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DEPARTMENT OF FRESHMAN ENGINEERING

CERTIFICATE

This is to certify that this manual is a Bonafide record of practical work carried out in the **Engineering chemistry Laboratory** for the **B. Tech (FRESHMAN ENGINEERING) I&II Semester** Programme during the academic year **2025–2026**.

This manual has been prepared by **Mrs. M. Krishnaveni (Assistant Professor)**,

Mrs.G. Bhagyalaxmi (Assistant Professor) Freshman Engineering, with my/our own efforts and to the best of our knowledge.

Signature of HOD



DEPARTMENT OF FRESHMAN ENGINEERING

PREFACE

This book entitled “Engineering chemistry Lab Manual” is intended for the use of First year B. Tech students of Marri Laxman Reddy Institute of Technology and Management, Dundigal, Hyderabad.

The main objective of the Engineering chemistry Lab Manual is to furnish the conceptual understanding of the basic principles. The experiments are selected from various areas of chemistry like water treatment, viscosity, preparation of rubbers like Bakelite and Thiokol rubber, surface tension, etc. The book was written as per the new syllabus prescribed by the JNTUH University in a simple language.

Viva voice questions also included in the book. These experiments will help the students to expertise in the analysis of various concepts. Hence, we hope this book serve for better understanding by the student community with all details of experiments.

By,

Mrs. M. Krishnaveni (Assistant Professor),



DEPARTMENT OF FRESHMAN ENGINEERING

ACKNOWLEDGEMENT

It was really a good experience, working in Engineering Chemistry lab. First, we would like to thank Dr.K. Suresh Babu (Professor), Dr. B. Shekhar (Assoc Professor) ,Mrs. K. Venkata Swamy (Asst Professor),Dr. MD. Muqeed (Asst. Professor) Mrs. G. Bhagyalaxmi (Asst. Professor), Mrs. M. KrishnaVeni (Asst Professor), Mrs. Divya (Asst Professor) Department of Freshman engineering, Marri Laxman Reddy Institute of technology & Management for giving the technical support in preparing the document.

We express our sincere thanks to Dr. K. Suresh Babu, Professor, Marri Laxman Reddy institute of Technology & Management, for his concern towards us and gave us an opportunity to prepare Engineering Chemistry laboratory manual.

We are deeply indebted and gratefully acknowledge the constant support and valuable patronage of Prof. Ravi Prasad, Academic In charge, Marri Laxman Reddy Institute of technology & Management.

we are unboundedly grateful to him for timely Corrections and scholarly guidance. We express our hearty thanks to Prof. R. Murali Prasad, Principal, Marri Laxman Reddy Institute of technology & Management, for giving us this wonderful opportunity for preparing the Engineering Chemistry manual. At last, but not the least we would like to thank the entire Freshman engineering faculties those who had inspired and helped me to achieve my goal.

Department of Freshman Engineering



DEPARTMENT OF FRESHMAN ENGINEERING

GENERAL INSTRUCTIONS

1. Students are instructed to come to Engineering chemistry laboratory on time. Late comers are not entertained in the lab.
2. Students should be punctual to the lab. If not, conducted experiments will not be repeated.
3. Students are expected to come prepared at home with the experiments which are going to be performed.
4. Students are instructed to display their identity cards and apron before entering into the lab.
5. Students are instructed not to bring mobile phones to the lab.
6. The equipment's and other accessories used in Environmental Engineering lab should be handled with care and responsibility.
7. Any damage to the equipment's during the lab session is student's responsibility and penalty or fine will be collected from the student.
8. Students should update the records and lab observation books session wise. Before leaving the lab, the student should get his lab observation book signed by the faculty.
9. Students should submit the lab records 2/3 days in advance to the concerned faculty members in the staffroom for their correction and return.
10. Students should not move around the lab during the lab session.
11. If any emergency arises, the student should take the permission from faculty member concerned in written format.
12. The faculty members may suspend any student from the lab session on disciplinary grounds.



DEPARTMENT OF FRESHMAN ENGINEERING

SAFETY MEASURES

ENGINEERING CHEMISTRY LABORATORY

Chemistry Lab Do's & Don'ts

The chemistry laboratory must be a safe place in which to work and learn about chemistry. Most of these involve just using common sense.

1. Wear a chemical-resistant apron.
2. Be familiar with your lab assignment before you come to lab. Follow all written and verbal instructions carefully. Observe the safety alerts in the laboratory directions. If you do not understand a direction or part of a procedure, ask the teacher before proceeding.
3. When entering the lab/classroom, do not touch any equipment, chemicals, or other materials without being instructed to do so. Perform only those experiments authorized by the instructor.
4. No student may work the laboratory without an instructor present. Work only with your lab partner(s). Do not venture to other lab stations for any reason.
5. Do not wear bulky or dangling clothing.
6. Never eat or drink in the laboratory. Don't chew on the end of a pen which was lying on the lab bench.
7. Wash acid, base, or any chemical spill off of yourself immediately with large amounts of water. Notify your teacher of the spill.
8. Clean up spills immediately. If you spill a very reactive substance such as an acid or base, notify the people in the area and then obtain assistance from your teacher. Acid spills should be neutralized with baking soda, base pills with vinegar before cleaning them up.
9. If chemical substances get in your eye, wash the eye out for 15 minutes. Hold your eye open with your fingers while washing it out.
10. When weighing never place chemicals directly on the balance pan. Never weigh a hot object.
11. Never smell anything in the laboratory unless your teacher tells you it is safe. Do not smell a substance by putting your nose directly over the container and inhaling. Instead, waft the vapors toward your nose by gently fanning the vapors toward yourself.



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VISION & MISSION OF THE INSTITUTE

Vision of the Institute:

To be a globally recognized institution that fosters innovation, excellence, and leadership in education, research, and technology development, empowering students to create sustainable solutions for the advancement of society.

Mission of the Institute:

To foster a transformative learning environment that empowers students to excel in engineering, innovation, and leadership.

To produce skilled, ethical, and socially responsible engineers who contribute to sustainable technological advancements and address global challenges.

To shape future leaders through cutting-edge research, industry collaboration, and community engagement.

VISION & MISSION OF THE DEPARTMENT

Vision of the Department:

To empower students to be skilled, competitive, and dedicated Engineers by imparting advanced technical knowledge and ethical values, equipping them to play a key role in the planning and execution of the nation's infrastructure and development activities.

Mission of the Department:

DM1: Provide exceptional education in engineering through a combination of excellent teaching, advanced facilities, and continuous mentorship.

DM2: Produce civil engineering graduates who demonstrate exceptional skills and expertise.

DM3: Encourage professional development to address complex technical challenges and engage in innovation with creativity, leadership, ethics, and social awareness.



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Program Educational Objectives (PEOs)

PEO 1	Professional Excellence Analyze, design, build, maintain, or improve civil engineering-based systems, considering environmental, economic, and societal requirements.
PEO 2	Multidisciplinary Approach Develop a strong educational foundation to design and conduct experiments, meeting needs within multidisciplinary constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability, while analyzing and interpreting data.
PEO 3	Continued Self-Learning Identify, formulate, and solve engineering problems, and engage in lifelong learning in advanced areas of civil engineering and related fields.
PEO 4	Effective Contribution to Society Utilize modern engineering techniques, skills, and tools necessary for civil engineering practice, serving the community as ethical and responsible professionals.



DEPARTMENT OF FRESHMAN ENGINEERING
ENGINEERING CHEMISTRY LABORATORY
COURSE DISCRIPTOR

1	Department	COMPUTER SCIENCE ENGINEERING							
2	Course Name	ENGINEERING CHEMISTRY LAB							
3	Course Code	2410072							
4	Year/Semester	I/I							
5	Regulation	MLRS-R24							
6	Structure of the course	Theory				Practical			
		Lecture 0	Tutorials 0	Practical 0	Credit 0	L 0	T 0	P 2	C 1
7	Type of course	BS x	HS x	ES ✓	PC x	PE x	OE x	PS ✓	MC x
8	Course Offered	Odd Semester		✓	Even Semester			✓	
9	Total lecture, tutorial and practical hours for this course Offered (16 weeks of teaching per semester)								
	Lectures: 0 Hours		Tutorials: 0 hours		Practical: 32 hours				
10	Course Coordinator	Dr.madhavi							
11	Date Approved by BOS								
12	Course Webpage	www.mlritm.ac.in/							
13	Prerequisites/ Co-requisites	Level	Course Code	Semester	Prerequisites				
		-	2410072	I/I	-				

14. Course Overview:

The course encourages the use of analytical tools from an engineering standpoint. Engineering chemistry by providing hands-on experience with the principles and techniques used in the study of chemical processes, material properties, and the application of chemistry in various engineering fields. It provides the overview of analytical techniques, and outline the importance of volumetric analysis and virtual lab experiments. The lab course is designed to help students develop practical skills in chemical analysis, synthesis, and



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experimentation. It enhances their problem-solving abilities, reinforces key scientific principles, and prepares them for more advanced studies in both chemistry and engineering applications.

15. Course Objectives:

The students will try to learn:

The course consists of experiments related to the principles of chemistry required for engineering student. The student will learn:

1. Estimation of hardness of water to check its suitability for drinking purpose.
2. Students are able to perform estimations of acids and bases using conductometry, potentiometry methods.
3. Students will learn to prepare polymers such as Bakelite and Thiokol rubber in the laboratory.
4. Students will learn skills related to the lubricant properties such as saponification value, surface tension and viscosity of oils.

16. Course Outcomes:

After successful completion of the course, students should be able to:

C01	Recall the steps involved in estimating the amount of iron (Fe) in a sample using volumetric analysis and list the reagents and equipment used to determine water hardness by the complexometric method. (BL1)
C02	Contrast the fundamental concepts related to conductometry and potentiometry for acid-base concentration analysis. (BL2)
C03	Explain the chemical reactions involved in forming Bakelite (phenol-formaldehyde) and Thiokol (sulphur-based polymerization) rubbers. (BL2)
C04	Demonstrate the procedure to measure viscosity of lubricating oils using a viscometer (e.g, capillary, rotational), and compare the viscosity profiles of different grades of lubricating oils. (BL3)
C05	Describe how virtual labs simulate real-world conditions through the working principles of: photovoltaic effect in solar cells, lithium-ion movement in EV batteries, redox reactions in fuel cells, and stimuli-responsive behaviour of smart materials. (BL2)

17. Employability Skills:

Example: Communication skills / Programming skills / Project based skills /



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Project based skills refer to the technical and soft skills that students or professionals develop while performing experiments, analysing data, and working with equipment. These skills are highly valued by employers as they demonstrate the ability to work effectively in a laboratory or industrial setting.

18. Content Delivery / Instructional Methodologies:

✓	 Day to Day lab evaluation	✓	 Demo Video	✓	 Viva Voce questions	x	 Open Ended Experiments
x	 Competitions	x	 Hackathons	x	 Certifications	✓	Probing Further Questions

19. Evaluation Methodology:

Each laboratory will be evaluated for a total of 100 marks consisting of 40 marks for Continuous Internal Evaluation (CIE) and 60 marks for semester end lab examination. Out of 40 marks for internal evaluation:

1. A write-up on day-to-day experiment (aim, components/procedure, expected outcome) which shall be evaluated for 10 marks
2. 10 marks for viva-voce/ tutorial/ case study/ application/ poster presentation.
3. Internal practical examination shall be evaluated for 10 marks.
4. The remaining 10 marks are for Laboratory Project (Design/ Software / Hardware Model/ App Development/ Prototype/presentation).

Table 1: CIE marks distribution

Component						
Type of Assessment	Day to day performance	Exam	Viva-voce	Open ended Experiments	Total Marks	
CIE marks	10	10	10	10	40	

Continuous Internal Evaluation (CIE): One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which



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will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

- 10 marks for write-up
- 15 for experiment/program
- 15 for evaluation of results
- 10 marks for presentation on another experiment/program in the same laboratory course and
- 10 marks for viva-voce on concerned laboratory course.

20. Course content:

CO 1	a) Determination of parameters like hardness of water by complexometric method and determine the given Fe amount by volumetric analysis
	b. Measurement of hardness of different water samples, determine the total hardness by EDTA method
CO 2	a. Able to perform methods such as conductometry, potentiometry in order to find out the concentrations or equivalence points of acids and bases
	b. Determine the strength of the unknown solution by conductometry and potentiometry
CO 3	a. Students are able to prepare polymer Thiokol rubber from different monomers
CO 4	a. Estimation the viscosity of lubricant oils. To know its properties for the proper lubrication of machinery in industries and determine the acid value of lubricating oils
	b. Know the property of lubricating oil viscosity by using Ostwald viscometer.
	c. b. To know the acid value of lubricating oil coconut oil
CO 5	a. Learn about construct, functioning and applications of virtual lab experiments
	b. Construction of Fuel cell and its working. c. Smart materials for Biomedical applications d. Batteries for electrical vehicles.



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21. Course Plan:

The course plan is meant as a guideline. Probably there may be changes.

S. No	Topics to be covered	CO's	Reference
1	Introduction		
2	Estimation of Hardness of water by EDTA Complexometric method	CO1	Lab manual
3	Estimation of strength of strong acid using strong base by conductometry	CO1	Lab manual
4	Estimation of the concentration of strong and weak acid in an acid mixture by Conductometry	CO2	Lab manual
5	Estimation of concentration of Fe ⁺² ion by Potentiometry using KMnO ₄	CO2	Lab manual
6	Estimation of concentration of strong acid with strong base by Potentiometry using Quinhydrone	CO3	Lab manual
7	Internal lab-1		Lab manual
8	Determination of an acid concentration using pH meter	CO4	Lab manual
9	Preparation of Bakelite	CO4	Lab manual
10	Preparation Nylon-6, 6	CO5	Lab manual
11	Determination of rate of corrosion of mild steel in the presence and absence of inhibitor	CO5	Lab manual
12	Estimation of acid value of given lubricant oil.	CO5	Lab manual
13	Estimation of Viscosity of lubricant oil using Ostwald's Viscometer	CO5	Lab manual
14	Virtual experiments		
	A. Construction of Fuel cell and its working		



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	B. Smart materials for Biomedical applications		
	C. Batteries for electrical vehicles		

22. Experiments for Enhanced Learning:

S. No	Design Oriented Experiments
1	Smart materials and their applications
2	Batteries for electrical vehicles
3	Construction of Fuel cell and its working.

23. PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES:

PO No.	NBA Statement / Vital Features	Key Components	No. of Key Components
PO1	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems (Engineering Knowledge).	<ol style="list-style-type: none"> Scientific Principles: Application of scientific principles and methodologies. Mathematical Principles: Utilization of mathematical concepts in problem-solving. Interdisciplinary Integration: Integration of knowledge from various engineering disciplines. Engineering Specialization: Application of specialized engineering knowledge in complex engineering problems. 	4



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<p>PO 2.</p>	<p>Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and Engineering sciences (Problem Analysis).</p>	<ol style="list-style-type: none"> 1. Identity: Recognizing and defining complex engineering problems or opportunities. 2. Formulate: Structuring and abstracting the problem for systematic analysis. 3. Review: Examining research literature 4. Analyse: Investigating problems using data collection and relevant methodologies. 5. First Principles: Applying mathematical, natural, and engineering sciences in problem-solving. 6. Substantiated Conclusions: Ensuring accuracy and reliability through validation. 7. Experimental Design: Planning and conducting experiments for problem analysis. 8. Solution Development: Implementing and testing solutions through experimentation. 9. Interpretation: Evaluating results to draw meaningful engineering conclusions. 10. Documentation: Recording findings systematically for future reference and learning. 	<p>10</p>
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PO 3.	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations (Design/Development of Solutions).	<ol style="list-style-type: none">1. Design: Investigate and define a problem while identifying constraints, including environmental, sustainability, health, and safety considerations.2. Solutions: Understand customer and user needs while considering factors such as aesthetics.3. System Components: Identify and manage cost drivers in engineering solutions.4. Processes: Use creativity to develop innovative engineering solutions.5. Specified Needs: Ensure fitness for purpose across production, operation, maintenance, and disposal.6. Public Health & Safety: Manage the design process and evaluate outcomes for safety and risk assessment.7. Cultural Considerations: Understand the commercial and economic context of engineering processes.8. Societal Considerations: Apply management techniques to achieve engineering objectives in a broader context.9. Environmental Considerations: Promote sustainable development through engineering activities.10. Appropriate Considerations: Be aware of legal frameworks governing engineering activities, including personnel, health, safety, and environmental risks.	10
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<p>PO 4.</p>	<p>Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (Conduct Investigations of Complex Problems).</p>	<ol style="list-style-type: none"> 1. Research-Based Knowledge: Gain a deep understanding of materials, equipment, processes, and products through research to address engineering problems effectively. 2. Research Methods: Develop essential laboratory and workshop skills to carry out experimental investigations and gather reliable data. 3. Design of Experiments: Address complex problems in various engineering contexts, including operations, management, and technology development. 4. Analysis: Leverage technical literature and reliable information sources. 5. Interpretation of Data: Follow appropriate codes of practice and industry standards when analyzing and interpreting experimental data. 6. Synthesis: Ensure high-quality results by integrating various data sources and considering quality control during engineering investigations. 7. Valid Conclusions: Draw valid conclusions by addressing technical uncertainties through sound reasoning and scientific principles. 8. Engineering Principles: Apply fundamental engineering principles to analyses and interpret key engineering processes and challenges. 9. Modelling Techniques: Use analytical and modelling techniques to identify, classify, and describe the performance of engineering systems and components. 10. Quantitative Methods: Employ 	<p style="text-align: center;">10</p>
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		analytical software and quantitative methods efficiently and accurately.	
PO 5.	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations (Modern Tool Usage).	<ol style="list-style-type: none"> 1. Create: Develop engineering solutions using modern tools across various disciplines. 2. Select: Identify appropriate prediction and modelling tools for diverse engineering applications. 3. Apply: Utilize IT tools in engineering analysis, design, and decision-making. 4. Techniques: Implement simulation tools in different engineering fields. 	4
PO 6.	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice (The Engineer and	<ol style="list-style-type: none"> 1. Contextual Knowledge: Understand the commercial and economic context of engineering processes. 2. Management Techniques: Apply management strategies in engineering objectives within this context. 3. Sustainable Development: Promote sustainable development through engineering activities. 	5



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	Society).	<ol style="list-style-type: none"> 4. Legal Awareness: Recognize relevant legal requirements governing engineering practices, including health, safety, and environmental risks. 5. Professional Ethics: Uphold high standards of professional and ethical conduct in engineering. 	
PO 7.	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development (Environment and Sustainability).	<ol style="list-style-type: none"> 1. Socio-Economic Impact: Understand the socio-economic effects of engineering solutions on society. 2. Political Impact: Recognize the political implications and responsibilities of engineering solutions. 3. Environmental Impact: Assess the environmental consequences of engineering practices and solutions. 4. Sustainability: Demonstrate the importance of sustainable development in engineering solutions. 	4
PO 8.	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice (Ethics).	<ol style="list-style-type: none"> 1. Ethical Judgement: Make informed decisions based on ethical principles, using professional codes of ethics to guide actions and evaluate the ethical aspects of practice. 2. Integrity: Demonstrate a strong sense of trust and integrity, standing firm in one's values while acting responsibly and ethically. 3. Fairness and Equity: Ensure fair treatment and equity in all professional activities, valuing diversity and respecting others' perspectives. 4. Professional Responsibility: Adhere to the norms of engineering practice by committing to high ethical standards and demonstrating ethical behavior in all professional engagements. 	4



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<p>P09</p>	<p>Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings (Individual and Teamwork).</p>	<ol style="list-style-type: none"> 1. Independence: Work effectively as an individual, taking ownership of tasks and driving progress independently. 2. Maturity: Demonstrate maturity by focusing on goal achievement, requiring minimal external motivation. 3. Self-Direction: Approach vaguely defined problems with systematic problem-solving skills to find solutions. 4. Team Collaboration: Engage in teamwork during various activities, including hands-on labs and multidisciplinary projects. 5. Adaptability: Participate in diverse team settings, adjusting to different roles and projects such as mini projects and design tasks. 6. Project Management: Understand and apply principles of teamwork and project management to effectively complete assignments and projects. 7. Peer Evaluation: Contribute to team dynamics by evaluating and reflecting on individual and group performance. 8. Building Relationships: Foster teamwork and lasting relationships, contributing to both academic success and post-graduation professional networks. 9. Organizational Integration: Collaborate with individuals across all levels of an organization, demonstrating adaptability and interpersonal skills. 10. Effective Communication: Develop strong relationships through positive interactions, 	<p>10</p>
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		showcasing an ability to get along with others and work cohesively in teams.	
PO10	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions (Communication).	<ol style="list-style-type: none"> Clarity: Communicate complex engineering concepts clearly and concisely in written reports and design documentation. Grammar and Punctuation: Ensure high standards of grammar and punctuation in written communication, maintaining professionalism and clarity. References: Properly reference sources in written communication, ensuring accuracy and academic integrity. Speaking Style: Deliver oral presentations effectively, with appropriate speaking style to engage the audience and convey technical information clearly. Subject Matter: Demonstrate a deep understanding of the subject matter, clearly communicating complex ideas during oral discussions and presentations. 	5
PO11	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments (Project Management and Finance).	<ol style="list-style-type: none"> Scope Definition: Define the project scope clearly to ensure alignment with objectives and requirements. Critical Success Factors: Identify and prioritize critical success factors necessary for project completion and success. Deliverables: Ensure the timely delivery of project outputs, meeting the predefined objectives and quality standards. 	10



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		<ol style="list-style-type: none"> 4. Work Breakdown Structure: Develop and organize a structured breakdown of tasks and activities to achieve project goals. 5. Scheduling: Create and manage schedules to ensure tasks are completed on time and milestones are met. 6. Budget Management: Develop and manage project budgets, ensuring that resources are used efficiently and within financial constraints. 7. Quality Assurance: Apply quality control measures to ensure that project deliverables meet the required standards. 8. Human Resources Planning: Plan and allocate human resources effectively, ensuring the right skills and team dynamics. 9. Stakeholder Management: Identify and manage stakeholders, ensuring their needs and expectations are addressed throughout the project. 10. Risk Management: Develop a risk register and apply strategies to identify, assess, and mitigate project risks. 	
<p>PO12</p>	<p>Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change (Life -</p>	<ol style="list-style-type: none"> 1. Professional Certificate: Pursue professional, Academic, Global certifications. 2. Advanced Education: Begin and work towards advanced programs to further deepen knowledge. 3. Continuous Learning: Stay updated on industry trends and emerging technologies to remain relevant in the field. 4. Skill Acquisition: Learn at least 2–3 new significant skills annually to 	<p>8</p>



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	<p>Long Learning).</p>	<p>ensure continuous growth and development.</p> <ol style="list-style-type: none"> 5. Training Commitment: Dedicate time for formal training for a standard duration of training each year. 6. Personal Development: Engage in ongoing self-improvement efforts to enhance both personal and professional growth. 7. Adaptability: Be adaptable to technological changes by actively pursuing new learning opportunities and challenges. 8. Networking: Build a network with industry peers and professionals to stay informed and grow knowledge through collaboration 	
PSOs	Program Specific Outcomes		No. of Key Components
<p>PSO1</p>	<p>Applications of Computing: Ability to use knowledge in various domains to provide solution to new ideas and innovations.</p> <ol style="list-style-type: none"> 1. Base for project 2. Develop innovative Project 3. Inter domain knowledge integration to create innovative solutions 4. Collaborative efforts and diverse perspectives for new ideas and innovations 		<p style="text-align: center;">4</p>
<p>PSO2</p>	<p>Programming Skills: Identify required data structures, design suitable algorithms, develop and maintain software for real world problems.</p> <ol style="list-style-type: none"> 1. Identify Data Structure 2. Design Algorithms 3. Implementation of projects using programming skill 4. Develop and maintain software for real world problems and modify overtime. 		<p style="text-align: center;">4</p>
<p>PSO3</p>	<p>Entrepreneur and higher studies: Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.</p> <ol style="list-style-type: none"> 1. Usage of existing tools 2. Computational base for higher studies 		<p style="text-align: center;">4</p>



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	3. Developing Entrepreneurial Mindset 4. Use experimental tools for creating innovative career path	
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24. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engg. Specialization to the solution of complex engineering problems.	3	CIE/ SEE/ Viva-Voce/ Day to Day Performance / Project & Presentation
PO2	Problem analysis: Identify, formulate, research literature, and analyse engineering problems to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.	4	CIE/ SEE/ Viva-Voce/ Day to Day Performance / Project & Presentation
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	3	CIE/ SEE/ Viva-Voce/ Day to Day Performance / Project & Presentation
PO7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	4	CIE/ SEE/ Viva-Voce/ Day to Day Performance / Project & Presentation
PO8	Individual and team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.	3	CIE/ SEE/ Viva-Voce/ Day to Day Performance / Project & Presentation
PO9	Communication: Communicate effectively with	3	CIE/ SEE/ Viva-



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	the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.		Voce/ Day to Day Performance / Project & Presentation
PO11	Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments	3	CIE/ SEE/ Viva-Voce/ Day to Day Performance / Project & Presentation
PO12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	3	CIE/ SEE/ Viva-Voce/ Day to Day Performance / Project & Presentation

25. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PSO1	Applications of Computing: Ability to use knowledge in various domains to provide solution to new ideas and innovations.	2	CIE/ SEE/ Viva-Voce/ Day to Day Performance / Project & Presentation
PSO2	Programming Skills: Identify required data structures, design suitable algorithms, develop and maintain software for real world problems.	2	CIE/ SEE/ Viva-Voce/ Day to Day Performance / Project & Presentation
PSO3	Entrepreneur and higher studies: Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.	2	CIE/ SEE/ Viva-Voce/ Day to Day Performance / Project & Presentation



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3 = High; 2 = Medium; 1 = Low

26. MAPPING OF EACH CO WITH PO(s), PSO(s):

Course Outcomes	PROGRAM OUTCOMES												PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
C01	✓	✓	-	-	-	-		✓	✓	-	-	✓	-	-	-
C02	✓	✓	-	-	-	-		-	✓	-	-	✓	-	-	-
C03	✓	✓	-	-	-	-	✓	✓	✓	-	✓	✓	-	-	-
C04	✓	✓	-	-	-	-	✓	✓	-	-	-	✓	-	-	-
C05	✓	✓	-	-	-	✓	✓	✓	✓	-	✓	✓	-	-	-

27. JUSTIFICATIONS FOR CO – PO / PSO MAPPING - DIRECT:

Course Outcomes	PO'S/ PSO'S	Justification for mapping (Students will be able to)	No. of Key Competencies
C01	PO1	Explaining how hard water impacts industrial processes (e.g., scaling in boilers), domestic use (soap inefficiency), and environmental sustainability (e.g., soil quality). Recognizing the importance of monitoring water quality for public health and regulatory compliance.	1
	PO2	Interpretation and context: Explaining the significance of results:	1



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	<p>Water hardness: Linking hardness values to water quality standards and industrial/domestic implications (e.g., scaling, soap efficiency).</p> <p>Iron content: Discussing health/environmental impacts of excess Fe (e.g., toxicity, pipe corrosion).</p>	
PO6	<p>Analyzing how errors (e.g., misreading burettes, contamination) affect results and refining techniques for future work.</p> <p>Understanding how water hardness and Fe analysis relate to real-world challenges (e.g., corrosion in pipelines, environmental pollution).</p>	1
PO7	<p>Explaining how hard water affects public health (e.g., mineral intake) and domestic/industrial systems (e.g., scaling in pipes, reduced efficiency of water heaters).</p> <p>Recognizing the need for water softening to comply with public health standards (e.g., WHO guidelines).</p> <p>Environmental ethics: Discussing the sustainability of chemical methods (e.g., use of EDTA in complexometric titrations, which can persist in ecosystems).</p> <p>Advocating for eco-friendly alternatives (e.g., biodegradable chelating agents) or proper disposal of chemical waste (e.g., Fe-containing solutions).</p> <p>Ethical responsibility: Ensuring accurate reporting of results to avoid misleading conclusions that could harm communities (e.g., underreporting Fe levels in drinking water).</p> <p>Addressing equity issues (e.g., access to clean water in underserved regions).</p>	2
PO8	<p>Proposing cost-effective or eco-friendly alternatives (e.g., replacing EDTA with biodegradable chelators for hardness testing).</p> <p>Developing portable kits for on-site water quality testing in remote areas.</p> <p>Entrepreneurial mindset:</p>	2



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		<p>Identifying market needs (e.g., water hardness testing services for small industries or households).</p> <p>Creating workflows to scale lab techniques (e.g., Fe analysis) for industrial/commercial use.</p> <p>Interdisciplinary integration:</p>	
	PO9	<p>1. Sustainable Analytical Practices</p> <p>Eco-friendly methodologies:</p> <p>Using green chemistry principles (e.g., minimizing EDTA waste in complexometric titrations, replacing toxic reagents like $K_2Cr_2O_7$ with safer alternatives for Fe analysis).</p> <p>Waste management:</p> <p>Proper disposal of chemicals (e.g., heavy metal-containing solutions from Fe titrations).</p>	
		<p>2. Addressing Global Water Challenges</p> <p>Connecting to SDGs:</p> <p>Linking water hardness and Fe analysis to UN Sustainable Development Goal 6 (Clean Water and Sanitation).</p> <p>Global relevance:</p> <p>Solving water quality issues in regions affected by hard water (e.g., arid areas) or Fe contamination (e.g., mining regions).</p>	1
		<p>3. Interdisciplinary Collaboration</p> <p>Integrating fields:</p> <p>Combining chemistry with environmental science (e.g., modeling Fe pollution's impact on ecosystems) or engineering (e.g., designing corrosion-resistant pipes based on hardness data).</p> <p>Data-driven solutions:</p> <p>Using analytical results to inform policy (e.g., setting regional water quality standards).</p>	
		<p>4. Ethical Leadership and Advocacy</p> <p>Community engagement:</p>	



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		<p>Educating communities about water testing and safe practices (e.g., workshops on interpreting hardness/Fe levels).</p> <p>Advocacy: Promoting affordable water-testing kits for underserved populations.</p>	
		<p>5. Lifelong Learning and Innovation</p> <p>Adapting to advancements: Exploring modern tools (e.g., IoT sensors for real-time water hardness monitoring).</p> <p>Research-driven solutions: Investigating novel chelating agents or nanomaterial-based methods for Fe removal.</p>	
	PO11	<p>Explaining how accurate determination of acid/base concentrations impacts public health (e.g., monitoring pH in drinking water, pharmaceutical formulations) or industrial processes (e.g., wastewater treatment, food quality control).</p>	6
	PO12	<p>Documentation and presentation:</p> <p>Procedures: Accurately describing experimental steps (e.g., calibration of electrodes in potentiometry, preparation of solutions for conductometric titrations).</p> <p>Data representation: Presenting results clearly (e.g., plotting conductivity vs. volume graphs for conductometry or pH/mV vs. volume curves for potentiometry to identify equivalence points).</p> <p>Visual aids: Using tables, graphs, or diagrams to illustrate trends (e.g., sharp conductivity drops in strong acid-strong base titrations).</p> <p>Interpretation and context: Explaining how the equivalence point relates to stoichiometry and acid-base strength (e.g., why weak acid-strong base titrations have gradual pH shifts). Linking results to real-world applications (e.g., environmental monitoring of acid rain, pharmaceutical quality control).</p>	4



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		<p>Scientific language: Using precise terminology (e.g., "endpoint vs. equivalence point," "ionic mobility," "Nernst equation"). Structuring reports with logical flow (e.g., Introduction, Methods, Results, Discussion).</p>	
CO2	PO1	<p>Effective Collaboration and Teamwork Role allocation and shared responsibilities: Working in teams to execute experiments (e.g., one student calibrates the pH meter for potentiometry, another prepares solutions for conductometric titrations).</p>	1
	PO2	<p>Proper disposal of chemical waste (e.g., acids, bases, or heavy metals from electrodes) to prevent environmental contamination. Sustainable practices: Minimizing reagent use (e.g., reducing volumes in conductometric titrations) or adopting green solvents.</p>	
	PO6	<p>Business modeling: Cost-benefit analysis of replacing traditional titrations with automated conductometric/potentiometric systems. Interdisciplinary Integration Combining fields: Linking chemistry with data science (e.g., big data analytics for pH trends in urban water systems). Collaborating with environmental engineers to design acid-neutralization systems based on titration data.</p>	1
	PO7	<p>Sustainability and Environmental Stewardship Green Chemistry Integration: Reducing chemical waste by optimizing titration volumes (e.g., microscale conductometric titrations to minimize reagent use).</p>	2



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	<p>Using eco-friendly electrolytes (e.g., biodegradable ionic solutions) instead of hazardous chemicals.</p> <p>Waste Management: Proper disposal of spent solutions (e.g., acids/bases) and electronic waste (e.g., old electrodes, conductivity probes).</p>	
PO8	<p>Understanding the Environmental, Health, and Societal Implications of Polymer Synthesis</p> <p>Ethical Responsibility: Safe Handling of Hazardous Monomers: Recognizing risks associated with raw materials (e.g., formaldehyde in Bakelite synthesis is carcinogenic; dichloroethane/dichloromethane in Thiokol production is toxic).</p>	2
PO9	<p>Proposing greener alternatives (e.g., bio-based resins, sustainable vulcanization methods). Highlighting safety improvements (e.g., substitutes for formaldehyde in phenolic resins).</p>	1
PO11	<p>Effective Collaboration and Use of Modern Tools in Polymer Synthesis</p> <p>Teamwork in Laboratory Settings: Collaborating to divide tasks (e.g., one student handles monomer preparation, another monitors reaction conditions like temperature or pH). Peer review of procedures (e.g., verifying stoichiometric ratios for phenol-formaldehyde reactions or sulfur-to-monomer ratios in Thiokol synthesis). Staying updated on innovations in polymer science (e.g., sustainable vulcanization methods for rubber).</p>	6
PO 12	<p>1. Ethical Responsibility in Safe Practices</p> <p>Hazardous Material Handling: Safely managing toxic monomers (e.g., formaldehyde in Bakelite, dichloroethane in Thiokol) using PPE, fume hoods, and protocols to prevent exposure.</p>	4



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		<p>Ethical obligation to avoid shortcuts (e.g., improper stoichiometry to speed up reactions).</p> <p>2. Environmental Stewardship Waste Management: Proper disposal of carcinogens (e.g., formaldehyde residues) and sulfur-containing byproducts from Thiokol synthesis. Sustainability Awareness: Addressing the non-recyclability of Bakelite and environmental persistence of polysulfide rubbers. Exploring biodegradable or recyclable alternatives (e.g., bio-based phenolic resins). 3. Societal Impact Analysis Applications vs. Consequences: Benefits: Bakelite's role in electrical insulation; Thiokol's use in aerospace sealants. Drawbacks: Health risks (formaldehyde emissions), plastic pollution, and landfill persistence. Equity Considerations: Ensuring access to safer polymer alternatives in low-resource communities. 4. Advocacy for Sustainable Innovation Green Chemistry Integration: Reducing reliance on toxic monomers (e.g., replacing formaldehyde with lignin-derived aldehydes). Adopting solvent-free or energy-efficient polymerization methods. Circular Economy: Designing polymers for easier recycling (e.g., reversible crosslinking in Thiokol).</p>	
CO3	PO1	<p>Effective Collaboration and Teamwork Role allocation and shared responsibilities: Working in teams to execute experiments (e.g., one student calibrates the pH meter for potentiometry, another prepares solutions for conductometric titrations).</p>	1
	PO2	<p>Sustainability and Green Chemistry</p>	1



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	<p>Circular Economy Practices: Designing polymers for recyclability (e.g., reversible crosslinking in Thiokol). Adopting solvent-free polymerization or bio-derived raw materials.</p> <p>Waste Valorisation: Repurposing byproducts (e.g., sulphur from Thiokol synthesis into fertilizers).</p>	
PO6	<p>Interdisciplinary Innovation and Global Relevance</p> <p>Cross-Disciplinary Collaboration: Partnering with materials engineers to enhance polymer properties (e.g., flame resistance in Bakelite for electronics). Working with environmental scientists to mitigate pollution (e.g., reducing sulphur emissions in Thiokol production).</p>	1
PO7	<p>Ensuring precise measurement of viscosity (e.g., using viscometers like Rotational or Say bolt) and acid value (via titration with KOH) to avoid misleading results that could compromise machinery performance or safety.</p> <p>2. Societal and Environmental Awareness</p> <p>Industrial Impact: Linking viscosity results to machinery efficiency (e.g., improper viscosity can cause wear, energy waste, or equipment failure).</p>	2
PO8	<p>Specifying equipment (viscometer type, burette, pH meter) and standards followed (e.g., ASTM D445 for viscosity, ASTM D664 for acid value).</p> <p>Data Presentation: Organizing results in tables (e.g., viscosity at different temperatures, titration volumes) and graphs (e.g., viscosity vs. temperature curves).</p> <p>Effective Data Interpretation and Analysis</p> <p>Viscosity Insights:</p>	2



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	<p>Explaining how viscosity values correlate with lubrication efficiency (e.g., high viscosity may reduce fuel economy; low viscosity risks wear). Relating temperature-dependent viscosity changes to machinery performance (e.g., using SAE or ISO viscosity grades).</p>	
PO9	<p>Modern Tool Proficiency: Using advanced instruments like digital viscometers, automated titration systems, or software (e.g., viscosity-temperature modelling tools, pH stat analysers). Applying industry-standard methods (e.g., ASTM D445 for viscosity, ASTM D664 for acid value). Adaptability and Continuous Learning: Staying updated on innovations (e.g., IoT-enabled sensors for real-time viscosity monitoring, eco-friendly titration reagents). Troubleshooting equipment (e.g., calibrating viscometers, resolving electrode drift in pH meters).</p>	1
PO11	<p>1. Proper disposal of used lubricants, titration reagents, and solvents to prevent soil/water contamination. Sustainable Practices: 2. Advocating for biodegradable lubricants or re-refined oils to reduce environmental footprint. Minimizing chemical use (e.g., micro-titration techniques for acid value determination). 3. Societal and Industrial Impact Awareness Machinery Longevity and Safety: Linking viscosity results to machinery efficiency (e.g., improper viscosity causes wear, energy waste, or catastrophic failure). Highlighting how high acid value (indicating oxidation) accelerates corrosion, risking worker safety and environmental leaks. Public Health:</p>	6



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	<p>Addressing risks from improper oil disposal (e.g., groundwater contamination affecting communities near industrial zones).</p> <p>4. Advocacy for Sustainable Innovation</p> <p>Green Alternatives: Promoting bio-based lubricants or additives to neutralize acids (e.g., over based detergents).</p> <p>Circular Economy: Encouraging oil recycling/re-refining to extend lifecycle and reduce crude oil dependency.</p> <p>Education and Outreach: Training industries on sustainable oil management (e.g., ISO 14000 environmental standards).</p> <p>5. Regulatory Compliance and Lifecycle Analysis</p> <p>Adherence to Standards:</p>	
PO12	<p>1. Innovative Methodologies and Tools</p> <p>Advanced Instrumentation: Using IoT-enabled viscometers for real-time viscosity monitoring in industrial machinery. Adopting automated titration systems or portable acid value analysers for rapid, on-site oil quality checks.</p> <p>Data-Driven Innovation: Applying machine learning to predict oil degradation trends from historical viscosity/acid value data.</p> <p>2. Entrepreneurial Application and Commercialization</p> <p>Product Development: Designing customized lubricant blends tailored to machinery needs (e.g., high-temperature stability or acid-neutralizing additives).</p> <p>Business Solutions: Launching oil analysis services for SMEs (e.g., predictive maintenance packages based on viscosity/acid value trends).</p> <p>3. Interdisciplinary Collaboration</p> <p>Cross-Field Integration:</p>	4



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		<p>Partnering with data scientists to model oil performance or with mechanical engineers to optimize lubrication systems.</p> <p>Industry Partnerships: Collaborating with refineries to improve oil reclamation processes using acid value data.</p> <p>4. Sustainability and Green Chemistry</p> <p>Eco-Friendly Practices: Promoting bio-based lubricants (e.g., plant-derived oils) to reduce reliance on petroleum. Innovating closed-loop recycling systems for used oils, minimizing waste.</p> <p>Waste Valorisation: Converting acidic oil byproducts into industrial raw materials (e.g., soap production from neutralized fatty acids).</p>	
	PSO1	<p>Sustainable Practices and Environmental Stewardship</p> <p>Eco-Friendly Testing Methods: Reducing chemical waste in acid value titrations (e.g., micro-titration techniques) and promoting solvent-free viscosity measurements. Advocating for biodegradable lubricants or re-refined oils to minimize reliance on petroleum-based products.</p> <p>Circular Economy Integration: Designing protocols for oil recycling and reprocessing to extend lifecycle (e.g., acid neutralization to restore used oils).</p>	1
	PSO2	<p>Highlighting scenarios where virtual labs complement, but do not replace, hands-on experimentation (e.g., hazardous reactions, advanced research prototyping).</p>	1
CO4	PO1	<p>Discussing the role of virtual labs in modern science (e.g., training for hazardous experiments, remote education, or prototyping industrial processes).</p>	1



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PO2	<p>Mastering software and platforms used in virtual labs (e.g., Python-based simulations, Unity for 3D modelling, for engineering applications).</p> <p>Leveraging tools like AI-driven analytics to interpret virtual experiment outcomes (e.g., predicting reaction yields or optimizing parameters).</p>	1
PO6	<p>1. Ethical Design and Accessibility Construct:</p> <p>Ensuring virtual labs are designed inclusively (e.g., compatibility with screen readers, subtitles for hearing-impaired users).</p> <p>Addressing digital equity (e.g., low-bandwidth versions for users in remote/rural areas).</p> <p>Functioning:</p>	1
PO7	<p>Avoiding biases in simulations (e.g., culturally neutral examples, diverse representation in virtual scenarios).</p> <p>Applications:</p> <p>Promoting ethical use of virtual labs (e.g., avoiding plagiarism of simulated data in academic work).</p>	2
PO8	<p>1. Advanced Technological Integration</p> <p>Designing virtual labs using cutting-edge technologies like AI-driven simulations, VR/AR immersion, or machine learning algorithms to replicate complex real-world phenomena.</p> <p>Functioning:</p> <p>Leveraging real-time data analytics and adaptive feedback systems to enhance user interaction and learning outcomes.</p> <p>Applications:</p> <p>Enabling high-fidelity simulations for fields like quantum physics, synthetic biology, or advanced chemistry.</p> <p>2. Interdisciplinary Collaboration</p> <p>Involving cross-functional teams (educators, software engineers, domain scientists) to ensure accuracy, usability, and pedagogical effectiveness.</p> <p>Functioning:</p>	2



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		Integrating diverse expertise to troubleshoot technical challenges (e.g., balancing computational efficiency with scientific precision).	
	PO9	<p>1. Sustainable and Eco-Conscious Design Developing virtual labs with energy-efficient coding and green cloud infrastructure to minimize carbon footprints (e.g., optimizing server usage, reducing computational waste). Functioning: Highlighting how virtual labs reduce reliance on physical resources (e.g., no disposable lab equipment, reduced chemical usage). Applications: Advocating for virtual labs as tools to replace resource-intensive experiments (e.g., hazardous chemical reactions, animal testing).</p>	1
	PO11	<p>Environmental and societal relevance: Water hardness: Explaining how hard water impacts industrial processes (e.g., scaling in boilers), domestic use (soap inefficiency), and environmental sustainability (e.g., soil quality). Recognizing the importance of monitoring water quality for public health and regulatory compliance. Ethical and safety practices: Proper disposal of chemicals (e.g., EDTA, buffer solutions, iron-containing waste) to minimize environmental harm. Ensuring accuracy in analysis to avoid misleading results that could affect public health or industrial decisions. Safe handling of reagents (e.g., strong acids, redox agents like KMnO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$). Sustainability awareness: Recommending water-softening methods (e.g., ion exchange) that balance efficacy with environmental impact.</p>	6



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		Advocating for sustainable practices in metal analysis (e.g., minimizing reagent waste).	
	PO12	<p>Interpretation and context: Explaining the significance of results: Water hardness: Linking hardness values to water quality standards and industrial/domestic implications (e.g., scaling, soap efficiency). Iron content: Discussing health/environmental impacts of excess Fe (e.g., toxicity, pipe corrosion).</p>	4
C05	PO1	<p>Analysing how errors (e.g., misreading burettes, contamination) affect results and refining techniques for future work. Connecting theory to practice: Understanding how water hardness and Fe analysis relate to real-world challenges (e.g., corrosion in pipelines, environmental pollution). Engagement with literature: Researching updated methods (e.g., alternative chelating agents for hardness or greener redox reagents for Fe analysis).</p>	1
	PO2	<p>Ensuring accurate reporting of results to avoid misleading conclusions that could harm communities (e.g., underreporting Fe levels in drinking water). Addressing equity issues (e.g., access to clean water in underserved regions).</p>	1
	PO6	<p>Designing Solutions for Real-World Challenges Innovative problem-solving: Proposing cost-effective or eco-friendly alternatives (e.g., replacing EDTA with biodegradable chelators for hardness testing). Developing portable kits for on-site water quality testing in remote areas. Entrepreneurial mindset: Identifying market needs (e.g., water hardness testing services for small industries or households).</p>	1
	PO7	<p>1. Sustainable Analytical Practices Eco-friendly methodologies:</p>	2



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	<p>Using green chemistry principles (e.g., minimizing EDTA waste in complexometric titrations, replacing toxic reagents like $K_2Cr_2O_7$ with safer alternatives for Fe analysis).</p> <p>Waste management: Proper disposal of chemicals (e.g., heavy metal-containing solutions from Fe titrations).</p>	
	<p>2. Addressing Global Water Challenges</p> <p>Connecting to SDGs: Linking water hardness and Fe analysis to UN Sustainable Development Goal 6 (Clean Water and Sanitation).</p> <p>Global relevance: Solving water quality issues in regions affected by hard water (e.g., arid areas) or Fe contamination (e.g., mining regions).</p>	
	<p>3. Interdisciplinary Collaboration</p> <p>Integrating fields: Combining chemistry with environmental science (e.g., modelling Fe pollution's impact on ecosystems) or engineering (e.g., designing corrosion-resistant pipes based on hardness data).</p> <p>Data-driven solutions: Using analytical results to inform policy (e.g., setting regional water quality standards).</p> <p>4. Lifelong Learning and Innovation</p> <p>Adapting to advancements: Exploring modern tools (e.g., IoT sensors for real-time water hardness monitoring).</p> <p>Research-driven solutions: Investigating novel chelating agents or nanomaterial-based methods for Fe removal.</p>	



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PO8	<p>In potentiometric titration of a weak acid, PO6 requires students to explain why accurate equivalence point determination is critical for industries like pharmaceuticals (e.g., ensuring drug stability and safety).</p>	2
PO9	<p>Scientific language: Using precise terminology (e.g., "endpoint vs. equivalence point," "ionic mobility," "Nernst equation"). Structuring reports with logical flow (e.g., Introduction, Methods, Results, Discussion).</p>	1
PO11	<p>Effective Collaboration and Teamwork Role allocation and shared responsibilities: Working in teams to execute experiments (e.g., one student calibrates the pH meter for potentiometry, another prepares solutions for conductometric titrations). Peer review of data (e.g., cross-checking equivalence point calculations or conductivity measurements). Problem-solving as a group: Resolving discrepancies (e.g., inconsistent pH readings in potentiometry or unexpected conductivity trends in conductometry). Collaborative interpretation of titration curves (e.g., identifying inflection points for equivalence).</p>	6
PO12	<p>Proper disposal of chemical waste (e.g., acids, bases, or heavy metals from electrodes) to prevent environmental contamination. Sustainable practices: Minimizing reagent use (e.g., reducing volumes in conductometric titrations) or adopting green solvents. Societal Relevance and Impact Public health applications: Linking acid/base concentration analysis to safe drinking water (e.g., monitoring pH in municipal supplies) or pharmaceutical quality control. Industrial implications:</p>	4



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		Using potentiometric data to optimize wastewater treatment (e.g., neutralization of acidic effluents).	
	PSO1	<p>Applications of Computing: Ability to use knowledge in various domains to provide solution to new ideas and innovations.</p> <p>Key components:</p> <ol style="list-style-type: none"> 1. Develop innovative Project 2. Problem Identification and Analysis: Accurately identify and analyze specific problem requirements and constraints. 3. Data-Driven Applications: Develop data-centric applications that leverage concepts from algorithms, system software, web design, etc. 4. Data Structure Utilization: Employ appropriate data structures to represent and manipulate data effectively 	0
	PSO2	<p>Programming Skills: Identify required data structures, design suitable algorithms, develop and maintain software for real world problems.</p> <p>Key components:</p> <ol style="list-style-type: none"> 1. Identify Data Structure 2. Design Algorithms 3. Implementation of projects using programming skill. 4. Secure Software Development: Create robust software systems that are resistant to vulnerabilities and attacks. 	0



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	PS03	<p>Entrepreneur and higher studies: Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies.</p> <p>Key components:</p> <ol style="list-style-type: none"> 1. Usage of Computational Tools. 2. Computational base for higher studies. 3. Technical Proficiency: Acquire a deep understanding of advanced frameworks, platforms, and technologies relevant to engineering practice and higher education. 4. Entrepreneurial Mindset: Develop the entrepreneurial skills and mindset required to identify and pursue innovative business opportunities. 	0
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2. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

Course Outcomes	PROGRAM OUTCOMES												PSOs		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
	4	10	10	10	4	5	4	4	10	5	10	8	4	4	4
C01	1	1	-	-	-	-	-	2	1	-	-	4	-	-	-
C02	1	4	-	-	-	-	-	-	4	-	-	4	-	-	-
C03	1	1	-	-	-	-	2	2	1	-	6	4	-	-	-
C04	1	1	-	-	-	-	1	2	6	-	-	4	-	-	-
C05	1	1	-	-	-	1	2	2	1	-	5	4	-	-	-

29. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO/ PSO):



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Course Outcomes	PROGRAM OUTCOMES											PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
C01	25	10	-	-	-	-	-	50	10	-	-	50	-	-	-
C02	25	40	-	-	-	-	-	-	40	-	-	50	-	-	-
C03	25	10	-	-	-	-	50	50	10	-	60	50	-	-	-
C04	25	40	-	-	-	-	25	50	60	-	-	50	-	-	-
C05	25	10	-	-	-	20	50	50	10	-	50	50	-	-	-

30. COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S, CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation,

2 - $40\% < C < 60\%$ – Moderate

1- $5 < C \leq 40\%$ – Low/ Slight

3 - $60\% \leq C < 100\%$ – Substantial /High

Course Outcome S	PROGRAM OUTCOMES											PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
C01	1	1	-	-	-	-	-	2	1	-	-	2	-	-	-
C02	1	2	-	-	-	-	-	-	2	-	-	2	-	-	-
C03	1	1	-	-	-	-	2	2	1	-	3	2	-	-	-
C04	1	2	-	-	-	-	1	2	3	-	-	2	-	-	-
C05	1	1	-	-	-	1	2	2	1	-	2	2	-	-	-
Total	5	7	-	-	-	1	5	8	8	-	5	10	-	-	-



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Average	1	1.4	-	-	-	1	1.6	2	1.6	-	2.5	2	-	-	-
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31. ASSESSMENT METHODOLOGY DIRECT:




CIE Exams	✓	SEE	✓	Laboratory Practices	✓
Certification	--	Viva-Voce / PPT / Project	✓	Open Ended Experiments	✓

32. ASSESSMENT METHODOLOGY INDIRECT:

x	Assessment of Projects by Experts	✓	Course End Survey (CES)
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33. RELEVANCE TO SUSTAINABILITY GOALS:

Engineering chemistry as a versatile and important subject, can play a significant role in engineering field

x	1		No Poverty: Engineering Chemistry, which blends chemical engineering with chemistry, often provides high-paying career opportunities Engineering Chemistry plays a key role in developing technologies that can aid in poverty alleviation.
✓	2		Zero Hunger: Engineering chemistry can be applied in agriculture to optimize resource use, predict crop yields, and manage supply chains, contributing to food security and sustainable agriculture practices.
✓	3		Good Health and Well-Being: Engineering chemistry is extensively used in bioinformatics, medical imaging, and other healthcare applications, supporting advancements in medical research and improving healthcare delivery.



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✓	4		<p>Quality education: Engineering chemistry is a crucial interdisciplinary branch of study that combines principles of both engineering and chemistry. It plays a pivotal role in the development of new materials, sustainable energy solutions, industrial processes, and environmental protection. To ensure the delivery of quality education in Engineering Chemistry, several key elements must be considered.</p>
x	5		<p>Gender Equality: A supportive work environment is critical for promoting gender equality and empowering women to thrive in the field of engineering chemistry. Gender Equality but also for fostering innovation, creativity, and sustainability in the field.</p>
x	6		<p>Clean water and sanitation: Clean water and sanitation is a key global goal, emphasized in Sustainable Development Goal 6 (SDG 6) of the United Nations, which seeks to ensure the availability and sustainable management of water and sanitation</p>
✓	7		<p>Affordable and clean energy In the field of, innovations and developments play a pivotal role in advancing clean and affordable energy technologies. Engineering chemistry integrates the principles of chemistry and engineering to create more efficient, sustainable, and cleaner energy sources and systems.</p>
✓	8		<p>Decent work and economic growth: Engineering chemistry plays a crucial role in shaping industries and sectors such as energy, materials, manufacturing, agriculture, and healthcare, all of which are fundamental to economic growth.</p>
✓	9		<p>Industry, Innovation and Infrastructure: Engineering chemistry is central to the development of sustainable materials and eco-friendly production methods. For example, the creation of biodegradable plastics, recyclable composites, and bio-based chemicals helps</p>



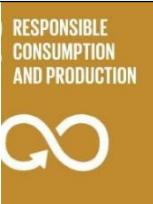



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			reduce environmental impact while stimulating new industries and markets.
x	10		<p>Reduced inequalities: Engineering chemistry can help create more equitable societies where individuals, regardless of their background, have equal opportunities to thrive. Collaboration between governments, industries, research institutions, and communities is essential to fully realize the potential of engineering chemistry in achieving reduced inequalities and promoting inclusive and sustainable development.</p>
✓	11		<p>Sustainable Cities and Communities: Engineering chemistry plays a pivotal role in developing technologies and processes that help cities become more resource-efficient, climate-resilient, and socially inclusive. From clean energy systems to waste management, water treatment, and green building materials, engineering chemistry offers solutions that can drive the transformation of urban areas into sustainable communities.</p>
✓	12		<p>Responsible consumption and production: Engineering chemistry enables industries to transition towards more responsible and circular production models. Responsible consumption and production are central principles for achieving sustainable development.</p>
✓	13		<p>Climate action: Engineering chemistry helps mitigate climate change and supports the transition to a low-carbon economy. Engineering chemistry is crucial in advancing climate action by developing technologies that reduce carbon emissions, promote the use of renewable energy, optimize resource utilization, and minimize waste.</p>



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x	14		<p>Life below water: Engineering chemistry plays an essential role in the conservation and restoration of life below water by developing technologies that reduce pollution, improve water quality, promote sustainable marine resource management, and mitigate the effects of climate change on oceans.</p>
x	15		<p>Life on land: Engineering chemistry is instrumental in creating solutions that support the sustainability of life on land, ensuring that human activities are aligned with environmental stewardship. By advancing technologies in sustainable agriculture, pollution control, land restoration, sustainable construction, and carbon sequestration</p>
✓	16		<p>peace, justice, and strong institutions: Engineering chemistry has a critical role to play in advancing the objectives of peace, justice, and strong institutions. Through its contributions to environmental protection, sustainable development, public health, and ethical innovation</p>
✓	17		<p>Partnerships for the Goals: Engineering chemistry plays a pivotal role in achieving these goals by providing innovative technologies, developing sustainable practices, and fostering global collaboration across sectors. From advancing green technologies to improving public health, environmental protection</p>

Signature of Course Coordinator
Name & Designation-M.Krishnaveni

HOD



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ACADEMIC CALENDAR 2025 - 26

2025 - B.Tech. I & II Semesters (MLRS-R24)


I Semester


SNo.	Description	Period		Duration
		From	To	
1	Induction Program	11.08.2025	16.08.2025	1 Week
2	Commencement of Class work	18.08.2025		
3	1 st Spell of instructions	18.08.2025	27.09.2025	6 Weeks
4	Dussehra Recess	29.09.2025	04.10.2025	1 Week
5	1 st Spell of instructions (Contd.)	06.10.2025	18.10.2025	2 Weeks
6	First Mid Term Examinations	20.10.2025	25.10.2025	1 Week
7	Parent-Teacher Meeting	01.11.2025		
8	2 nd Spell of instructions	27.10.2025	13.12.2025	7 Weeks
9	Second Mid Term Examinations	15.12.2025	20.12.2025	1 Week
10	Semester End Examinations/Supply	22.12.2025	03.01.2026	2 Weeks
11	Practical End Examinations	05.01.2026	10.01.2026	1 Week
12	Sankranti Recess	12.01.2026	17.01.2026	1 Week

II Semester

SNo.	Description	Period		Duration
		From	To	
1	Commencement of Class work	19.01.2026		
2	1 st Spell of instructions	19.01.2026	14.03.2026	8 Weeks
3	First Mid Term Examinations	16.03.2026	21.03.2026	1 Week
4	2 nd Spell of instructions	23.03.2026	09.05.2026	7 Weeks
5	Last date of instructions	09.05.2026		
6	Summer Vacation/Internship	11.05.2026	06.06.2026	4 Weeks
7	Second Mid Term Examinations	08.06.2026	13.06.2026	1 Week
8	Semester End Examinations/Supply	15.06.2026	27.06.2026	2 Weeks
9	Practical End Examinations	29.06.2026	04.07.2026	1 Week

*Commencement of III Semester class work: 06.07.2026


Dr. B. Ravi Prasad
Dean Academics


Bhushan Kundeti
Controller of Examinations


Dr. R. Murali Prasad
Principal


Dr. P. Sridhar
Director



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DEPARTMENT OF FRESHMAN ENGINEERING **ENGINEERING CHEMISTRY LABORATORY**

Course: I B. TECH I SEM

A.Y: 2025-2026

W.e.f: 25-08-2025

Engineering chemistry Laboratory (25100072)

Day	10:35 AM To 11:30AM	11:30A M To 12:25PM	12:25PM To 01:20PM	02:10PM To 03:5 PM	03:05PM To 04:00 PM
Monday			LUNCH		
Tuesday	CSE-B				
Wednesday	CSE-C				
Thursday	CSE-D				
Friday					
Saturday	CSE-E				CSE-A



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2510072: ENGINEERING CHEMISTRY LAB

B.Tech. I Year I Sem.

L T P C

0 0 2 1

Course Description: The course includes experiments based on fundamental principles of chemistry essential for engineering students, aiming to develop practical skills and reinforce theoretical concepts.

Course Objectives

1. Students will understand and perform experiments based on core chemical principles relevant to engineering applications.
2. Students will learn to estimate the hardness of water to assess its suitability for drinking purposes.
3. Students will acquire the ability to perform acid-base titrations using instrumental methods such as conductometry, potentiometry, and pH metric.
4. Students will gain hands-on experience in synthesizing polymers like Bakelite and Nylon – 6, 6 in the laboratory.
5. Students will learn to determine the unknown concentration of potassium permanganate (KMnO₄) using a calibration curve.

Course Outcomes:

CO1: Develop the practical skills through hands-on chemistry experiments relevant to engineering.

CO2: Determine the important parameters such as water hardness and the corrosion rate of mild steel under various conditions.

CO3: Apply the techniques like conductometry, potentiometry, and pH metric to determine concentrations or equivalence points in acid base reactions.

CO4: synthesize the polymers such as Bakelite and Nylon-6,6.

CO5: Determine the unknown concentration of strong acid with strong base by Potentiometry using quinhydrone



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List of Experiments:

I. Volumetric Analysis: Estimation of Hardness of water by EDTA Complexometric method.

II. Conductometry:

1. Estimation of the concentration of strong acid by Conductometry.
2. Estimation of the concentration of strong and weak acid in an acid mixture by Conductometry.

III. Potentiometry:

1. Estimation of concentration of Fe^{+2} ion by Potentiometry using KMnO_4 .
2. Estimation of concentration of strong acid with strong base by Potentiometry using quinhydrone

IV. pH Metry: Determination of an acid concentration using pH meter.

V. Preparations:

1. Preparation of Bakelite.
2. Preparation Nylon – 6, 6.

VI. Corrosion: Determination of rate of corrosion of mild steel in the presence and absence of inhibitor.

VI Lubricants:

1. Estimation of acid value of given lubricant oil.
2. Estimation of viscosity of lubricant oil using Ostwald's Viscometer.

VII Virtual lab experiments:

1. Construction of Fuel cell and it's working.
 2. Smart materials for Biomedical applications
 3. Batteries for electrical vehicles.
 4. Functioning of solar cell and its applications.



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OPEN ENDED EXPERIMENTS:

1. Aspirin
2. Paracetamol

REFERENCE BOOKS:

1. Lab manual for Engineering chemistry by B. Ramadevi and P. Aparna, S Chand Publications, New Delhi (2022)
2. Vogel's text book of practical organic chemistry 5th edition
3. Inorganic Quantitative analysis by A.I. Vogel, ELBS Publications.
4. College Practical Chemistry by V.K. Ahluwalia, Narosa Publications Ltd. New Delhi (2007).



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DEPARTMENT OF FRESHMAN ENGINEERING **ENGINEERING CHEMISTRY LABORATORY**

Virtual lab details

Name of the Virtual Lab: EC LAB

Virtual Lab Host Institute: NIT, IIT Kharagpur

URL/Link to Lab: <https://batterywala.in>,

<https://smart-material.com>

[https://en.wikipedia.org › wiki › Fuel cell](https://en.wikipedia.org/wiki/Fuel_cell)

Academic Year: 2025

Semester-I&II

List of Experiments Available in Virtual Lab

- A. Construction of Fuel cell and its working
- B. Smart materials for Biomedical applications
- C. Batteries for electrical vehicles



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DEPARTMENT OF FRESHMAN ENGINEERING ENGINEERING CHEMISTRY LABORATORY

LAB PLANNER

S.No	Experiment	CO	Virtual Lab Availability	Date planned	Date conducted
1	EDTA METHOD	1	NO		
2	POTENTIOMETRY	1	NO		
3	CONDUCTOMETRY	2	NO		
4	ACID VALUE	2	NO		
5	NYLON6,6	3	NO		
6	BATTERIES	3	YES		
7	MID-II				
8	BAKELITE	4	NO		
9	FUELCELL	4	YES		
10	SMART MATERIALS	4	YES		
11	CORROSION	5	NO		
12	VISCOSITY	5	NO		
13	PH METRY	5	NO		
14	MID-II				



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DEPARTMENT OF FRESHMAN ENGINEERING

ENGINEERING CHEMISTRY LABORATORY

LAB PLANNER

SUBJECT		ENGINEERING CHEMISTRY														
S.No	Roll No	LAB-2 (SR006)							LAB-1 (SR012)							
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15
1		1	2	3	4	5	6	7	8	9	10	11	12	LAB INTRODUCTION	INTERNAL 1	INTERNAL 2
2		2	3	4	5	6	1	8	9	10	11	12	7			
3		3	4	5	6	1	2	9	10	11	12	7	8			
4		4	5	6	1	2	3	10	11	12	7	8	9			
5		5	6	1	2	3	4	11	12	7	8	9	10			
6		6	1	2	3	4	5	12	7	8	9	10	11			
7		1	2	3	4	5	6	7	8	9	10	11	12			
8		2	3	4	5	6	1	8	9	10	11	12	7			
9		3	4	5	6	1	2	9	10	11	12	7	8			
10		4	5	6	1	2	3	10	11	12	7	8	9			
11		5	6	1	2	3	4	11	12	7	8	9	10			
12		6	1	2	3	4	5	12	7	8	9	10	11			
13		1	2	3	4	5	6	7	8	9	10	11	12			
14		2	3	4	5	6	1	8	9	10	11	12	7			
15		3	4	5	6	1	2	9	10	11	12	7	8			
16		4	5	6	1	2	3	10	11	12	7	8	9			
17		5	6	1	2	3	4	11	12	7	8	9	10			
18		6	1	2	3	4	5	12	7	8	9	10	11			
19		1	2	3	4	5	6	7	8	9	10	11	12			
20		2	3	4	5	6	1	8	9	10	11	12	7			
21		3	4	5	6	1	2	9	10	11	12	7	8			
22		4	5	6	1	2	3	10	11	12	7	8	9			
23		5	6	1	2	3	4	11	12	7	8	9	10			
24		6	1	2	3	4	5	12	7	8	9	10	11			
25		1	2	3	4	5	6	7	8	9	10	11	12			
26		2	3	4	5	6	1	8	9	10	11	12	7			
27		3	4	5	6	1	2	9	10	11	12	7	8			
28		4	5	6	1	2	3	10	11	12	7	8	9			
29		5	6	1	2	3	4	11	12	7	8	9	10			
30		6	1	2	3	4	5	12	7	8	9	10	11			
31		1	2	3	4	5	6	7	8	9	10	11	12			



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32			2	3	4	5	6	1		8	9	10	11	12	7	
33			3	4	5	6	1	2		9	10	11	12	7	8	
34			4	5	6	1	2	3		10	11	12	7	8	9	
35			5	6	1	2	3	4		11	12	7	8	9	10	
36			6	1	2	3	4	5		12	7	8	9	10	11	
37			1	2	3	4	5	6		7	8	9	10	11	12	
38			2	3	4	5	6	1		8	9	10	11	12	7	
39			3	4	5	6	1	2		9	10	11	12	7	8	
40			4	5	6	1	2	3		10	11	12	7	8	9	
41			5	6	1	2	3	4		11	12	7	8	9	10	
42			6	1	2	3	4	5		12	7	8	9	10	11	
43			1	2	3	4	5	6		7	8	9	10	11	12	
44			2	3	4	5	6	1		8	9	10	11	12	7	
45			3	4	5	6	1	2		9	10	11	12	7	8	
46			4	5	6	1	2	3		10	11	12	7	8	9	
47			5	6	1	2	3	4		11	12	7	8	9	10	
48			6	1	2	3	4	5		12	7	8	9	10	11	
49			1	2	3	4	5	6		7	8	9	10	11	12	
50			2	3	4	5	6	1		8	9	10	11	12	7	
51			3	4	5	6	1	2		9	10	11	12	7	8	
52			4	5	6	1	2	3		10	11	12	7	8	9	
53			5	6	1	2	3	4		11	12	7	8	9	10	
54			6	1	2	3	4	5		12	7	8	9	10	11	
55			1	2	3	4	5	6		7	8	9	10	11	12	
56			2	3	4	5	6	1		8	9	10	11	12	7	
57			3	4	5	6	1	2		9	10	11	12	7	8	
58			4	5	6	1	2	3		10	11	12	7	8	9	
59			5	6	1	2	3	4		11	12	7	8	9	10	
60			6	1	2	3	4	5		12	7	8	9	10	11	

1.ACID VALUE	4.CONDUCTOMETRY	7. EDTA	10.CONDUCTOMETRY
2.VISCOSITY	5.POTENTIOMETRY	8.POTENTIOMETRY	11.BATTERIES
3.BAKELITE	6.FUEL CELL	9.CORROSION	12.SMART MATERIALS



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RUBRICS USED TO ASSESS LEARNINGS IN LABORATORIES

1. RUBRICS FOR DAY-TO-DAY EVALUATION

Parameter	Max Marks	Level-1 (Very Poor)	Level-2 (Poor)	Level-3 (Average)	Level-4 (Good)	Level-5 (Excellent)
Observation Book	05	No observations or irrelevant data. (0-1)	Incomplete or incorrect data. (2)	Basic values with some errors. (3)	Mostly correct with good format. (4)	Fully correct, clear, and well-formatted. (5)
Result	05	No result or major errors. (0-1)	Result partially obtained. (2)	Acceptable result with limited error. (3)	Near-correct result and reasonable error. (4)	Accurate result. (5)
Viva-Voce	05	Did not answer any questions. (1)	Answered very few questions. (2)	Answered some questions with help. (3)	Answered most questions correctly. (4)	Answered all questions accurately. (5)
Avg(A)	5	1	2	3	4	5
Record Writing(B)	05	Not submitted. (0-1)	Submitted but mostly incomplete. (2)	Submitted with some missing/wrong parts. (3)	Submitted with minor issues. (4)	Fully complete, correct algorithm & flowchart. (5)
Total(A+B)	10	2	4	6	8	10



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2. RUBRICS FOR INTERNAL EVALUATION

Criterion	Max Marks	Level-1 (<i>Very Poor</i>)	Level-2 (<i>Poor</i>)	Level-3 (<i>Average</i>)	Level-4 (<i>Good</i>)	Level-5 (<i>Excellent</i>)
Design/Tool/Apparatus Selection	4 Marks	Incorrect tool/design and no reasoning. (0)	Tool/design selection attempted with unclear logic. (1)	Satisfactory selection with partial justification. (2)	Correct selection and proper analysis with few errors. (3)	Smart selection with accurate, relevant analysis. (4)
Execution (Code/Debug/Run) /Analysis/Method Used	4 Marks	Did not attempt or completely failed to execute. (0)	Attempted but unable to proceed or with major errors. (1)	Partial execution with some logic/syntax errors. (2)	Mostly correct execution with minimal help. (3)	Fully correct and independently executed program. (4)
Results& Documentation	2 Marks	Incomplete or poorly presented. (0)	Basic structure but lacks clarity or formatting. (0.5)	Complete but generic or with formatting issues. (1)	Well-structured and mostly clear. (1.5)	Well-organized, professional, and engaging documentation. (2)
Viva-Voce (Understanding of Concepts)	10 Marks	No understanding; could not answer questions. (0)	Answered a few with difficulty. (4)	Answered half the questions with basic clarity. (6)	Good understanding with confident answers. (8)	Answered all questions with clarity and depth. (10)
Open Ended Experiment or Virtual lab	10 Marks	Does not understand the aim or theory (0)	Very limited understanding; major errors (4)	Major calculation errors (6)	Logical conclusion with explanation (8)	Very neat, well-structured, and complete (10)



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3. RUBRICS FOR SEMESTER END EXAMINATIONS

Criterion	Max Marks	Level-1 (Very Poor) (0–2 marks)	Level-2 (Poor) (3–4 marks)	Level-3 (Average) (5–6 marks)	Level-4 (Good) (7–9 marks)	Level-5 (Excellent) (10–12 marks)
Preparedness for the Experiment	15 marks	No clarity on objective or procedure. Unable to explain basics.	Limited idea of the objective/procedure. Needed prompting.	Has basic understanding; minor gaps in concept or preparation.	Well-prepared, with clear understanding of steps and background.	Fully prepared with strong conceptual clarity and confident explanation.
Performance in the Laboratory	15 marks	Unable to perform experiment. Relied entirely on examiner's help.	Performed with multiple errors and constant support.	Performed with some errors; required occasional help.	Performed mostly independently with minimal support.	Performed independently, efficiently, and with precision.
Calculations & Graphs	10 marks	No or incorrect calculations. Graphs missing or irrelevant.	Multiple calculation errors. Graphs/plots inaccurate or poorly labeled.	Calculations partially correct. Graphs present but with some flaws.	Correct calculations and graphs with minor errors.	Accurate calculations and well-labeled graphs with proper interpretation.
Results & Error Analysis	10 marks	No result or invalid result. No error analysis attempted.	Incorrect result with vague or no error discussion.	Acceptable result. Error analysis attempted but limited.	Correct result with sound error discussion.	Accurate result with detailed and relevant error analysis.
Viva-Voce (Subject Knowledge)	10 marks	Unable to answer any questions. No conceptual understanding.	Answered few questions with poor logic.	Answered half of the questions with average understanding.	Answered most questions with clarity and confidence.	Answered all questions with depth, clarity, and reasoning.



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1. ESTIMATION OF HARDNESS OF WATER BY EDTA METHOD

INTRODUCTION:

Volumetric analysis is one of the quantitative methods of analysis which basically involves the determination of the quantity of a substance present in a given solution by reacting a known volume of it with a solution of another substance of known concentration.

The process by which this analysis is carried out is called 'titration'.

Hardness of water is determined by titrating with a standard solution of ethylenediamine tetra acetic acid (EDTA) which is a complexing agent. Since EDTA is insoluble in water, the disodium salt of EDTA is taken for this experiment. EDTA can form four or six

AIM:

To estimate the total hardness, permanent hardness and temporary hardness of water by using standard solution of EDTA

APPARATUS:

Burette, pipette, Conical flask, Beakers, Standard flask, Burette stand and funnel etc..

CHEMICALS REQUIRED:

Buffers, EDTA solⁿ, Eriochrome black-T, Magnesium sulphate etc.

PRINCIPLE:

Hard water which contains Ca^{2+} and Mg^{2+} ions which forms wine red color complex with the indicator

Ca^{2+} (or) Mg^{2+} + EBT \longrightarrow Ca-EBT (or) Mg-EBT
(Wine red color complex)
EDTA forms a colour less complex with the metal ions (Ca^{2+} and Mg^{2+})

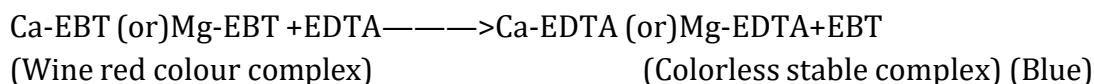


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When free ions are not available, EDTA extracts the metal from (ion) metal ion indicator complex, there by releasing the free indicator *PROCEDURE:*

STEP-I

PREPARATION OF STANDARD SOLUTION OF MgSO₄:

Weigh the approx. 0.25gm of MgSO₄ and transfer into 100ml standard flask through the funnel and dissolve in minimum quantity of distilled water. Make up the solution up to the mark with distilled water and shake the flask well for uniform concentration then calculate the Molarity of MgSO₄.

$$\text{M. Wt. of MgSO}_4 = 246.48 \text{ gm}$$

$$0.25 \quad 1000$$

$$\text{Molarity of MgSO}_4 (\text{M}_1) = \frac{\quad \times \quad}{246.48 \quad 100} = 0.01$$

$$\text{M}_1 = 0.01$$

STEP-III

STANDARDISATION OF HARD WATER:

Pipette out (measure) 20ml of tap water into a conical flask add 2 ml of buffer sol. and add 2 to 3 drops of EBT indicator. Titrate the wine red color solution. Titrate the conical flask solution with EDTA taken in burette, till blue color appears, end point is obtained. Repeat the titration to get concurrent values.

	Volume of Hard water in (V ₃)	Burette Reading		Volume of EDTA consumed (V ₂)
		Initial	Final	
	20			
	20			
	20			



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M_3 = Molarity of hard water = ?

V_3 = Volume of Hard water = 20ml

M_2 = EDTA Molarity =

V_2 = Volume of EDTA consumed = $M_3V_3 = M_2V_2$

$M_3 = M_2V_2/v_3$

Total hardness = $M_3 \times 100 \times 1000 = PP$

RESULT:

- 1) Total Hardness in given sample is _PPM
- 2) Permanent Hardness in given sample is __PPM
- 3) Temporary hardness in given sample is ___

VIVA QUESTIONS

S.No	Question	CO	Blooms Taxonomy
1	What are complex metric titrations?	CO1	Understand
2	Expand EDTA?	CO1	Remember
3	Which type of ligand is EDTA?	CO1	Remember
4	Name the most widely used indicator in EDTA titrations. How does it act?	CO1	Remember
5	How this pH is maintained?	CO1	Remember
6	What is a buffer solution?	CO1	Remember
7	What is a basic buffer? Give an example?	CO1	Remember
8	Write the structure of EDTA?	CO1	Remember
9	What is the indicator used in this experiment?	CO1	Remember
10	What is hardwater?	CO1	Remember



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11	Why is buffer added?	CO1	Remember
12	What is total hardness of water?	CO1	Remember
13	What are the chemicals used in EDTA experiment?	CO1	Remember
14	How this pH is maintained?	CO1	Remember
15	Write the types of hardness of water?	CO1	Remember
16	What is a basic buffer? Give an example?	CO1	Remember
17	What is the indicator used in this experiment?	CO1	Remember
18	Which type of ligand is EDTA?	CO1	Remember
19	At what pH the hardness of water is estimated by EDTA method?	CO1	Remember
20	Name the most widely used indicator in EDTA titrations. How does it act?	CO1	Remember



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2. ESTIMATION OF HCL BY CONDUCTOMETRIC TITRATION

INTRODUCTION:

Conductometric titration is a laboratory method of quantitative analysis used to identify the concentration of a given analyte in a mixture. Conductometric titration involves the continuous addition of a reactant to a reaction mixture and the documentation of the corresponding change in the electrolytic conductivity of the reaction mixture. It can be noted that the electrical conductivity of an electrolytic solution is dependent on the number of free ions in the solution and the charge corresponding to each of these ions.

AIM:

To determine the strength of the strong acid by titration with strong base Conductometrically.

APPARATUS:

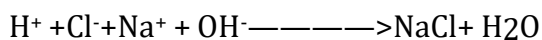
Conductivity Bridge, Conductivity cell, Burette, Beakers, Standard flask, pipette, Burette Stand

CHEMICALS REQUIRED:

Sodium hydroxide, Hydrochloric acid

PRINCIPLE:

At first solution contain H^+ and Cl^- ions. Since H^+ ions possess greater mobility, it follows that the conductivity is mainly due to H^+ ions. The addition of NaOH is represented by the equation.

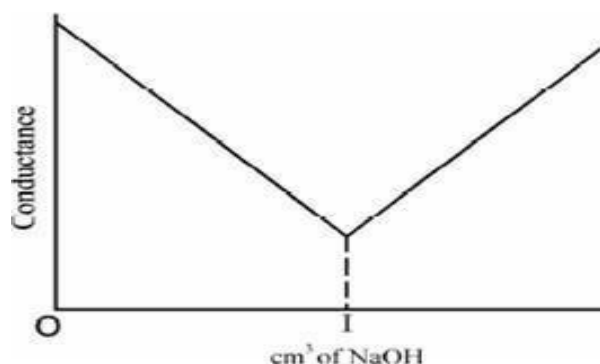


As NaOH is added the H^+ ions are removed. The conductivity decreases as Na^+ ions do not possess much mobility. At the neutralization point the solution contains Na^+ ions and Cl^- ions and will have minimum conductance value. If NaOH is further added this will add OH^- ions and so the conductivity increases.

PROCEDURE:

A standard solution of 0.1N NaOH is prepared. Similarly, 0.1N HCl is prepared. 20 ml

of HCl is taken in a 100 ml beaker and to it 20 ml of distilled water is added and kept in a thermostat. The conductivity cell is washed with distilled water and rinsed with acid soln. The cell is kept in acid containing beaker and it is connected to the bridge. The conductivity of the soln. is measured by adjusting the reading. NaOH soln. is taken into burette and add 1 ml of soln. to acid, stirred well and conductance is measured. Each time 1 ml of base is added to acid stirred well and the conductance is measured. For every instance, an equal number of values are taken on either side of the point of maximum. Repeat the procedure of addition of 1ml NaOH and noting the conductivity of the resulting solution. Take 20-25 readings.



S. No	Volume of NaOH	Observed conductance
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		



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16		
17		
18		
19		
20		

FORMULA:

$$N_1V_1=N_2V_2$$

N1 = Normality of

NaOH = 0.1 N2 =?

V1 = Volume of HCl =

20ml V2 = End point

from the graph

RESULT:

The normality of strong acid (HCl) determined by titrating against a strong base (NaOH)

=

Viva questions: -

S.No	Question	CO	Blooms Taxonomy
1	Define conductance?	CO1	Understand
2	Give the definition of neutralization point?	CO1	Remember
3	What are the units of conductance?	CO1	Remember
4	Explain graph?	CO1	Remember
5	What is Acid & Base?	CO1	Remember
6	What are conductors? How are they classified?	CO1	Remember
7	Differentiate metallic and electrolytic conductors?	CO1	Remember
8	Define the specific conductance? With units.	CO1	Remember



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9	Explain the term Equivalent conductance? With units.	CO1	Remember
10	Define Conductance? Write its units.	CO1	Remember
11	What is single electrode potential?	CO1	Remember
12	What is EMF of cell? How the emf of cell is calculated?	CO1	Remember
13	Calculate the molecular weight for HCl	CO1	Remember
14	Differentiate Primary and Secondary cells?	CO1	Remember
15	Give the applications of Batteries?	CO1	Remember
16	Write cell reactions of Daniel cell?	CO1	Remember
17	Define electro chemical series? Write its applications?	CO1	Remember
18	Explain the construction of calomel electrode?	CO1	Remember
19	Mention the types of electrodes?	CO1	Remember
20	Give examples for strong acid.	CO1	Remember



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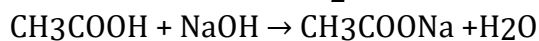
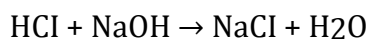
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2. ESTIMATION OF THE CONCENTRATION OF STRONG AND WEAK ACID IN AN ACID MIXTURE BY CONDUCTOMETRY

Aim: To estimate the concentration of a mixture of acids with a strong base by conductometric method.

Basic Principle: When a mixture of acid containing a strong acid and weak acid is titrated with a strong base, the neutralization takes place in the following way. First strong acid reacts with the strong base and then weak acid reacts with strong base.



(salt, strong electrolyte)

The conductance of the mixture falls on the addition of NaOH due to the neutralization of highly mobile H^+ ions with the base, till all the strong acid is neutralized. Then the Conductivity rises due to the neutralization of the weak acid to the salt, which is a strong Electrolyte. Finally, the conductivity rises rapidly as the alkali is introduced in excess after the neutralization of the weak acid.

Procedure:

- 1) Preparation of 0.01N HCl: Dissolve 0.83 ml of conc. HCl in 1000 ml water and shake the flask well for uniform concentration.
- 2) Preparation of 0.01N CH_3COOH : Dissolve 0.58 ml of CH_3COOH in 1000 ml of water and make up the solution up to the mark with distilled water and shake the flask well for uniform concentration.
- 3) Preparation of 0.1N NaOH solution: Dissolve 4 gms of NaOH into 1000 ml of distilled water in a flask and shake the flask well for uniform concentration.
- 4) Preparation of standard Oxalic acid solution: Dissolve exactly 0.63 gms of Oxalic acid in a 100 ml standard flask, in small amount of distilled water and make up the solution with distilled water up to the mark of the flask. Shake the flask well for uniform concentration.

PROCEDURE:

II. CONDUCTOMETRIC TITRATION OF THE MIXTURE OF ACIDS

Pipette out 20ml of HCl solution and 20ml of CH_3COOH solution into a 250 ml beaker. Wash the conductivity cell with distilled water and dip it in mixture of acids taken in the beaker. Connect the terminals of the conductivity cell to the conductivity bridge. Measure the conductance of the solution



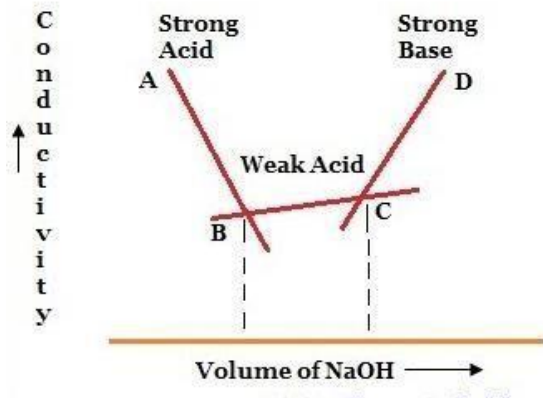
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S.NO	Volume of NaOH added(ml)	Conductance ohm ⁻¹
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		



calculations:

A) NaOH VS HCl

$$N_1V_1 = N_2V_2$$

N_1 = Normality of NaOH =

V_1 = Volume of NaOH (burette reading – from graph) N_2 = Normality of HCl ?

V_2 =

volume of

HCl N_2 =

$$N_1V_1 / V_2$$

B) NaOH VS CH₃COOH

N_1 = Normality of NaOH =

V_1 = Volume of NaOH (burette reading –



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from graph) N_3 = Normality of CH_3COOH

-----?

V_3 = volume of CH_3COOH

$N_1V_1 = N_3V_3$

Amount of the strong acid = $N_3 \times 36.5$ gms/litre

Amount of weak acid (CH_3COOH) = $N_4 \times 60$

ms/litre

RESULT:

The strength of HCl calculated by conductometric titration against NaOH is = ___g/l

The strength of CH_3COOH calculated by conductometric titration against NaOH is



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VIVA QUESTIONS

S.No	Question	CO	Blooms Taxonomy
1	What is conductometric titration?	CO1	Understand
2	What is relationship between conductivity and specific conductivity?	CO1	Remember
3	What are the factors affecting conductivity?	CO1	Remember
4	How is the end point determined in conductometric titration?	CO1	Remember
5	What are the applications of conductometric titrations?	CO1	Remember
6	Define EMF of a cell	CO1	Remember
7	What is the potential of hydrogen electrode	CO1	Remember
8	Why the conductivity first decreases and then increases in model graph?	CO1	Remember
9	Differentiate metallic and electrolytic conductors.	CO1	Remember
10	What is a weak acid?	CO1	Remember
11	What is a weak base?	CO1	Remember
12	Give an example of weak acid.	CO1	Remember
13	Give an example of weak base	CO1	Remember
14	What are the units of conductance?	CO1	Remember
15	Define electro chemical series? Write its applications?	CO1	Remember
16	Differentiate Primary and Secondary cells?	CO1	Remember
17	Calculate the molecular weight for NaOH.	CO1	Remember
18	Define Normality	CO1	Remember
19	Give an example of strong acid.	CO1	Remember
20	Give an example of strong base.	CO1	Remember



4 ESTIMATIONS OF Fe^{2+} BY POTENTIOMETRY

INTRODUCTION:

It is the procedure through which the quantity of the given test substance is determined by the measured addition of titrant until the entire test substance undergoes reaction. After the titration process, the potential difference between the two electrodes (namely the reference and indicator electrode) is measured in conditions where a thermodynamic equilibrium is maintained and the current passing through the electrodes does not disturb this equilibrium.

AIM: To estimate the Fe^{2+} (Ferrous Iron) by potentiometry

APPARATUS: Potentiometer, Beaker, Burette, burette stand.

CHEMICALS REQUIRED: $FeSO_4$ sol, $KMnO_4$ solution.

PROCEDURE:

Potassium permanganate is used for determination of Fe^{2+} . Potential at which the substance changes color must be such that the change occurs close to the equivalence point, permanganate has strong color by itself. Approximately 0.1N $FeSO_4$ is prepared and standard decinormal solution of $KMnO_4$ is prepared. Exactly 20 ml of $FeSO_4$ is pipette out into a clean 100ml of beaker. Platinum electrode (working electrode) and calomel electrode (reference electrode) are dipped in the solution and is being titrated is against $KMnO_4$ in burette. The solution is stirred well with a glass rod. The end reading is taken after adding definite amount of $KMnO_4$. Finally, after knowing the range in which the end point can be located, the whole experiment is repeatedly adding in steps of 1ml in the end point.

CALCULATIONS:

S. No	Volume of $KMnO_4$	Observed EMF
1		
2		
3		
4		
5		



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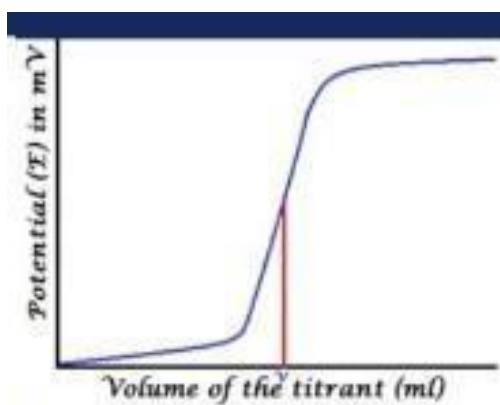
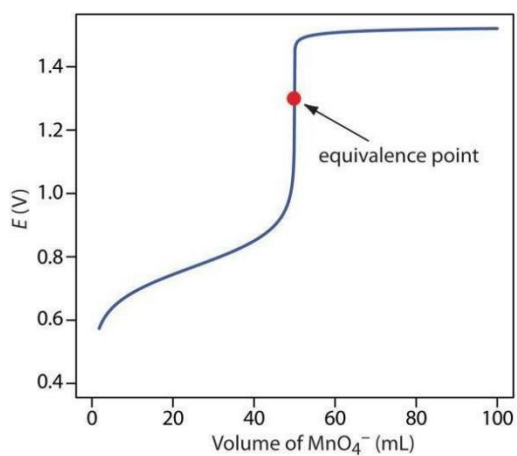
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6		
7		
8		
9		
10		
11		

GRAPH:

Graph is plotted of which one is between volume of KMnO_4 and observed EMF.





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FORMULA:

$$N_1V_1 = N_2V_2$$

N_1 = Normality of KMnO_4 = 0.1N

V_1 = Volume of KMnO_4 = -----
(from graph)

N_2 = Normality of FeSO_4

=? V_2 = Volume of FeSO_4 =

20ml

RESULT:

The Normality of FeSO_4 (Fe^{+2}) determined by titrating against KMnO_4 = _____N



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VIVA QUESTIONS

S.No	Question	CO	Blooms Taxonomy
1	What is potentiometric titration?	CO2	Understand
2	What are redox reactions?	CO2	Remember
3	What is the principle of potentiometric titration?	CO2	Remember
4	What are the electrodes used in potentiometric titration?	CO2	Remember
5	What is neutralization point?	CO2	Remember
6	What is the color of FeSO ₄ ?	CO2	Remember
7	Write the different electrode reactions occur at the electrode?	CO2	Remember
8	Write the oxidation state of Ferrous Iron?	CO2	Remember
9	What are the advantages of potentiometric titration?	CO2	Remember
10	Define normality?	CO2	Remember
11	What is oxidation and reduction?	CO2	Remember
12	Define std. electrode potential?	CO2	Remember
13	What are the electrodes used in potentiometric titration?	CO2	Remember
14	Define indicator?	CO2	Remember



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15	What are the chemicals used in potentiometry?	CO2	Remember
16	What is meant by reference electrode?	CO2	Remember
17	What is meant by reference electrode?	CO2	Remember
18	What is the principle of potentiometric titration?	CO2	Remember
19	What is indicator electrode in potentiometry?	CO2	Remember
20	Write the atomic number of Iron?	CO2	Remember

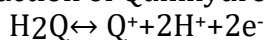
5. ESTIMATIONS OF CONCENTRATION OF STRONG ACID WITH STRONG BASE BY POTENTIOMETRY USING QUINHYDRONE

Aim: To estimate the concentration of strong acid by potentiometrically using Quinhydrone

Apparatus: Potentiometer, platinum electrode, calomel electrode, beaker, stirrer burette, pipette, **Chemicals:** Quinhydrone powder, Sat. KCl, HCl, NaOH.

Principle: In Potentiometric acid base titrations, the following cell is set up in acid solution. (Hg/Hg₂Cl₂) reference electrode // (HCl/H⁺, Q, QH₂/Pt) Indicator electrode
(To determine the EMF of another electrode)

Here, Quinhydrone electrode is used as indicator electrode where potential indicates the change in concentration of ions titrated reaction of Quinhydrone electrode is



And its potential is given by

$$\text{Quinhydrone} = [E^0 - 0.059 P^H]$$

Cell representation: Hg/Hg₂Cl₂(s), H⁺ // KCl/Q, QH₂/pt

Therefore, EQ decreases logarithmically as a concentration of H⁺ decreases and the decrease in the [H⁺] depends on the volume of titrant added.

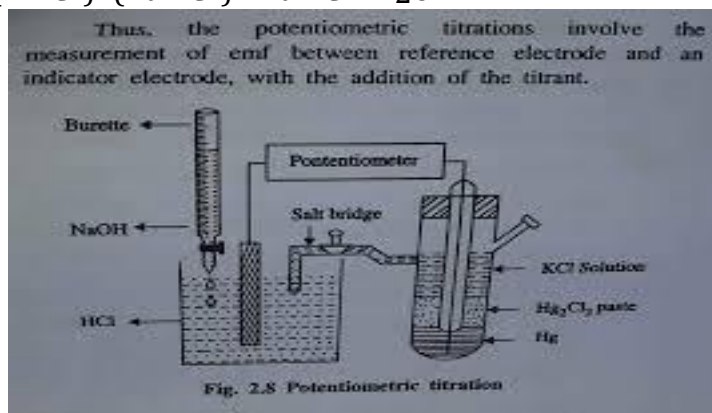
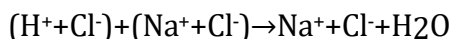


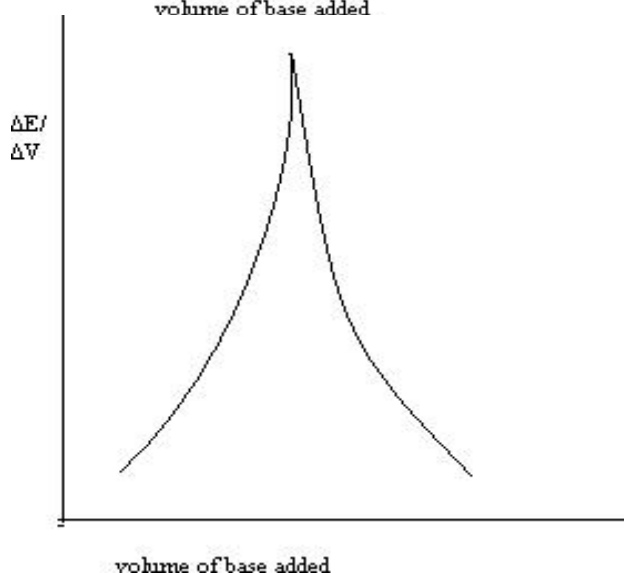
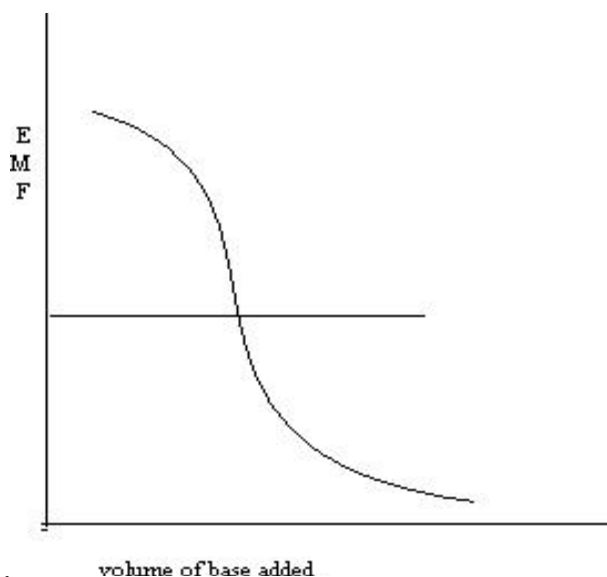
fig. Potentiometric Titrations

Procedure: Take 20ml of the acid solution in 100ml beaker. Add a pinch of Quinhydrone to saturate the solution. Dip the indicator (Pt) and reference electrodes (standard calomel electrode SCE) in the solution. Connect the two electrodes to the potentiometer. We find that the cell EMF is not in the range of potentiometer. The terminal connections at the potentiometer may be interchanged to obtain appropriate contact of positive and negative poles. Record the initial value of the cell EMF. Add the alkali solution to the acid solution in steps of 1ml. shake well before and after each addition and measure the cell EMF at each stage. From this rough titration, find out the approximate volume needed for the end point. Repeat the titration by adding 1 or 2ml of alkali in initial steps but by adding 1 or 2 drops of alkali at a

time in the ml step. Expected to involve the end point. Subsequent additions can be made in steps of 1 or 2 ml of alkali again.

Data recording and graph: Plot a graph between cell EMF (y-axis) and volume of alkali used (x-axis). From this graph, read the end volume of the titrant. It may be pointed out that so long as Quinhydrone is used as an indicator electrode, we shall have to take the acid solution in the beaker and alkali in the burette.

Plot a graph between $\Delta E/\Delta V$ vs volume of alkali added and P^H cell versus volume of alkali added.





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Observations: Table

S.No	Vol.of NaOH (V)	EMF in volts(E)	ΔE in mVolts	ΔV in ml	$\Delta E/\Delta V$ in mVolts/ml
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					



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Calculations:

$$N_1V_1=N_2V_2$$

N_1 = Normality of NaOH

V_1 = Volume of NaOH (burette
reading) N_2 = Normality of HCl ?

V_2 = volume of HCl

$$N_2 = N_1V_1/V$$

Result: The neutralization point obtained when a strong acid is titrated against strong base potentiometrically is -----

Viva Questions:

S. No	Question	CO	Blooms Taxonomy
1	What is potentiometric titration?	CO1	Understand
2	Why is potentiometry preferred over indicator methods in some titrations?	CO1	Remember
3	What is the principle of potentiometric acid–base titration?	CO1	Remember
4	What is quinhydrone?	CO1	Remember
5	Why is quinhydrone used as an indicator electrode in this experiment?	CO1	Remember
6	Which electrode system is formed when quinhydrone is added to the solution?	CO1	Remember
7	What is the role of the reference electrode in potentiometry?	CO1	Remember
8	Name the reference electrode commonly used in this experiment.	CO1	Remember
9	How does pH affect the potential of the quinhydrone electrode?	CO1	Remember



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10	Why is quinhydrone not suitable for alkaline solutions above pH 8?	CO1	Remember
11	What happens to the electrode potential at the equivalence point?	CO1	Remember
12	How is the end point determined in potentiometric titration?	CO1	Remember
13	What is the Nernst equation and its relevance in this experiment?	CO1	Remember
14	Why should the solution be stirred continuously during titration?	CO1	Remember
15	What type of titration curve is obtained for strong acid–strong base titration?	CO1	Remember
16	Why is no visual indicator required in potentiometric titration?	CO1	Remember
17	What precautions should be taken while adding quinhydrone?	CO1	Remember
18	What is the advantage of using quinhydrone electrode over glass electrode?	CO1	Remember
19	What sources of error may affect potentiometric titration results?	CO1	Remember
20	How is the concentration of the unknown strong acid calculated from titration data?	CO1	Remember



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6. DETERMINATION OF AN ACID CONCENTRATION USING PH METER

AIM: To determine the concentration of an acid using pH meter.

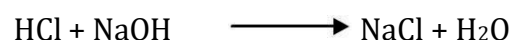
REQUIREMENTS:

1. P^H meter, 2. Glass electrode 3. burette, 4. Beaker 5. stirrer, 6. Volumetric flask

CHEMICALS REQUIRED: HCl, NaOH, distilled water

PRINCIPLE:

When a solution of strong acid (HCl) is titrated with the solution of a strong base (NaOH), the change in P will be reflected in the change in EMF. When a small amount of alkali is added to the acid, a little change in the EMF is produced in the beginning. This change in electrode potential depends upon the fraction of hydrogen ions removed. As an equivalence point reaches, the fraction of the hydrogen ions removed by constant volume of standard alkali increases rapidly, thereby causing a rapid change in the EMF. Thus, if the EMF of the cell is plotted against the volume of the standard alkali added, a curve is obtained. As the changes in EMF is much more rapid near the equivalent point, the exact equivalent point is obtained by differential method where, a graph of $\Delta E/\Delta V$ vs volume of alkali added, gives the maximum of the curve which corresponds to equivalence point of the titration.



The cell can be represented as $\text{H}_2(\text{Pt})/\text{acid solution} // \text{KCl (aq)} / \text{Calomel electrode}$

Preparation of reagents

1. 0.1N, HCl dilute 0.86 ml of 11.6 N and 36% concentrated HCl (mol.wt 36.5 0 to 100ml with distilled water
2. 0.1 n NaOH: dissolve 0.4 gm of NaOH (mol. wt 40) in 100ml of distilled water.

PROCEDURE:

- a. calibrate the instrument before starting the experiment
- b. take 20ml of acid solution in a 100ml beaker and immerse the pH electrode in to the solution.



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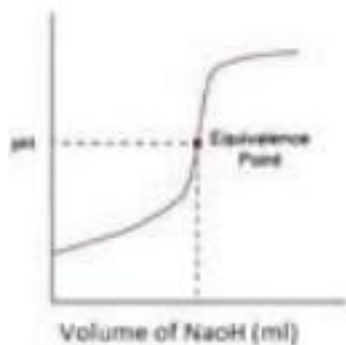
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- c. first carry out the rough titrations by adding 1 ml of NaOH and measure the EMF
- d. Near the end point smaller additions should be added.
- e. Plot pH values or EMF values the volume of NaOH added. Draw a smooth curve , the point of intersection gives the equivalence point
- f. Plot another graph between $\Delta E / \Delta V$ values against the titer readings as abscissa
- g. The maximum of curve represents the equivalence point.

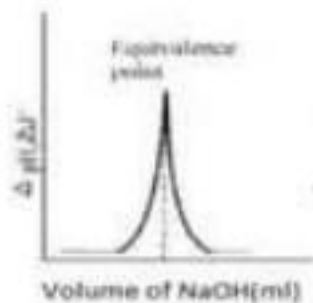
Table 2

S.No	Vol.of NaOH	pH	Δ pH	ΔV in ml	Δ pH/ ΔV
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

Sigmoidal Graph



Differential Graph



Calculations:

$$N_1V_1 = N_2V_2$$

N_1 = Normality of NaOH

V_1 = Volume of NaOH (burette reading)
 N_2 = Normality of HCl ?

V_2 = volume of HCl

$$N_2 = N_1V_1/V_2$$

RESULT:

- a) Equivalence point between strong acid (HCl – NaOH) and strong base =-----
 b) Concentration of strong acid HCl =----- N.



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Viva Questions:

S. No	Question	CO	Blooms Taxonomy
1	What is pH and how is it defined mathematically?	CO1	Understand
2	What is the principle behind a pH meter?	CO1	Remember
3	Which electrode is used in a pH meter?	CO1	Remember
4	Why is calibration of a pH meter necessary?	CO1	Remember
5	Which standard buffer solutions are commonly used for calibration?	CO1	Remember
6	What is the role of the glass electrode in pH measurement?	CO1	Remember
7	How does temperature affect pH measurement?	CO1	Remember
8	What is meant by electrode potential?	CO1	Remember
9	Why should the electrode be rinsed with distilled water before use?	CO1	Remember
10	What precautions should be taken while using a pH meter?	CO1	Remember
11	How is the concentration of an acid determined from its pH value?	CO1	Remember
12	What is the relationship between pH and hydrogen ion concentration?	CO1	Remember
13	Why is a pH meter preferred over indicators for accurate measurements?	CO1	Remember
14	What type of acids can be analyzed using a pH meter?	CO1	Remember
15	What are buffer solutions and why are they used in calibration?	CO1	Remember
16	What is the effect of strong and weak acids on pH values?	CO1	Remember
17	What are the sources of error in pH measurement?	CO1	Remember
18	How should the pH electrode be stored when not in use?	CO1	Remember
19	What happens if the pH electrode dries out?	CO1	Remember
20	How does a pH meter convert electrical signals into pH values?	CO1	Remember

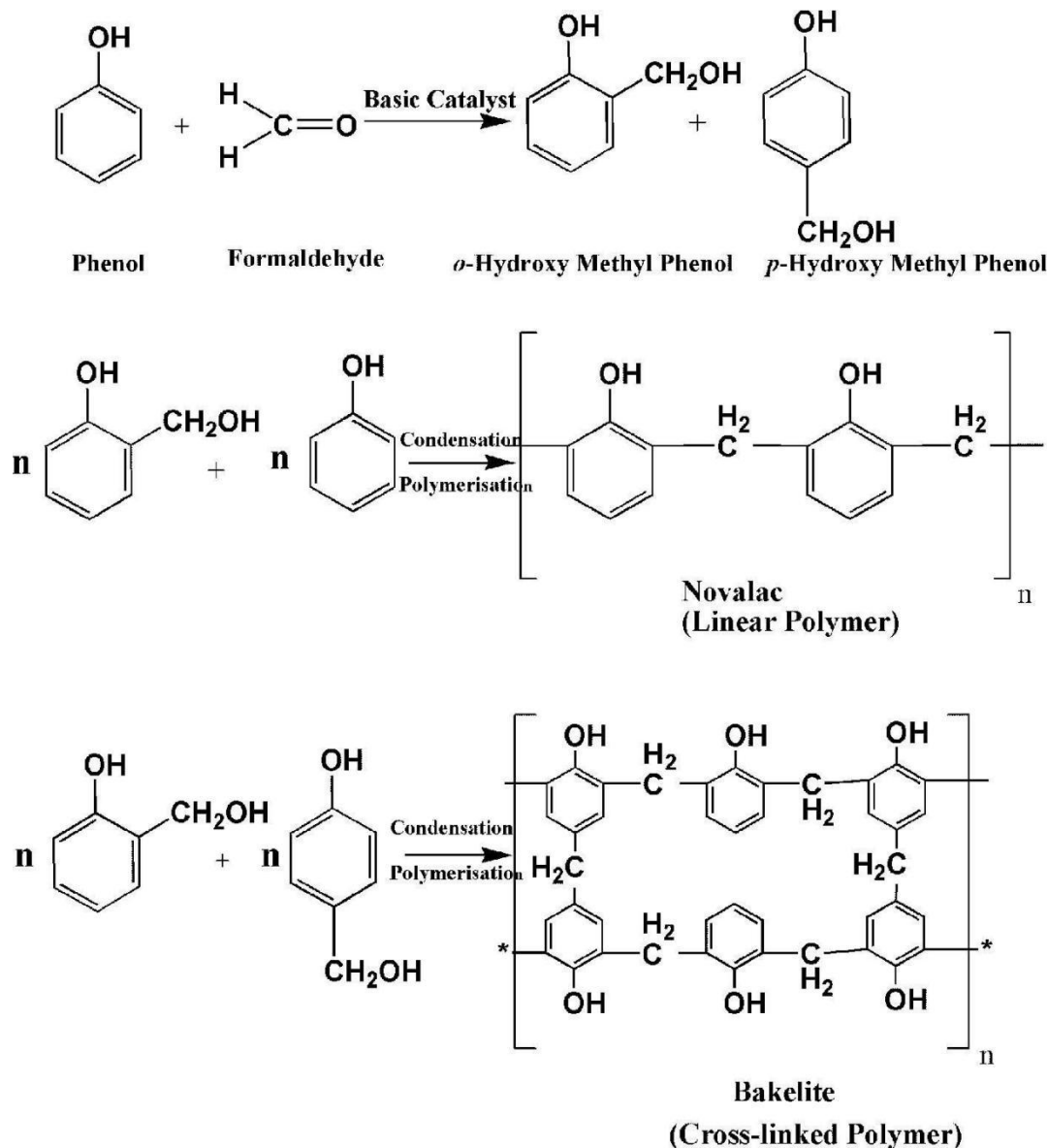
7. PREPARATION OF BAKELITE

AIM: - To prepare Phenol Formaldehyde resin. (Bakelite)

CHEMICALS USED: - Glacial acetic acid, 40% Formaldehyde solution, Phenol, conc. H₂SO₄ .

APPARATUS REQUIRED: - Glass rod, beakers, funnel, measuring cylinder, dropper and filter paper.

PRINCIPLE: - Phenol formaldehyde resins (PFs) are condensation polymers and are obtained by condensing phenol with formaldehyde in the presence of an acidic or alkaline catalyst. They were first prepared by *Backeland*, an American Chemist who gave them the name as *Bakelite*.





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These are thermosetting polymers.

PROCEDURE: -

1. Place 5ml of glacial acetic acid and 2.5ml of 40% formaldehyde solution in a 500ml beaker and add 2 grams of phenol.
2. Add few ml of conc. Sulphuric acid into the mixture carefully. Within 5 min. a large mass of plastic is formed.
3. The residue obtained is washed several times with distilled water, and filtered product is dried and yield is calculated.

RESULT: - The weight of the phenol formaldehyde resin is----- g.

USES OF BAKELITE:

- Bakelite due to its high resistance to electricity and heat is used in automotive components and industrial applications.
- Due to its excellent insulating properties, it is used for making switches and other electrical appliances.
- It is also used to make various kitchenware products like frying pans etc.
- Plastic items like telephone parts, cabinets, heater handles, Phonograph records
- Soft Bakelite is used as binding glue for laminated wooden plants, and in varnishes
- Sulphonated Bakelite is used as Ion exchange resins.
- For impregnating fabrics, wood and paper etc.

Viva Questions:

S.No	Question	CO	Blooms Taxonomy
1	Phenol formaldehyde is also called as.	CO4	Understand
2	What do you understand by resin?	CO4	Remember
3	Give main uses of the phenol formaldehyde resin.	CO4	Remember
4	What type of co-polymer is phenol formaldehyde resin	CO4	Remember
5	Briefly describe the properties of phenolic resins.	CO4	Remember
6	Write chemical reactions for preparation of phenolic resins.	CO4	Remember
7	Give the condensation reaction for the formation of Bakelite	CO4	Remember
8	What is Novolac ?	CO4	Remember



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9	Novolac is an example of which type of polymer	C04	Remember
10	What is the catalyst used in the condensation reaction for the formation of Bakelite?	C04	Remember
11	Why is Bakelite thermosetting ?	C04	Remember
12	What is the Byproduct in Bakelite formation reaction?	C04	Remember
13	What do you observe during the during the reaction?	C04	Remember
14	How do you Calculate the yield of the product?	C04	Remember
15	How do you wash the product to remove excess Phenol or catalyst ?	C04	Remember
16	How is Novolac different from Bakelite?	C04	Remember
17	Why is Bakelite widely used in electrical appliances?	C04	Remember
18	How does the molecular structure explain its heat resistance?	C04	Remember
19	What is the functionality of the monomers in Bakelite?	C04	Remember
20	Why must phenol be handled with extreme care in the lab?	C04	Remember



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Result: weight of Nylon 6,6-----gm

Viva Questions:

S.No	Question	CO	Blooms Taxonomy
1	What are the two monomers used in this lab experiment?	CO2	Understand
2	Why is it named Nylon 6,6?	CO2	Remember
3	What type of polymerization reaction is this?	CO2	Remember
4	What functional group is formed in the polymer backbone?	CO2	Remember
5	What is the by-product of the reaction when using adipoyl chloride?	CO2	Remember
6	What is interfacial polymerization?	CO2	Remember
7	Why are two immiscible solvents used?	CO2	Remember
8	Which monomers are dissolved in which solvents?	CO2	Remember
9	Which layer is the top layer and why?	CO2	Remember
10	Why should you not stir the mixture during the "rope trick"?	CO2	Remember
11	Why is NaOH (sodium hydroxide) added to the aqueous phase?	CO2	Remember
12	Why is adipoyl chloride used in the lab instead of adipic acid?	CO2	Remember
13	What is the industrial method for making Nylon 6,6?	CO2	Remember
14	How do you ensure a high molecular weight polymer is formed?	CO2	Remember
15	Why must the nylon fiber be washed with water or ethanol after preparation?	CO2	Remember
16	Is Nylon 6,6 a thermoplastic or a thermosetting polymer?	CO2	Remember
17	What type of intermolecular force gives Nylon its high strength?	CO2	Remember
18	Why does the nylon fiber become stronger when "drawn" (stretched)?	CO2	Remember
19	What are the common safety hazards in this experiment?	CO2	Remember
20	Give two industrial uses of Nylon 6,6	CO2	Remember



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Applications of Nylon 6,6

1. Used as thread in bristles, for tooth brushes.
2. As gears, fittings, bearings in automotive industry.
3. Thread, rope, filaments, nets, for making of air bags, tires, ropes, conveyor belts, hoses etc.
4. Gun frames, water proof to make swim wear,
5. Surgical sutures, strings, for musical instruments.
6. In hosiery and knitted garment



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9. DETERMINATION OF RATE OF CORROSION OF MILD STEEL IN THE PRESENCE AND ABSENCE OF INHIBITOR

Aim: Determination of rate of corrosion of mild steel in the presence and absence of inhibitor and calculate the efficiency of inhibitor.

Apparatus: 250ml beaker, glass hooks, mild steel specimen.

Chemicals; 10% HCl solution, inhibitor stock solution. Thioune, 5 gmino-8-quinolin

Basic principle: Corrosion is the process of gradual decay of metal/alloys by chemical or electrochemical reaction with the environment. Corrosion of mild steel in an aqueous acidic environment is example of electrochemical corrosion and proceeds through evolution of hydrogen gas.

At anode: $\text{Fe} \rightarrow \text{Fe}^{+2} + 2\text{e}^-$

At cathode: $\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$

in the presence of an inhibitor molecules get chemisorbed on the surface of the mild steel and form protective film which is quite stable in the acidic environment. This protective film acts as a barrier between the metal and environment. Hence further corrosion is prevented.

Procedure:

Prepare the acidic environment in the absence and presence of an inhibitor, as shown in table 1.

Table 1:

Acidic environment	10% HCl solution (ml)	Inhibitor solution(ml)	Total volume (ml)
Absence an inhibitor	100	0	100
Presence of an Inhibitor	90	0	100

Prepare the surfaces of 4 mild steel samples as to obtain smooth and bright surfaces use Emery pers. By this process you are removing the rust already formed on the surface. Clean the metal races by immersing in acetone. By this you can remove any oily or greasy material on the face. Dry in the water bath for 5 minutes, cool and weigh the samples by means of an electronic Hance and record the weights.

Immerse samples 1 and 2 in the acidic environment in the absence of inhibitor and samples 3 a - in the acidic environment in the presence of inhibitor by means of glass hooks for 30 minutes after which take out samples and wash in running water to remove the loosely held rust or other corrosion products.

Rinse the plates with acetone, dry in oven for 5 minutes, cool and record the weights.

Observation table:



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S.No.	Weight immersion (mg)	Weight after 30 min immersion (mg)	Weight loss (mg)	Surface area of the sample dm ²	Corrosion rate (mdd)
1					
2					
3					
4					

Calculation:

Corrosion Rate for Each Sample:

Weight of the metal sample before immersion = W_1 mg

Weight of the metal sample after 30 min immersion = W_2 mg

Weight loss $W_1 - W_2$ mg = X mg = (loss of mass) =

Surface area of the sample = Y dm² in²

Immersion period = Z hrs/days = Z days/hrs/day's

Corrosion rate = $X / Y Z$ mdd (mg / d m² / day)

$$= \frac{534 \times \text{LOSS OF MASS}}{d \times \text{surface area} \times \text{hr}}$$

$$= \frac{534 \times X}{d \times Y Z}$$

Viva Questions:

S.No	Question	CO	Blooms Taxonomy
1	Define corrosion.	CO2	Understand
2	What is the electrochemical theory of corrosion?	CO2	Remember
3	Why is mild steel specifically used in this experiment?	CO2	Remember
4	What is a corrosion inhibitor?	CO2	Remember
5	How are inhibitors classified?	CO2	Remember



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6	Why is it necessary to polish the mild steel specimen before the experiment?	C02	Remember
7	Which acids are commonly used as the corrosive medium?	C02	Remember
8	How do you ensure all corrosion products are removed before the final weighing?	C02	Remember
9	What happens to the current density (I_{corr}) in electrochemical tests when an inhibitor is added?	C02	Remember
10	Why is distilled water used for washing instead of tap water?	C02	Remember
11	What does a color change from light yellow to dark brown in the solution indicate?	C02	Remember
12	Why is the inhibitor's efficiency often lower at higher temperatures?	C02	Remember
13	How does the pH of the medium change during the experiment?	C02	Remember
14	How do gas bubbles attached to the metal surface affect the results?	C02	Remember
15	Give units for Corrosion rate	C02	Remember
16	Give the anodic and cathodic reaction in this experiment	C02	Remember
17	Why is acetone used to wash the mild steel coupons after polishing?	C02	Remember
18	What is the purpose of using different grades of emery paper?	C02	Remember
19	How do gas bubbles attached to the metal surface affect the results?	C02	Remember
20	Why does the corrosion rate usually increase with temperature?	C02	Remember



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10. ESTIMATION OF ACID VALUE OF GIVEN LUBRICANT OIL

INTRODUCTION:

A lubricant (sometimes shortened to lube) is a substance that helps to reduce friction between surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move. It may also have the function of transmitting forces, transporting foreign particles, or heating or cooling the surfaces.

Lubrication is the process of reducing friction between touching surfaces moving relative to each other by introducing a lubricant between the surfaces, which is a material with a lower shear strength than the surfaces.

Lubricants do not necessarily completely prevent asperities, but they reduce their number and weaken their junctions. So, lubrication also reduces the rate of sliding wear.

Good lubricants have high pour points (the lowest temperature at which an oil will flow), high viscosity indices (see later) and good resistance to oxidation.

AIM: To determine the acid value of coconut oil

APPARATUS: Burette, Beakers, pipette, Burette Stand

CHEMICALS REQUIRED:

Phenolphthalein indicator -Weigh 1 g of phenolphthalein and dissolve in 100 mL of ethanol.
Sodium hydroxide titrant -Weigh accurately 4.0 g of sodium hydroxide and place it in a 1000-mL volumetric flask. Make up to the mark with water. Ethanol-ether solution -Prepare a mixture of ethanol and diethyl ether (1:1, v/v). Neutralize with sodium hydroxide titrant and add 1.0 mL of phenolphthalein indicator until pink coloration is observed. Freshly prepare the solution.

PRINCIPLE:

In chemistry, acid value (or neutralization number or acid number or acidity) is the mass of Sodium hydroxide (NaOH) in milligrams that is required to neutralize one gram of chemical substance. The acid number is a measure of the number of carboxylic acid groups in a chemical compound, such as a fatty acid, or in a mixture of compounds. It is an important quality measurement of crude oil.



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PROCEDURE:

Weigh accurately a quantity of the fatty oil being examined as indicated in Table 1 and place it in a 250-mL conical flask, then add 50 mL of ethanol-ether solution. Shake it well. If necessary, reflux the mixture gently until the substance is completely dissolved. Titrate the solution with sodium hydroxide titrant until pink color at ion can be observed which persists for 30 s.

Measure the volume of sodium hydroxide titrant used and calculate the acid value according to the following equation:

$$V \text{ Acid value} = V_{\text{NaOH}} \times 4.0/W$$

Where,

V_{NaOH} = Volume of sodium hydroxide titrant used (mL)

W = Weight of the fatty oil being examined (g)

S. No	Volume of acid	Burette Reading (ml)		Volume of NaOH consumed (ml)
		Initial	Final	
1	2 ml			
2	2 ml			
3	2 ml			

When the acid value is less than 10, it is suggested that a 10-mL semi-micro burette may be used for the titration.

RESULT:

The acid value of coconut oil is _____



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Viva Questions:

S.No	Question	CO	Blooms Taxonomy
1	What is acid value?	CO1	Remember
2	Write the formula of ethanol?	CO1	Remember
3	How can we calculate the acid value?	CO1	Remember
4	What percentage of lauric acid in coconut oil?	CO1	Remember
5	What does an acid taste like?	CO1	Remember
6	How many carbons are there in lauric acid?	CO1	Remember
7	What fatty acids are in coconut oil?	CO1	Remember
8	What is the IUPAC name of lauric acid? (Dodecanoic acid)	CO1	Remember
9	Write the structure of lauric acid?	CO1	Remember
10	Write the formula of diethyl ether?	CO1	Remember
11	What are the chemicals used in this experiment?	CO1	Remember
12	Write the common name of KOH? (Caustic potash.)	CO1	Remember
13	What is the color change at the end point?	CO1	Remember
14	Name the indicator used in this experiment?	CO1	Remember
15	What is the structure of KOH	CO1	Remember
16	What are the uses of lauric acid?	CO1	Remember
17	What is a base number in an engine oil?	CO1	Remember
18	Define lubrication?	CO1	Remember
19	What is the source of lauric acid? (it is abundant in coconut)	CO1	Remember
20	What does an base taste like?	CO1	Remember



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11. ESTIMATION OF VISCOSITY OF LUBRICANT OIL USING OSTWALD'S VISCOMETER

INTRODUCTION:

A lubricant (sometimes shortened to lube) is a substance that helps to reduce friction between surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move. It may also have the function of transmitting forces, transporting foreign particles, or heating or cooling the surfaces.

Lubrication is the process of reducing friction between touching surfaces moving relative to each other by introducing a lubricant between the surfaces, which is a material with a lower shear strength than the surfaces.

The most important property of an oil for lubricating purposes is its viscosity. Viscosity provides some measure of the resistance of a fluid to shearing flow.

Good lubricants have high pour points (the lowest temperature at which an oil will flow), high viscosity indices (see later) and good resistance to oxidation.

AIM: To determine the absolute viscosity of a liquid by using Ostwald's viscometer.

APPARATUS:

Oswald's viscometer, stopwatch, density bottle, rubber bulbs, Beakers, etc.

CHEMICALS REQUIRED:

Standard liquid (water), test liquid etc.

PRINCIPLE: (POISEUILLE'S PRINCIPLE)

If a liquid flows with in a uniform velocity at a rate of 'V' in 't' seconds through a capillary tube of radius 'r' and length 1cm under a driving pressure 'p' dynes/ cm². Then,

The co-efficient of viscosity is given as =



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$$V = \frac{\pi \Delta p r^4 t}{8 \eta L}$$

V: volume of the liquid
r: radius of vessel
t: time
 η : coefficient of viscosity
 Δp : change of pressure
L: vessel length

The Poiseuille's law is applicable only to linear flow or stream line flow. For a given Oswald's viscometer, the length, radius and volume of liquids are constants and at end are combined to a single constant.

- $t_1 = k \eta_1$ (viscosity Standard liquid)
- $t_2 = k \eta_2$ (viscosity of test liquid)

Relative viscosity $\eta_1 / \eta_2 = t_1 / t_2$ Units: (CGS) dynes-sec/cm² or poise

PROCEDURE:

Clean thoroughly and dry the Oswald's viscometer, a definite volume of standard liquid is allowed to flow into 'A' arm such that it rises above the values X and Y. The same procedure is repeated with the test liquid and note the time by stopcock.

CALCULATIONS:

S. No	Standard liquid (t ₁)	Test liquid(t ₂)
TRIAL-I		
TRIAL-II		
TRIAL-III		

Weight of empty density bottle (W₁) = _____ gm. Weight of empty bottle + water (W₂)



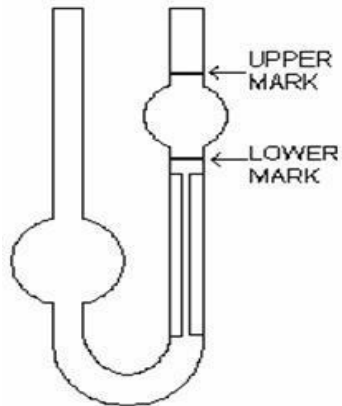
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= _____ gm.



Weight of empty bottle + liquid (W3) = _____ gm

$\frac{W2-w1}{\text{Density of water } [\rho_1]} = \frac{\quad}{\quad} =$
(

25

$\frac{W3-w1}{\text{Density of liquid } [\rho_2]} = \frac{\quad}{\quad} =$
(

W3-w1

25

Viscosity Standard liquid [1] at 25°C = 1.0019 cps



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RESULT:

Absolute viscosity of a given liquid η = _____ cps

Viva Questions:

S. No	Question	CO	Blooms Taxonomy
1	Define viscosity?	CO1	Remember
2	Write the units of viscosity?	CO1	Remember
3	What is the apparatus used to determine the viscosity?	CO1	Remember
4	Discuss about lubricant?	CO1	Remember
5	What is formula of viscosity?	CO1	Remember
6	Define flash point to fabricant?	CO1	Remember
7	Classification of lubricant	CO1	Remember
8	Define cloud and pour point to fabricant?	CO1	Remember
9	What is density?	CO1	Remember
10	Name the units of density?	CO1	Remember
11	What are the chemicals are used in this experiment?	CO1	Remember
12	Is glycerol a lubricant?	CO1	Remember
13	Write the IUPAC name of glycerol?	CO1	Remember
14	What is the apparatus used in determination off lash point?	CO1	Remember
15	What is lubrication?	CO1	Remember
16	Write the structure of glycerol?	CO1	Remember
17	What is the volume of density bottle?	CO1	Remember
18	Write the examples of vegetable oils?	CO1	Remember
19	What are refractories?	CO1	Remember
20	Define lubrication.	CO1	Remember



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1. VIRTUAL LAB EXPERIMENTS:

A. Construction of Fuel cell and its working

INTRODUCTION:

A fuel cell can be defined as an electrochemical cell that generates electrical energy from fuel via an electrochemical reaction. Fuel cells require a continuous input of fuel and an oxidizing agent (generally oxygen) in order to sustain the reactions that generate the electricity. Therefore, these cells can constantly generate electricity until the supply of fuel and oxygen is cut off. A fuel cell is similar to electrochemical cells, which consists of a cathode, an anode, and an electrolyte. In these cells, the electrolyte enables the movement of the protons. Today, these devices are used as the primary or secondary source of power for many facilities including industries, commercial buildings, and residential buildings.

Working of Fuel Cell:

The working of this fuel cell involved the passing of hydrogen and oxygen into a concentrated solution of sodium hydroxide via carbon electrodes. The cell reaction can be written as follows:

Cathode Reaction: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ Anode Reaction: $2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$ Net Cell Reaction: $2H_2 + O_2 \rightarrow 2H_2O$

However, the reaction rate of this electrochemical reaction is quite low. This issue is overcome with the help of a catalyst such as platinum or palladium. In order to increase the effective surface area, the catalyst is finely divided before being incorporated into the electrodes.

Applications of fuel cell

Fuel cell technology has a wide range of applications. Currently, heavy research is being conducted in order to manufacture a cost-efficient automobile which is powered by a fuel cell. A few applications of this technology are listed below.

- Fuel cell electric vehicles, or FCEVs, use clean fuel and are therefore more eco-friendly than internal combustion engine-based vehicles.
- They have been used to power many space expeditions including the Apollo space program.
- Generally, the by-products produced from these cells are heat and water.
- The portability of some fuel cells is extremely useful in some military applications.
- These electrochemical cells can also be used to power several electronic devices.



B. Smart materials for Biomedical applications

INTRODUCTION:

Smart materials are having ability to change its shape according to the external stimulus like temperature, pressure, electric field, magnetic field, etc. Because of their responsiveness, smart materials are also known as responsive materials. These are usually translated as "active" materials although it would be more accurate to say "reactive" materials. The materials used for biomedical applications are: **Metals, ceramics, plastic, glass, and even living cells and tissue** all can be used in creating a biomaterial. They can be reengineered into molded or machined parts, coatings, fibers, films, foams, and fabrics for use in biomedical products and devices. Smart materials include **piezoelectric materials, magneto rheostatic materials**, electro rheostatic materials, and shape memory alloy.

TYPES OF SMART MATERIALS

1. Shape Memory Alloys (SMAs)

Shape memory alloys (SMA) are materials that “remember” their original shape and can go back to this original shape after deformation under a stimulus. They are also known as smart alloys or memory metals.

2. Piezo electric Materials

The term piezoelectricity is a blend of two terms: “piezo” which is a Greek term meaning pressure and “electricity” referring to electric charges. By the application of stress or strain piezoelectric material changes the mechanical energy into electrical energy and vice-versa. Similarly, piezoelectric actuators convert electrical signals into a mechanical movement which is used for adjusting mirrors, lenses and various auto motive parts.

3. Magneto-Rheological Fluids

Magneto-Rheological Fluids (MRFs) will change their rheological properties like



stress and viscosity on the application of the magnetic field. Magneto-Rheological Fluids (MRFs) are also called Magneto-Sensitive Smart Materials. Magneto-Rheological Fluids (MRFs) have the properties such as visco-elastic in nature, magnetic property, light in weight, controllable modulus and excellent sound absorbing.

4. Electro-Rheological Fluids:

The Electro-Rheological Fluids (ERFs) is the suspension of very small particles in electrical insulating fluid when the electric field is applied, they will rapidly form a solid-like structure in the direction of the field. Electro-Rheological Fluids (MRFs) have the properties such as stiff damping coefficient is changed in the electric field, high dielectric constant, interfacial bond strength, constant rheology and dielectric in nature.

5. Optical Fiber

A flexible and transparent fiber which is made by drawing glass/ plastic to a diameter slightly thicker than the diameter of the human hair is called Optical Fiber. These are used quite often to transmit the light between the ends of the fiber.

APPLICATIONS OF SMART MATERIALS:

SMA's have been used in bioengineering applications such as dental wires such as those used in dental braces, mending broken bones using metal plates, and for medical devices that help open clogged veins and arteries. They are used as wires and tubes in applications with hot fluids flowing through them. These materials are ideal as they can retain their shape even in a heated environment.

Piezo electric materials can be employed in monitoring many bodily signals because they convert mechanical energy into an electrical signal. They are especially applicable to monitoring dynamic pressure changes; many human vital signs consist of rhythmic activities like the heart beat or breathing.

Magneto rheological (MR) fluid, whose rheological properties can be changed reversibly by applied magnetic field, offers superior capabilities and opportunities since its invention. The most crucial feature of MR fluid is its controllable and continuous



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yield stress. Taking this advantage, MR fluid is gaining popularity in various medical applications to meet their force/torque requirements. With MR fluid, natural and stable limb motions in lower limb prostheses, exoskeletons, and orthoses, flexible muscle trainings in rehabilitation devices, and high transparency and resolution haptic feedback can be realized.

Fiber optic technology allows surgeons to repair organs, diagnose joint problems, and remove diseased tissues, leaving the patient with a shorter recovery time than more invasive surgical methods.

C. Batteries for Electric Vehicles:

INTRODUCTION:

EVs are vehicles that are either partially or fully powered on electric power. Electric vehicles have low running costs as they have fewer moving parts for maintaining and also very environmentally friendly as they use little or no fossil fuels (petrol or diesel). An electric vehicle battery (EVB, also known as a traction battery) is a rechargeable battery used to power the electric motors of a battery electric vehicle (BEV) or hybrid electric vehicle (HEV). Typically, lithium-ion batteries, they are specifically designed for high electric charge (or energy) capacity.

Most of today's all-electric vehicles and plug-in hybrid electric vehicles (PHEVs) use lithium-ion batteries, though the exact chemistry often varies from that of consumer electronics batteries. Research and development are ongoing to reduce their relatively high cost, extend their useful life, and address safety concerns in regard to overheating.

Lithium-ion batteries are currently used in most portable consumer electronics such as cellphones and laptops because of their high energy per unit mass relative to other electrical energy storage systems. They also have a high power-to-weight ratio, high energy efficiency, good high-temperature performance, and low self-discharge. Most components of lithium-ion batteries can be recycled, but the cost of material recovery remains a challenge for the industry. The U.S. Department of Energy is also supporting the Lithium-Ion Battery Recycling Prize to develop and demonstrate profitable solutions for collecting, sorting, storing, and transporting spent and discarded lithium-ion batteries for eventual recycling and materials recovery. Most of today's all-electric vehicles and PHEVs (plug-in hybrid electric vehicles) use lithium-ion batteries, though the exact chemistry often varies from that of consumer electronics batteries. Research and development are ongoing to reduce their relatively high cost, extend their useful life, and address safety concerns in regard to overheating.

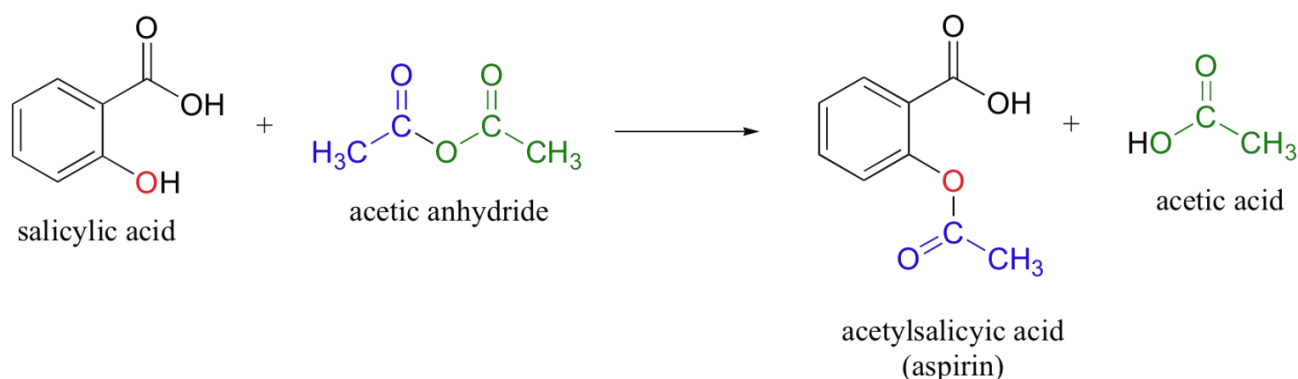
OPEN ENDED EXPERIMENT-1
PREPARATION OF ASPIRIN

AIM: To prepare Aspirin by acetylation of Salicylic acid.

APPARATUS: Conical flask, glass rod, funnel, watch glass.

CHEMICALS REQUIRED: Salicylic acid, acetic anhydride, concentrated sulphuric acid (H₂SO₄) and cold water.

PRINCIPLE: The chemical name of Aspirin is acetyl salicylic acid. Aspirin is acetyl derivative of salicylic acid and prepared by the acetylation of salicylic acid in presence of concentrated sulphuric acid which acts as catalyst.



PROCEDURE:

1. Take 1g of salicylic acid, 3 mL of acetic anhydride into a conical flask and 3 drops of concentrated sulphuric acid and shake well.
2. Heat this mixture on a water bath at 70⁰C for about 20 min.
3. Cool the mixture in an ice bath with constant stirring.
4. Then add 20 mL of ice-cold water to decompose excess of acetic anhydride.
5. A white solid precipitate of aspirin appears.

USES: It is used:

- i. In the treatment of arthritis as an inflammatory agent,
- ii. As a medicine which prevents heart attacks by checking blood clotting in arteries,
- iii. As a pain killer for treatment of headaches.

SIDE EFFECTS: Gastric problems and brain disorders in children.

RESULT: The yield obtained is _____g.

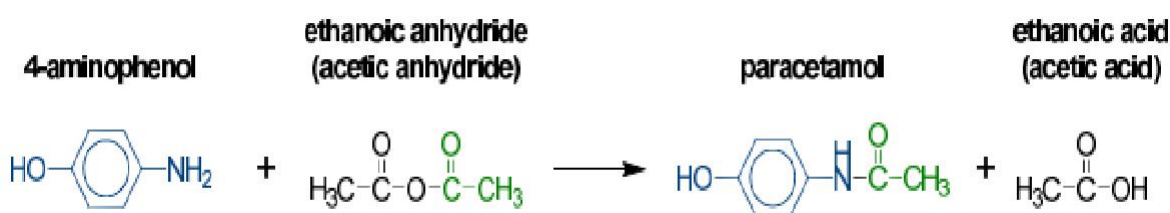
OPEN ENDED EXPERIMENT-2 -PARACETAMOL

AIM: To prepare paracetamol in the laboratory

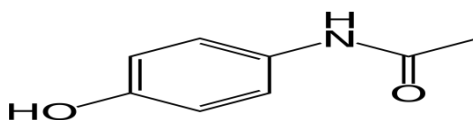
APPARATUS: Conical flask, beaker, watch glass, glass rod

CHEMICALS REQUIRED: 4-aminophenol, acetic anhydride

PRINCIPLE: Paracetamol is used as an analgesic (pain killer) and antipyretic (fever reducing). Paracetamol is made by reacting 4-aminophenol with acetic anhydride (more commonly called acetic anhydride). This reaction forms an amide bond and acetic acid as a byproduct. When the reaction is complete the paracetamol is then isolated and purified.



STRUCTURE OF PARACETAMOL:



PROCEDURE:

Place 2g of the 4-aminophenol into a clean and dry conical flask, add 15ml of water and stir vigorously for a few minutes.

Add 2.5ml of acetic anhydride and continue stirring until the suspension dissolves and a precipitate (Paracetamol) eventually forms.

1. After 10 minutes filter the precipitate, washing with small amounts of cold, distilled water.
2. After drying, place the crude product in a clean conical flask and recrystallize by heating until it just dissolves in approximately 20ml of water.
3. Cool the flask in ice until crystals of the purified paracetamol appear.
4. Repeat recrystallisation process to achieve a more purer product

RESULT: The yield obtained is _____g