I

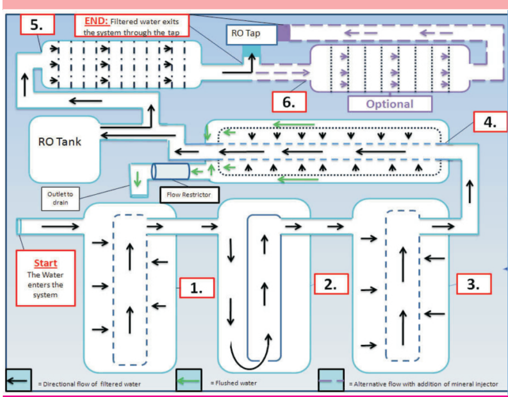
Name ______________________

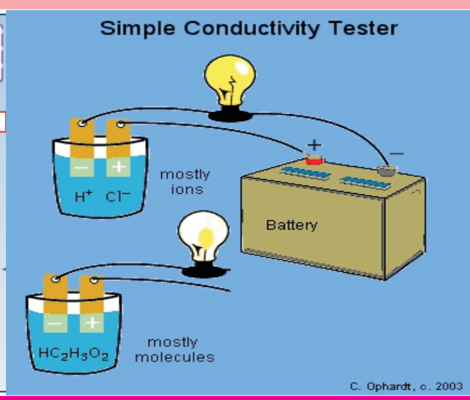
Roll No. ______________ Year 20 _____ 20 _____

Exam Seat No. ______________________

ELECTRICAL & ELECTRONICS GROUPS | SEMESTER - II | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL FOR APPLIED SCIENCE (CHEMISTRY) (22211)





MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual for

Applied Science – Chemistry

(22211)

Semester-II

(EE/EP/EU/IE/IS/IC)

Maharashtra State
Board of Technical Education, Mumbai

(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education,
(Autonomous) (ISO 9001 : 2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
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(Printed on December, 2017)

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr. / Ms. ………………………………………………… Roll No. ………., of First Semester of Diploma in………………….. …………………………………… of Institute,…………………………. ……………………………….(Code: ……………...) has completed the term work satisfactorily in Subject **Applied Science-Chemistry (22211)** for the academic year 20…….. to 20…….. as prescribed in the curriculum.

Place: …………… Enrollment No:.……………

Date: …………… Exam. Seat No: ……………

Subject Teacher **Head of the Department** **Principal**

Seal of Institution

Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-base education as the focus and accordingly, relatively large amount of time is allotted for the practical work. Thisdisplays the great importance of laboratory work making each teacher, instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities.Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practicals to ***focus*** on the***outcomes***, rather than the traditional age old practice of conducting practicals to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing thepractical.The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken,which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Diploma engineers have to deal with various materials and machines. The study of concepts and principles of water treatment and analysis, electrochemistry and batteries, metals and their alloys, insulators and others will help them in understanding the engineering courses where emphasis is laid on the applications. This course is developed in the way by which fundamental information will help the diploma engineers to apply the concepts and principles of advanced chemistry in various engineering applications to solve broad based problems.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Programme Outcomes (POs) to be achieved through Practicals

PO 1. **Basic knowledge**: Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Discipline specific engineering problems.

PO 2. **Discipline knowledge**: Apply Discipline specific engineering knowledge to solve broad-based engineering related problems.

PO 3. **Experiments and practice**: Plan to perform experiments and practices to use the results to solve broad-based engineering problems.

PO 4. **Engineering tools**: Apply relevant technologies and tools with an understanding of the limitations

PO 5. **The engineer and society**:Assess social, health, safety, legal and cultural issues andthe consequent responsibilities relevant to practice in field of engineering.

PO 6. **Environment and sustainability**:Applyengineering solutions also forsustainable development practices in social and environmental contexts.

PO7.**Ethics**:Apply ethical principles for commitment to professional ethics,responsibilitiesand norms of the practice also in the field of engineering.

PO 8. **Individual and team work**:Function effectively as a leader and team member indiverse/ multidisciplinary teams.

PO 9. **Communication**: Communicate effectively in oral and written form.

PO 10. **Life-long learning**: Engage in independent and life-long learning activities in the context of technological changes also in the engineering and allied industry.

Practical- Course Outcome matrix (EE/EP/EU/IS Group)

S. No.	Title of the Practical	CO d.	CO e.	CO f.
1	Determine alkalinity of given water sample.	√	-	-
2	Determine total hardness, temporary hardness and permanent hardness of water sample by EDTA methods.	√	-	-
3	Determine specific conductance and equivalent conductance of given sample salt solution.	-	√	-
4	Determine equivalence point of acetic acid and ammonium hydroxide using conductivity meter.	-	√	-
5	Determine chloride content in the given water sample.	√	-	-
6	Prepare Thiokol rubber.	-	-	√
7	Separate two miscible liquids like acetone and water using distillation technique.	-	-	√
8	Determine acid value of given resin.	-	-	√

Brief Guidelines to Teachers

1. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters which is not mentioned in the printed practicals.
3. For difficult practicals if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.

Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a **dated log book** for the whole semester, apart from this laboratory manual which s/he has to **submit for assessment to the teacher** in the next practical session.
2. Students should read the precaution carefully before start of experiment.

Content Page

List of Practicals and Progressive Assessment Sheet

* To be transferred to Proforma of CIAAN-2017

Practical No. 1: Alkalinity of Water Sample

I Practical Significance

Boiler is an important equipment for various industrial processes to produce steam using water. Nature of water plays important role in terms of efficiency of boiler and various problems caused to the boiler. Water is also used in different industries such as textile, paper, sugar, pharmaceuticals etc. for various industrial processes. Diploma engineers has to deal with the different uses of water during their course of work and also have to deal with the problems caused by hard water like boiler corrosion, caustic embrittlement, scales and sludge formation. This experiment will help diploma engineers to determine the magnitude of alkalinity along with the nature of different types of alkalinity which is required to control corrosion, amount of lime and soda needed for water softening, in conditioning of boiler feed water.

II Relevant Program Outcomes (POs)

- **Basic knowledge**: An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices and to use the results to solve engineering problems.
- **Engineering tools:** Apply appropriate technologies and tools with an understanding of the limitations.
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse/multidisciplinary teams.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the context of engineering industries.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***'Apply principles of advanced physics and chemistry to solve broad based engineering problems'***.

i. Measurement skill
ii. Calculation

IV Relevant Course Outcome(s)

- Select relevant water treatment process for various applications.

V Practical Outcome

- Determine alkalinity of given water sample.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.

VII Minimum Theoretical Background

Alkalinity is a measure of ability of water to neutralize the acids. Alkalinity of water means the total content of those substances in it which causes an increased OH^- ion concentration up on dissociation or due to hydrolysis. Alkalinity of a sample of water is due to the presence of OH^- (hydroxide ion), HCO_3^- (bicarbonate ion), CO_3^{2-}

(carbonate ion) or a mixer of two ions present in water. The OH^- and HCO_3^- ions together is not possible since they combine together to form CO_3^{2-} ions.

$[(OH)^- + (HCO_3)^- \longrightarrow CO_3^{2-} + H_2O]$

The presence of OH^-, CO_3^{2-}- and HCO_3^- can be estimated separately by titration against

standard acid using phenolphthalein and methyl orange as indicators

The determination is based on the following reactions

(i) $OH^- + H^+ \longrightarrow H_2O$

(ii) $CO_3^{2-} + H^+ \longrightarrow HCO_3^-$

(iii) $HCO_3^- + H^+ \longrightarrow H_2O + CO_2$

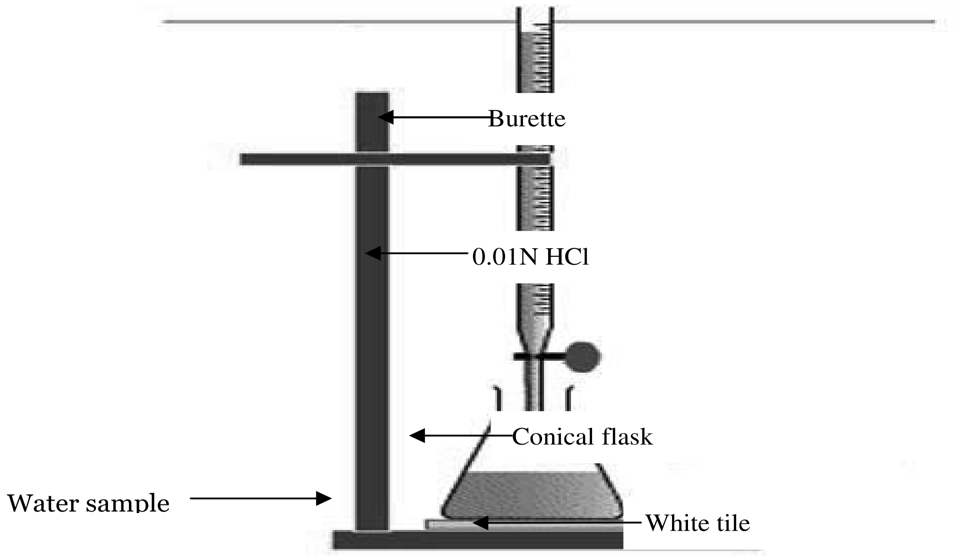
The titration of water sample against a standard acid up to phenolphthalein end point (P) marks the completion of reaction (i) and (ii) only. This amount of acid used thus corresponds to OH^- plus one half of the normal CO_3^{2-}present. On the other hand, titration of the water sample against a standard acid to methyl orange end point (M) marks the completion of reaction (i), (ii) and (iii). Hence the total amount of acid used represents the total alkalinity.

Thus,

$P = OH^- + ½\, CO_3^{2-}$ (Acid required to neutralize alkalinity due to OH^- and half ofCO_3^{2-})

$M = OH^- + CO_3^{2-} + HCO_3^-$ (Acid required to neutralize alkalinity due to OH^-, CO_3^{2-}, HCO_3^-)

VIII Practical set-up / Circuit diagram / Work Situation



IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Burette	Borosil glass , Capacity 25 ml /50 ml	One per group
2.	Conical flask	Borosil glass, Capacity 250 ml/100 ml	One per group
3.	Beaker	Borosil glass, Capacity 250 ml/100 ml	One per group
4.	Pipette	Borosil glass, Capacity 25ml / 10 ml	One per group
5.	Hydrochloric acid	0.01 N	As per requirement
6.	Phenolphthalein indicator		
7.	Methyl orange indicator		
8.	Water sample		

X Precautions to be Followed

1. All the glass apparatus should wash thoroughly with distilled water before use.
2. Before use, the burette and pipette should rinse properly.
3. Remove an air bubbles if present in the nozzle of the burette before taking an initial reading
4. Place the conical flask on a white tile to observe the color change at the end point.
5. Shaking of the titration flask should be continuous during addition of the solution from burette.

XI Procedure

Part A: For determination of alkalinity of water

1. Wash the burette with water.
2. Rinse the burette with 0.01 N HCl solution. Fill it with 0.01 N HCl.
3. Remove air bubble if present, and adjust zero level correctly.
4. Rinse the pipette with sample water. Take 25 ml of sample water in conical flask with the help of pipette.
5. Add 2-3 drops of phenolphthalein indicator into the water sample in conical flask. color of the solution becomes pink.
6. Add 0.01N HCl solution from burette into the conical flask very slowly, till pink color changes to colourless.
7. Note the volume of HCl as a phenolphthalein end point (‘P’ ml.)
8. Add 2-3 drops of methyl orange indicator to the same water sample in a conical flask. colour of the solution becomes yellow. (Do not fill the burette)
9. Continue the addition of 0.01N HCl to water sample from burette till it becomes reddish orange.
10. Note the volume of HCl for methyl orange end point as ‘M’ml.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

XIII Procedure Followed:-

1. **Alkalinity of Water:**
   a. Solution in conical flask :___________________
   b. Solution in burette :_________________________
   c. Indicator used(to obtain P ml):_____________________
   d. End Point:_____________________________
   e. Indicator used (to obtain M ml):_____________________
   f. End Point:_____________________________

XIV Observations and Calculations (use blank sheet provided if space not sufficient)

colour of water sample changes from light pink to colorless and then from yellow to orange red.

Observation table 1: Alkalinity of water (Phenolphthalein end point)

S. No.	Burette Reading	Constant Burette Reading (Volume of 0.01N HCl)
1.	ml	P = _______________ml
2.	ml	
3.	ml	

Observation table 2: Alkalinity of water (Methyl orange end point)

S. No.	Burette Reading	Constant Burette Reading (Volume of 0.01N HCl)
1.	ml	M = _______________ml
2.	ml	
3.	ml	

Follow following table for calculation of alkalinity present due of OH^-, CO_3^{2-} and HCO_3^-

Type of Water sample	Result of titration	Acid required to neutralize Hydroxide alkalinity	Acid required to neutralize Carbonate alkalinity	Acid required to neutralize Bicarbonate alkalinity
A	**P = 0** (If phenolphthalein end point is zero, then alkalinity is due to only bicarbonate.)	**-**	**-**	**M**
B	**P = ½ M** (If phenolphthalein end point is exactly half the total titration, then only carbonate alkalinity is present.)	**-**	**2P**	**-**

C	**P= M (**If methyl orange end point is zero and only there is phenolphthalein end point, then the alkalinity is due to hydroxide alone.)	**M**	**-**	**-**
D	**P < ½ M (**If phenolphthalein end point is less than half the total titration, then alkalinity is due to both carbonate and bicarbonate. **)**	**-**	**2P**	**M-2P**
E	**P > ½ M(**If phenolphthalein end point is greater than half the total titration, then alkalinity is due to both carbonate and hydroxide.)	**2P-M**	**2(M-P)**	**-**

Calculation

I: Alkalinity due to OH^- (if P= M)

Step 1:

1000 ml of 1 N HCl ≡ 17 g of **OH^-**

$$\text{'M' ml of 0.01N HCl} = \frac{(17 \times M \times 0.01)}{1000} \text{ g of } OH^-$$

$$= \frac{(17 \times \ldots\ldots \times 0.01)}{1000} \text{ g of } OH^-$$

= ---------------(y) g of**OH^-**

Step 2:

25 ml water sample contain(y) = -------------- g of **OH^-**

1000 ml water sample contain(y × 40)= -------------g of **OH^-**

i.e. 1000 ml water sample contain (y× 40 × 1000)= ----------mg of **OH^-**

i.e. 1000 ml water sample contain -------------- mg of **OH^-**

II: Alkalinity due to CO_3^{2-} (if P < ½ M)

Step 1:

1000 ml of 1 N HCl ≡ 30 g of **CO_3^{2-}**

$$\text{2P ml of 0.01N HCl} = \frac{(30 \times 2P \times 0.01)}{1000} \text{ g of } CO_3^{2-}$$

$$= \frac{(30 \times \ldots\ldots \times 0.01)}{1000} \text{ g of } CO_3^{2-}$$

= …………..(y) g of **CO_3^{2-}**

Step 2:

25 ml water sample contain(y) = -------------- g of **CO_3^{2-}**

1000 ml water sample contain(y × 40)= -------------g of **CO_3^{2-}**

i.e. 1000 ml water sample contain (y× 40 × 1000)= ----------mg of**CO_3^{2-}**

i.e. 1000 ml water sample contain --------------- mg of **CO_3^{2-}**

III: Alkalinity due to HCO_3^- (if P < ½ M)

Step 1:

1000 ml of 1 N HCl ≡ 61 g of HCO_3^-

[2P-M] ml of 0.01N HCl $= \frac{(61 \times [2P-M] \times 0.01)}{1000}$ g of HCO_3^-

$= \frac{(61 \times [\ldots\ldots\ldots] \times 0.01)}{1000}$ g of HCO_3^-

= ……..…..(y) g of HCO_3^-

Step 2:

25 ml water sample contain (y) = ------------- g of HCO_3^-

1000 ml water sample contain (y × 40)= ------------g of HCO_3^-

i.e. 1000 ml water sample contain(y× 40 × 1000)= ----------mg of HCO_3^-

i.e. 1000 ml water sample contain --------------- mg of HCO_3^-

XIII Results

1. Alkalinity due to OH^- = -------------- mg/lit
2. Alkalinity due to CO_3^{2-} = --------------mg/lit
3. Alkalinity due to HCO_3^- = -------------mg/lit

XIV Interpretation of Results (Give meaning of the above obtained results)

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

XV Conclusions (Actions/decisions to be taken based on the interpretation of results).

…………………………………………………………………………………………

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XVI Practical Related Questions

1. ‘The water sample does not contain OH^- and HCO_3^- ions together.’ Give reason.
2. Explain the role of phenolphthalein and methyl orange indicator in above titration.
3. List the ions responsible to make water alkaline.

Space for Answer

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XIX References / Suggestions for further reading

1. Applied Chemistry : Theory and practice, O.P.Vermani, A.K.Narula, New age International Publication New Delhi 2005 ISBN: 8122408141
2. Practical book on Engineering chemistry,Dr.P.K.Khatua, Platinum publishers Kolkata,ISBN : 0788189872438
3. Experiments in Applied Chemistry, Sunita Rattan, *ISBN*-10: 8188458058; *ISBN*-13: 978-8188458059

XX Suggested Assessment Scheme

Performance indicators		Weightage
Process related: 15 Marks		**60%**
1	Cleaning and filling the burette	10 %
2	Measurement of water sample	10%
3	Burette reading when Phenolphthalein changes colour	20%
4	Burette reading when Methyl orange changes colour	20%
Product related: 10 Marks		**40%**
5	Alkalinity due to CO_3^{2-}	10 %
6	Alkalinity due to HCO_3^- orOH^-	10 %
7	Practical related questions	10 %
8	Submitting the journal in time	10%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……………………..
2. ……………………..
3. ……………………..
4. ……………………..

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 2: Hardness of water sample

I Practical Significance

Boilers are the important equipment for various industrial processes to produce steam using water. Nature of water plays an important role in terms of efficiency of boiler and various problems caused to the boiler. Water is usedin different industries such as textile, paper, sugar, pharmaceuticals etc. for various industrial processes. Diploma engineers has to deal with the different uses of water during their course of work and also have to deal with the problems caused by hard water like boiler corrosion, caustic embrittlement, scales and sludge formation. This experiment will help diploma engineersto determine the magnitude of hardness along with the nature of hardness.

II Relevant Program Outcomes (POs)

- **Basic knowledge**:An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices and to use the results to solve engineering problems.
- **Engineering tools:**Apply appropriate technologies and tools with an understanding of thelimitations.
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse/multidisciplinary teams.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the context of engineering industries.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***'Apply principles of advanced physics and chemistry to solve broad based engineering problems'***.

i. Measurement skill
ii. Calculation

IV Relevant Course Outcome(s)

- Select relevant water treatment process for various applications.

V Practical Outcome

- Determine total hardness, temporary hardness and permanent hardness of water sample by EDTA methods.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.

VII Minimum Theoretical Background

Hard water contains salts of calcium and magnesium in the form of their chlorides, sulphates and carbonates. Hardness of water is determined in terms of equivalent of $CaCO_3$ in ppm. Ethylene diamine tetra acetic acid (EDTA) is a reagent that forms EDTA-metal complex with many metal ions (but not with alkali metal ions such as Na^+ and K^+). In alkaline medium (pH=10), it forms stable complexes with the alkaline earth metal ions Ca^{2+} and Mg^{2+}. The EDTA reagent can be used to measure the total quantity of dissolved Ca^{2+} and Mg^{2+} ions in a water sample.

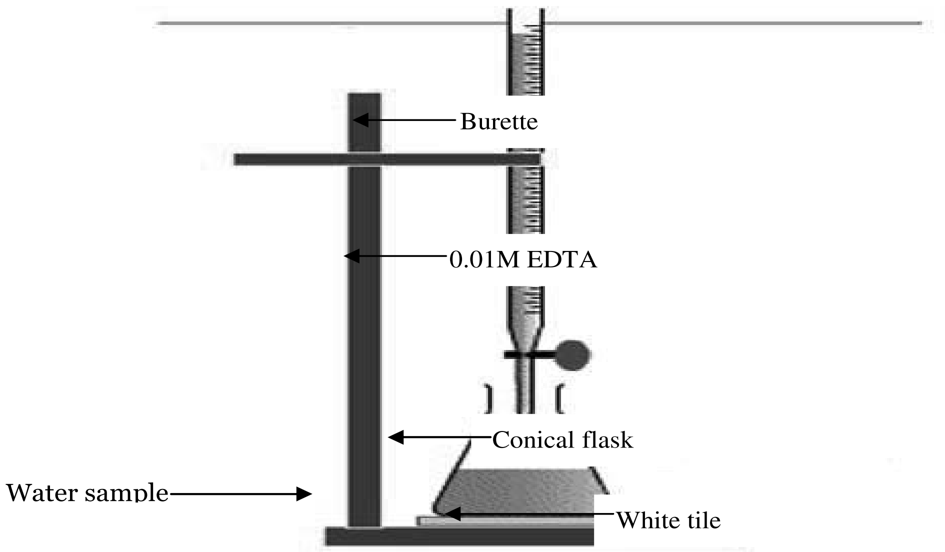
Determination of hardness of water is based on the fact that when indicator, Eriochrome Black -T (EBT) is added to hard water in alkaline medium, it forms wine red colour complex with Ca^{2+} and Mg^{2+} ions

Ca^{2+} +EBT ⟶ Ca^{2+} — EBT
(Wine red unstable complex)

Ca^{2+} EBT +EDTA ⟶ Ca^{2+} EDTA+EBT
(Wine red unstable complex) (colourless stable
Ca- EDTA complex) (Blue)

Thus the total hardness of a water sample can be estimated by titration with standard solution of EDTA.

VIII Practical set-up / Circuit diagram / Work Situation



IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Burette	Borosil glass , Capacity 25 ml /50 ml	One per group
2.	Conical flask	Borosil glass, Capacity 250 ml/100 ml	One per group
3.	Beaker	Borosil glass, Capacity 250 ml/100 ml	One per group
4.	Pipette	Borosil glass, Capacity 25ml / 10 ml	One per group
5.	EDTA solution	0.01 M	As per Requirement
6.	Buffer solution	pH = 10	
7.	Eriochrome Black T indicator		
8.	Water sample	Hard water sample	

X Precautions to be Followed

1. All the glass apparatus should wash thoroughly with distilled water before use.
2. Remove an air bubbles if present in the nozzle of the burette before taking initial reading.
3. Shaking of the titration flask should be continuous during addition of the solution from burette.
4. Place the conical flask on a white tile to observe the colour change at the end point.

XI Procedure

Part A: Process for total hardness of water

1. Wash the burette with water.
2. Rinse the burette with 0.01 M EDTA solution.
3. Fill the burette with 0.01M EDTA solution.
4. Remove air bubble if present, and adjust zero level correctly.
5. Rinse the pipette with sample water. Take 25 ml of sample waterin conical flask with the help of pipette.
6. Add 5 ml of buffer solution of pH 10 using measuring cylinder and 2 drops of Eriochrome Black -T indicator (EBT) into the conical flask.
7. Colourof the solution becomes wine red.
8. Add EDTA solution from burette into the conical flask very slowly, till wine red solutionchanges to light blue color.

Part B: Process for permanent hardness of water.

1. Boil the given water sample for 5-10 minutes and filter.
2. Take 25 ml of the filtered water in the titration flask.
3. Follow the remaining procedure as part A from point 1 to 8.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

XIII Procedure Followed:-

Hardness of Water:-

a. Solution in conical flask: ___________________
b. Solution in burette: ______________________
c. Indicator used:___________________________
d. End Point: _____________________________

XIV Observations and Calculations (use blank sheet provided if space not sufficient)

Color of water sample changes from wine red to sky blue.

Observation table 1: Part A :For total hardness of water

S. No.	**Burette Reading**	**Constant Burette Reading (Volume of 0.01M EDTA)**
1.	ml	X_1 = ______________ml
2.	ml	
3.	ml	

Observation table 2: Part B :For Permanent hardness of water

S. No.	**Burette Reading**	**Constant Burette Reading (Volume of 0.01M EDTA)**
1.	ml	X_2 = ______________ ml
2.	ml	
3.	ml	

Calculation

Part A:For total hardness of water:

Step 1:

1000 ml of 1 M EDTA≡ 100 g of $\mathbf{CaCO_3}$

$$X_1 \text{ml of } 0.01\text{M EDTA} = \frac{(100 \times X_1 \times 0.01)}{1000} \text{ g of } \mathbf{CaCO_3}$$

$$= \frac{(100 \times \ldots\ldots \times 0.01)}{1000} \text{ g of} \mathbf{CaCO_3}$$

= -------------- (y) g of $\mathbf{CaCO_3}$

Step 2:

25 ml water sample contain (y) = --------- g of $\mathbf{CaCO_3}$

1000 ml water sample contain (y × 40) = --------- g of $\mathbf{CaCO_3}$

i.e.1000 ml water sample contain (y× 40 × 1000) = ------------mg of $\mathbf{CaCO_3}$

i.e.1000 ml water sample contain --------- mg of $\mathbf{CaCO_3}$

Part B :For Permanent hardness of water

Step 1:

1000 ml of 1 M EDTA ≡100 g of $\mathbf{CaCO_3}$

$$X_2 \text{ml of } 0.01\text{M EDTA} = \frac{(100 \times X_2 \times 0.01)}{1000}$$

$$= \frac{(100 \times \ldots\ldots \times 0.01)}{1000}$$

= ………..(z) g of $CaCO_3$

Step 2:
25 ml water sample contain (z) = --------- g of $CaCO_3$

1000 ml water sample contain (z×40) = --------- g of $CaCO_3$

i.e.1000 ml water sample contain (z×40 × 1000) = ------------ mg of $CaCO_3$

i.e.1000 ml water sample contain ------------- mg of $CaCO_3$

XV Results

1. The total hardness of given sample of water is………ppm of $CaCO_3$ equivalent.
2. The permanent hardness of given sample of water is………ppm of $CaCO_3$ equivalent.
3. The temporary hardness of given sample of water is………ppm of $CaCO_3$ equivalent.

XVI Interpretation of Results (Give meaning of the above obtained results)

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVII Practical Related Questions

1. Write the reaction between EDTA and magnesium ion in hard water.
2. Explain the process to remove temporary hardness of water.
3. State the role of buffer solution in the given titration.

Space for Answer

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XIX References / Suggestions for further reading

1. Applied Chemistry : Theory and practice, O.P.Vermani, A.K.Narula, New age International Publication New Delhi 2005 ISBN: 8122408141
2. Experiments and calculations in engineering chemistry,Dr. S.S. DaraS.Chand. Publication, New Delhi, 2011, *ISBN*:8121908647
3. Experiments in general chemistry Principles and modern applications, Thomas G. Greco; Lyman H. Richard; Gerald S. Weiss, Pearson, 2011,ISBN-13:978-0131493919

XX Suggested Assessment Scheme

Performance indicators		Weightage
Process related: 15 Marks		**60%**
1	Measurements of solution	10 %
2	Burette Reading of Part A	20%
3	Removal of temporary hardness	10 %
4	Burette Reading of Part B	20%
Product related: 10 Marks		**40%**
5	Calculation for Total hardness of water	10%
6	Calculation for Permanent hardness of water	10%
7	Calculation for Temporary hardness of water	05%
8	Practical related questions	10 %
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……………………..
2. ……………………..
3. ……………………..

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 3: Specific conductance and equivalent conductance

I Practical Significance

Conductivity measurements are used routinely in many industrial and environmental applications as a fast, inexpensive and reliable way of measuring the ionic content in a solution. Conductivity measurement is an extremely useful method, especially for quality control purposes. Estimation of the total number of ions in a solution can be performed using conductivity measurements. Specific conductance (conductivity) of an electrolyte solution is a measure of its ability to conduct electricity. Diploma engineers to monitor and continuously trend the performance of batteries, water purification systems.

II Relevant Program Outcomes (POs)

- **Basic knowledge**:An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices and to use the results to solve engineering problems.
- **Engineering tools:**Apply appropriate technologies and tools with an understanding of thelimitations.
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse/multidisciplinary teams.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the context of engineering industries.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***'Apply principles of advanced physics and chemistry to solve broad based engineering problems'***.

i. Measurement skill
ii. Calibration of instrument

IV Relevant Course Outcome(s)

- Use relevant batteries for different applications.

V Practical Outcome

- Determine specific conductance and equivalent conductance of given sample salt solution.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.

VII Minimum Theoretical Background

The conductance is the property of the conductor (metallic as well as electrolytic) which facilitates the flow of electricity through it. It is equal to the reciprocal of resistance i.e.

Conductance = 1/ Resistance = 1/R

Units of conductance: Ω^{-1}.

The resistance of any conductor varies directly as its length (*l*) and inversely as its cross-sectional area (*A*), i.e. Mathematically

R ál / A
R = ρ l / A
Where 'ρ' is the specific resistance. l /A is known as cell constant.
If l = 1 cm and A = 1 cm², then R = ρ
The specific resistance is, thus defined as the resistance of one centimeter cube of a conductor.
The reciprocal of specific resistance is termed the specific conductance or it is the conductance of one centimeter cube of a conductor.
It is denoted by the symbol κ (kappa) Thus,

$\kappa = \frac{1}{\rho}$ Where κ kappa (specific conductance)

Specific conductance is also called conductivity.
Further,

$$\rho = \frac{A \times R}{l}$$

$$\Rightarrow \frac{1}{\rho} = \frac{l}{A} \times \frac{1}{R}$$

$$\Rightarrow \kappa = \frac{l}{A} \times C$$

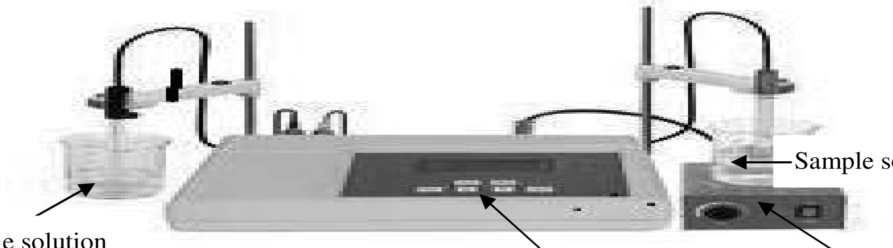
or Specific **conductance = Conductance × cell constant**
In the case of electrolytic solutions, the specific conductance is defined as the conductance of a solution of definite dilution enclosed in a cell having two electrodes of unit area separated by one centimeter apart.
Unit of specific conductance: Ω^{-1} cm^{-1}

Equivalent Conductance
One of the factors on which the conductance of an electrolytic solution depends is the concentration of the solution. In order to obtain comparable results for different electrolytes, it is necessary to take equivalent conductances.
Equivalent conductance is defined as the conductance of all the ions produced by one gram equivalent of an electrolyte in a given solution.
According to definitions,
$\lambda = k \times V$
Where V is the volume in ml containing 1 g equivalent of the electrolyte.

$$\lambda = \frac{k \times 1000}{N}$$

Where N is the normality of solution
Unit of equivalent conductance: Ω^{-1} cm^{-2} $equiv^{-1}$

VIII Practical set-up / Circuit diagram / Work Situation



IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Conductivity meter with magnetic stirrer and conductivity cell	Conductivity range – 0.01 uS/cm to 200 mS/cm, Cell constant – digital 0.1 to 2.00; Temp. range – 0 to 100^0C	One per group
2.	Electronic balance	Electronic balance, with the scale range of 0.001g to 500g. pan size 100 mm; response time 3-5 sec.; power requirement 90-250 V, 10 watt.	One per batch
3.	Beaker	Borosil glass, 100ml / 250 ml	One per group
4.	Measuring cylinder	Borosil glass, 50 ml ,100ml	One per group
5.	Volumetric flask	Borosil glass,100ml,250ml	One per group
6.	Solutions. (strong electrolyte,weakelectrolyte,non-electrolyte)	Prepare different solutions of different concentration	As per requirement

X Precautions to be Followed

1. Conductivity meter must be standardized with KCl solution before daily use.
2. Conductivity cell must be kept clean.
3. Use conductivity water for preparation of solution.
4. Make sure that instrument is giving stable reading.

XI Procedure

Part A: Preparation of 0.1 N KCl solution and calibration of conductivity meter

1. Set up the conductivity meter, conductivity cell beaker containing solution of electrolyte, burette etc. as shown in diagram.
2. Weigh exactly 0.745 gm of KCl. Transfer in to 200 ml beaker and dissolved in 50 ml conductivity or distilled water.
3. Transfer the dissolved KCl solution to 100 ml volumetric flask and dilute it up to the mark using conductivity or distilled water.
4. Take 50 ml 0.1 N KCl solution in 100 ml beaker.

5. Insert conductivity cell in a solution and calibrate the conductivity meter as given in instruction manual.

Part B: Determination of observed conductance

1. Rinse the conductivity cell with conductivity or distilled water.
2. Take 50 ml salt solution in 100 ml beaker. Place it on the magnetic stirrer.
3. Dip the conductivity cell in a salt solution and wait for steady reading.
4. Note down the displayed reading directly.
5. Repeat the procedure for remaining salt solutions.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

XIII Procedure Followed:-

1.Calibration of conductivity meter by __________ solution.

2. Determination of conductance by ____________ ml of sample solution by conductivity meter.

XIV Observations and Calculations (use blank sheet provided if space not sufficient)

Room Temperature = ………..^{0}C.

Cell constant = …………….cm $^{-1}$.

S.No.	Salt solution	Observed conductance	Specific conductance in Ω^{-1} cm^{-1} (Observed conductance × cell constant)	Equivalent conductance in Ω^{-1}cm^{-2} equiv^{-1} = Specific conductivity ×V (V = Volume of solution containing 1 g equivalent of substance)
1	A			
2	B			
3	C			
4	D			
5	E			

XV Results

1. Specific conductance of solution A =……………….
2. Specific conductance of solution B =……………….
3. Specific conductance of solution C =……………….
4. Specific conductance of solution D =……………….
5. Specific conductance of solution E =……………….

XVI Interpretation of Results (Give meaning of the above obtained results)

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. Write unit of cell constant.
2. Explain the process to calibrate conductivity meter.
3. State formula for conversion of specific conductance to equivalent conductance.

Space for Answers

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XIX References / Suggestions for further reading

1. Applied Chemistry : Theory and practice, O.P.Vermani, A.K.Narula, New age International Publication New Delhi 2005 ISBN: 8122408141
2. Experiments and calculations in engineering chemistry,Dr. Dara, S. S.Chand. Publication, New Delhi, 2011, *ISBN*:8121908647
3. Experiments in Applied Chemistry, Sunita Rattan, *ISBN*-10: 8188458058; *ISBN*-13: 978-8188458059
4. Web reference:
   http://www.analytical-chemistry.uoc.gr/files/items/6/618/agwgimometria_2.pdf
   http://sciencing.com/standard-method-calibration-conductivity-meter-5607698.html
   https://www.youtube.com/watch?v=WhyMOVvAu3s

XX Suggested Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

Performance indicators		Weightage
Process related: 15 Marks		**60%**
1	Preparation of 0.01 N KCl solution	10 %
2	Calibration of conductivity cell	10%
3	Measurement of the conductance of five different solution	30%
4	Working in team	10%
Product related: 10 Marks		**40%**
5	Practical related questions and identification of type of electrolyte	20 %
6	Submitting the journal in time	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……………………..
2. ……………………..
3. ……………………..
4. ……………………..

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 4: Equivalence point using conductivity meter.

I Practical Significance

Conductivity measurements are used routinely in many industrial and environmental applications as a fast, inexpensive and reliable way of measuring the ionic content in a solution. Conductivity measurement is an extremely useful method, especially for quality control purposes. Estimation of the total number of ions in a solution or direct measurement of components in process can be performed using conductivity measurements. Specific conductance of an electrolyte solution is a measure of its ability to conduct electricity. For example, the measurement of product conductivity is a typical way to monitor and continuously trend the performance of water purification systems. Diploma engineers has to take conductivity measurements which are used extensively in many industries such as for monitoring quality in public water supplies, in hospitals, in boiler water etc.

II Relevant Program Outcomes (POs)

- **Basic knowledge**: An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices and to use the results to solve engineering problems.
- **Engineering tools:** Apply appropriate technologies and tools with an understanding of the limitations.
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse/multidisciplinary teams.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the context of engineering industries.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***'Apply principles of advanced physics and chemistry to solve broad based engineering problems'***.

i. Measurement skill
ii. Calibration of instrument
iii. Calculation
iv. Plotting a graph

IV Relevant Course Outcome(s)

- Use relevant batteries for different applications.

V Practical Outcome

- Determine equivalence point of acetic acid and ammonium hydroxide using conductivity meter.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.

VII Minimum Theoretical Background

Electrovalent compounds are also known as the electrolytes because when fused or dissolved in water, they ionize into cations and anions and carry electric current. The types of electrolytes are strong and weak electrolytes depending on their degree of ionization. Strong electrolyte has higher degree of ionization and weak electrolyte has lower degree of ionization.

Conductivity of solution of electrolyte depends upon the number of ions present in the solution. Strong electrolytes produce more ions and have higher conductivity while weak electrolytes produce fewer ions and have lower conductivity. Electrical conductivity is a measure of the ability of a solution to carry a current. Current is carried by ions in solution. All ions present in the solutions contribute to the current flowing through the sensor and therefore, contribute to the conductivity measurement. Electrical conductivity can therefore be used as a measure of the concentration of ionisable solutes present in the salt solution.

Weak acids and bases are not completely dissociated into ions hence they are poor conductors of electricity because they contain a low concentration of ions in solution. Hence conductometric titrations are done for weak acids and weak bases where no indicator gives sharp change in color.

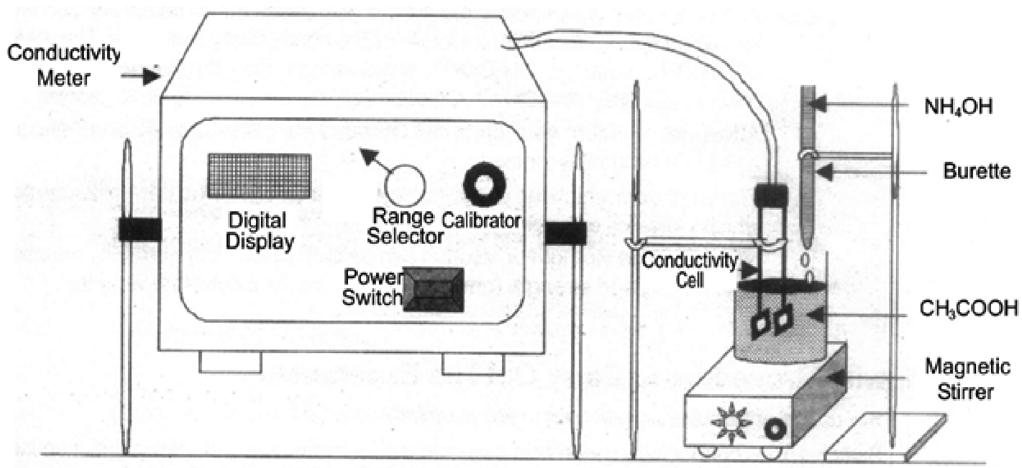
When CH_3COOH is titrated against NH_4OH, in the beginning, CH3COOH in the beaker has lower conductance as it is a weak acid. The addition of NH_4OH solution from burette increases conductance due to formation of salt CH_3COONH_4 having higher degree of ionization.

After neutralization the further addition of NH_4OH to CH_3COOH does not change conductance of solution because dissociation of NH_4OH is suppressed by CH_3COONH_4 in the solution due to common ion effect.

The conductivity cell contains two platinum electrodes fixed by sealing into a glass tube. The electrodes are 1 cm apart and have cross sectional area 1cm^2.Cell constant is the ratio of length (cm) to cross sectional area (cm^2) of the electrodes in a conductivity cell.

$$\text{Cell Constant} = \frac{\text{Length}}{\text{Area}} = \frac{L}{A}$$, Unit of cell constant is cm^{-1}.

VIII Practical set-up / Circuit diagram / Work Situation



IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Conductivity meter with magnetic stirrer	Conductivity range – 0.01 uS/cm to 200 mS/cm, Cell constant – digital 0.1 to 2.00; Temp. range – 0 to 100^0C	One per group
2.	Electronic balance	Electronic balance, with the scale range of 0.001g to 500 g. pan size 100 mm; response time 3-5 sec.; power requirement 90-250 V, 10 watt.	One per batch
3.	Beaker	Borosil glass 250 ml/100 ml	One per group
4.	Burette	Borosil glass 25 ml / 50ml	One per group
5.	Pipette / Measuring cylinder	Borosil glass 25ml / 10 ml	One per group
6.	Acetic acid solution	0.01 M	
7.	Ammonium hydroxide solution	pH = 10	

X Precautions to be Followed

1. Conductivity meter must be calibrated with KCl solution before use.
2. Conductivity cell must be kept clean.
3. Use conductivity water for preparation of solution.
4. Make sure that instrument is giving stable reading.

XI Procedure

1. Set up the conductivity meter, conductivity cell beaker containing solution of electrolyte, burette etc. as shown in diagram.
2. Switch on the conductivity meter and calibrate the instrument as per instruction manual.
3. Wash the conductivity cell with distilled water.
4. Wash and clean burette, conical flask and beaker with distilled water.
5. Take 50 ml of acetic acid solution using measuring cylinder in the beaker and place it onthe magnetic stirrer.
6. Place the conductivity cell and magnetic needle in acetic acid solution and start magnetic stirrer.
7. Start electric current and measure the conductivity of acetic acid solution.
8. Fill the burette with NH_4OH solution up to the zero mark.
9. Add 1 ml of NH_4OH solution from burette to acetic acid each time and stir well.
10. Note down conductance of acetic acid in beaker after each addition of NH_4OH solution in observation table.
11. Note down the conductance values till conductance remains constant.
12. Plot a graph of conductance (Y-axis) against volume of NH_4OH added from burette (X-axis).

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

XIII Procedure Followed

a. Solution in conical flask:--___________________

b. Solution in burette:-__________________________

c. End Point:-____________________________

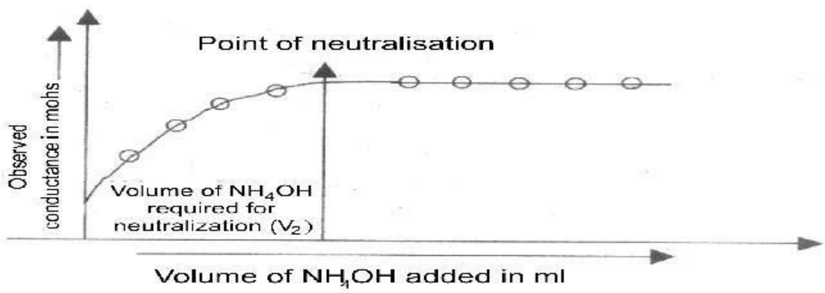
XIV Observations and Calculations(use blank sheet provided if space not sufficient)

S. No.	Volume of NH_4OH added	Conductance in mhos	S. No.	Volume of NH_4OH added	Conductance in mhos
1	0 ml		14	13 ml	
2	1 ml		15	14 ml	
3	2 ml		16	15 ml	
4	3 ml		17	16 ml	
5	4 ml		18	17 ml	
6	5 ml		19	18 ml	
7	6 ml		20	19 ml	
8	7 ml		21	20 ml	
10	9 ml		23	22 ml	
11	10 ml		24	23 ml	
12	11 ml		25	24 ml	
13	12 ml		26	25 ml	

Table for conductometric titration of weak acid and weak base.

Calculations:-

Plot a graph of conductance (Y – axis) against volume of NH_4OH added (X – axis). In the graph it is observed that with each addition of NH_4OH conductance increases, reaches a certain maximum value and then remains constant. The volume of NH_4OH (on X-axis) at which the constant conductance is obtained indicates neutralization point or equivalence point of titration.



XV Results

The equivalence point of acetic acid and ammonium hydroxide reaction = ……….ml.

XVI Interpretation of Results (Give meaning of the above obtained results)

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. Why does acetic acid in beaker show lowest conductance when NH_4OH is not added?
2. Name the ions which cause conductivity in this experiment.
3. Conductance of the solution remains constant after neutralization point. Give reason.

Space for Answers

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References / Suggestions for Further Reading

1. Applied Chemistry : Theory and practice, O.P.Vermani, A.K.Narula, New age International Publication New Delhi 2005 ISBN: 8122408141
2. Practical book on Engineering chemistry,Dr.P.K.Khatua, Platinum publishers Kolkata, ISBN : 0788189872438
3. Web reference:http://www.analytical-chemistry.uoc.gr/files/items/6/618/agwgimometria_2.pdf ,http://sciencing.com/standard-method-calibration-conductivity-meter-5607698.html

XIX Assessment Scheme

Performance indicators		Weightage
Process related: 15 Marks		**60%**
1	Calibration of conductivity cell	10 %
2	Perfect measurement of the solution	10 %
3	Addition of exact volume of NH_4OH solution with constant stirring	40%
Product related: 10 Marks		**40%**
4	Determination of exact neutralization point by plotting graph	20 %
5	Answer to sample questions	10 %
6	Submitting the journal in time	10%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……………………..
2. ……………………….
3. ………………………
4. ………………………

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Practical No. 5: Chloride content of water sample

I Practical Significance

Boiler is animportant equipment for various industrial processes to produce steam using water. Nature of water plays important role in terms of efficiency of boiler and various problems caused to the boiler.Water is also used in different industries such as textile, paper, sugar, pharmaceuticals etc. for various industrial processes.. At high temperature and pressure, chloride of calcium and magnesium reacts with water forming hydrochloric acid. Hence water becomes acidic and causes boiler corrosion.

Diploma engineers has to deal with the different uses of water during their course of work and also have to deal with the problems caused by hard water like boiler corrosion, caustic embrittlement, scales and sludge formation. This experiment will help diploma engineers to determine the magnitude of chloride content which is required to control corrosion and helps in selection of water supplies for human use.

II Relevant Program Outcomes (POs)

- **Basic knowledge**:An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices and to use the results to solve engineering problems.
- **Engineering tools:**Apply appropriate technologies and tools with an understanding of thelimitations.
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse/multidisciplinary teams.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the context of engineering industries.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***'Apply principles of advanced physics and chemistry to solve broad based engineering problems'***.

i. Measurement
ii. Calculation

IV Relevant Course Outcome(s)

- Select relevant water treatment process for various applications.

V Practical Outcome

- Determine chloride content in the given water sample.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.

VII Minimum Theoretical Background

Water contains dissolved chloride salts of calcium, magnesium and sodium. These salts ionize to give chloride ions in water. If water contains chloride ions above 250 ppm is not suitable for drinking or industrial purposes.

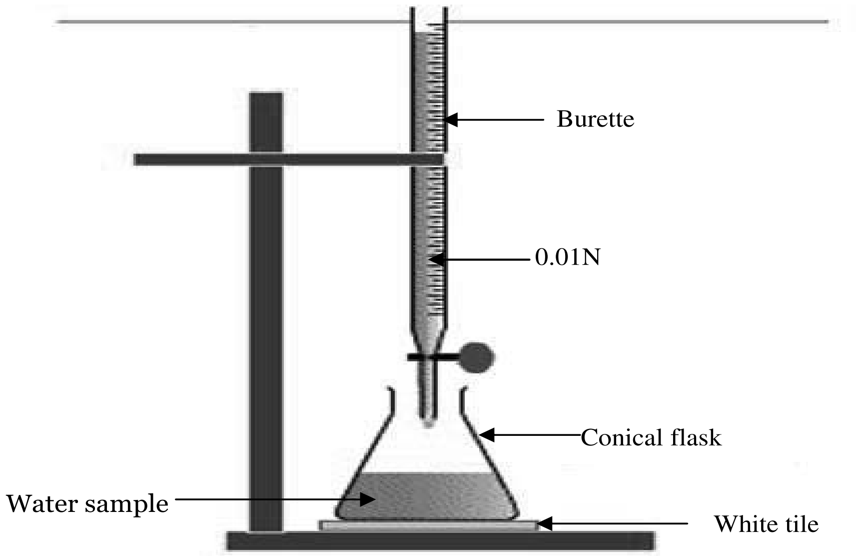
When sample of water is titrated against silver nitrate solution, using potassium chromate as indicator. The chloride present in water is precipitated as AgCl. As soon as all the chlorides are precipitated out, then even a single drop of $AgNO_3$ added in excess gives a red precipitate of silver chromate.

$$AgNO_3 + Cl^- \longrightarrow AgCl\downarrow + NO_3^-$$

$$AgNO_3 + K_2CrO_4 \longrightarrow AgCrO_4\downarrow + KNO_3$$

Red ppt

VIII Practical set-up / Circuit diagram / Work Situation



IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Burette	Borosil glass , Capacity 25 ml /50 ml	One per group
2.	Conical flask	Borosil glass, Capacity 250 ml/100 ml	One per group
3.	Beaker	Borosil glass, Capacity 250 ml/100 ml	One per group
4.	Pipette	Borosil glass, Capacity 25ml / 10 ml	One per group
5.	Silver nitrate	0.01N	As per Requirement
6.	Potassium chromate indicator		
7.	Water sample		

X Precautions to be followed

1. Wash all the glass apparatus thoroughly with distilled water before use.
2. Remove air bubbles if present in the nozzle of the burette before taking initial reading.
3. Place the conical flask on a white tile to observe the color change at the end point.
4. Add solution dropwise from burette, with constant shaking of flask.

XI Procedure

1. Wash the burette with distilled water.
2. Rinse the burette with 0.01 N $AgNO_3$solution. Fill it with 0.01 N $AgNO_3$solution.
3. Remove air bubble if present, and adjust zero level correctly.
4. Rinse the pipette with sample water. Take 25 ml of sample water in conical flask withthe help of pipette.
5. Add 2-3 drops of potassium chromate indicator into the water sample in conical flask. colour of the solution becomes yellow
6. Add 0.01 N $AgNO_3$ solution from burette into the conical flask very slowly, till yellowcoloursolution changes to brick red.
7. Note down the reading, repeat the procedure to get constant reading.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

XIII Procedure Followed

1. Chloride content in water
   a. Solution in conical flask:___________________
   b. Solution in burette:________________________
   c. Indicator used:_____________________
   d. End Point:____________________________

XIV Observations and Calculations (use blank sheet provided if space not sufficient)

Observe the Color of water sample changes from yellow to brick red.

S. No.	Burette Reading	Constant Burette Reading (Volume of 0.01N $AgNO_3$)
1.	ml	Z = ____________ ml
2.	ml	
3.	ml	

Calculation:

Step 1:

1000 ml of 1 N $AgNO_3$ $\equiv$ 35.5 g of **Cl^-**

$$\text{'Z' ml of } 0.01N\ AgNO_3 = \frac{(35.5 \times Z \times 0.01)}{1000} \text{ g of } Cl^-$$

$$= \frac{(35.5 \times ..... \times 0.01)}{1000} \quad \text{g of } \mathbf{Cl^-}$$

$$= ....(y) \text{ g of } \mathbf{Cl^-}$$

Step 2:

25 ml water sample contain (y) = ………………… g of $\mathbf{Cl^-}$

1000 ml water sample contain (y × 40) = ………………… g of $\mathbf{Cl^-}$

i.e. 1000 ml water sample contain (y × 40 × 1000)= ………………… mg of $\mathbf{Cl^-}$

i.e. 1000 ml water sample contain ------------- mg of $\mathbf{Cl^-}$

XV Results

Chloride content in the given water sample = ------------ mg/lit

XVI Interpretation of Results (Give meaning of the above obtained results)

…………………………………………………………………………………………

…………………………………………………………………………………………

XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

…………………………………………………………………………………………

…………………………………………………………………………………………

XVIII Practical Related Questions

1. Name the salts which produce Cl^- ions in water sample.
2. Write the color change at the end point.
3. Write the reaction of between indicator and $AgNO_3$ solution.

Space for Answers

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XIX References / Suggestions for further reading

1. Engineering chemistry, Shashi Chavla, S. Chand publication New Delhi 2013 ISBN : 1234567155036
2. Laboratory manual on Engineering Chemistry, Dr.SudhaRani,Dhanpat Rai Publishing Company, ISBN-9788187433132

XX Suggested Assessment Scheme

Performance indicators		Weightage
Process related: 15 Marks		**60%**
1	Cleaning and filling burette	10 %
2	Measurement of water sample	10%
3	Burette reading when potassium chromate changes color	20 %
4	Working in team	20 %
Product related: 10 Marks		**40%**
5	Chloride content (Cl^-)	20 %
6	Answer to sample questions	10 %
7	Submission of report in time	10 %
Total (25 Marks)		**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 6: Thiokol rubber

I Practical Significance

Polysulphide rubber is very important for industrial purpose. It is used for lining of fuel storage tank. It is also used in the manufacture of oil and gaseous resistant tubing and of gas tight diaphragms for gas meters. From the liquid Thiokol, sealing compounds are prepared. Now a days thiokol rubber is used in printing, textile industry.

II Relevant Program Outcomes (POs)

- **Basic knowledge**: An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices and to use the results to solve engineering problems.
- **Engineering tools**: Apply appropriate technologies and tools with an understanding of the limitations.
- **Environment and sustainability**: Understand the impact of the engineering solutions in societal and environmental contexts, and demonstrate the knowledge and need for sustainable development.
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse/multidisciplinary teams.
- **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the context of engineering industries.
  of the limitations.

III Competency and Skills

This practicalis expectedto developthe followingskillsforthe industry identified competency***'Apply principles of advanced physics and chemistry to solve broad based engineering problems'.***

i. Measurement skill
ii. Preparation of solutions
iii. Weighing skill

IV Relevant Course Outcome(s)

- Use relevant metals, alloys and insulating materials in various applications.

V Practical Outcome

- Prepare Thiokol rubber.

VI Minimum Theoretical Background

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.

VII Minimum Theoretical Background

Thiokol rubber is a artificial liquid elastomer with low moisture permeability and outstanding chemical and oil resistance. Thiokol rubber is used as a substitute for natural rubber in many cases.. It is polymer having sulfur structure used as sealant in construction and engineering projects and plays a important role in high rise building construction. Thiokol rubber can be prepared by the condensation of 1,2-dichloro ethane with sodium polysulphide. It will have elasticity depending on sulfur content .It will resist organic solvent action. It is mixed with carbon, zinc oxide or some natural rubber to make it more harder and better wearing qualities.

S S

n $Cl\text{-}CH_2\text{-}CH_2\text{-}Cl$ + n $Na\text{-}S\text{-}S\text{-}Na$ + n $Cl\text{-}CH_2\text{-}CH_2\text{-}Cl$

↓

S S

n $Cl\text{-}CH_2\text{-}CH_2\text{-}S\text{-}S\text{-}CH_2\text{-}CH_2)n$ + 2n NaCl

Thiokol rubber (yellow solid)

VIII Practical set-up / Circuit diagram / Work Situation

Not Applicable

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Beaker	Borosil glass, 250 ml	One per group
2.	Electronic balance	With the scale range of 0.001g to 500g. pan size 100 mm; All response time 3-5 sec.; power requirement 90-250 V, 10 watt.	One per batch
3.	Glass rod		One per group
4.	Water bath		One per group
5.	Burner		One per group
6.	Chemicals	Sodium hydroxide, 1,2-dichloroethane	As per requirements

X Precautions to be Followed

1. Wear safety goggles, apron and rubber gloves while working in laboratory.
2. Handle ethylene dichloride with extreme care as it is irritant to skin and eyes.
3. Sulphur is a fire risk in finely divided form. It may cause irritation to skin and mucous membrane.
4. Use water bath as reaction is exothermic.

XI Procedure

1. Dissolve 3 g of sodium hydroxide in 100 ml of distilled water in a beaker. Heat the solution to boiling. Place the stirring rod in beaker to prevent bumping of solution.
2. Add 6 g of sulphur powder, stir until all the sulphur has dissolved completely. A yellow to deep red solution is obtained due to the formation of sodium polysulphide. Filter the solution if some sulphur remains undissolved.
3. Allow the solution to cool below 83^0C (the boiling point of 1,2- dichloroethane), now add 15 ml of 1,2- dichloroethane with stirring.
4. Continue stirring for 15-20 minutes until rubber molecule separates out as a lump.
5. Decant the supernant liquid, wash the product with water and allow excess 1,2-dichloroethane to evaporate.

XII Resources Used

S.No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

XIII Procedure Followed (use blank sheet provided if space not sufficient)

1. Weight of sodium hydroxide taken -------------- gm
2. Weight of Sulphur powder taken ---------------gm
3. Volume of 1-2 dichloroethane taken ------------gm
4. Stirring time of solution to separate rubber molecule -------- minutes

XIV Observations and Calculations (use blank sheet provided if space not sufficient)

S.No.	Description	Symbol	Weight in grams
1.	Weight of empty beaker	W_1	……………… g
2.	Weight of beaker + Thiokol rubber	W_2	……………….g
3.	Weight of Thiokol rubber	$W= W_2-W_1$	……………….g

Calculations - NA

XV Results

The weight of Thiokol rubber =………….…….g.

XVI Interpretation of Results (Give meaning of the above obtained results)

……………………………………………………………………………………………
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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. Name the constituents used in the preparation of Thiokol rubber.
2. State the type of reaction in the formation of Thiokol rubber.
3. Write the reaction between 1, 2-dichloro ethane with sodium polysulphide.

Space for Answer

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XIX References / Suggestions for Further Reading

1. Experiments and calculations in engineering chemistry, Dr. Dara, S. S., S.Chand. Publication, New Delhi, 2011, *ISBN*:8121908647
2. Web reference:www.chymist.com/Synthetic%20Rubber.pdf

XX Assessment Scheme

Performance Indicators		Weightage %
Process related: 15 Marks		**60%**
1	Measurement and preparation of solution	30%
2	Mixing of solution with precaution taken	20%
3	Working in team	10%
Product related: 10 Marks		**40%**
4	Preparation of Thiokol rubber	20 %
5	Practical related questions	10 %
6	Submitting the journal in time	10 %
Total (25 Marks)		100%

Names of Student Team Members

1. ……………………..
2. ………………………
3. ………………………
4. ………………………

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.7: Distillation Technique

I Practical Significance

The goal of distillation is to purify an impure sample, collect the pure sample leaving behind the impurities. Diploma engineers has to use distillation process for purification of substances as well as separation of substances during their course of work. In industry distillation technique is used to separate economically important component of fossil fuel such as natural gas, kerosene, gasoline, heavy oils, lubricant etc. Also used in purification of spirit or alcohol which the major byproduct of food industry.

II Relevant Program Outcomes (POs)

- **Basic knowledge**: An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices and to use the results to solve engineering problems.
- **Engineering tools:** Apply appropriate technologies and tools with an understanding of the limitations.
- **Environment and sustainability**: Understand the impact of the engineering solutions in societal and environmental contexts, and demonstrate the knowledge and need for sustainable development
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse/multidisciplinary teams.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the context of engineering industries.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***'Apply principles of advanced physics and chemistry to solve broad based engineering problems'***.

i. Measurement skills
ii. Handling glassware

IV Relevant Course Outcome(s)

- Use relevant metals, alloys and insulating materials in various applications.

V Practical Outcome

- Separate two miscible liquids like acetone and water using distillation technique.

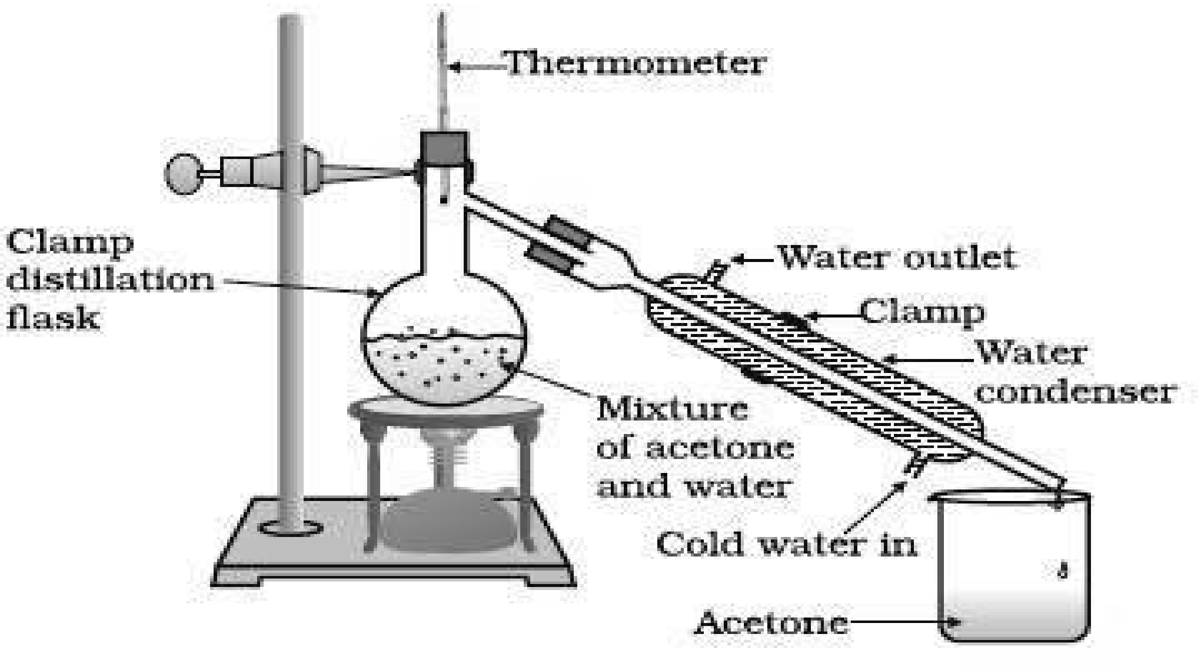
VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Practice good housekeeping.
- Maintain tools and equipment.
- Practice energy conservation.

VII Minimum Theoretical Background

Purification and reuse of acetone is done by distillation method. This process of distillation has been used for many years and it is beneficial for getting highly pure compound from its impure form. The process of distillation starts with heating the liquid to its boiling point .The liquid evaporates, forming vapour .The vapours are then cooled by passing it through pipes at a lower temperature means circulating cold water around it. The cooled vapours then condenses forming distillate. The distillate is a purified form of original substance.

VIII Practical set-up / Circuit diagram / Work Situation



IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Water condenser	Borosil glass	One Per group
2.	Thermometer	110-200^{0}C	One Per group
3.	Receiver flask	Borosil glass,250 ml flask with cork	One Per group
4.	Round bottom flask	Borosil glass, 250 ml flask with cork	One Per group
5.	Water bath		One Per group
6.	Burner		One Per group
7.	Water + Acetone Mixture	1: 1 proportion	As per requirement
8.	Measuring cylinder	100 ml	One per group

X Precautions to be Followed

1. Add small porcelain piece to round bottom flask to avoid bumping of mixture.
2. As acetone is highly volatile and inflammable, handle it carefully near the burner.
3. Heat the mixture using water bath without fail.
4. Use water bath with temperature control as far as possible.

XI Procedure

1. Take a mixture of acetone and water (1:1) in round bottom distillation flask.
2. Assemble the distillation setup as shown in figure.
3. Insert thermometer in one hole.
4. Connect the side tube of the round bottom distillation flask to doubled walled condenser.

5. Heat the mixture with gas burner using water bath. The acetone vaporizes, when temperature reaches to its boiling point.
6. The vapours produced by evaporation escape through the side arm into the condenser.
7. The cold water circulating in the condenser condenses the acetone vapour into liquid which collects in closed receiver.
8. The temperature increases when total acetone is separated from the mixture. The water is left in the flask.
9. Record the temperature when first drop of acetone is collected in receiver.

XII Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					

XIII Actual Procedure Followed (use blank sheet provided if space not sufficient)

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XIV Observations and Calculations(use blank sheet provided if space not sufficient)

S. No.	Description	Reading
1.	Total volume of acetone + water mixture	…..ml
2.	Volume of pure acetone collected by distillation process	…..ml
3.	Temperature at which acetone is collected	…. ^{0}C

- Actual volume of acetone in mixture before distillation is …… (V)ml

Calculations

$$\text{Percentage separation} = \frac{\text{Volume of collected acetone after distillation}}{\text{Volume of acetone in mixture before distillation}} \times 100$$

$$\text{Percentage separation} = \frac{\ldots\ldots\ldots\ldots\ldots\ldots}{\ldots\ldots\ldots\ldots\ldots\ldots} \times 100$$

Percentage separation = …………%

XV Results

1. The boiling point of acetone = ………….^{0}C.
2. The percentage of acetone separated =…………%.

XVI Interpretation of Results (Give meaning of the above obtained results)

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XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. Write the name of liquid which is volatile in the given mixture.
2. "Direct heating of mixture on burner is avoided" Justify.
3. Why separated acetone is collected in closed receiver?

Space for Answers

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XIX References / Suggestions for Further Reading

1. Experiments in general chemistry Principles and modern applications,Thomas G. Greco; Lyman H. Richard; Gerald S. Weiss, Pearson, 2011,ISBN-13:978-0131493919
2. Applied Chemistry :Theory and practice,O.P.Vermani,A.K.Narula,New age International Publication New Delhi 2005 ISBN: 8122408141
3. Web reference :www.odinity.com/fractional-distillation-experiment/
   www.chemistry.sc.chula.ac.th/bsac/Org%20Chem%20Lab_2012/Exp.6[1].pdf
   http://www.wiredchemist.com/chemistry/instructional/laboratory-tutorials/distillation

XX Suggested Assessment Scheme

Performance Indicators		Weightage %
Process related: 15 Marks		**60%**
1	Experimental setup	30%
2	Proper collection of separated acetone	30%
Product related: 10 Marks		**40%**
3	Exact recording of temperature	20%
4	Practical related questions	10%
5	Submitting the journal in time	10%
Total (25 Marks)		100

Names of Student Team Members

1. ……………………..
2. ……………………….
3. ………………………
4. ………………………

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 8: Acid value of resin

I Practical Significance

Acid value of resin is required in evaluating in amount of constituent to be mixed during manufacturing of resin. Resins are used in powder coating formulation and in powder coating formulation, the amount of hardener needed is usually governed by acid number. Diploma engineers have to test coating for mechanical performance, appearance and weathering. Acid value determines the utility of resin as well as being a significant quality control measure. The resins containing a high concentration of residual acid groups (also referred to as under condensed resins) had to be formulated according to their total reactive number, the sum of acid and hydroxyl numbers, in order to achieve complete cure. High acid numbers also caused poor overbake and salt spray resistance.

II Relevant Program Outcomes (POs)

- **Basic knowledge**: An ability to apply knowledge of basic mathematics, science and engineering to solve the engineering problems.
- **Experiments and practice:** An ability to plan and perform experiments and practices and to use the results to solve engineering problems.
- **Engineering tools:** Apply appropriate technologies and tools with an understanding of the limitations.
- **Environment and sustainability**: Understand the impact of the engineering solutions in societal and environmental contexts, and demonstrate the knowledge and need for sustainable development.
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse/multidisciplinary teams.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the context of engineering industries.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***'Apply principles of advanced physics and chemistry to solve broad based engineering problems'***.

i. Measurement skill
ii. Preparation of solutions
iii. Weighing skill

IV Relevant Course Outcome(s)

- Use relevant metals, alloys and insulating materials in various applications.

V Practical Outcome

- Determine acid value of given resin.

VI Relevant Affective domain related Outcome(s)

- Follow safe practices.
- Demonstrate working as a leader/a team member.
- Practice good housekeeping.

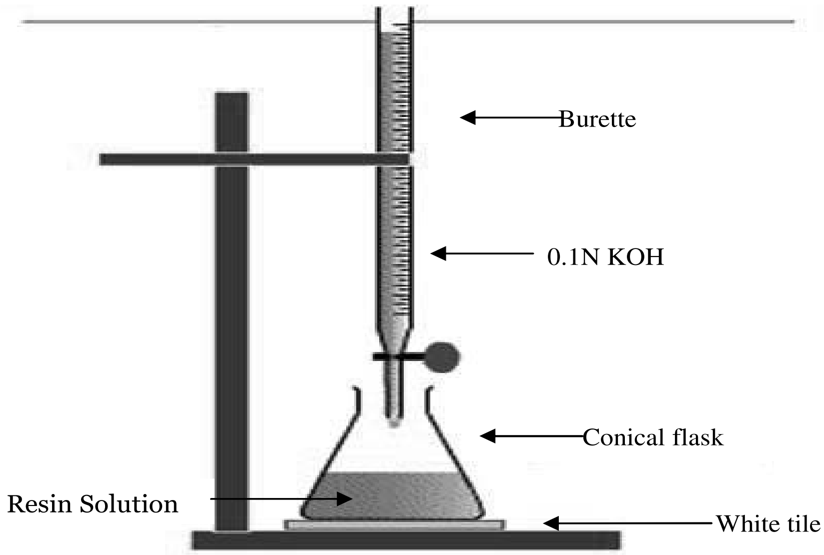
VII Minimum Theoretical Background

Acid value corresponds to the amount of carboxylic acid groups in resins. The number of milligram of KOH required to neutralize free acid in one gram of resin material is called acid value of resin material. It is also used in evaluating plasticizers, in which acid value should be as low as possible. For determination of acid value the resin material is dissolved in proper solvent usually neutral ethyl alcohol. It is then titrated against standard alkali solution using phenolphthalein indicator.

Acid value is calculated by formula ,

$$\text{Acid Value} = \frac{5.6 \times \text{Volume of 0.1 N KOH used in ml}}{\text{Weight of resin taken}}$$

VIII Practical set-up / Circuit diagram / Work Situation



IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Burette	Borosil glass , 25ml	One per group
2.	Beaker	Borosil glass, 250ml	One per group
3.	Conical flask	Borosil glass, 25ml	One per group
4.	Burette stand	Iron or plastic material	One per group
5.	Electronic balance	With the scale range of 0.001g to 500g. pan size 100 mm; All response time 3-5 sec.; power requirement 90-250 V, 10 watt.	One per batch
6.	Chemicals	Resin material, 0.1N KOH, ethanol, phenolphthalein	As per requirement

X Precautions

1. All the glass apparatus should wash thoroughly with distilled water before use.
2. Before use, the burette and pipette should rinse properly.
3. Remove an air bubbles if present in the nozzle of the burette before taking an initial reading

4. Place the conical flask on a white tile to observe the color change at the end point
5. Shaking of the titration flask should be continuous during addition of the solution from burette.

XI Procedure

1. Weigh 1 to 5 g of resin material and dissolved in 100 ml of neutral ethanol at room temperature. Take 1:1 ethanol-water mixture by volume at pH =7.0 can be used in place of ethanol.
2. The solution is titrated against 0.1 N KOH solution by using phenolphthalein indicator till faint pink color is formed.
3. Note down the burette reading (x ml).

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XIII Procedure Followed

a. Solution in conical flask:___________________
b. Solution in burette:_________________________
c. Indicator used:_____________________
d. End Point:____________________________

XIV Observations and Calculations(use blank sheet provided if space not sufficient)

	Description	Value
1.	Weight of plastic material	………………g
2.	Burette reading (x ml)	………………ml

Calculations

1000 ml of 1 N KOH ≡ 56 g of KOH

1 ml of 0.1 NKOH= 5.6 mg of KOH

$$\text{Acid Value} = \frac{5.6 \times \text{Burette reading (x ml) x } 0.1}{\text{Weight of resin taken}} \text{ mg of KOH}$$

$$\text{Acid Value} = \frac{5.6 \times \text{……………..x } 0.1}{\text{………………..}} \text{ mg of KOH}$$

Acid Value = ……………. mg of KOH

XV Results

Acid value of given resin material = ……………mg of KOH

XVI Interpretation of Results (Give meaning of the above obtained results)

……………………………………………………………………………………………
……………………………………………………………………………………………

XVII Conclusions (Actions/decisions to be taken based on the interpretation of results).

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XVIII Practical Related Questions

1. Name the type of reaction in the titration of resin with KOH.
2. State the molecular weight of KOH.
3. Write the meaning of acid value of resin.

Space for Answer

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XIX References / Suggestions for Further Reading

1. Applied Chemistry :Theory and practice, O.P. Vermani, A.K. Narula, New age International Publication New Delhi 2005 ISBN: 8122408141
2. Experiments and calculations in engineering chemistry,Dr. Dara, S. S.,S.Chand. Publication, New Delhi, 2011, *ISBN*:8121908647
3. Web reference:https://books.google.co.in/books?isbn=8178331616

XX Assessment Scheme

Performance indicators		Weightage
Process related: 15 Marks		**60%**
1	Weighing and dissolution of resin material	20%
2	Burette reading	40%
Product related: 10 Marks		**40%**
3	Determination of acid value	20%
4	Practical related questions	10 %
5	Submitting the journal in time	10%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……………………..
2. ……………………..
3. ……………………..
4. ……………………...

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

List Of Laboratory Manuals Developed by MSBTE

First Semester:

1	Fundamentals of ICT	22001
2	English	22101
3	English Work Book	22101W
4	Basic Science (Chemistry)	22102
5	Basic Science (Physics)	22102

Second Semester:

1	Bussiness Communication Using Computers	22009
2	Computer Peripherals & Hardware Maintenace	22013
3	Web Page Design with HTML	22014
4	Applied Science (Chemistry)	22202
5	Applied Science (Physics)	22202
6	Applied Machines	22203
7	Basic Surveying	22205
8	Applied Science (Chemistry)	22211
9	Applied Science (Physics)	22211
10	Fundamental of Electrical Engineering	22212
11	Elements of Electronics	22213
12	Elements of Electrical Engineering	22215
13	Basic Electronics	22216
14	'C' programming Language	22218
15	Basic Electronics	22225
16	Programming in "C"	22226
17	Fundamentals of Chemical Engineering	22231

Third Semester:

1	Applied Multimedia Techniques	22024
2	Advanced Serveying	22301
3	Highway Engineering	22302
4	Mechanics of Structures	22303
5	Building Construction	22304
6	Concrete Technology	22305
7	Strength Of Materials	22306
8	Automobile Engines	22308
9	Automobile Transmission System	22309
10	Mechanical Operations	22313
11	Technology Of Inorganic Chemicals	22314
12	Object Oriented Programming Using C++	22316
13	Data Structure Using 'C'	22317
14	Computer Graphics	22318
15	Database Management System	22319
16	Digital Techniques	22320
17	Principles Of Database	22321
18	Digital Techniques & Microprocessor	22323
19	Electrical Circuits	22324
20	Electrical & Electronic Measurment	22325
21	Fundamental Of Power Electronics	22326
22	Electrical Materials & Wiring Practice	22328
23	Applied Electronics	22329
24	Electrical Circuits & Networks	22330
25	Electronic Measurments & Instrumentation	22333
26	Principles Of Electronics Communication	22334
27	Thermal Engineering	22337
28	Engineering Matrology	22342
29	Mechanical Engineering Materials	22343
30	Theory Of Machines	22344

Fourth Semester:

1	Hydraulics	22401
2	Geo Technical Engineering	22404
3	Chemical Process Instrumentation & Control	22407
4	Fluid Flow Operation	22409
5	Technology Of Organic Chemicals	22410
6	Java Programming	22412
7	GUI Application Development Using VB.net	22034
8	Microprocessor	22415
9	Database Managment	22416
10	Electric Motors And Transformers	22418
11	Industrial Measurements	22420
12	Digital Electronics And Microcontroller Applications	22421
13	Linear Integrated Circuits	22423
14	Microcontroller & Applications	22426
15	Basic Power Electronics	22427
16	Digital Communication Systems	22428
17	Mechanical Engineering Measurments	22443
18	Fluid Mechanics and Machinery	22445
19	Fundamentals Of Mechatronics	22048
20	Guidelines & Assessment Manual for Micro Projects & Industrial Training	22049

Fifth Semester:

1	Network Management & Administration	17061
2	Solid Modeling	17063
3	CNC Machines	17064
4	Behavioral Science(Hand Book)	17075
5	Behavioral Science (Assignment Book)	17075
6	Windows Programming using VC++	17076
7	Estimation and Costing	17501
8	Public Health Engineering	17503
9	Concrete Technology	17504
10	Design of Steel Structures	17505
11	Switchgear and Protection	17508
12	Microprocessor & Application	17509
13	A.C. Machines	17511
14	Operating System	17512
15	Java Programming	17515
16	System Programming	17517
17	Communication Technology	17519
18	Hydraulic & Pneumatics	17522
19	Advanced Automobile Engines	17523
20	Basic Electrical & Electronics	17524
21	Measurement and Control	17528
22	Power Engineering	17529
23	Metrology & Quality Control	17530
24	Computer Hardware & Networking	17533
25	Microcontroller	17534
26	Digital Communication	17535
27	Control System & PLC	17536
28	Audio Video Engineering	17537
29	Control System	17538
30	Industrial Electronics and applications	17541
31	Heat Transfer Operations	17560
32	Chemical Process Instrumentation & control	17561

Sixth Semester:

1	Solid Modeling	17063
2	Highway Engineering	17602
3	Contracts & Accounts	17603
4	Design of R.C.C. Structures	17604
5	Industrial Fluid Power	17608
6	Design of Machine Elements	17610
7	Automotive Electrical and Electronic Systems	17617
8	Vehicle Systems Maintenance	17618
9	Software Testing	17624
10	Advanced Java Programming	17625
11	Mobile Computing	17632
12	System Programing	17634
13	Testing & Maintenance of Electrical Equipments	17637
14	Power Electronics	17638
15	Illumination Engineering	17639
16	Power System Operation & Control	17643
17	Environmental Technology	17646
18	Mass Transfer Operation	17648
19	Advanced Communication System	17656
20	Mobile Communication	17657
21	Embedded System	17658
22	Process Control System	17663
23	Industrial Automation	17664
24	Industrial Drives	17667
25	Video Engineering	17668
26	Optical Fiber & Mobile Communication	17669
27	Therapeutic Equipment	17671
28	Intensive Care Equipment	17672
29	Medical Imaging Equipment	17673

Pharmacy Lab Manual

First Year:

1	Pharmaceutics - I	0805
2	Pharmaceutical Chemistry - I	0806
3	Pharmacognosy	0807
4	Biochemistry and Clinical Pathology	0808
5	Human Anatomy and Physiology	0809

Second Year:

1	Pharmaceutics - II	0811
2	Pharmaceutical Chemistry - II	0812
3	Pharmacology & Toxicology	0813
4	Hospital and Clinical Pharmacy	0816

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