with clamp
Sand bath
Crystallising dish
Test tube
Cork
Crude sample of copper sulphate
Dil. H_2SO_4
Distilled water


Beakers
Spatula
Glass rod
Measuring jars
China dish
Filter paper
Iron stand with clamp
Sand bath
Crystallising dish
Test tube
Cork
Crude sample of copper sulphate
Dil. H_2SO_4
Distilled water

EXPLORATION:

Students will be provided with an impure sample of benzoic acid. Based on their theoretical knowledge of crystallization, they will be asked to figure out a process to perform crystallization and purify the sample.

EXPLANATION:

Students will be asked to perform the following activity-

- Take around 150 mL of water in a beaker and boil it over a tripod stand.
- In another beaker, take 2-3 g of crude benzoic acid and gradually add a minimum amount of boiling water to it with stirring.
- Filter the solution immediately with a filter paper placed on a funnel.
- Let the filtered solution cool itself slowly and then cool it by placing it

in a cold-water bath.

- Separate the crystals by filtration using funnel and filter paper. Then wash the crystals with water and dry them on a filter paper.

ELABORATION:

Students will understand the whole procedure of crystallization. They will follow the steps and purify the benzoic acid. They will also be asked to weigh the obtained crystals and find out its % yield. They will also note down its shape and colour in the lab manual.

Alternate way to perform the recrystallization of benzoic acid-

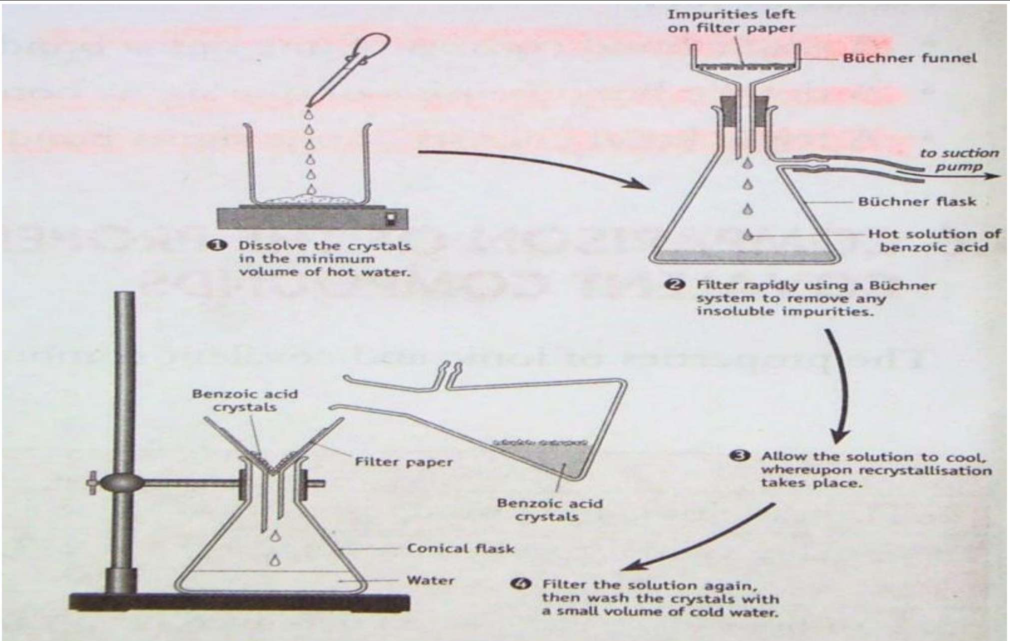


Fig. 5.6 Recrystallising benzoic acid using water as a solvent.

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

1. What is solubility?
2. What is the application of crystallization?
3. Where do we observe crystallization in daily life?
4. What is mother liquor? What is its purpose?
5. What is the structure of benzoic acid?
HOME ASSIGNMENT
1. Try recrystallizing a substance available at home like sugar or salt. Compare the shape, colour and size of the obtained crystals to that of benzoic acid crystals. Identify the reason behind the difference, if any.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 28

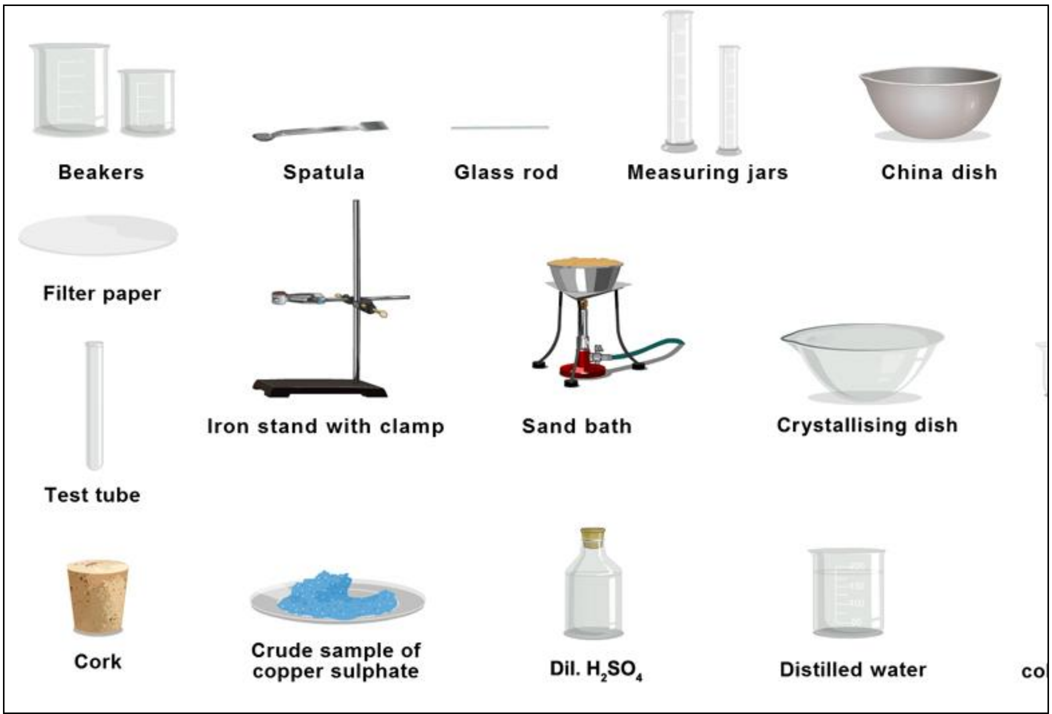
Class/ Grade Level - XI

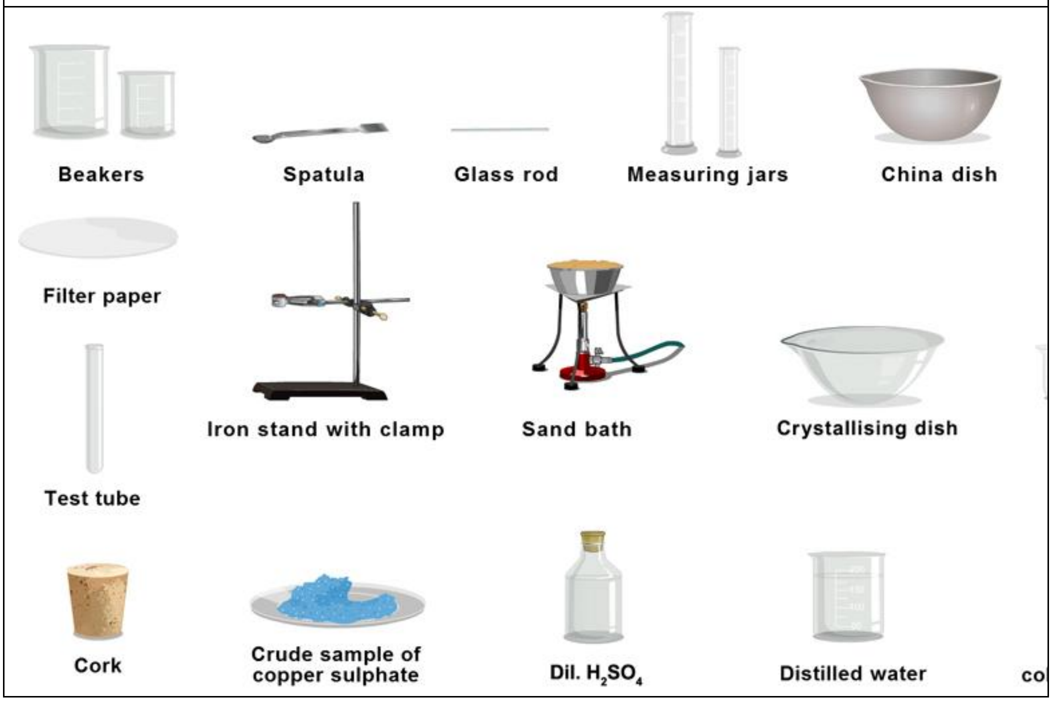
PRACTICAL OVERVIEW

• **Practical Title**
To purify impure sample of copper sulphate by the process of crystallization.
Practical Summary: The substances used for chemical purposes should be free of any kind of impurities i.e., they should be pure. These impurities may or may not be soluble in the solvent in which the substance under

consideration dissolves. There are multiple methods available for the purification of a substance, but they entirely depend on the nature of the impurity. Some examples of such methods are filtration, sedimentation, decantation, and crystallization. Crystallization is a separation technique to separate solids from a solution. Through this process, the atoms or molecules of a compound arrange themselves in a form of 3D lattice to minimize the energy of the system.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Purification using crystallization.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To prepare the crystals of copper sulphate from their impure samples through crystallization.
• To understand the procedure of crystallization in laboratories.
• To understand the principle of crystallization in purification techniques.
Learning Outcomes:
Learners will-
• Understand the meaning of the term: 'crystallization'.
• Acquire the skills of performing the experiment.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What is crystallization?
2. What is the principle behind crystallization?
3. Why do we need purification techniques?
Practical Lesson Content Questions:
1. How to perform crystallization?

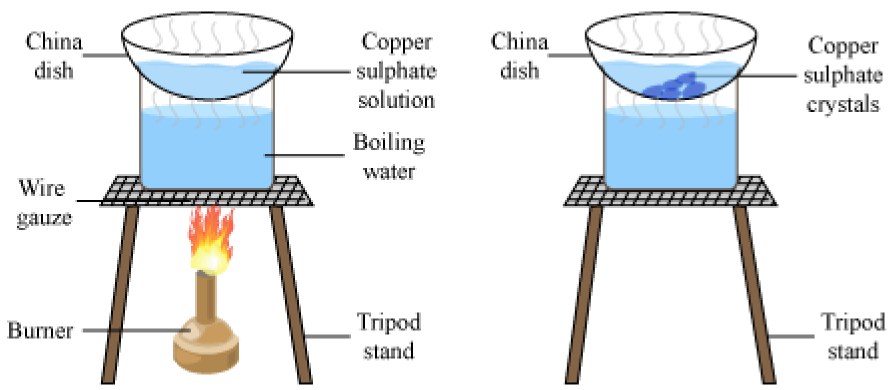
2. What are the precautions while performing crystallization?
3. What is mother liquor?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What is solute?
• What is solvent?
• What is a saturated solution?
Language Skills:
Students should have the basic skills of making notes, comprehending and organizing the matter.
ENGAGEMENT:
Students will be asked about their understanding of crystals. We will ask them to collect some examples of crystalline solids. How do they think crystallization could be used to purify the substance?
They will be asked about the harvesting of salts, sugar crystals etc. to attract their attention towards the topic.
Apparatus and Chemicals required: Beakers, spatula, glass rod, measuring jars, china dish, funnel, filter paper, crystallizing dish, crude sample of copper sulphate, dilute sulphuric acid, distilled water etc.


Beakers
Spatula
Glass rod
Measuring jars
China dish
Filter paper
Iron stand with clamp
Sand bath
Crystallising dish
Test tube
Cork
Crude sample of copper sulphate
Dil. H_2SO_4
Distilled water


Beakers
Spatula
Glass rod
Measuring jars
China dish
Filter paper
Iron stand with clamp
Sand bath
Crystallising dish
Test tube
Cork
Crude sample of copper sulphate
Dil. H_2SO_4
Distilled water

EXPLORATION:
Students will be provided with an impure sample of copper sulphate. Based on their theoretical knowledge of crystallization, they will be asked to figure out a process to perform crystallization and purify the sample.
EXPLANATION:
Students will be asked to perform the following activity-
• Add small quantities of crude copper sulphate to 25-30 mL of water in a beaker. Dissolve it completely.
• Add more copper sulphate to it and prepare a saturated solution. Add 2-3 mL of dilute sulphuric acid to make the solution clear.

• Filter the solution using a filter paper and funnel and collect in a china dish. Heat the contents of the china dish till the volume reaches one third at least with continuous stirring.
• Then, place the china dish on a water filled beaker and allow it to cool completely.
• Deep blue-coloured crystals will appear and in about half an hour, the crystallization is complete.
• Decant the mother liquor carefully and wash the crystals with ethyl alcohol containing a small amount of cold water.
• Transfer the filtered crystals on a filter paper and let it dry completely.



ELABORATION:

Students will understand the whole procedure of crystallization. They will follow the steps and purify the copper sulphate. They will also be asked to weigh the obtained crystals.

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:
1. What is solubility?
2. What is the application of crystallization?
3. Where do we observe crystallization in daily life?
4. What is mother liquor? What is its purpose?
5. Why do we add dilute sulphuric acid while preparing the saturated solution of copper sulfate?
HOME ASSIGNMENT
1. Observe the phenomenon of recrystallization in your surroundings taking place naturally. List the examples and discuss it in your class.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

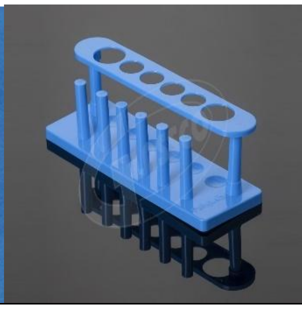
PRACTICAL LESSON PLAN NUMBER - 29

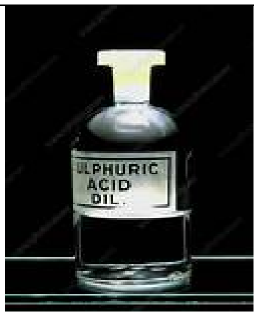
Class/ Grade Level - XI

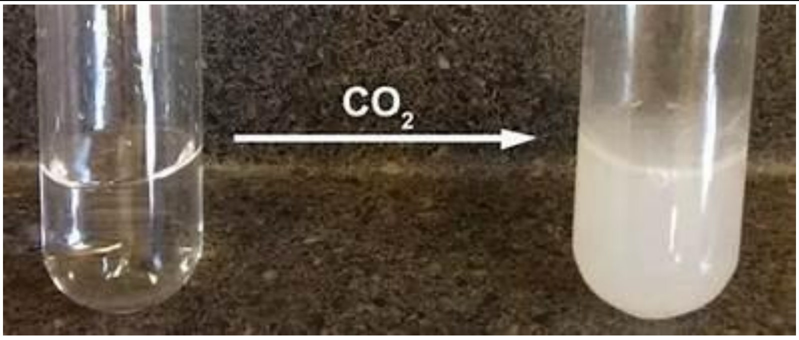
PRACTICAL OVERVIEW

• **Practical Title**
To determine the carbonate ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is

analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of carbonate ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine carbonate ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of carbonate ions.
Learning Outcomes:
Learners will-
• Be able to determine carbonate ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:

1. What are the physical characteristics of carbonate ion salts?
2. What precautions to be taken while performing the chemical analysis of carbonate ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to list the carbonate salts used in daily life. What is the main purpose of using carbonate salts in daily life?
will be asked to ponder if all the carbonate salts will be harmless? Students will be asked to draw the structure of carbonate ion based on Lewis dot structures and will also find out the hybridization of carbon.
Apparatus and chemicals required: Test tubes, Bunsen burner, dilute sulphuric acid, test tube holder, test tube stand, lime water, magnesium sulphate etc.
  


  
EXPLORATION:
Students will be provided with a salt and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.
They may also try heating the salt.
Eventually, they will realize they need chemical analysis for the confirmation of anion.
EXPLANATION:
Students will be asked to follow the procedure to determine carbonate ion in the salt-
• Take a small quantity of salt in a test tube. Add 2-3 mL dilute sulphuric acid to it. You will observe brisk effervescence if carbonate ion is

present.
• For confirmation test,
Take a small quantity of salt in a test tube and add 2-3 mL of dilute sulphuric acid. Then, pass the evolved gas through lime water. If lime water turns milky, it confirms the presence of carbonate ion.

• Another test for confirmation: Add magnesium sulphate solution to the salt solution. The formation of white precipitate confirms the carbonate ion.

ELABORATION:
When dilute sulphuric acid is added to the salt, carbon dioxide gas evolves which leads to the appearance of effervescence.
In the confirmation tests,
Lime water turns milky as carbon dioxide gas reacts with lime water to form calcium carbonate which appears milky.
When magnesium sulphate is added, carbon dioxide gas evolves from the salt and reacts with it and forms magnesium carbonate which precipitates out.
They will be asked to note down their observations in a practical lab file in

tabular form with 3 columns (experiment, observation, inference).
EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What type of bond is present in an inorganic salt?
HOME ASSIGNMENT
1. Identify the carbonate salts in the items used in your households like shampoo, cleaner etc.
List at least 5 products and the role of carbonate in the products.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

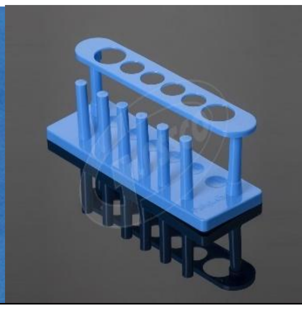
PRACTICAL LESSON PLAN NUMBER - 30

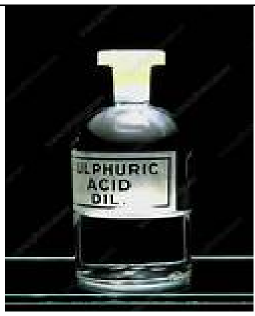
Class/ Grade Level - XI

PRACTICAL OVERVIEW

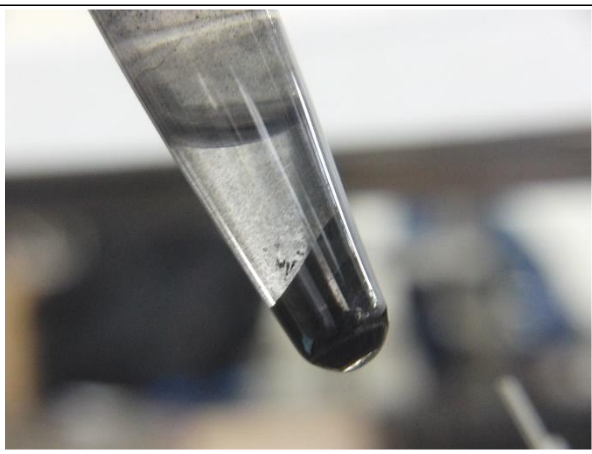
• **Practical Title**
To determine the sulphide ion in the given salt.

Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Determination of sulphide ion.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine sulphide ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of carbonate ions.
Learning Outcomes:
Learners will-
• Be able to determine sulphide ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?

Practical Lesson Content Questions:
1. What are the physical characteristics of carbonate ion salts?
2. What precautions to be taken while performing the chemical analysis of carbonate ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to find out the products containing sulphide anion used in daily life along with their uses. Also, ponder if those products have any harmful effect on human health.
Apparatus and chemicals required: Test tubes, Bunsen burner, dilute sulphuric acid, test tube holder, test tube stand, sodium nitroprusside, lead acetate, cadmium carbonate etc.
  


   
EXPLORATION:
Students will be provided with a salt and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.
They may also try heating the salt to check any smell or changes.
Eventually, they will realize they need chemical analysis for the confirmation of anion.
EXPLANATION:
Students will be asked to follow the procedure to determine sulphide ion in the

salt-
• Take a small quantity of salt in a test tube. Add 2-3 mL dilute sulphuric acid to it. If you observe rotten egg-like smell, sulphide ion may be present.
• For confirmation of the same, perform the following test.
1. Sodium nitroprusside test: Take a small amount of salt solution in a test tube and add a few drops of sodium nitroprusside solution. Purple or violet colour appearance confirms the presence of sulphide ion.

2. Lead acetate test: Take a small amount of salt solution in a test tube and add lead acetate solution to it. Appearance of black precipitate confirms the presence of sulphide ion.

3. Cadmium carbonate test: Take a small amount of salt solution, add a suspension of cadmium carbonate in water. Yellow precipitate confirms the presence of sulphide ion.

ELABORATION:

When dilute sulphuric acid is added to the salt, hydrogen sulphide gas evolves which leads to the smell of rotten eggs.

In the confirmation tests,

1. When sodium nitroprusside is added to the salt, the purple or violet colouration appears due to the complex formation with sulphide.
2. When lead acetate is added to the salt, black precipitate appears of PbS which confirms sulphide.
3. When cadmium carbonate is added to the salt, yellow precipitate of Cadmium sulphide is formed which confirms the presence of sulphide ion.

They will be asked to note down their observations in a practical lab file in tabular form with 3 columns (experiment, observation, inference).

EVALUATION (Viva – Voce)

Students will be asked to answer the following question:

1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What is the complex formed in the nitroprusside test?

HOME ASSIGNMENT

1. Take different samples of disposed water from your kitchen, washroom, and school as well. Identify the presence of sulphide ion in the samples.

RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 31

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the nitrate ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of nitrate ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES

Objectives:
• To determine nitrate ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of nitrate ions.
Learning Outcomes:
Learners will-
• Be able to determine nitrate ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of nitrate ion salts?
2. What precautions to be taken while performing the chemical analysis of nitrate ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?

Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Nitrogen is an important part of the ecosystem. Nitrate anion plays a vital role in nitrogen fixation also. Read about the nitrogen cycle and the role of nitrate salts in it.
What do you think will happen if nitrate salts were not present?
Apparatus and chemicals required: Test tubes, Bunsen burner, conc. sulphuric acid, test tube holder, test tube stand, diphenylamine, copper chips, ferrous sulphate etc.
   
 

EXPLORATION:

Students will be provided with a salt and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.

They may also try heating the salt. They may observe fumes.

Eventually, they will realize they need chemical analysis for the confirmation of anion.

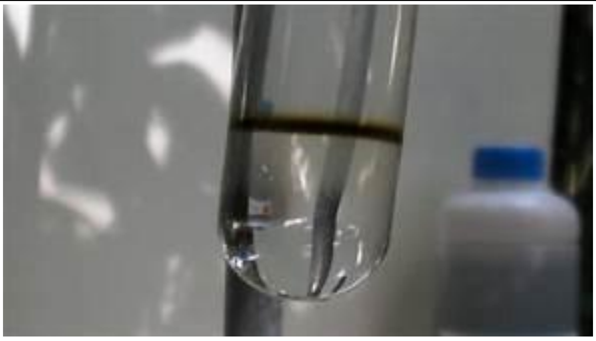
EXPLANATION:

Students will be asked to follow the procedure to determine the presence of nitrate ion in the salt-

- Take a small quantity of the salt in a dry test tube and heat it. You may observe colored fumes which indicate the presence of nitrite/nitrate/chloride/iodide ions.
- Further, take a small quantity of salt in a test tube, add 1-2 mL of conc. sulphuric acid. You may observe the evolution of brown vapours of nitrogen peroxide if nitrate is present.
- For confirmation,

1. Diphenylamine test: Take a part of aqueous solution of the salt and add a few drops of diphenylamine. Appearance of deep blue colouration confirms the presence of nitrate ion.

2. Copper Chip test: Heat a small quantity of the original salt with concentrated sulphuric acid and a few copper chips. Evolution of dark brown

fumes confirms the presence of nitrate ion.
3. Brown Ring test: Take a part of the aqueous solution and add a small quantity of freshly prepared solution of ferrous sulphate to it. Then, pour concentrated sulphuric acid slowly along the sides of the test tube. A dark brown ring is formed at the junction of the layers of the acid and the solution which confirms the presence of nitrate ion.

ELABORATION:
When conc. Sulphuric acid is added to the salt, evolution of brown vapours of nitrogen peroxide marks the presence of nitrate ion.
For confirmation,
1. Diphenylamine test: In the presence of nitrate diphenylamine gets oxidised, giving a blue colouration.
2. Copper Chip test: The reddish-brown fumes are due to the formation of NO_2 gas.
3. Brown Ring test: The brown ring is due to the formation of a nitrosonium complex.
They will be asked to note down their observations in a practical lab file in tabular form with 3 columns (experiment, observation, inference).
EVALUATION (Viva – Voce)
Students will be asked to answer the following question:
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation test?
3. Write down the reaction observed in the performed tests?
4. What is the chemical formula of the complex formed at brown ring?

HOME ASSIGNMENT
1. Different fruits and green leafy vegetables like spinach, beetroot, mustard green, radish, turnip etc. Extract their fresh juices and identify the presence of nitrate ion in the same.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 32

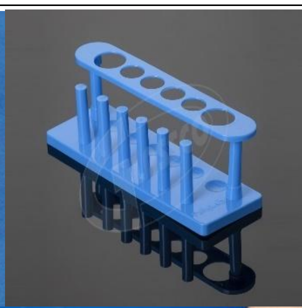
Class/ Grade Level - XI

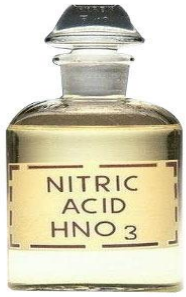
PRACTICAL OVERVIEW

• **Practical Title**
To determine the chloride ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out in order to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.

Targeted Content Standards and Benchmarks: Confirmation of chloride ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine chloride ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of chloride ions.
Learning Outcomes:
Learners will-
• Be able to determine chloride ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of chloride ion salts?
2. What precautions to be taken while performing the chemical analysis of chloride ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating and handling of apparatus.

Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending and organizing the matter.
ENGAGEMENT:
Students will be asked to understand the role of chloride ions in nature. In what areas chloride ions are in abundance?
What is the role of chloride ion in the human body? What will happen if the level of chloride is not maintained in the human body?
Apparatus and chemicals required: Test tubes, Bunsen burner, conc. sulphuric acid, test tube holder, test tube stand, silver nitrate, dilute nitric acid, potassium dichromate, acetic acid, lead acetate, etc.



EXPLORATION:

Students will be provided with a salt and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.

They may also try heating the salt.

Eventually, they will realize they need chemical analysis for the confirmation of anion.

EXPLANATION:

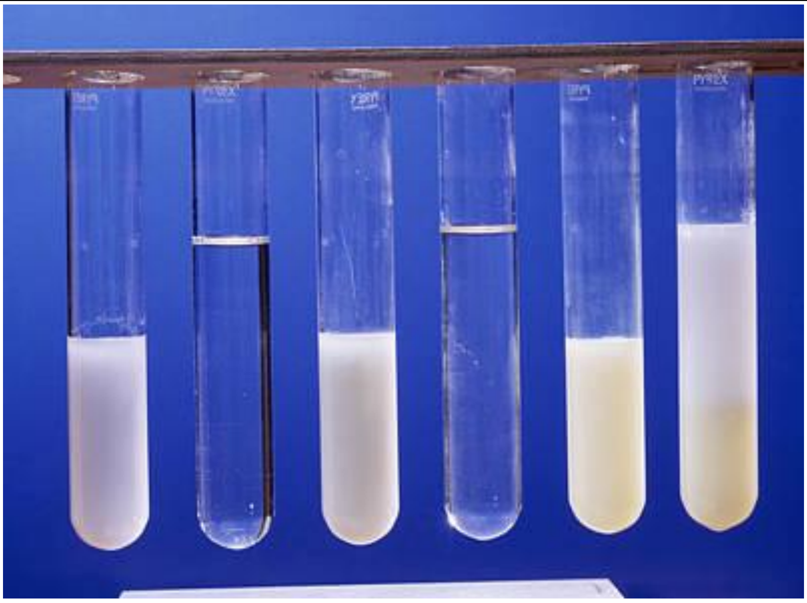
Students will be asked to follow the procedure to determine chloride ion in the salt-

- Take a small quantity of the salt in a dry test tube and heat it. If you observe colourless fumes with a pungent smell, chloride may be present.

- Further, take a small quantity of salt in a test tube, add 1-2 mL of conc. sulphuric acid. You may observe colourless gas with a pungent smell, form white fumes with aqueous ammonia when a glass rod dipped in aqueous ammonia is shown over the mouth of the test tube.

- For confirmation,

1. Silver Nitrate test: Take a portion of aqueous solution and acidify it with dil. HNO_3. Boil it for some time, let it cool and then add silver nitrate solution to it. A white precipitate soluble in ammonium hydroxide confirms the presence of chloride.



2. Chromyl Chloride test: Mix a small quantity of the salt with a small amount of powdered potassium dichromate. Take the mixture in a test tube and add conc. H_2SO_4.

Heat the test tube and pass the red vapors evolved into the gas detector containing NaOH solution. To the yellow solution thus obtained, add dil. CH_3COOH and lead acetate solution. A yellow precipitate confirms the presence of chloride ion.

ELABORATION:

When conc. Sulphuric acid is added to the salt, evolution of colorless vapours with a pungent smell of HCl gas marks the presence of chloride ion.

1. Silver nitrate test: A white precipitate of silver chloride is formed which dissolves in ammonium hydroxide forming a soluble complex.
2. Chromyl chloride test: The red fumes are due to the formation of chromyl chloride (CrO_2Cl_2).

CrO_2Cl_2 reacts with NaOH to form a yellow solution of sodium chromate (Na_2CrO_4). Na_2CrO_4 reacts with lead acetate in the presence of dil. acetic acid to form yellow precipitate of lead chromate ($PbCrO_4$).

They will be asked to note down their observations in a practical lab file in tabular form with 3 columns (experiment, observation, inference).

EVALUATION (Viva – Voce)

Students are asked to answer the following question based on the experiment-

1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation test?
3. Write down the reaction observed in the performed tests?
4. Write the chemical formula of soluble complex formed in silver nitrate test.

HOME ASSIGNMENT

1. Take three samples of water, home tap water, school tap water and distilled water. Identify the presence of chloride ion in the samples. Also, try to comment on the concentration of chloride ion in the

samples with respect to the amount of the precipitate.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 33

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the bromide ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of bromide ion in salt.

21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine bromide ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of bromide ions.
Learning Outcomes:
Learners will-
• Be able to determine bromide ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of bromide ion salts?
2. What precautions to be taken while performing the chemical analysis of bromide ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?

- What physical skills are accounted for in physical examination of salts?

Language Skills:

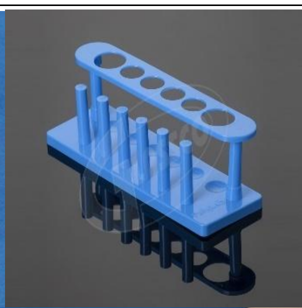
Students should have the basic skills of making notes, comprehending, and organizing the matter.

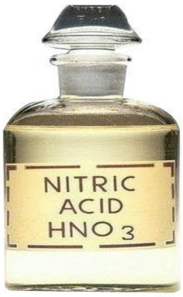
ENGAGEMENT:

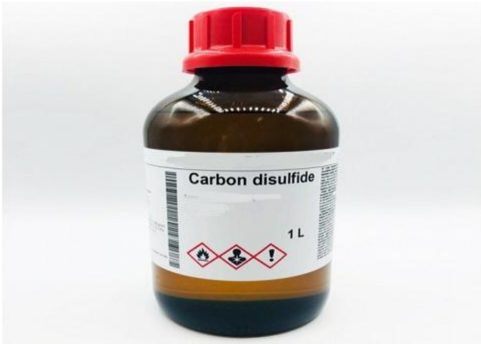
In daily life, bromine is usually identified in pesticides and water treatment solutions. Students will be asked to find out the ways in which bromine is used in mentioned solutions. What salts are used? How do those salts work? What is the quantity used for such salts?

Also, find out if the human body needs bromine?

Apparatus and chemicals required: Test tubes, Bunsen burner, conc. sulphuric acid, test tube holder, test tube stand, silver nitrate, dilute nitric acid, Manganese dioxide, carbon disulphide, etc.





EXPLORATION:

Students will be provided a salt and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.

They may also try heating the salt.

Eventually, they will realize they need chemical analysis for the confirmation of anion.

EXPLANATION:

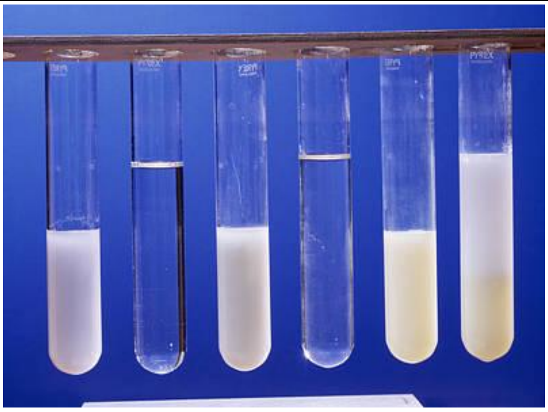
Students will be asked to follow the procedure to determine bromide ion in the salt-

- Take a small quantity of salt in a test tube, add 1-2 mL of conc. sulphuric acid. You may observe reddish brown gas with a pungent smell, which when brought near a starch paper, turns the paper yellow.

- For confirmation,

1. Silver Nitrate test: Take a portion of aqueous solution and acidify it with dil. HNO_3. Boil it for some time, let it cool and then add silver nitrate solution to it. A light-yellow precipitate partially soluble in ammonium hydroxide

confirms the presence of bromide.



2. Manganese dioxide test: Heat a small quantity of the salt with solid MnO_4 and conc. H_2SO_4. Evolution of yellow brown vapour of bromine which turns starch paper yellow confirms the presence of bromide ions.

3. Chlorine water test: Take a portion of aqueous solution of salt and acidify it with dil. HCl. Add 1-2 mL of carbon disulphide and then chlorine water. Shake vigorously and allow it to stand. If the carbon disulphide layer acquires orange colouration, bromide ion is present.

ELABORATION:

When conc. Sulphuric acid is added to the salt, evolution of reddish-brown vapours with a pungent smell of Br_2 gas marks the presence of bromide ion.

1. Silver Nitrate test: A light yellow ppt. is obtained which is partially soluble in ammonium hydroxide.
2. Manganese dioxide test: Evolution of yellowish-brown vapours of bromine takes place, which turns the starch paper yellow.
3. Chlorine water test: Bromine liberated during the reaction being

soluble in carbon disulphide (CS_2) imparts an orange colour to the CS_2 layer.
EVALUATION (Viva – Voce)
Students are asked to answer the following question based on the experiment-
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. Write the chemical formula of partially soluble complex formed in silver nitrate test.
5. How do you prepare chlorine water?
HOME ASSIGNMENT
1. Bromide ion is known to be present in sedative drugs. One of the commonly available sedative drugs is Xanax. You can identify the presence of bromide ion in the drug.
2. Bromide is also added as a food additive in breads. Collect different samples of bread and identify the presence of ion in it. Also, find out the form in which bromide is added in the food.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 34

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the sulphate ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out in order to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of sulphate ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine sulphate ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of sulphate ions.
Learning Outcomes:
Learners will-
• Be able to determine sulphate ion in given salt.
• Understand all the chemical reactions taking place in various tests.

• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of sulphate ion salts?
2. What precautions to be taken while performing the chemical analysis of sulphate ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Students will be asked to list at least three different sulphate salts and their uses in daily life. Also, try to identify the harmful effects of sulphate in nature.
Apparatus and chemicals required: Test tubes, Bunsen burner, conc. sulphuric acid, test tube holder, test tube stand, Barium chloride, sodium carbonate, charcoal, sodium nitroprusside, china dish, lead acetate, ammonium acetate etc.





ACID
CONC.

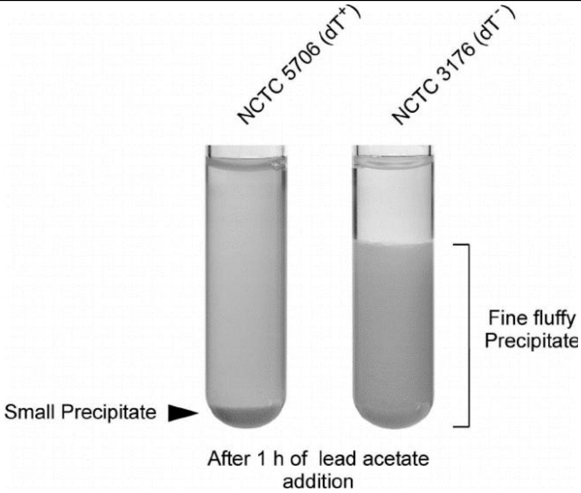

Danger
BARIUM
CHLORIDE

Sodium Carbonate


EXPLORATION:
Students will be provided with a salt and asked to identify the anion present in it. They will be asked to judge the physical characteristics of the salt like color, smell, density etc.
They may also try heating the salt.
Eventually, they will realize they need chemical analysis for the confirmation of anion.

EXPLANATION:
Students will be asked to follow the procedure to determine sulphate ion in the salt-
• Take a small amount of salt and boil it with dilute HCl in a test tube. Then, filter the solution and to the filtrate, add $BaCl_2$ solution. A white precipitate may indicate the presence of sulphate ions.
• For confirmation,
1. Barium Chloride test: To a part of aqueous solution of the salt add barium chloride solution. A white precipitate is observed. Add dil. HCl to it and shake. The white precipitate will be insoluble in HCl.

2. Matchstick test: Mix a small amount of the salt with sodium carbonate and a little powdered charcoal so as to get a paste. Take some of this paste on one end of a wooden splinter and heat in the reducing flame till the mass fuses. Dip the fused mass into a sodium nitroprusside solution taken in a china dish. Violet streaks mark the presence of sulphate ion.
3. Lead acetate test: Take a part of aqueous solution of salt and add lead acetate solution. A white precipitate is formed which is insoluble in excess of hot ammonium acetate solution confirms the presence of sulphate.



ELABORATION:
When Barium chloride is added to the acidified aqueous solution of salt, the white precipitate of barium sulphate indicates the presence of sulphate ion.
For confirmation,
1. Barium Chloride test: Insoluble precipitate of barium sulphate in dil. HCl is observed as the confirmation of sulphate ion.
2. Matchstick test: Violate streaks confirms the presence of sulphate ion.
3. Lead acetate test: The white precipitate is lead sulphate ($PbSO_4$) which is insoluble in excess of hot ammonium acetate. This confirms the presence of sulphate ion.
They will be asked to note down their observations in a practical lab file in tabular form with 3 columns (experiment, observation, inference).
EVALUATION (Viva – Voce)
Students are asked to answer the following question based on the experiment-
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What are the uses of sulphate salts in daily life?
HOME ASSIGNMENT
1. Test for the presence of sulphate ion in different varieties of detergents. You may also test in shampoo.

RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB-RESOURCES: http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 35

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the phosphate ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of phosphate ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:

• To determine phosphate ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of phosphate ions.
Learning Outcomes:
Learners will-
• Be able to determine phosphate ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of anion in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of phosphate ion salts?
2. What precautions to be taken while performing the chemical analysis of phosphate ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:

Students should have the basic skills of making notes, comprehending, and organizing the matter.

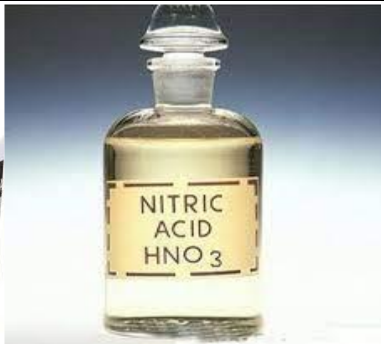
ENGAGEMENT:

Students will be asked to ponder the biological importance of phosphate salts. They will be asked to understand the role of phosphate ions in the human body especially.

Also, what is the commercial importance of phosphate?

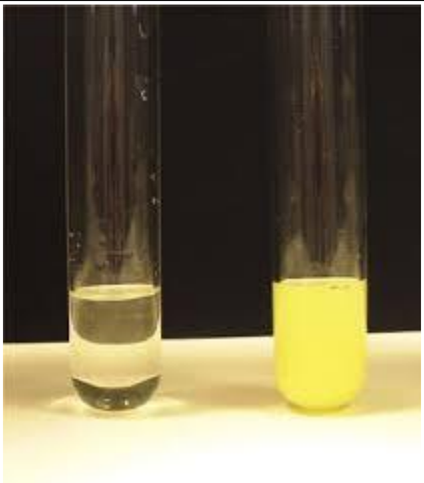
Apparatus and chemicals required: Test tubes, bunsen burner, conc. sulphuric acid, test tube holder, test tube stand, ammonium molybdate, nitric acid, magnesia mixture etc.

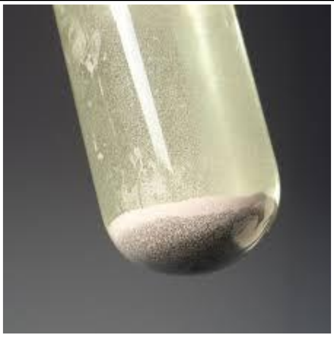


EXPLORATION:

Students will be provided with a alt and asked to identify the anion present in

it. They will be asked to judge the physical characteristics of the salt like color, smell, density etc.
They may also try heating the salt.
Eventually, they will realize they need chemical analysis for the confirmation of anion.
EXPLANATION:
Students will be asked to follow the procedure to determine phosphate ion in the salt-
• Take a small amount of salt and boil it with dilute nitric acid in a test tube. Add a few drops of ammonium molybdate solution to it. A yellow precipitate may indicate the presence of phosphate ions.
• For confirmation,
1. Ammonium molybdate test: To the aqueous solution add concentrated nitric acid and boil. Add ammonium molybdate solution in excess and again boil. Yellow precipitate will confirm the presence of phosphate ion.

2. Magnesia mixture test: Take a small amount of aqueous solution of salt. Add magnesia mixture to it and allow to stand. Presence of white precipitate confirms the phosphate ion.



ELABORATION:

When ammonium molybdate is added to the acidified aqueous solution of salt, the yellow precipitate of ammonium phosphate molybdate indicates the presence of phosphate ion.

For confirmation,

1. Ammonium molybdate test: yellow precipitate of ammonium phosphate molybdate is observed as the confirmation of phosphate ion.
2. Magnesia mixture test: White precipitate of magnesium ammonium phosphate is observed as the confirmation of phosphate ion.

EVALUATION (Viva – Voce)

Students are asked to answer the following question based on the experiment-

1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation test?
3. Write down the reaction observed in the performed tests?
4. What are the chemical formulas of ammonium phosphate molybdate and magnesium ammonium phosphate? Also, what is the oxidation state of phosphorus in both the chemical compounds?

HOME ASSIGNMENT

1. Collect soil from a plant at your home and test for the presence of phosphate in the same.

RESOURCES:

Laboratory Manual NCERT Class XI

BOOKS:

NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 36

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the ammonium ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes color, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the presence of cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of ammonium ion in salt.
21^{st} CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine ammonium ion in the given salt.
• To understand the physical and chemical examination of cation.

• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of ammonium ions.
Learning Outcomes:
Learners will-
• Be able to determine ammonium ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of cation in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
3. What is the criteria of identification of an ion?
Practical Lesson Content Questions:
1. What are the physical characteristics of ammonium ion salts?
2. What precautions to be taken while performing the chemical tests of ammonium ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and

organizing the matter.

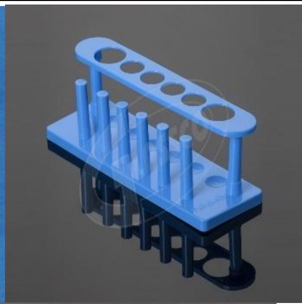
ENGAGEMENT:

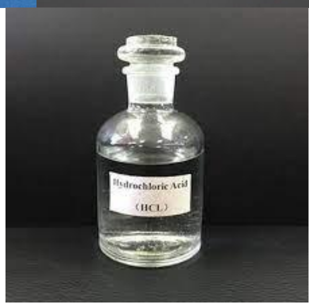
Ammonium salts are used as a rich source of nitrogen in fertilizers. What are the other biological importance of ammonium salts?

Ammonium salts are also an important component of medicines, and it also has other commercial uses.

Look for other uses and importance of the ammonium salts including its role in nitrogen cycle.

Apparatus and chemicals required: Test tubes, Bunsen burner, dil. hydrochloric acid, test tube holder, test tube stand, concentrated sodium hydroxide, Nessler's reagent etc.





EXPLORATION:

Students will be provided with a salt and asked to identify the cation present in

it. They will be asked to judge the physical characteristics of the salt like color, smell, density etc.
They may also try heating the salt.
Eventually, they will realize they need chemical analysis for the confirmation of cation.
EXPLANATION:
Students will be asked to follow the procedure to determine ammonium ion in the salt-
• Take a small amount of solid salt in a test tube. Add concentrated solution of sodium hydroxide to it and heat the contents. You may observe an ammoniacal smell if ammonium ion is present.
• For confirmation,
1. Take a small amount of solid salt in a test tube. Add concentrated solution of sodium hydroxide to it and heat the contents. Dip a glass rod in HCl and bring it near the mouth of the test tube. You will observe white fumes which confirms the presence of ammonium ion.

2. Nessler's reagent test: Pass the gas evolved in above test through Nessler's reagent taken in a test tube. Brown precipitate is formed which confirms the presence of ammonium ion.

ELABORATION:

When sodium hydroxide is added to the solid salt, ammonia gas is evolved as a preliminary examination of ammonium salt.

In the examination tests,

1. When a glass rod dipped in dil. HCl is brought near the mouth of the test tube, a gas evolved is ammonia which gives white fumes with HCl due to the formation of NH_4Cl.
2. When the gas evolved in the above test is passed through Nessler's reagent, brown precipitate is observed due to formation of a complex $H_2N.HgO.HgI$. It confirms the presence of ammonium ion.

They will be asked to note down their observations in a practical lab file in tabular form with 3 columns (experiment, observation, inference).

EVALUATION (Viva – Voce)

Students are asked to answer the following question based on the experiment-

1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What is Nessler's reagent?
5. What is the complex formed with Nessler's reagent?
6. How do pass the gas evolved through the Nessler's reagent?

HOME ASSIGNMENT

1. Collect soil from a plant at your home and test for the presence of

ammonium ion in the same.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

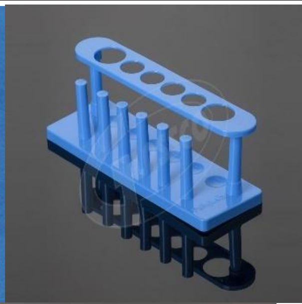
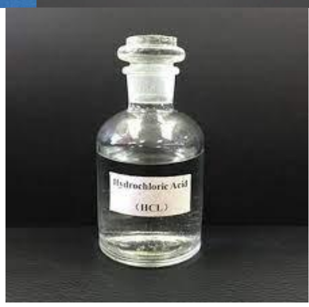
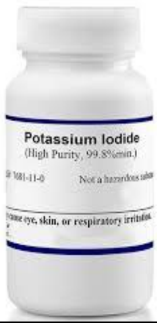
PRACTICAL LESSON PLAN NUMBER - 37

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the lead ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analysed for the radicals, i.e., cation and anion. The physical examination of salt includes colour, state, smell or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of lead ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES

Objectives:
• To determine lead ion in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of lead ions.
Learning Outcomes:
Learners will-
• Be able to determine lead ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of cation in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of lead ion salts?
2. What precautions to be taken while performing the chemical analysis of lead ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?

Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Lead is known as a toxic metal. Find out the lethal dose of lead for a human body?
What will be the repercussions if lead is thrown in a water body?
How do you think lead can be extracted from water? Try reading recent research articles on lead pollution and its measures.
Apparatus and chemicals required: Test tubes, Bunsen burner, dil. hydrochloric acid, test tube holder, test tube stand, potassium iodide, potassium chromate etc.
   
 

EXPLORATION:

Students will be provided with a salt and asked to identify the cation present in it. They will be asked to judge the physical characteristics of the salt like color, smell, density etc.

They may also try heating the salt.

Eventually, they will realize they need chemical analysis for the confirmation of cation.

EXPLANATION:

Students will be asked to follow the procedure to determine lead ion in the salt-

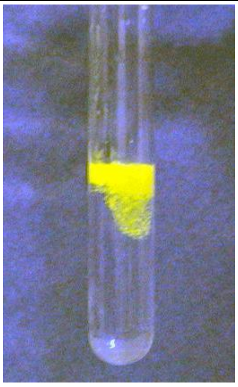
- Take a small amount of salt solution and add dilute HCl to it. Then, centrifuge the content and wash the precipitate. Presence of white precipitate indicates the lead cation in salt.

- For confirmation,

Boil the white precipitate with 5-10 mL of water. Precipitate will dissolve. $PbCl_2$ is soluble in hot water. Then, divide the solution into three parts.

1. Cool the first part. White crystalline precipitate of $PbCl_2$ will be observed as the confirmation of lead ion.


2. Potassium iodide test: To the second part of the solution, add potassium iodide solution. Yellow precipitate due to the formation of PbI_2 will be observed as the confirmation of lead ion.

3. Potassium chromate test: To the third part of the solution, add potassium chromate solution. Yellow precipitate due to the formation of $PbCrO_4$ will be observed as the confirmation of lead ion.

ELABORATION:
When HCl is added to the salt solution, precipitate of $PbCl_2$ is observed indicating the presence of lead cation.

When the white ppt. is boiled with water, the precipitate dissolves because the $PbCl_2$ is soluble in hot water.
When potassium iodide is added, yellow precipitate of PbI_2 is observed whereas when potassium chromate is added, yellow precipitate of $PbCrO_4$ is observed. Both serve as confirmation for the presence of lead cation.
They will be asked to note down their observations in a practical lab file in tabular form with 3 columns (experiment, observation, inference).
EVALUATION (Viva – Voce)
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation salt?
3. Write down the reaction observed in the performed tests?
4. What are the other cations present in the same group as lead?
HOME ASSIGNMENT
1. It is well known that paint contains lead. Collect a few samples of different varieties of paints and identify the presence of lead in them.
You may also take samples of lead-free paints and confirm the same.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 38

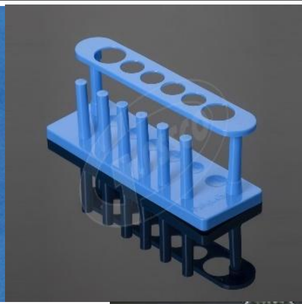
Class/ Grade Level - XI

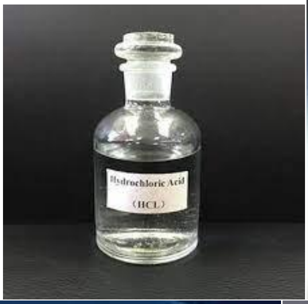
PRACTICAL OVERVIEW

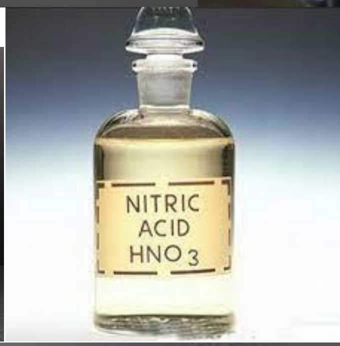
• **Practical Title**
To determine the ferrous ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes color, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of ferrous ion in salt.
21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine ferrous ion in the given salt.
• To understand the physical and chemical examination of cation.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of ferrous ions.
Learning Outcomes:
Learners will-
• Be able to determine ferrous ion in given salt.
• Understand all the chemical reactions taking place in various tests.

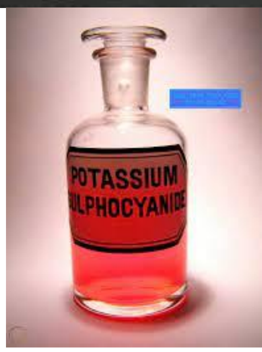
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of cation in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of ferrous ion salts?
2. What precautions to be taken while performing the chemical analysis of ferrous ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?
• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Iron is an important element in biological as well as commercial aspects. Students will be asked to list five important commercial uses of Iron and five important biological uses of Iron.
What disease is caused by deficiency of iron in the human body? What is the optimum level of iron in the human body?
Which vegetables and fruits are the rich source of iron?
Apparatus and chemicals required: Test tubes, bunsen burner, conc. Nitric

acid, test tube holder, test tube stand, ammonium chloride, ammonium hydroxide, potassium ferrocyanide, potassium sulphocyanide etc.





EXPLORATION:

Students will be provided with a salt and asked to identify the cation present in it. They will be asked to judge the physical characteristics of the salt like color, smell, density etc.

They may also try heating the salt.

Eventually, they will realize they need chemical analysis for the confirmation of cation.

EXPLANATION:

Students will be asked to follow the procedure to determine ferrous ion in the salt-

- Take about 5 ml of salt solution in a test tube and add 4-5 drops of conc. HNO_3. Boil the solution for some time. Add to it about 2 g of solid NH_4Cl and boil again.

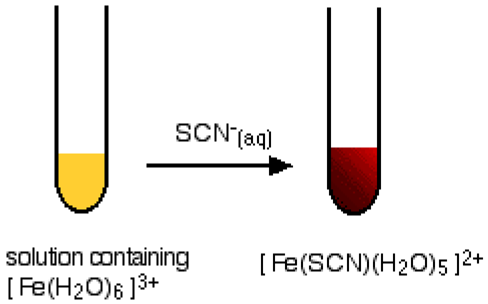
Cool the solution and add excess ammonium hydroxide to it and shake. Reddish brown precipitate indicates the presence of ferrous ion.

- For confirmation,

Dissolve the reddish-brown ppt. in dilute HCl and divide the solution into two parts.

1. Potassium ferrocyanide test: To the first part of the solution, add potassium ferrocyanide solution. Prussian blue colour is observed as confirmation of ferrous ion.

2. Potassium sulphocyanide test: To the second part of the solution, add a little potassium sulphocyanide solution. Blood red colouration is observed as confirmation of ferrous ion.



ELABORATION:

Reddish brown precipitate is observed due to the formation of ferric hydroxide in the preliminary test of the salt indicating the presence of ferrous ion.

In the confirmation test,

1. When potassium ferrocyanide is added, the Prussian blue colour is observed as confirmation of ferrous ion due to the formation of ferric ferrocyanide, $Fe_4[Fe(CN)_6]_3$.
2. When potassium sulphocyanide is added, the Blood red coloration is observed as confirmation of ferrous ion due to the formation of Ferric sulphocyanide, $Fe(CNS)_3$.

They will be asked to note down their observations in a practical lab file in tabular form with 3 columns (experiment, observation, inference).

EVALUATION (Viva – Voce)

Students are asked to answer the following question based on the experiment-

1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation test?
3. Write down the reaction observed in the performed tests?
4. What are the other cations present in the same group as ferrous?
5. What type of bonding is present in the complexes observed in the confirmatory tests?

HOME ASSIGNMENT

1. An open slice of apple oxidizes easily when left in open. Take fresh apple juice and confirm the presence of iron in the juice.

Take a packed apple juice as well and identify the presence of iron in it.
Compare the result obtained from fresh juice and packed juice.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

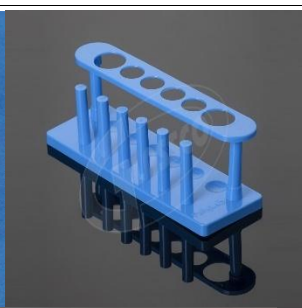
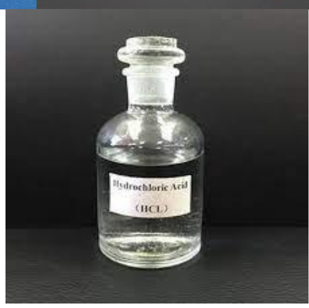
PRACTICAL LESSON PLAN NUMBER - 39

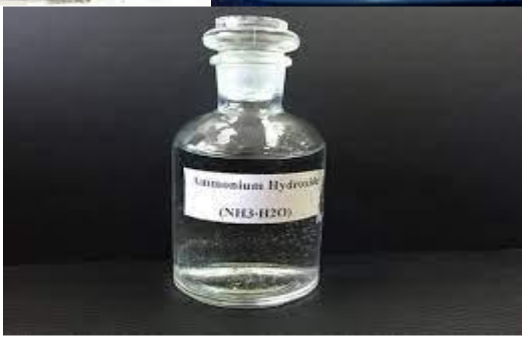
Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the nickel ion in the given salt.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes color, state, smell, or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of Nickel ion in salt.

21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine nickel ion in the given salt.
• To understand the physical and chemical examination of cation.
• To understand the chemical reaction and their balanced equations that take place during the tests.
• To understand all the procedures of performing the test for identification of nickel ions.
Learning Outcomes:
Learners will-
• Be able to determine nickel ion in given salt.
• Understand all the chemical reactions taking place in various tests.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of cation in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmation tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of nickel ion salts?
2. What precautions to be taken while performing the chemical analysis of nickel ion?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?

• What physical skills are accounted for in physical examination of salts?
Language Skills:
Students should have the basic skills of making notes, comprehending, and organizing the matter.
ENGAGEMENT:
Nickel is often used in making alloys. What properties of nickel help the same?
What are the electronic properties of nickel?
Nickel also has many other commercial uses like in making coins. List some other important uses of nickel?
Is nickel important in biological functions also? Analyze your findings about nickel ion.
Apparatus and chemicals required: Test tubes, bunsen burner, dil. hydrochloric acid, test tube holder, test tube stand, ammonium chloride, ammonium hydroxide, H_2S gas, dimethylglyoxime solution, Bromine water etc.
   



EXPLORATION:

Students will be provided with a salt and asked to identify the cation present in it. They will be asked to judge the physical characteristics of the salt like colour, smell, density etc.

They may also try heating the salt.

Eventually, they will realize they need chemical analysis for the confirmation of cation.

EXPLANATION:

Students will be asked to follow the procedure to determine nickel ion in the salt-

- Take about 5 ml of salt solution in a test tube and add 4-5 drops of

conc. HNO_3. Boil the solution for some time. Add to it about 2 g of solid NH_4Cl and boil again.
Cool the solution and add excess ammonium hydroxide to it and shake. Then, pass H_2S gas through the ammoniacal solution. If you observe black precipitate, nickel or cobalt may be present.
• If the initial salt is greenish in color, proceed with the confirmation of nickel ion
• For confirmation,
1. Dimethylglyoxime test: Take around 5 mL of original salt solution in a test tube. Add ammonium hydroxide to it followed by the addition of a few drops of dimethyl glyoxime. Bright rose red precipitate is obtained as the confirmation of nickel ion.

2. Sodium hydroxide - Br_2 test: Take around 5 mL of original salt solution in a test tube and add sodium hydroxide in excess. Green precipitate will be observed. Add bromine water to the same content and boil. A black precipitate is observed as the confirmation of nickel ion.

ELABORATION:
When H_2S gas is passed through the ammoniacal solution, black precipitate of NiS is observed as an indication of nickel ion.
In the confirmation test,
1. The bright red colour is due to the formation of Ni–dimethylglyoxime complex; $Ni(dmgH)_2$. It confirms the presence of nickel ion.
2. The green precipitate is due to the formation of Ni $(OH)_2$. The black precipitate is due to the formation of nickelic hydroxide, $Ni(OH)_3$. It confirms the presence of nickel ion.
They will be asked to note down their observations in a practical lab file in tabular form with 3 columns (experiment, observation, inference).
EVALUATION (Viva – Voce)
Students are asked to answer the following question based on the experiment-
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmation test?
3. Write down the reaction observed in the performed tests?
4. What is the structure of the Nickel DMG complex?
HOME ASSIGNMENT
1. Why do nickel salts appear coloured?
2. What precautions must be taken while handling H_2S gas?

RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

INSTRUCTIONAL PLAN OF EXPERIMENTATION

(PHYSICAL MODE)

PRACTICAL LESSON PLAN NUMBER - 40

Class/ Grade Level - XI

PRACTICAL OVERVIEW

• **Practical Title**
To determine the barium, calcium and strontium ion in the given salt with the help of flame test.
Practical Summary: In inorganic qualitative analysis, the given salt is analyzed for the radicals, i.e., cation and anion. The physical examination of salt includes color, state, smell or taste of the salt but these methods have very limited scope due to the toxic nature of salts. Therefore, a chemical analysis of the substance needs to be carried out to identify and confirm the cation and anion in the salts.
Subject Area: Chemistry & Education
Approximate Time Needed: 40 minutes.
Targeted Content Standards and Benchmarks: Confirmation of Ba, Ca and Sr ions in salt with flame test.

21st CENTURY STUDENT OBJECTIVES / LEARNING OUTCOMES
Objectives:
• To determine Ba, Ca and Sr ions in the given salt.
• To understand the physical and chemical examination of anions.
• To understand the theoretical aspect of flame test.
• To understand all the procedures of performing the test for identification of Ba, Ca and Sr ions.
Learning Outcomes:
Learners will-
• Be able to determine Ba, Ca and Sr ions in given salt.
• Understand the flame test.
• Understand the physical and chemical tests for determination of ions.
• Be able to perform all the physical and chemical analysis required for the identification of cations in the salt.
CURRICULUM FRAMING QUESTION
Essential Question:
1. What are salts?
2. What is the difference between preliminary and confirmatory tests?
Practical Lesson Content Questions:
1. What are the physical characteristics of Ba, Ca and Sr ion salts?
2. What precautions to be taken while performing the chemical analysis of Ba, Ca and Sr ions?
3. What is a flame test?
LESSON DETAILS
Pre-Requisite Skills-
Observing qualities, measuring quantities, sorting/classifying, inferring, predicting, experimenting, communicating, and handling of apparatus.
Conceptual Knowledge:
• What are salts?

- What physical skills are accounted for in physical examination of salts?
- What is a flame?

Language Skills:

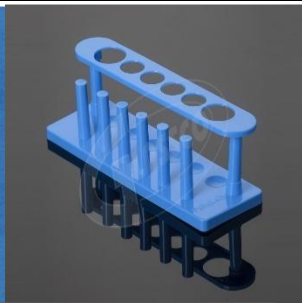
Students should have the basic skills of making notes, comprehending, and organizing the matter.

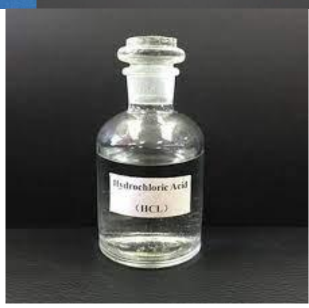
ENGAGEMENT:

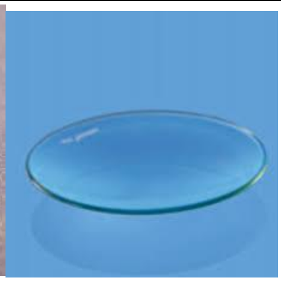
We often use the physical and chemical characteristics of a salt to determine the cations and anions present in the same. Have you ever wondered if electronic properties could be used for the same?

Find out ways in which the electronic properties could be used for the identification of cations?

Apparatus and chemicals required: Test tubes, bunsen burner, conc. hydrochloric acid, test tube holder, test tube stand, platinum wire, watch glass etc.



EXPLORATION:
Students will be provided with three different salts and asked to identify the cation present in it. They will be asked to judge the physical characteristics of the salt like color, smell, density etc.
They may also try heating the salt.
Eventually, they will realize they need chemical analysis for the confirmation of cation.
EXPLANATION:
Students will be asked to perform the flame test following the procedure mentioned here-
• Take conc. HCl in a watch glass and clean platinum wire by dipping in it. Then, heat the wire strongly in the flame. Repeat the process till the platinum rod imparts no colour to the flame.
• Prepare a paste of the given salts individually with conc. HCl on a clean watch glass. Make a loop on one end of the platinum wire and place some amount of paste on the loop. Introduce the paste on the loop to the flame and observe the colour it imparts to the flame.
1. For Calcium: The flame appears non-persistent brick red.

2. For Strontium: The flame appears persistent crimson red.


3. For barium: The flame appears grassy green after prolonged heating.

ELABORATION:
When salts are heated in a flame, the electrons in a metal ion gain energy and excite to a higher energy level from a lower energy level. Ions are not stable at a higher energy level, hence return to the ground with the release of energy. This energy released corresponds to the visible region and imparts color which varies from one metal ion to another. Hence, each metal has its characteristic change of color when it is heated.
They will be asked to note down their observations in a practical lab file in tabular form with 3 columns (experiment, observation, inference).
EVALUATION (Viva – Voce)
Students are asked to answer the following question based on the experiment-
1. What physical features did you observe in the given salt?
2. What is the difference between preliminary and confirmatory test?
3. What are the limitations of flame tests?
4. Why do metal ions impart color to the flame?
5. Why is hydrochloric acid used in the flame test?
6. What is the range of wavelengths for visible region?

7. What mandatory precautions should be taken for flame tests?
HOME ASSIGNMENT
1. Take different samples of water from your home, school, distilled water etc. Perform the identification tests of Ca, Ba and Sr in those samples and compare your results.
RESOURCES:
Laboratory Manual NCERT Class XI
BOOKS:
NCERT Textbook Class XI
WEB RESOURCES:
http://amrita.OLabs.edu.in/?sub=73&brch=7&sim=112&cnt=1

APPENDIX C

EXPERIMENTAL SELF- EFFICACY SCALE

Questionnaire on Experimental Self – Efficacy

Students often develop anxiety towards performing experiments due to the perceived negative outcomes resulting from lack of understanding and improper experimentation. A need was felt to examine the impact of virtual experimental platforms in chemistry laboratory education on experimental self-efficacy. You are requested to give your valuable response on 5-point Likert Scale regarding experimental self-efficacy. Kindly mention your agreement from strongly agree to strongly disagree.

This information will be used for research purpose only.

Name: **Class:**

School Name: **Email id:**

Roll No: **Gender:**

There are 12 statements on which your opinion is sought in terms of strongly agree, agree, neutral, disagree and strongly disagree. Kindly tick most appropriate decision of agreement.

1st dimension: Conceptual Understanding

1. I believe I have a sound grasp of the theory behind laboratory experiments before performing experiments.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

2. Experimental concepts become clearer to me as I perform the experiments

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

3. I am confident that I understand the underlying chemical phenomena in the experiment.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

2nd Dimension: Laboratory Hazards

4. I can usually handle the glass apparatus in the laboratory on my own without any fear of breakage and injury.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

5. I am confident of working in the laboratory without chemical spillage.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

6. I am always alert in laboratory and have minimal accidents.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

3rd Dimension: Procedural Complexity

7. After an experiment, I have no difficulty figuring out how my calculation procedures and errors affected my results.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

8. When presented with laboratory results, I know how to interpret them and draw relevant conclusions from them

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

9. I do not struggle with processing information in background articles and relating them to my own laboratory procedures and results.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

4th Dimension: Sufficiency of Resources

10. I find it easy to complete the exercise in the laboratory even though there is limited personal participation in performing experiments

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

11. It is easy for me to understand theory and concepts properly in spite of limited availability of physical instruments

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

12. I do not find it challenging to understand an experiment even if there is only one try due to limited availability of chemicals.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

Appendix D

Scientific Attitude Scale Questionnaire

Scientific Attitude is measured in term of rationality, open mindedness, confidence in scientific methods, curiosity & aversion to superstitions. A need was felt to examine the effect of virtual experimental platforms in chemistry laboratory education on Scientific attitude.

I would like to request you to give your valuable opinion on 5-point Likert Scale regarding Scientific Attitude. Kindly mention your agreement from strongly agree to strongly disagree. Asterisk sign (*) sign represent negative statement.

This information will be used for research purpose only.

Name: **Class:**

School Name: **Email id:**

Roll No. **Gender:**

1 Rationality

1.Traditional society hampers the growth of science

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

2. Science is suitable for all students regardless of the gender.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

3. Scientific careers are more useful to the advancements in the society .

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

4. Studying science is not everybody's cup of tea.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

5*. Traditional beliefs should be accepted even when they are against scientific re-search.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

6. Studying science subjects enhance our intellect.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

7*. Scientist does not live normal family life.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

II Open-mindedness

8*. Science makes us dependent on machines.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

9*. Sharing knowledge with others is harmful.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

10. Any new thing can be criticized in the absence of facts .

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

11. Science subjects have infinite opportunities.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

12*. Science is responsible for low moral standards.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

13. Positive criticism is useful for advancement of knowledge.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

14*. Opinion of novice (new/un-experienced person) should be rejected even though supported by evidence.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

15*. Scientific advancements have only adverse effects on mankind.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

16.Study of science helps in thinking new ideas.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

17*. One may feel offended from a person who has different thinking from him/her.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

III Confidence in Scientific Method

18. Enough evidence should be collected before accepting an idea.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

19. Testing of Knowledge should be procedural.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

20. One should be honest and truthful in collecting and recording data.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

21*. Data can be manipulated according to the need.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

22. One should suspend (delay) his/her decision in the absence of sufficient data.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

23.Known is the basis to know the unknown.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

24. Questioning attitude helps in defining a problem.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

25. Any hypothesis should be accepted or rejected on the basis of sufficient evidence.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

26. Knowledge should be considered tentative.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

IV Curiosity

27. One should explore the unknown.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

28.There is no conclusion as final or ultimate.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

29. There is a scientific cause for everything that takes place in the world.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

30*. To do enquiry is a task of scientists and not of common man.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

31.One should report his/her discovery even if it is contradictory to religion.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

32.One should search for reality behind appearance.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

V Aversion to Superstition

33.Scientist should report his/her discovery even if it is contradictory to religion.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

34*. Use of lemon and green chillies protects from evil eye.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

35*. Ghosts exist.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

36*. For the solution of a problem one should go to an astrologers.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

37.There is nothing like fate man makes his own fate.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

38*.Praying /recitation of mantras before exam helps to score more marks .

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

39*.A black cat when crosses one's path , brings bad luck.

a) Strongly agree B) Agree C) Neutral d) Disagree e) Strongly disagree

APPENDIX E

List of Experts

Name of Experts	Institutions
Dr R K Parashar	Professor, Chemistry, Department of Education in Science and Mathematics
Dr Anjni	Professor, Chemistry, Department of Education in Science and Mathematics
Dr Ruchi Verma	Professor, Chemistry, Department of Education in Science and Mathematics
Dr Sunita Malhotra	Professor, School of Sciences, IGNOU
Dr Jasim Ahmad	Professor, Dept of Teacher Training and Non-Formal Education Jamia Millia Islamia, Delhi
Ms Shalini Prakash Language Expert	Former Incharge Senior Section & HOD English, DAV Public School, Vasant Kunj, New Delhi

APPENDIX F

DIFFICULTY INDEX & DISCRIMINATION INDEX OF CHEMISTRY PRACTICAL ACHIEVEMENT TEST (CPAT)

Ques No	Difficulty Value	Discrimination Index	Item Decision
1	0.91	-0.19	Rejected
2	0.50	-0.11	Rejected
3	0.88	-0.17	Rejected
4	0.56	0.48	Selected
5	0.57	0.48	Selected
6	0.56	0.48	Selected
7	0.90	-0.20	Rejected
8	0.56	0.48	Selected
9	0.55	0.46	Selected
10	0.56	0.48	Selected
11	0.56	0.50	Selected
12	0.56	0.50	Selected
13	0.50	-0.07	Rejected
14	0.50	0.96	Selected
15	0.50	1.00	Selected
16	0.50	1.00	Selected
17	0.49	0.98	Selected
18	0.52	0.96	Selected
19	0.38	0.31	Rejected
20	0.50	0.96	Selected
21	0.51	0.98	Selected
22	0.49	0.98	Selected
23	0.34	0.28	Rejected

24	**0.50**	**0.96**	Selected
25	**0.44**	**0.39**	Selected
26	**0.51**	**0.98**	Selected
27	**0.50**	**1.00**	Selected
28	**0.51**	**0.98**	Selected
29	**0.50**	**1.00**	Selected
30	**0.50**	**1.00**	Selected
31	**0.50**	**1.00**	Selected
32	**0.50**	**1.00**	Selected
33	**0.51**	**0.98**	Selected
34	**0.51**	**0.98**	Selected
35	**0.51**	**0.98**	Selected
36	**0.51**	**0.98**	Selected
37	**0.51**	**0.98**	Selected
38	**0.84**	**0.31**	Rejected
39	**0.84**	**0.31**	Rejected
40	**0.51**	**0.98**	Selected
41	**0.62**	**0.31**	Rejected
42	**0.50**	**1.00**	Selected
43	**0.50**	**1.00**	Selected
44	**0.50**	**1.00**	Selected
45	**0.51**	**0.98**	Selected
46	**0.34**	**0.28**	Rejected
47	**0.50**	**1.00**	Selected
48	**0.44**	**0.39**	Selected
49	**0.51**	**0.98**	Selected
50	**0.44**	**0.39**	Selected
51	**0.50**	**0.96**	Selected

52	**0.62**	**0.61**	Selected
53	**0.44**	**0.39**	Selected
54	**0.49**	**0.98**	Selected
55	**0.50**	**0.96**	Selected
56	**0.49**	**0.98**	Selected
57	**0.84**	**0.31**	Rejected
58	**0.84**	**0.31**	Rejected
59	**0.51**	**0.98**	Selected
60	**0.50**	**1.00**	Selected
61	**0.51**	**0.98**	Selected
62	**0.51**	**0.98**	Selected
63	**0.50**	**1.00**	Selected
64	**0.50**	**1.00**	Selected
65	**0.83**	**0.33**	Rejected
66	**0.50**	**1.00**	Selected
67	**0.50**	**1.00**	Selected
68	**0.50**	**1.00**	Selected
69	**0.50**	**1.00**	Selected
70	**0.51**	**0.98**	Selected
71	**0.51**	**0.98**	Selected
72	**0.44**	**0.39**	Selected
73	**0.50**	**1.00**	Selected
74	**0.50**	**1.00**	Selected
75	**0.50**	**1.00**	Selected
76	**0.51**	**0.98**	Selected
77	**0.51**	**0.98**	Selected
78	**0.51**	**0.98**	Selected
79	**0.62**	**0.61**	Selected

80	**0.62**	**0.61**	Selected
81	**0.62**	**0.61**	Selected
82	**0.62**	**0.61**	Selected
83	**0.50**	**1.00**	Selected
84	**0.50**	**1.00**	Selected
85	**0.50**	**1.00**	Selected
86	**0.51**	**0.98**	Selected
87	**0.51**	**0.98**	Selected
88	**0.51**	**0.98**	Selected
89	**0.51**	**0.98**	Selected
90	**0.50**	**1.00**	Selected
91	**0.50**	**1.00**	Selected
92	**0.50**	**1.00**	Selected
93	**0.50**	**1.00**	Selected
94	**0.62**	**0.61**	Selected
95	**0.62**	**0.61**	Selected
96	**0.62**	**0.61**	Selected
97	**0.62**	**0.61**	Selected
98	**0.56**	**0.48**	Selected

Appendix G

Chemistry Practical Achievement Test

This Achievement Test is prepared to evaluate the knowledge, understanding, application & skill of students in Chemistry Practical when it is performed by virtual mode. I request you to give suitable answers of the following questions. This information will be used for research purpose only.

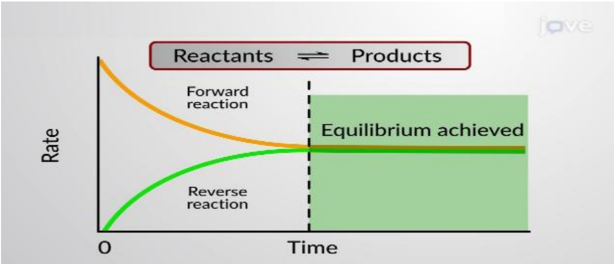
Name-

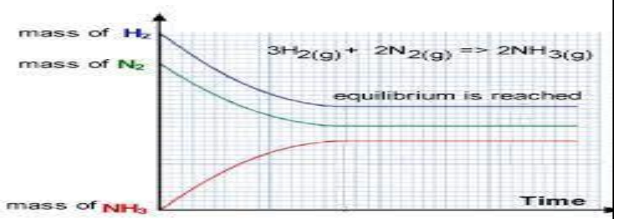
Class-

SchoolName-

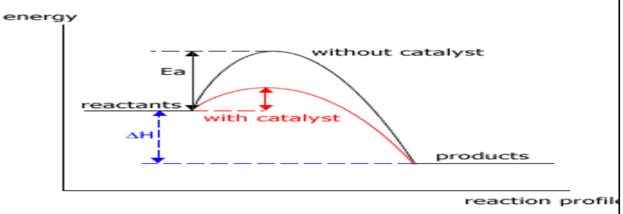
Age-

S. No.	**Experiment**	
I	**Equilibrium**	
1.	Analyze the shift in equilibrium between ferric ions and thiocyanate ions by increasing/decreasing the concentration of either of the ions. True/False: For an exothermic reaction, increasing the temperature will shift the reaction towards the forward direction.	
0.	Two chemicals are mixed together in a test tube in order to set the equilibrium. The colour obtained in the test tube is compared with the reference test tube. What is the role of reference test tube? A. It is used to compare the intensity of colour observed in the other test tubes giving an idea about the direction of equilibrium. B. To match the colour observed in the other test tubes to the reference test tube. C. It has no role in the experiment. D. To dilute the sample size.	
0.	What is the colour of $[Co(H_2O)_6]^{+2}$ ions and $[CoCl_4]^{-2}$ ions respectively:	Source: https://thumbs.dreamstime.com/z/test-tube-rainbow-9460182.jpg

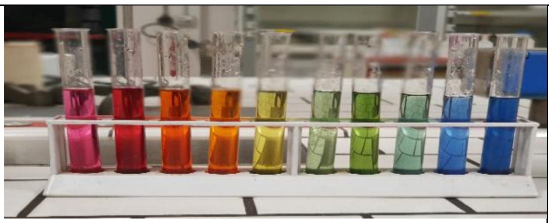
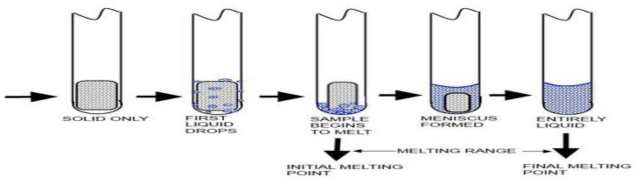
<table>
<tr>
<td></td>
<td>
</td>
<td>A. Pink and Blue
B. Blue and Pink.
C. Red and Yellow.
D. Yellow and Red.</td>
</tr>
<tr>
<td>0.</td>
<td>Which one of the following is CORRECT regarding chemical equilibrium?

</td>
<td>Source:
https://www.jove.com/science-education-library/116/chemical-equilibrium

A. Equilibrium is achieved only when pressure of the reaction is decreased.
B. Equilibrium is achieved when forward reaction rate equals reverse reaction rate.
C. Equilibrium constant depends on the initial concentration of the reactant.
D. Equilibrium is achieved only when temperature of the reaction is increased. It is used to compare the intensity of colour observed in the other test tubes giving an idea about the direction of equilibrium.</td>
</tr>
<tr>
<td>0.</td>
<td>The reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ [ΔH = -92.22 KJ/mol] is at equilibrium. How will the system respond if the temperature is increased?

</td>
<td>Source:
https://tinyurl.com/56mwdfkw

A. The reaction becomes endothermic. B. The equilibrium will shift to the right.
C. No change in the equilibrium position of the reaction. D. The</td>
</tr>
</table>

		equilibrium will shift to left.
0.	What is the effect of a catalyst on a system at equilibrium?  	Source: https://www.ibchem.com/IB16/07.26.htm A. The rate of reaction decreases. B. The enthalpy of reaction first increases then decreases. C. Increase the rate of reaction by making a new low energy pathway. D. The potential energy of the product decreases.
II	**To determine the pH of the given sample using pH paper /Universal indicator**	
7.	What is the nature of the blood in the human body? A. Strongly basic B. Slightly acidic C. Strongly acidic D. Slightly basic	
8.	True/False: pH is defined as the negative logarithm of hydronium ion concentration in moles per litre.	
9.	Shalini & Shivam performed different activities to determine the nature of a solution. Shalini checked the pH of the solution and got its value 4.5. Shivam dipped the litmus paper in the solution. What is his observation about the change of colour of litmus paper & nature of solution?	
		Source: https://tinyurl.com/3zja2w9f A. Solution turns blue litmus paper red and is acidic. B. Solution turns blue litmus paper

		red and is basic. C. Solution turns red litmus paper blue and is acidic. D. Solution turns red litmus paper blue and is basic
10.	Complete the following sentence- When water is added to a weak acid then concentration of hydronium ion .... and the pH of the solution................................	
		Source: https://www.thoughtco.com/add-sulfuric-acid-to-water-606099 A. Increases, Decreases B. Decreases, Increases C. Decreases, Decreases D. Increases, Increases
11.	Complete the following sentence- The relationship between pH and pOH of an aqueous solution is..................................	
12.	What is the effect of a rise in temperature on the pH of pure water? A. pH value increases. B. pH value decreases. C. pH value remains same. D. pH value first increases then decreases.	
13.	What is the nature of lemon juice and oranges? A. Slightly basic B. Acidic C. Neutral D. Amphoteric	
14.	Look at the color of the solutions (pink to blue from left to right) placed in the test tube in the picture and mention which of the following statements is correct regarding their pH?	

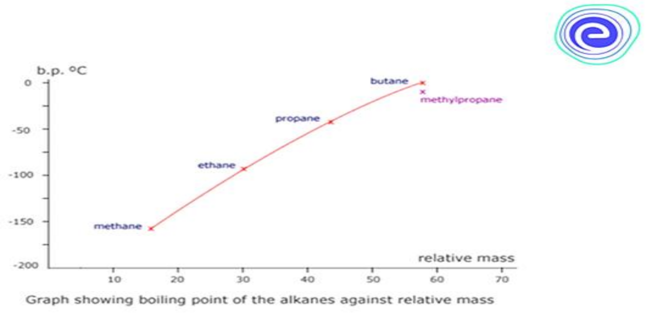
		Source: https://en.wikipedia.org/wiki/PH A. pH increases from left to right. B. pH decreases from left to right. C. Acidity increases from left to right. D. Basicity decreases from left to right
III	**Determination of melting point of an organic compound**	
15.	Which of the following is known as the temperature at which a substance in solid state changes to liquid state at normal atmospheric pressure? A. Melting point. B. Boiling point. C. Freezing point. D. Triple point.	
16.	A solution is kept in a liquid bath for heating. The instructor is continuously stirring the solution. Fill in the blanks using suitable option (Increase, decrease, make uniform)- The liquid bath is stirred continuously in order to .... the temperature throughout.	
17.	True/False: Melting point determination of a substance gives an idea about the purity of the substance.	
18.	Observe the steps of melting given below and indicate the nature of the substance. 	Source: https://chembam.com/definitions/melting-point/ A. Crystalline B. Amorphous C. Liquid D. Gas
IV	**Determination of the boiling point of an organic compound**	
19.	Complete the sentence using suitable option (Increase, decrease)- On increasing the pressure outside, the boiling point of liquid........................	
20.	True/False: At higher altitude, the boiling point of liquid increases.	
21.	When some non-volatile liquid is added to a liquid, the boiling point of the liquid will- A. Increase. B. Decrease. C. Increase then decrease. D. Remain	

the same.

22. What is the boiling point of pure water at sea level?

A. 99 °C B. 103.7 °C C. 273 °C D. 100 °C

23. Observe the graph plotted between molecular weight and the boiling point of alkanes and choose the most correct option.



Source: https://www.embibe.com/exams/alkanes/

A. It increases with an increase in molecular weight.

B. It increases with decrease in molecular weight.

C. It decreases with an increase in molecular weight.

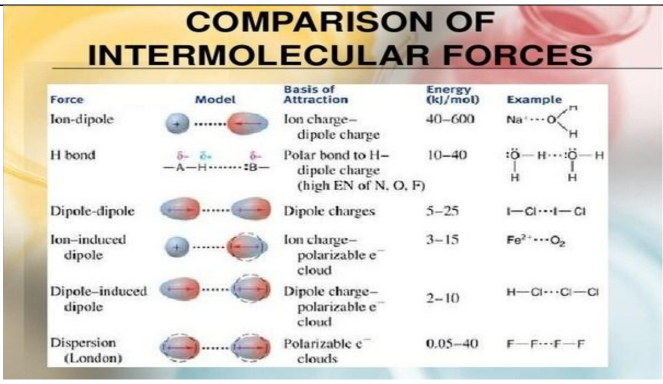
D. Its molecular weight does not affect the boiling point.

24. Why is food cooked more quickly in a pressure cooker?

A. Water boils at lower temperature. B. Water boils at higher temperature

C. Vapour pressure is lowered. D. Presence of food elevates boiling temperature

25. Observe the given table carefully and mention which of the following compounds has the lowest boiling point.


COMPARISON OF INTERMOLECULAR FORCES

Force	Model	Basis of Attraction	Energy (kJ/mol)	Example
Ion-dipole		Ion charge–dipole charge	40–600	Na⁺···O(H)H
H bond	δ- δ+ δ- —A—H·······:B—	Polar bond to H–dipole charge (high EN of N, O, F)	10–40	:Ö—H···:Ö—H
Dipole-dipole		Dipole charges	5–25	I—Cl···I—Cl
Ion–induced dipole		Ion charge–polarizable e⁻ cloud	3–15	Fe^{2+}···O_2
Dipole–induced dipole		Dipole charge–polarizable e⁻ cloud	2–10	H—Cl···Cl—Cl
Dispersion (London)		Polarizable e⁻ clouds	0.05–40	F—F···F—F

Source: https://tinyurl.com/42d64m7v

A. H_2O

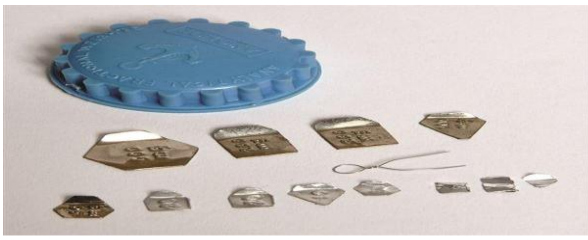
B. ICl

C. HCl

D. F_2

V Preparation of standard solution of Sodium carbonate.

<table>
<tr><td>26.</td><td colspan="2">Shivam wanted to prepare M/20 sodium carbonate solution for acid base titration. He weighed 10.6 g of sodium carbonate in the two-pan balance available in his school lab. After performing titration, he did not get an accurate result. His teacher told him that there is some error in weighing. Which of the following points he missed-</td></tr>
<tr><td></td><td></td><td>Source:
https://www.indiamart.com/proddetail/chemical-balance-2243507355.html

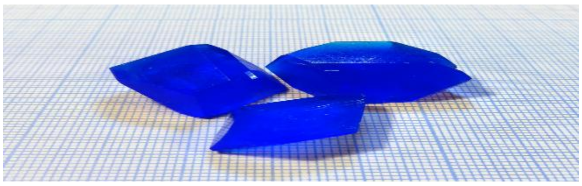
A. He cleaned the pans of the balance with a hairbrush.
B. He leveled the balance by adjusting the leveling screw.
C. He placed weights and fractional weights with wet hands.
D. He took a clean and dry watch glass & kept an appropriate amount of salt in it.</td></tr>
<tr><td>27.</td><td colspan="2">True/False: The equivalent mass of H_2SO_4 is 98u.</td></tr>
<tr><td>28.</td><td colspan="2">What is the molarity of the solution obtained by diluting 13.9 ml of 18 M H_2SO_4 to 100 ml?
A. 0.25 M B. 1.8 M C. 18 M D. 2.5 M</td></tr>
<tr><td>29.</td><td colspan="2">Which one of the following is the Normality equation?
A. $N_1N_2 = V_1V_2$ B. $N_1+V_1 = N_2+V_2$ C. $N_1/V_2 = N_2/V_1$ D. $N_1V_2 = N_2V_1$</td></tr>
<tr><td>30.</td><td colspan="2">Shalini wanted to weigh a substance with the help of a two-pan balance. She found that the imprint on fractional weights had faded. Can you help her to identify the fractional weights?</td></tr>
<tr><td></td><td></td><td>Source:
https://th.bing.com/th/id/OIP.CRjUDnX1kliUijgIDhSDWwHaHd?pid=ImgDet&rs=1

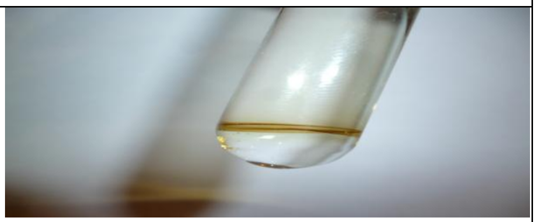
She may identify them by</td></tr>
</table>

		A. shape B. size C. color D. thickness
VI	**Determination of strength of a given solution of hydrochloric acid by titrating it against standard sodium carbonate solution.**	
31.	What is the indicator used in strong base-weak acid titration? A. Potassium permanganate B. Phenolphthalein C. Methyl yellow D. Methyl orange	
32.	True/False: Last drop of the solution should not be blown out of the jet end of the pipette because pipette is calibrated using this liquid into account. Source: https://tinyurl.com/yc32dwzs	
33.	What is an indicator? A. It is a chemical substance which changes colour at the end point. B. Solution of known concentration to determine the concentration of unknown solution. C. A solution of unknown concentration whose strength is to be determined. D. An indicator is a catalyst.	
34.	True/False: The number of replaceable hydrogen atoms in a molecule of the acid is known as the basicity of an acid.	
35.	Which meniscus is customary to read in case of colourless and transparent solutions?	
		Source: http://soft-matter.seas.harvard.edu/index.php/Drops,_menisci,_and_lenses A. Upper meniscus. B. As per choice.

<table>
<tr><td></td><td></td><td>C. Lower meniscus.
D. None of the above.</td></tr>
<tr><td>36.</td><td colspan="2">What is the pH of the solution obtained by the reaction between equivalent amount of a strong acid and a strong base?
A. 14 B. <7 C. >7 D. 7</td></tr>
<tr><td>37.</td><td colspan="2">What is the difference between endpoint and equivalence point in an acid base titration?
A. end point and equivalence point are same
B. end point is achieved before the equivalence point.
C. end point is the visible change and equivalence point is the actual completion of reaction.
D. end point is the actual completion of reaction and equivalence point is the visible change.</td></tr>
<tr><td>VII</td><td colspan="2">Crystallization of impure sample of benzoic acid</td></tr>
<tr><td>38.</td><td colspan="2">Complete the sentence-
The most important characteristic of a crystal is.......................................</td></tr>
<tr><td>39.</td><td colspan="2">Identify the shape of Benzoic acid crystals?</td></tr>
<tr><td></td><td></td><td>Source:
https://en.wikipedia.org/wiki/Benzoic_acid

A. Tetrahedral
B. Octahedral
C. Needle shaped.
D. Monoclinic</td></tr>
<tr><td>40.</td><td colspan="2">What is Mother Liquor?
A. Definite number of water molecules present with one formula unit of the compound.
B. Liquid left behind after the separation of crystals from a saturated solution.
C. Liquid, used to prepare a saturated solution of the solute.
D. It is the hot saturated solution</td></tr>
</table>

41.	If the crystals obtained are very small after the process of crystallization, what does it indicate? A. Solution has been concentrated more than that required for the crystallization stage. B. Solution has been concentrated less than that required for the crystallization stage. C. Reaction is in equilibrium. D. Reaction is irreversible.
VIII	**Crystallization of impure sample of Copper Sulphate**
42.	What is the crystal structure of blue vitriol?
	 Source: https://tinyurl.com/3xxkzbnw A. Monoclinic. B. Triclinic. C. Cubic. D. Octahedral.
43.	What is an example of crystalline solid? A. Quartz. B. Fused silica. C. Glass. D. Plastic.
44.	What is the chemical formula of blue vitriol? A. $CuSO_4$ B. $CuSO_4.5H_2O$ C. $FeSO_4.5H_2O$ D. $FeSO_4.7H_2O$
45.	What is the role of seeding in crystallization? A. It helps in the purification of crystals. B. It helps the crystals to achieve the desired shape and size. C. It does not have any important role. D. It helps in quick separation of crystals from saturated solution.
IX	**Determination of sulphide anion in a given salt**
46.	True/False: The sulphide salts smell like that of rotten eggs.
47.	Which of the following gases can turn the lead acetate paper black?
48.	 Source: https://tinyurl.com/598ajd2v A. H_2S B. NH_3 C. NO_2

		D. SO_2
49.	Name a gas which turns lime water milky other than CO_2 A. H_2S B. NH_3 C. NO_2 D. SO_2	
50.	Complete the sentence- When sodium sulphide reacts with sodium nitroprusside, It forms a violet complex $Na_4[Fe(CN)_5NOS]$. The charge on the anion is	 Source: https://tinyurl.com/yckmjhw3
X	**Determination of nitrate anion in a given salt**	
51.	Complete the sentence- When freshly prepared $FeSO_4$ solution is added to nitrate salt aqueous solution and afterwards ………….. is poured slowly along the sides of the test tube, a brown ring is formed as shown in the pic.	 Source: https://illumina-chemie.de/viewtopic.php?t=4407&start=30
52	True/False: Dark Red colouration is observed in the confirmatory test of nitrate ion in the salt when diphenylamine is added to it.	
XI	**Determination of chloride anion in a given salt**	
	The colour of the fumes observed when concentrated sulphuric acid is added to a chloride salt? A. Red B. Brown C. Black D. Colourless	
53.	Complete the sentence- The colour of the final precipitate observed in the chromyl chloride confirmatory test of chloride ion is.......................................	
54.	Which of the following gases evolves when concentrated sulphuric acid is added to a chloride salt?	

	A. H_2S B. NH_3 C. HCl D. SO_2
55.	True/False: When sodium hydroxide is added to silver chloride precipitate, a completely soluble complex is formed
XII	**Determination of bromide anion in a given salt**
56.	What is the colour of the fumes observed when concentrated sulphuric acid is added to a bromide salt? A. Red B. Reddish Brown C. Black D. White
57.	Which of the following gas evolves when a bromide salt is acidified with dil. HCl acid for chlorine water test? A. H_2S B. HBr C. HCl D. Br_2
58.	Complete the sentence- The colour imparted to the carbon disulphide layer in chlorine water test for the bromide ion is......................................
59	True/False: When ammonium hydroxide is added to light yellow silver bromide precipitate, a partially soluble complex is formed.
XIII	**Determination of sulphate anion in a given salt**
60.	The colour of the precipitate observed in Barium Chloride test of Sulphate salt is A. Red B. Reddish Brown C. Black D. White
61.	True/False: The precipitate observed in the Barium Chloride test of Sulphate salt is soluble in dil. HCl.
62.	Few drops of lead acetate solution is added to the sulphate aqueous solution. A white ppt is observed. What is the chemical name of the white ppt?
	 Source: https://www.sciencephoto.com/media/4683/view/barium-sulphate-precipitation A. Lead sulphate B. Barium sulphate

		C. Sodium sulphate D. Sodium acetate
XIV	**Determination of phosphate anion in a given salt**	
63.	Complete the sentence- The colour of precipitate observed in confirmatory test of phosphate salt with conc. HNO_3 and ammonium molybdate is	
XV	**Determination of ammonium cation in a given salt**	
64.	Name a cation which is not obtained from a metal. A. Pb^{2+} B. Mg^{2+} C. NH_4^+ D. As^{3+}	
65.	Complete the sentence- The gas evolved when sodium hydroxide is added to an ammonium salt is......................	
66.	Which one of the following reagents is used to test the presence of ammonium ion in a given salt? A. Nessler's reagent B. Ammonium thiocyanate C. Potassium ferrocyanide D. Dimethyl glyoxime	
67.	Complete the sentence- When sodium hydroxide is added to an ammonium salt, a gas is evolved. To confirm its presence, a rod dipped in HCl is brought near the mouth of the test tubes which evolves .... colour fumes.	
XVI	**Determination of lead cation in a given salt**	
68.	Which one of the following belongs to Group I & 2 cation? A. Pb^{2+} B. Mg^{2+} C. NH_4^+ D. Co^{2+}	
69.	What is the name of the product obtained by the reaction of lead ion with potassium iodide solution?	
		Source: https://tinyurl.com/4nf68abm A. Lead chromate B. Lead dichromate C. Lead oxide D. Lead iodide

70	Complete the sentence- Group reagent for group I captions is...........................
XVII	**Determination of iron cation in a given salt**
71.	Complete the sentence- Group reagent for group III is...............................
72.	True/False: Ammonium sulphate can be used instead of ammonium chloride for the precipitation of Iron cation.
73.	What is the colour of the salt containing Fe^{+3} ions? A. White B. Green C. Yellow D. Brown
74.	Iron salt aqueous solution is added with NH_4Cl, heated, cooled and dropped the liquid ammonia solution in excess. A reddish-brown precipitate is obtained. When potassium sulphocyanide is added to the ppt, which coloration confirms the presence of Iron? A. Prussian blue B. Green C. Blood Red D. Brown
75.	What is the colour of the salt containing Fe^{+2} ions? A. White B. Green C. Yellow D. Brown
XVIII	**Determination of nickel in a given salt**
76.	Nickel ion gets precipitated with hydrogen sulphide gas in the presence of acidic medium only. A. True B. False
77.	What is the colour of the salt containing Ni^{+2} ions? A. Buff White B. Bluish Green C. Crimson Red D. Dark Brown
78.	When H_2S gas is passed through the ammoniacal solution of group IV cations, which colour precipitate indicates the presence of nickel cation? A. Dull White B. Bluish Green C. Black D. Flesh colour
79.	Complete the sentence- The colour of the Nickel DMG complex obtained during the confirmatory analysis of Nickel is...............................

80.	When H_2S gas is passed through the ammoniacal solution of group IV cations, which cation gives the same colour precipitate as that of nickel cation? A. Co^{+2} B. Zn^{+2} C. As^{+2} D. Mn^{+2}
XIX	**Determination of barium, strontium & calcium cation by flame test in a given salt**
81.	Ca^{2+} ion gives……..color when inserted in blue flame. A. Pink-violet B. Golden yellow C. Brick-red D. Crimson red
82.	Shalini and shivam performed flame test to identify barium ion. Shalini got the beautiful apple green flame but shivam did not. What could be the reason?
	 Source: https://www.sciencephoto.com/media/5158/view/barium-flame-test A. Shivam performed the test with a Pt wire. B. Shivam inserted Pt wire in a luminous flame. C. Shivam inserted Pt wire in non-luminous flame D. Shivam prepared the paste of the salt in Conc. HCl
83.	Strontium salt is mixed with conc. HCl and when inserted in outer flame via Pt wire gives crimson red color. Why is it advised to make a paste in conc. HCl?
	 Source: https://tinyurl.com/2p8dwe3e A. Conc. HCl is an oxidizing agent. B. Conc. HCl is reducing agent. C. Conc. HCl converts salt into chloride which is volatile in non- luminous flame. D. Conc. HCl converts salt into chloride which is non-volatile in non- luminous

		flame.
84.	Rows have cations and columns have their group reagent. Match the columns with the rows and tick the most appropriate option. Rows Columns 1.Aluminium ion a Hydrogen Sulphide gas 2.Nickel ion b Ammonium carbonate solution 3.Barium c Sodium hydroxide solution 4.Ammonium d Ammonium hydroxide solution **Options** A. 1-d, 2-c, 3-b, 4-a B. 1-b, 2-c, 3-d, 4-a C. 1-d, 2-a, 3-b, 4-c D. 1-c, 2-d, 3-a, 2-b	

APPENDIX H

ANSWER KEY of CHEMISTRY PRACTICAL ACHIEVEMENT TEST (CPAT)

Q No	Answer	Q No	Answer	Q No	Answer
1	FALSE	**15**	A	**29**	C
2	A	**16**	UNIFORM	**30**	A
3	A	**17**	TRUE	**31**	B
4	B	**18**	B	**32**	TRUE
5	C	**19**	INCREASES	**33**	A
6	C	**20**	FALSE	**34**	TRUE
7	D	**21**	A	**35**	C
8	TRUE	**22**	D	**36**	D
9	A	**23**	A	**37**	C
10	A	**24**	B	**38**	GEOMERTY/ SHAPE
11	pH + pOH= 14	**25**	D	**39**	C
12	B	**26**	C	**40**	B
13	B	**27**	FALSE	**41**	A
14	A	**28**	D	**42**	B

Q No	Answer	Q No	Answer	Q No	Answer
43	A	**57**	D	**71**	AMMONIUM HYDROXIDE
44	B	**58**	PALE YELLOW	**72**	FALSE
45	D	**59**	TRUE	**73**	C
46	TRUE	**60**	D	**74**	C
47	A	**61**	FALSE	**75**	C
48	D	**62**	A	**76**	FALSE
49	4-	**63**	CANARY YELLOW	**77**	B
50	CONC. SULPHURIC ACID	**64**	C	**78**	C
51	FALSE	**65**	AMMONIA	**79**	ROSE RED
52	D	**66**	A	**80**	A
53	YELLOW	**67**	WHITE FUMES	**81**	C
54	C	**68**	A	**82**	B

55	TRUE	**69**	A	**83**	C
56	B	**70**	DIL HCl	**84**	C

APPENDIX I

SCORING NORMS OF CHEMISTRY PRACTICAL ACHIEVEMENT TEST

Grade	Marks %	Raw Score	Z score
Excellent	90 % & above	76 & above	1.04 & above
A	75% & less than 90%	63 & less than 76	0.60 & less than 1.04
B	60 % & less than 75%	50 & less than 63	0.16 & less than 0.60
C	50% & less than 60%	42 & less than 50	-0.12 & less than 0.16
D	33% & less than 50%	28 & less than 42	-0.59 & less than -0.12
E	Below 33%	Below 28	Less than -0.59

APPENDIX J

SCHEDULE OF DATA COLLECTION

No. of Classes	Date	Experiment Name
1	24.12.22	To determine the pH of the given sample using pH paper /Universal indicator
2	26.12.22	Study the shift in equilibrium between ferric ions and thiocyanate ions by increasing/decreasing the concentration of either of the ions
3	27.12.22	Determination of melting point of an organic compound.
4	28.12.22	Determination of boiling point of an organic compound
5	29.12 .22	Preparation of standard solution of Sodium carbonate.
6	30.12.22	Preparation of standard solution of Sodium carbonate.
7	9.1.23	Determination of strength of a given solution of hydrochloric acid by titrating it against standard Sodium Carbonate solution.
8	10.1.23	Determination of strength of a given solution of hydrochloric acid by titrating it against standard Sodium Carbonate solution.
9	11.1.23	Crystallization of impure sample of benzoic acid
10	12.1.23	Crystallization of impure sample of

		benzoic acid
11	13.1.23	Crystallization of impure sample of Copper Sulphate
12	16.1.23	Crystallization of impure sample of Copper Sulphate
13	17.1.23	General scheme of anion analysis
14	18.1.23	Determination of carbonate anion in a given salt
15	19.1.23	Determination of sulphide anion in a given salt
16	20.1.23	Scheme of analysis of 2nd group anions
17	21.1.23	Determination of nitrate anion in a given salt
18	23.1.23	Determination of chloride anion in a given salt
19	24.1.23	Determination of bromide anion in a given salt
20	27.1.23	Determination of sulphate anion in a given salt
21	30.1.23	General scheme of cation analysis
22	31.1.23	Determination of ammonium cation in a given salt
23	1.2.23	Scheme of analysis of 1st group cation analysis
24	2.2.23	Determination of lead cation in a given salt
25	3.2.23	Scheme of analysis of 3rd group cation analysis
26	4.2.23	Determination of iron cation in a

		given salt
27	6.2.23	Scheme of analysis of 4th group cation analysis
28	7.2.23	Determination of nickel cation in a given salt
29	8.2.23	Scheme of analysis of 5th group cation analysis
30	9 .2.23	Determination of barium, strontium & calcium cation by flame test in a given salt

LIST of PAPER PUBLICATION

S. No.	Name of Journal/ Book	Topic	Published Date (Date/Month/Year)	Volume/ Issue
1	European Chemical Bulletin	Effect of Constructivist Approach on the Academic Achievement, Experimental Self Efficacy, and Scientific Attitude of Secondary School Students Taught through Virtual Science Labs	July, 2022	Published: Eur. Chem. Bull. 2022,11(12), 2070-2089 **https://eurchembull.com/issue-content/construction-and-standardization-of-an-achievement-test-in-chemistry-practical-for-senior-secondary-students-14343**
2	Education & Society	Role of Virtual Science Laboratories in Developing Scientific Attitude	January-March: 2023	Vol-46, Issue-02,
3	Madhya Bharti - Humanities and Social Sciences	ROLE OF VIRTUAL SCIENCE LABORATORIES IN DEVELOPING	January – June: 2023	Vol-83 No. 7

		EXPERIMENTAL SELF EFFICACY		
4	INDIA'S DIAMOND ERA: Moving Towards Sustainable and Inclusive Growth(Book Chapter)	Role of Virtual Laboratory in Chemistry Practical Learning	April, 2023	
5	Library Progress International (SCOPUS Indexed)	Role Of Virtual Lab in Inculcating Scientific Attitude & Self Efficacy: Meta Analysis	July- Dec 2024	Vol. 44 No. 3

LIST of CONFERENCES

S. No.	Name of Conference	Date	Organized by	Topic of presentation
1	One Day Multidisciplinary International Conference on Contemporary Global Challenges & Opportunities in Education, Languages, Science and Humanities	January 15, 2023	I.N.M PG College, Meerut, India &ICERT	Role of Virtual Science Laboratories in Developing Experimental Self Efficacy
2	International Conference on Idea-Bankruptcy of Educationist and Thinkers	March 28-29, 2022	Bhagat Phool Singh Mahila Vishwavidyalya, Sonepat	Virtual Laboratories: a catalyst to develop experimental self- efficacy.
3	International	March 24-25,	Lovely Faculty	Role of virtual

	Conference on Recent Advances in fundamental and applied sciences (RAFAS 2023)	2023	of Technology and sciences, LPU	laboratories in inculcating scientific attitude & self-efficacy: Meta analysis
4	National seminar - INDIA'S DIAMOND ERA: Moving Towards Sustainable and Inclusive Growth	February 22, 2023	VMOU, Indian Accounting Association, Kota	Role of Virtual Laboratory in Chemistry Practical Learning