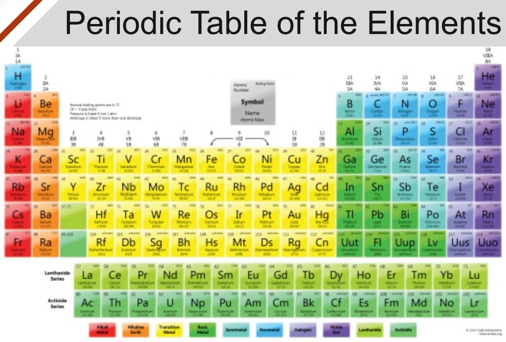
SCHEME : K

Name : ____________________________________
Roll No. : ________________ Year : 20___ 20___
Exam Seat No. : ____________________________

LABORATORY MANUAL FOR
APPLIED SCIENCE (CHEMISTRY)
(312308)



FIRST YEAR ENGINEERING

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.

A Laboratory Manual for

Applied Science-Chemistry

(312308)

Semester-II

(AE/AL/AO/CE/CR/CS/EE/EP/IC/IS/LE/ME/MK/PG)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous)(ISO9001:2015)(1SO/IEC27001:2013)

Maharashtra State Board of Technical Education,
(Autonomous) (ISO9001:2015)(ISO/IEC27001:2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on December, 2023)

MAHARASHTRA STATE
BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr./Ms. ....

Roll No. ....of Second Semester of Diploma in ....

of Institute ....(Code:..............) has

completed the term work satisfactorily in the Course **Applied Science- Chemistry**

(312308) for the Academic Year 20.........to 20..........as prescribed in the curriculum.

Place:........................ Enrollment No:..............................

Date:....................... Exam Seat No:...................................

Course coordinator **Head of the Department** **Principal**

Seal of
Institution

Preface

The primary focus of any engineering laboratory/fieldwork 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 'K' Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays 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 'K' 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 the practical. 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 science like metals, alloys, water treatment and analysis, fuel and combustion, cells and batteries will help the student to select and use relevant materials and methods which will be economical and eco-friendly.

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 Practical's

1. **Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.
2. **Problem analysis:** Identify and analyse well-defined engineering problems using codified standard methods.
3. **Design/ development of solutions:** Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.
4. **Engineering Tools, Experimentation and Testing:** Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.
5. **Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.
6. **Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.
7. **Life-long learning:** Ability to analyse individual needs and engage in updating in the context of technological changes.

List of relevant skills

1. Intellectual Skills
2. Psychomotor Skills
3. Affective Domain Skills
4. Teamwork
5. Prioritisation
6. Communication
7. Interpersonal skills
8. Research skills

Practical-Course Outcome Matrix

Sr. No.	Title of the Practical	CO 4.	CO 5.	CO 6.
1.	Standardization of $KMnO_4$ solution using standard oxalicacid and preparation of Fe alloy sample.	✓	-	-
2.	Determination of the percentage of iron Present in given Haematite ore by $KMnO_4$ solution.	✓	-	-
3.	Determination of percentage of copper in given copper ore.	✓	-	-
4.	Calculation of total hardness, temporary hardness and permanent hardness of water sample by EDTA method.	-	✓	-
5.	Determination of the alkalinity of a given water sample.	-	✓	-
6.	Determination of turbidity of a given water sample by Nephelometric method by using Nephelometer or simulation.	-	✓	-
7.	Determination of dissolved oxygen in the given water sample.	-	✓	-
8.	Determination of chloride content in the given water sample by Mohr’s method.	-	✓	-
9.	Determination of pH value of given solution using pH meter and universal indicator.	-	✓	-
10.	Determination of the moisture and ash content in a given coal sample using proximate analysis.	-	-	✓
11.	Determination of calorific value of given solid fuel using Bomb calorimeter.	-	-	✓
12.	Calculate the percentage of Sulphur in a given coal sample by ultimate analysis.(Gravimetric analysis)	-	-	✓
13.	Determination of conductance of given electrolyte by using a conductivity meter.	-	-	✓
14.	Determination of specific conductance and equivalence conductance of given salt sample solution.	-	-	✓
15.	Determination of equivalence point of acetic acid and ammonium hydroxide using conductivity meter.	-	-	✓

Guidelines to Course Coordinator

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 Course Coordinator*** 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, Course Coordinator could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Course Coordinatorshouldgiveopportunitytostudentsforhands-onafterthedemonstration.
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 Course Coordinator** in the next practical session.
2. Students should read the precaution carefully before start of experiment.

Content Page

List of Practical's and Formative Assessment Sheet

Sr. No.	Practical Outcome	Page No.	Date of Performance	Date of Submission	Assessment Marks	Dated Sign of Faculty	Remarks if any
1	Standardization of $KMnO_4$ solution using standard oxalic acid and preparation of Fe alloy sample.	1					
2	*Determination of the percentage of iron present in given Haematite ore by KMnO4 solution.	6					
3	*Determination of percentage of copper in given copper ore.	11					
4	*Calculation of total hardness, temporary hardness and permanent hardness of water sample by EDTA method.	17					
5	*Determination of the alkalinity of a given water sample.	23					
6	Determination of turbidity of a given water sample by Nephelometric method by using Nephelometer or simulation.	30					
7	Determination of dissolved oxygen in the given water sample.	35					
8	Determination of chloride content in the given water sample by Mohr's method.	41					
9	*Determination of pH value of given solution using pH meter and universal indicator.	46					
10	*Determination of the moisture and ash content in a given coal sample using proximate analysis.	51					
11	*Determination of calorific value of given solid fuel using Bomb calorimeter.	57					
12	Calculate the percentage of Sulphur in a given coal sample by ultimate analysis.(Gravimetric analysis)	62					
13	Determination of conductance of given electrolyte by using a conductivity meter.	67					
14	*Determination of specific conductance and equivalence conductance of given salt sample solution.	72					
15	Determination of equivalence point of acetic acid and ammonium hydroxide using conductivity meter.	78					
Total Marks							

'*' Marked Practicals (LLOs) are mandatory.

- To be transferred to Proforma of Assessment Norms (K3)

Practical No. 01 Standardization of $KMnO_4$

I. Practical Significance

a. The standardization of $KMnO_4$ is necessary to determine the strength of potassium permanganate with a standard solution of oxalic acid. This reaction helps to study the oxidation and reduction theory.

b. To determine the % of Fe in Alloy by volumetrically; first it is essential to prepare its solution.

II. Industry / Employer Expected Outcomes

1. Use the techniques and procedures required to prepare standard solutions
2. Measurement Skills
3. Handling of Glassware
4. Calculation

III. Relevant Course Outcome

CO4: Use the relevant metallurgical processes in different engineering applications.

IV. Practical Learning Outcome

1. Standardization of $KMnO_4$ solution using standard oxalic acid.
2. Preparation of Fe alloy sample.

V. Laboratory Learning Outcome:

1. Prepare $KMnO_4$ solution.
2. Prepare standard oxalic acid.
3. Standardize $KMnO_4$ solution.

VI. Relevant Affective domain Outcome:

1. Follow safety practices.
2. Demonstrate working as a leader/a team member.
3. Practice good housekeeping.

VII. Relevant Theoretical Background

a) The colour of potassium permanganate changes with the reaction; no further indicator is used in this experiment to determine the endpoint as the potassium permanganate is a self-indicator.

b) We heat the titration flask containing oxalic acid to about $60\text{-}70^0$C and then titrate it against $KMnO_4$. If the temperature is too low (below 55^0C), the interaction between the oxalic acid and the potassium permanganate will move too slowly. Above 70^0C, oxalate acid begins to decompose, so it’s important to stay in this range.

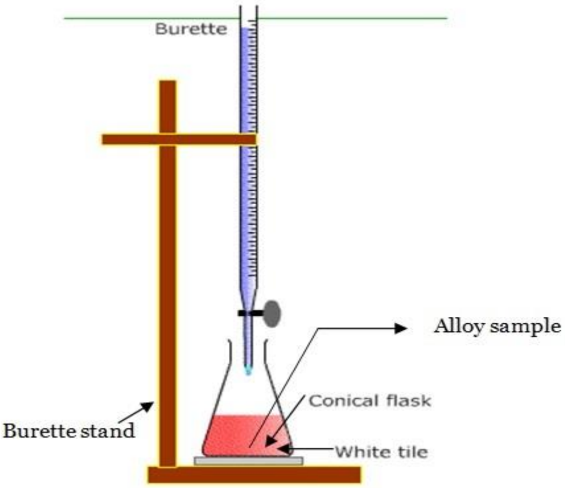
c) The reaction between oxalic acid and potassium permanganate is carried out in an acidic medium because permanganate ion in the acidic medium is a very strong oxidizing agent. Acidity is introduced by adding dil. solution of sulphuric acid.

d) In this experiment, potassium permanganate is the analyte and oxalic acid is the titrant. Here, potassium permanganate is the oxidizing agent and oxalic acid is the reducing agent.

e) Permanganate ($MnO_4^{-)}$ ion has a dark purple colour. In an acidic medium, MnO_4 is reduced to colourless manganous (Mn^{2+}) ions. On reaching the end point, the addition of the last single drop of permanganate imparts a light purple colour to the solution.

$$2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 \rightarrow 2MnSO_4 + 10CO_2 + 8H_2O + K_2SO_4$$

VIII. Circuit diagram / Experimental set-up / Work Situation:



IX. Resources Required

Sr.No.	Resources	Specifications	Quantity	Remark
1.	Burette	Capacity 25 ml / 50ml	1 per student	
2.	Round Bottom flask	250 ml	1 per group	
3.	Wire gauze	6 inches x 6 inches	1 per group	
4.	Conical flask	Capacity 100 ml	1 per student	
5.	Pipette / Measuring cylinder	Capacity 10 ml	1 per student	
6.	Volumetric flask	Capacity 250 ml	1 per group	
7.	Sample material/chemicals	Alloy sample, $KMnO_4$, H_2SO_4, Oxalic acid, zinc granules.	As per requirement	

X. Precautions

1. Cover the flask while heating.
2. Check the color on white background.
3. Add solution drop wise with constant stirring.
4. Follow the same procedure to carry out each reading.

XI. Procedure

Part A: Preparation of sample solution

1. Weigh exactly 1 g alloy and transfer it in to 250 ml round bottom flask.

2. Add 100 ml dilute sulphuric acid in to the round bottom flask and gently heat on wire gauze till the sample dissolves completely.
3. Add a few granules of zinc when sample dissolves.
4. Cool it and transfer in to 250 ml volumetric flask, dilute the solution up to 250 ml using distilled water.

Part B: Standardization of $KMnO_4$

1. Weigh the required amount of $KMnO_4$ using electronic/ Dhona / physical / chemical balance.
2. Dissolve weighed $KMnO_4$ in the distilled water, and transfer it to the 1000 ml volumetric flask. Dilute the solution up to the mark (1000 ml) using distilled water.
3. Take 10 ml of standard (0.1N) oxalic acid in conical flask.
4. Add 10 ml dilute sulphuric acid and heat the solution up to 70^{o}C.
5. Titrate the above solution against standard $KMnO_4$ solution till pink colour appears.
6. Repeat the procedure till concurred readings will be obtained.

XII. Observation

Solution in Burette: ___________________
Solution in Conical Flask: ________________
Indicator: ______________________________
End Point: ______________________________

XIII. Observation Table for Standardization of $KMnO_4$

Sr. No.	Burette Reading (ml)	Average Burette Reading
1.		V1 = ………..ml
2.		
3.		

XIV. Calculations:

A. Calculation for standardization of $KMnO_4$

N_1= Normality of $KMnO_4$
V_1 = Volume of $KMnO_4$
N_2= Normality of Oxalic acid
V_2 = Volume of Oxalic acid

$KMnO_4$ Vs. Oxalic Acid

$$N_1V_1 = N_2V_2$$

$$N_1 \times \_\_\_\_ = 0.1 \times 10$$

$$N_1 = \frac{0.1 \times 10}{\_\_\_\_}$$

N_1 = ……….. N

XV. Result:

Normality of given $KMnO_4$ = ……. N

XVI. Interpretation of Result:

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

XVII. Conclusion and Recommendation

…………………………………………………………………………………………
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XVIII. Practical Related Questions:

1. Describe the procedure for preparation of 1 normal Oxalic acid.
2. State the role of zinc granules in preparation of sample solution.
3. Write the Equivalent weight of $KMnO_4$.

XIX. References/ Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Practical Chemistry	Dr. N.K. Verma	Laxmi publications New Delhi, 2011 ISBN: 7008-594-2
2.	Applied Chemistry with Lab Manual	Anju Rawlley, Devdatta V. Saraf	New age International Publication New Delhi 2005 ISBN : 8122408141
3.	Experiments and calculations in engineering chemistry	Dr. S.S. Dara	S.Chand. Publication, New Delhi, 2011, ISBN:8121908647
4	Engineering chemistry	Shashi Chavla	Khanna Book Publishing Co. (P) Ltd. New Delhi, 2021, ISBN- 978-93-91505-44-8
5.	YouTube Video	MicroChem's Experiment	https://youtu.be/TkHX4FieKZ4?si=G-O7eK977ZqHh_yK

XX. Assessment Scheme:

Performance indicators		Weightage
Process related: 15 Marks		**60%**
1	Preparation of $KmnO_4$	10 %
2	Preparation of sample solution	10%
3	Accuracy in taking burette reading	20 %
4	Average burette reading	20 %
Product related: 10 Marks		**40%**
5	Calculation of Equivalent weight of $KMnO_4$	10 %
6	Calculation of Normality of $KMnO_4$	10 %
7	Answer to sample question	10 %
8	Submission of report in time	10 %
Total (25 Marks)		**100 %**

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

List of Student Team Members

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Space for Answer

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Practical No. 02 Percentage of Fe in Alloy

I. Practical Significance

Diploma engineers have to work in industry, which are related to different extraction processes. They have to do analysis of the alloys for its metal composition which is necessary to find the amount of metallurgical coke and flux required for extraction process. The determination of iron content in given alloy sample solution using titration can be used to solve broad based engineering problems.

II. Industry / Employer Expected Outcomes

1. Use the techniques and procedures required to prepare standard solutions
2. Measurement Skills
3. Handling of Glassware
4. Calculation

III. Relevant Course Outcome

CO4: Use the relevant metallurgical processes in different engineering applications.

IV. Practical Learning Outcome

Determination of the percentage of iron present in given Haematite ore by $KMnO_4$ solution.

V. Laboratory Learning Outcome:

1. Set up titration Assembly.
2. Record the observations.
3. Calculate percentage of iron in Haematite ore by titration method.

VI. Relevant Affective domain Outcome:

1. Follow safety practices.
2. Demonstrate working as a leader/a team member.
3. Practice good housekeeping.

VII. Relevant Theoretical Background

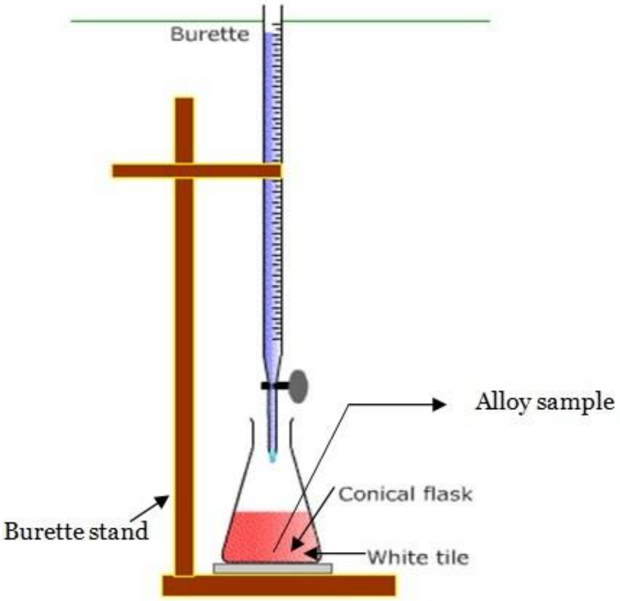
Steel is an important alloy of iron. For determination of the amount of iron in the given alloy sample, the alloy sample is dissolved in dil. H_2SO_4, iron is converted in to ferrous sulphate solution with liberation of hydrogen gas

$$Fe + H_2SO_4 \dashrightarrow FeSO_4 + H_2 \uparrow$$

The Fe^{2+} present in the solution can be determined by titrating it with standard $KMnO_4$ solution.

$$2KMnO_4 + 8\,H_2SO_4 + 10\,FeSO_4 \longrightarrow K_2SO_4 + 2\,MnSO_4 + 5\,Fe_2(SO_4)_3 + 8H_2O$$

VIII. Circuit diagram / Experimental set-up / Work Situation:



IX. Resources Required

Sr.No.	Resources	Specifications	Quantity	Remark
1.	Burette	Capacity 25 ml / 50ml	1 per student	
2.	Conical flask	Capacity 100 ml	1 per student	
3.	Pipette	Capacity 10 ml	1 per student	
4.	Measuring cylinder	Capacity 10 ml	1 per student	
5.	Sample material/chemicals	Fe Alloy Solution, $KMnO_4$, H_2SO_4,	As per requirement	

X. Precautions

1. Check the color on white background.
2. Add solution drop wise with constant stirring.
3. Follow the same procedure to carry out each reading.

XI. Procedure

Titration of Fe Alloy solution with standard solution:

1. Rinse and fill the burette with standard $KMnO_4$ solution.
2. Take 10 ml alloy solution in conical flask with the help of pipette. Add 10 ml dilute sulphuric acid to ensure acidic medium.
3. Add $KMnO_4$ solution drop wise using burette till light pink color appears.
4. Repeat the procedure till concurred readings will be obtained.

XII. Observation

Solution in Burette: ____________________
Solution in Conical Flask: __________________
Indicator: _______________________________
End Point: _______________________________

XIII. Observation Table for Determination of percentage of iron:

Sr. No.	Burette Reading (ml)	Average Burette Reading
1.		V3 = ………..ml
2.		
3.		

XIV. Calculations:

A. Calculation for determination of percentage of iron

STEP 1:

1000 ml 1N $KMnO_4$ ≡ 56 g of Fe

$$V_3 \text{ ml } N_1 \text{ N } KMnO4 = \frac{(56 \times V_3 \times N_1)}{1000}$$ (Take value of N_1 from Experiment No. 1)

$$= \frac{(56 \times \_\_\_\_\_\_ \times \_\_\_\_\_\_)}{1000}$$

= ……. …..(y) g of Fe

STEP 2

10 ml of sample solution contain =_________ (y) g of Fe
250 ml of sample solution contain = (y) × 25 g of Fe
= _________ × 25 g of Fe

= _________ (z) g of Fe

STEP 3

1 g of sample contain = ________ (z) g of Fe
100 g sample contain = (z) x 100 g of Fe
= ______x 100 g of Fe
= ________ g of Fe

XV. Result:

Percentage of iron in sample = ……. %

XVI. Interpretation of Result:

The Percentage of Iron in given alloy is …………% and hence Fe is (base metal /alloying element) ……………….. in given alloy.

XVII. Conclusion and Recommendation

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XVIII. Practical Related Questions:

1. Mention oxidation state of Fe required throughout this experiment.
2. Name the indicator used in this experiment.
3. Write the Equivalent weight of Iron.

XIX. References/ Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Practical Chemistry	Dr. N.K. Verma	Laxmi publications New Delhi, 2011 ISBN: 7008-594-2
2.	Applied Chemistry :Theory and practice	O.P.Vermani, A.K.Narula	New age International Publication New Delhi 2005 ISBN : 8122408141
3.	Experiments and calculations in engineering chemistry	Dr. S.S. Dara	S.Chand. Publication, New Delhi, 2011, ISBN:8121908647
4	A Manual of Practical Engineering Chemistry	Sudha Jain, Shradha Sinha	S. Chand Limited, 2002 ISBN : 8121921929, 9788121921923

XX. Assessment Scheme:

Process related assessment scheme

Sr.No.	Process related	Weightage (60%)
1.	Assembly preparation for titration	20%
2.	Accuracy in noting burette reading	20%
3.	Observation of colour change at end point	10%
4.	Following the safety precautions	10%

Product related assessment scheme

Sr. No.	Product related	Weightage (40%)
5.	Calculation of average burette reading	10%
6.	Calculation of % of Fe in alloy	10%
7.	Answer to sample questions	10%
8.	Submission of report in time	10%

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

List of Student Team Members

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2. ………………………….
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Space for Answer

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Practical No. 03 Percentage of Cu in Copper ore

I. Practical Significance

Diploma engineers have to work in industry, which are related to different extraction processes. They have to do analysis of the ore for its metal composition which is necessary to find the quality and to check whether its extraction is economical or profitable one or not. It also help Diploma engineer to find amount of reducing agent and flux required for extraction process. The determination of Copper content in given ore sample solution by volumetrically can be used to solve broad based engineering problems.

II. Industry / Employer Expected Outcomes

1. Use the techniques and procedures required to prepare standard solutions
2. Measurement Skills
3. Handling of Glassware
4. Calculation

III. Relevant Course Outcome

CO4: Use the relevant metallurgical processes in different engineering applications.

IV. Practical Learning Outcome

To determine of percentage of copper in given copper ore.

V. Laboratory Learning Outcome:

1. Prepare Cu ore sample.
2. Calculate percentage of Cu.

VI. Relevant Affective Domain Outcomes:

1. Follow safety practices.
2. Demonstrate working as a leader/a team member.
3. Practice good housekeeping.

VII. Relevant Theoretical Background

Copper present in ore sample is transformed into the solution in the form of cupric ions by addition of conc. Sulphuric acid. Copper sulphate solution when treated with KI at pH = 4 to 5.5, cupric iodide is formed. Cupric iodide is unstable and immediately decomposes to cuprous iodide with liberation of iodine gas. Liberated iodine is titrated against sodium thiosulphate using starch indicator.

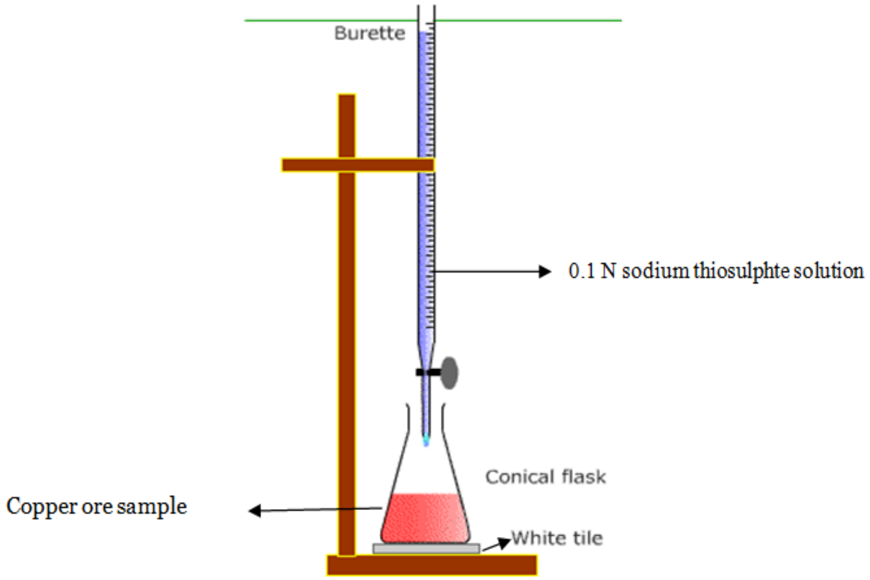
$$\underset{\text{Brass}}{Cu} \xrightarrow[\text{Conc. } HNO_3]{\text{heat}} Cu\,(NO_3)_2 \xrightarrow[H_2SO_4]{\text{heat}} \underset{\text{Solution}}{CuSO_4}$$

$$2CuSO_4 + 4KI \longrightarrow 2\,CuI_2 + 2K_2SO_4$$

$$2CuI_2 \longrightarrow Cu_2I_2 + I_2\uparrow$$

$$I_2 + 2Na_2S_2O_3 \longrightarrow \underset{\text{Sodium tetrathionate}}{Na_2S_4O_6} + 2NaI$$

VIII. Circuit diagram / Experimental set-up / Work Situation:



IX. Resources Required

Sr.No.	Resources	Specifications	Quantity	Remark
1.	Burette	Capacity 25 ml / 50ml	1 per student	
2.	Conical flask	Capacity 100 ml	1 per student	
3.	Pipette	Capacity 10 ml	1 per student	
4.	Measuring cylinder	Capacity 10 ml	1 per student	
5.	Sample material/chemicals	Cu Ore Solution, 0.1 N $Na_2S_2O_3$, 2N NaOH, 2N Acetic acid10% KI, Starch,	As per requirement	

X. Precautions

1. Cover the beaker while heating.
2. Check the colour on white background.
3. Add solution drop wise with constant stirring.
4. Remove an air bubble present in the nozzle of the burette before taking the initial reading.
5. Continuous shaking of the titration flask is necessary during titration.

XI. Procedure

Part A: Dissolution of Copper

1. Weigh exactly 1 gm copper ore sample and transfer it in to 250 ml beaker.
2. Add 10 ml concentrated nitric acid to dissolve the ore sample.
3. Add 20 ml water and cover the beaker with watch glass. Heat the beaker gently on wire gauze to dissolve the ore sample completely.
4. Cool the beaker to room temperature and add 10 ml concentrated sulphuric acid to it.

5. Heat the solution on low flame to evolve brown fumes of NO_2 gas completely.
6. Cool the solution and transfer it in a 100 ml volumetric flask. Dilute the solution up to the mark using distilled water.
7. Transfer the solution to a beaker for further estimation.

Part B: Volumetric estimation of copper.

1. Wash and clean the apparatus. Rinse and fill the burette with 0.1 N $Na_2S_2O_3$ solutions, adjust the zero mark.
2. Rinse the pipette and pipette out 10 ml sample solution in a conical flask.
3. Add 2 N NaOH drop wise with constant shaking to neutralize mineral acid present in the sample solution till slight blue turbidity of $Cu(OH)_2$ is obtained.
4. Add 2N acetic acid solution drop wise with constant shaking to dissolve the turbidity. A clear solution is obtained at pH 4 to 5.5.
5. The solution becomes yellowish brown due to liberation of iodine gas (equivalent of copper) when 10 ml of 10% KI solution is added.
6. Liberated iodine is titrated against 0.1 N $Na_2S_2O_3$ solutions till the brown solution turns pale yellow.
7. Add 1-2 ml of freshly prepared starch solution and continue titration till blue colour disappears.
8. Repeat the procedure till concurred readings will be obtained.

XII. Observation

Solution in Burette: __________________
Solution in Conical Flask: ________________
Indicator: ____________________________
End Point: ____________________________

XIII. Observation Table for determination of percentage of copper:

Sr. No.	Burette Reading (ml)	Average Burette Reading
1.		V = **................(ml)**
2.		
3.		

XIV. Calculations:

(A) Calculation for determination of amount of copper

STEP 1

1000 ml 1 N $Na_2S_2O_3$ ≡ 63.5 g of Cu

$$V\ ml\ 0.1\ N\ Na_2S_2O_3 = \frac{63.5 \times V \times 0.1}{1000}\ (y)\ g\ of\ Cu$$

$$= \frac{63.5 \times \ldots\ldots\ldots . \times 0.1}{1000}\ (y)\ \text{g of Cu}$$

$$= \ldots\ldots\ldots\ldots\ldots\ldots\ (y)\ \text{of Cu}$$

STEP 2

10 ml of sample solution contain =________ (y) g of Cu
100 ml of sample solution contain = (y) × 10 g of Cu
= ________ × 10 g of Cu

= ________ (z) g of Cu

STEP 3

1 g of sample contain = _______ (z) g of Cu
100 g sample contain = (z) x 100 g of Cu
= _____x 100 g of Cu
= _______ g of Cu

XV. Result:

Percentage of copper in given ore sample = ……. %

XVI. Interpretation of Result:

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XVII. Conclusion and Recommendation

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XVIII. Practical Related Questions:

1. Mention type of reaction when cupric ion converts into cuprous ion.
2. State the type of alloy which does not contain iron as a major component.
3. State the colour when iodine is liberated with addition of KI to alloy sample.
4. Name the type of titration involved in this experiment.

XIX. References/ Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Practical Chemistry	Dr. N.K. Verma	Laxmi publications New Delhi, 2011 ISBN: 7008-594-2
2.	Applied Chemistry :Theory and practice	O.P.Vermani,A.K.Narula	New age International Publication New Delhi 2005 ISBN : 8122408141
3.	Experiments and calculations in engineering chemistry	Dr. S.S. Dara	S.Chand. Publication, New Delhi, 2011, ISBN:8121908647
4	A Manual of Practical Engineering Chemistry	Sudha Jain, Shradha Sinha	S. Chand Limited, 2002 ISBN : 8121921929, 9788121921923

XX. Assessment Scheme:

Process related assessment scheme

Sr. No.	Process related	Weightage (60%)
1.	Preparation Cu ore solution	30%
2.	Burette Reading of Part B	30%

Product related assessment scheme

Sr. No.	Product related	Weightage (40%)
1.	Calculation for percentage of copper	20%
2.	Answer to sample questions	20%

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

List of Student Team Members

1. ……………………………….
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Practical No. 04 Hardness of water

I. Practical Significance

Diploma engineers have to work in number of industries such as paper, dyeing, textile, sugar etc. where water is essentially required for various process. Water which is used it must free from all impurities. As these impurities cause hardness to water. 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 hardness along with the nature of hardness.

II. Industry / Employer Expected Outcome

1. Use the techniques and procedures required to prepare standard solutions
2. Measurement Skills
3. Handling of Glassware
4. Calculation
5. Able to interpret and draw the conclusion from results

III. Relevant Course Outcome

CO5: Use relevant water treatment processes to solve industrial problems.

IV. Practical Learning Outcome

Calculation of total hardness, temporary hardness and permanent hardness of water sample by EDTA method.

V. Laboratory Learning Outcome:

1. Prepare EDTA solution of known concentration.
2. Determine total hardness of water by titration.

VI. Relevant Affective Domain Outcomes:

1. Follow safety practices.
2. Demonstrate working as a leader/a team member.
3. Practice good housekeeping.

VII. Relevant Theoretical Background

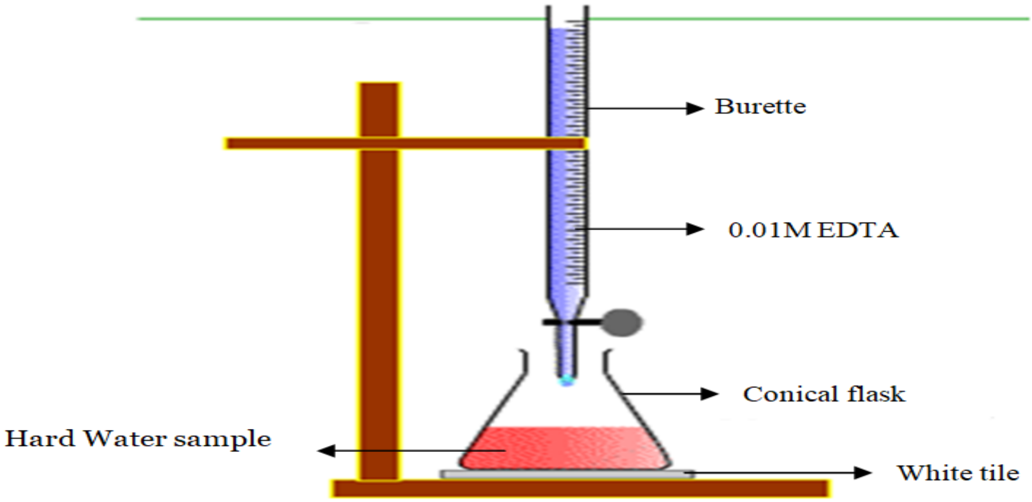
Hard water contains salts of calcium and magnesium in the form of their chlorides, sulphates and carbonates. Hardness of water is determined in terms of equivalent of $CaCO_3$ in ppm. Ethylene diamine tetra acetic acid (EDTA) is a reagent that forms EDTA-metal complex with many metal ions (but not with alkali metal ions such as Na^+ and K^+). In alkaline conditions (pH>9), 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.

$$Ca^{2+} + EBT \xrightarrow{\text{Alkaline Medium}} \underset{\text{(Wine red unstable complex)}}{Ca^{2+} - EBT}$$

$$\underset{\text{(Wine red unstable complex)}}{Ca^{2+} - EBT + EDTA} \longrightarrow \underset{\text{(Colourless stable complex of Ca-EDTA)}}{Ca^{2+} - EDTA} + \underset{\text{(Blue EBT)}}{EBT}$$

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

VIII. Circuit diagram / Experimental set-up / Work Situation:



IX. Resources Required

Sr. No.	Resources	Suggested Broad Specification	Quantity	Remark
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.	Erio chrome Black T indicator			
8.	Water sample	Hard water sample		

X. Precautions

1. All the glass apparatus should wash thoroughly with distilled water before use.
2. Remove an air bubble present in the nozzle of the burette before taking an initial reading.
3. Shaking of the titration flask should be continuous during addition of the solution from burette.
4. Place the conical flask on white tile to identify the color 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 water in 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 into the conical flask.
7. Color of the solution becomes wine red.
8. Add EDTA solution from burette into the conical flask very slowly, till wine red solution changes 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. Observation

Solution in Burette: __________________
Solution in Conical Flask: ________________
Indicator: _____________________________
End Point: _____________________________

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

Sr. No.	Burette Reading (ml)	Average Burette Reading
1.		V_1 = ………ml
2.		
3.		

Part B: For Permanent hardness of water

Sr. No.	Burette Reading (ml)	Average Burette Reading
1.		V_2 = ………ml
2.		
3.		

XIV. Calculations:

Part A: For total hardness of water:

STEP 1:

1000 ml of 1 M EDTA ≡ 100 g of $CaCO_3$

$$V_1\,ml\ 0.01\ M\ EDTA = \frac{(100 \times V_1 \times 0.01\ )}{1000}\ g\ of\ CaCO_3$$

$$= \frac{(100 \times \dots\dots\dots \times 0.01\ )}{1000}\ g\ of\ CaCO_3$$

= ………………… (y) g of $CaCO_3$

STEP 2:

25 ml water sample contain = --------- (y) g of $CaCO_3$

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

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

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

Part B: For Permanent Hardness of water:

STEP 1:

1000 ml of 1 M EDTA ≡ 100 g of $CaCO_3$

$$V_2 ml\ 0.01\ M\ EDTA = \frac{(100 \times V_2 \times 0.01\ )}{1000}\ g\ of\ CaCO_3$$

$$= \frac{(100 \times \dots\dots\dots \times 0.01\ )}{1000}\ g\ of\ CaCO_3$$

= ………………… (y) g of $CaCO_3$

STEP 2:

25 ml water sample contain = --------- (y) g of $CaCO_3$

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

i.e. 1000 ml water sample contain --------- (y× 40) x 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. Conclusion (Actions/decisions to be taken based on the interpretation of results).

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XVIII. Practical Related Questions:

1. Write the classification of hardness of salts depending on salts present in it.
2. Explain softening of water.
3. Give chemical equation for removal of temporary hardness on boiling of water.

XIX. References/ Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Practical Chemistry	Dr. N.K. Verma	Laxmi publications New Delhi, 2011 ISBN: 7008-594-2
2.	Applied Chemistry :Theory and practice	O.P.Vermani, A.K.Narula	New age International Publication New Delhi 2005 ISBN : 8122408141
3.	Experiments & calculations in engineering chemistry	Dr. S.S. Dara	S.Chand. Publication, New Delhi, 2011,ISBN:8121908647
4	A Manual of Practical Engineering Chemistry	Sudha Jain, Shradha Sinha	S. Chand Limited, 2002 ISBN : 8121921929, 9788121921923

XX. Assessment Scheme:

Process related assessment scheme

Sr. No.	Process related	Weightage (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 assessment scheme

Sr. No.	Product related	Weightage (40%)
1.	Calculation for Total hardness of water	10%
2.	Calculation for Permanent hardness of water	10%
3.	Calculation for Temporary hardness of water	5%
4.	Practical related questions	10%
5.	Submitting the journal in time	5%

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

List of Student Team Members

1. ………………………………..
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Practical No. 5 Alkalinity of water sample

I. Practical Significance

Boiler is 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. Industry / Employer Expected Outcomes

1. Use the techniques and procedures required to prepare standard solutions
2. Measurement Skills
3. Handling of Glassware
4. Calculation
5. Understand the different types of alkalinity

III. Relevant Course Outcome

CO5: Use relevant water treatment processes to solve industrial problems.

IV. Practical Learning Outcome

Determination of the alkalinity of a given water sample.

V. Laboratory Learning Outcome:

1. Prepare acid solution of known concentration.
2. Determine alkalinity of water sample.

VI. Relevant Affective domain Outcome:

4. Follow safety practices.
5. Demonstrate working as a leader/a team member.
6. Maintain tools and equipment.

VII. Relevant Theoretical Background

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

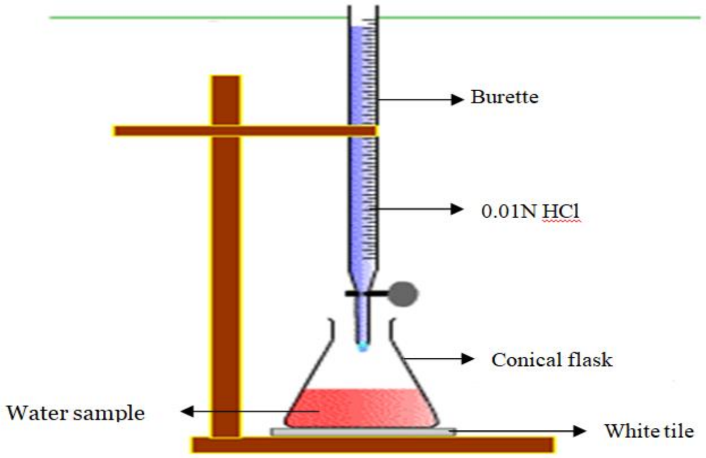
The titration of water sample against a standard acid up to phenolphthalein end point (P) marks the completion of reaction (i) and (ii) only. This amount of acid used thus corresponds to OH^- plus one half of the normal CO_3^{2-} present. On the other hand, titration of the water sample against a standard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

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

VIII. Circuit diagram / Experimental set-up / Work Situation:



IX. Resources Required

Sr. No.	Resource	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

1. All the glass apparatus should wash thoroughly with distilled water before use.
2. Before use, the burette and pipette should rinse properly. Remove an air bubbles if present in the nozzle of the burette before taking an initial reading.
3. Place the conical flask on white tile to identify the color change at the end point.
4. 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 colorless.
7. Note the phenolphthalein end point as ‘P’ ml.
8. Add 2-3 drops of methyl orange indicator to the same water sample in a conical flask. Color 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 methyl orange end point as ‘M’ml.

XII. Observation

Solution in Burette: ___________________

Solution in Conical Flask: _________________

Indicator: _____________________________

End Point: _____________________________

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

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

XIV. Observation

Solution in Burette: ___________________

Solution in Conical Flask: _________________

Indicator: _____________________________

End Point: _____________________________

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

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

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)**	**-**

XVI. Calculations:

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

Step 1:

1000 ml of 1 N HCl ≡ 17 g of OH^-

'M' ml of 0.01N HCl $= \dfrac{(17 \times M \times 0.01)}{1000} = \dfrac{(17 \times \quad \times 0.01)}{1000}$

-

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

Step 2:

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

1000 ml water sample contain = ------------- (y × 40) g 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-}

$$2P \text{ ml of } 0.01N \text{ HCl} = \frac{(30 \times 2P \times 0.01)}{1000} = \frac{(30 \times \qquad \times 0.01)}{1000}$$

= ……. …..(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 ofCO_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^-

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

= ……..…..(y) g 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^-

XVII. Result:

1. Alkalinity due to OH^- = --------------- ppm
2. Alkalinity due to CO_3^{2-} = --------------ppm
3. Alkalinity due to HCO_3^- = -------------ppm

XVIII. Interpretation of Result: (Give the meaning to above obtained result)

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XIX. Conclusion and Recommendation (Actions/decisions to be taken based on interpretation)

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XX. Practical Related Questions:

1. In the above titration two indicators are used and two readings are measured. Give reason.
2. If you have been given only Methyl Orange indicator to conduct the experiment. Conclude the inference.
3. List the ions responsible to make water alkaline.

XXI. References/ Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Practical Chemistry	Dr. N.K. Verma	Laxmi publications New Delhi, 2011 ISBN: 7008-594-2
2.	Applied Chemistry :Theory and practice	O.P.Vermani, A.K.Narula	New age International Publication New Delhi 2005 ISBN :8122408141
3.	Experiments and calculations in engineering chemistry	Dr. S.S. Dara	S.Chand. Publication, New Delhi, 2011, ISBN:8121908647
4	A Manual of Practical Engineering Chemistry	Sudha Jain, Shradha Sinha	S. Chand Limited, 2002 ISBN : 8121921929, 9788121921923
5	Engineering Chemistry	Dara, S. S.	National Council of Education Research and Training, New Delhi, 2015, ISBN : 8174505660

XXII. 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^- or OH^-	10 %
7	Practical related questions	10 %
8	Submitting the journal in time	10%
Total		**100 %**

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

List of Student Team Members

1. ……………………………
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Practical No. 06 Turbidity of Water

I. Practical Significance

Turbidity is the measure of relative clarity of a liquid. It is an optical characteristic of water and is a measurement of the amount of light that is scattered by material in the water when a light is shined through the water sample. The higher the intensity of scattered light, the higher the turbidity. Material that causes water to be turbid include clay, silt, very tiny inorganic and organic matter, algae, dissolved colored organic compounds, and plankton and other microscopic organisms. Turbidity in water causes troubles in water softening process, various industrial processes such as textile, sugar industry, irrigation and for steam generation in boilers. Diploma engineers requires the knowledge of the turbidity variation in raw water supplies which is useful to determine whether a supply requires special treatment by chemical coagulation and filtration before it may be used for a public water supply. Hence it is necessary to determine the turbidity and to remove by using proper water treatments.

II. Industry / Employer Expected Outcomes

1. Use the techniques and procedures required to prepare standard solutions for calibration of Nephelometer
2. Measurement Skills
3. Handling of Instrument
4. Able to identify factors responsible for turbidity and treatment method to prevent same.
5. Able to interpret the results obtained and give decisions or actions to be taken for further treatment.

III. Relevant Course Outcome

CO5: Use relevant water treatment processes to solve industrial problems.

IV. Practical Learning Outcome

Determination of turbidity of a given water sample by Nephelometric method by using Nephelometer or simulation.

V. Laboratory Learning Outcome:

1. Preparation of standard Formazine stock suspension
2. Proper handling of instrument to record the reading
3. Interpretation of result

VI. Relevant Affective domain Outcome:

1. Follow safe practices.
2. Demonstrate working as a leader/a team member.
3. Practice good housekeeping.
4. Maintain tools and equipment.
5. Practice energy conservation.

VII. Relevant Theoretical Background

Water is said to be turbid when it contains suspended particles. Turbidity may cause by foreign materials like algae, sand, clay, salt, chemical precipitate or other

organisms. When water becomes stationary, large suspended particles settle down quickly due to force of gravity and the lighter particles and fine particles takes very long time to settle. Turbidity is the amount of cloudiness in water.
Generally ground water is less turbid due to natural filtration.

- Various units are used for the measurement of turbidity-
Standard turbidity unit (mg/lit or ppm)
Jackson turbidity unit (J.T.U)
Nephelometric turbidity unit (N.T.U)

WHO suggested that the turbidity of water should be less than 1 N.T.U.

VIII. Circuit diagram / Experimental set-up / Work Situation:

Nephelometer

IX. Resources Required

Sr. No	Resources	Specifications	Quantity	Remark
1.	Nephelometer	Auto-ranging from 20-200 NTU,+/-2% of reading plus 0.1 NTU, power 220 Volts +/- 10% AC 50 Hz	One Per group	
2.	Volumetric Flask	Capacity 100 ml	Two Per group	
3.	Reagent bottle	Capacity 500 ml	One Per group	
4.	Sample material/chemicals	Sample Cell, Hydrazine sulphate, Hexamethylene tetramine, water samples, Tissue paper	As per requirement	
5.	Simulation Software	https://vlab.amrita.edu/?sub=2&brch=193&sim=575&cnt=4	NA	

X. Precautions

1. A sample solution should be placed in a cleaned plastic or glass bottle.
2. A sample should be analyzed as soon as possible after collection.
3. Finely divided air bubbles can cause high readings.
4. The presence of floating impurities will give low readings.

XI. Procedure

Step I – To prepare 400 NTU Formazin stock suspension

1. Dissolve 1g hydrazine sulphate [$(NH_2)_2 \bullet H_2SO_4$] in filtered water and dilute to 100 ml in a volumetric flask.
2. Dissolve 10g hexamethylenetetramine [$(CH_2)_6N_4$] in filtered water and dilute to 100 mL in a volumetric flask.
3. Mix 5 ml of hydrazine sulphate and 5 ml of hexamethylenetetramine solutions in a 100 ml volumetric flask and let stand 24 hours at 25 ± 3°C; dilute to the mark and mix.
4. To prepare 500 ml of 400 NTU standard, mix 25 ml of the reagent solutions in a 500 ml flask, dilute to the mark, and mix.

Step II – To determine the turbidity

1. Switch on the turbidity meter at least 30 minutes before the test.
2. Calibrate the turbidity meter to 400 NTU by using the standard solution by adjusting the calibration knob.
3. Calibrate the turbidity meter to zero NTU by using distilled water and by adjusting the knob.
4. To the sample cell, add the water up to the horizontal mark. Place it in the turbidity meter such that the vertical mark in the sample cell should coincide the mark in the turbidity meter and cover the sample cell.
5. Check the reading in turbidity meter and wait until stable reading is obtained.

For Simulation

1. Open Simulation software on your computer using link given in resources.
2. Select Test as Turbidity from variables.
3. First select standardization using formazine (20 NTU)
4. In nephelometer 20 NTU reading will be displayed.
5. Now select water sample as drinking water and Load the dample.
6. Observe the the reading displayed and note it.
7. Select water sample as Sea water and load the sample.
8. Observe the the reading displayed and note it.

XII. Observation Table

S. No.	Water sample	Temperature of the sample (^0C)	Turbidity in N.T.U
1.	Sample No. 1		
2.	Sample No. 2		
3.	Sample No. 3		
4.	Sample No. 4		

XIII. Observation Table for Simulation

S. No.	Water sample	Turbidity in N.T.U
1.	Drinking water	
2.	Sea water	

XIV. Calculations:

NA

XV. Results:

1. The turbidity of sample 1 is……………N.T.U.
2. The turbidity of sample 2 is ………… ..N.T.U.
3. The turbidity of sample 3 is……… N.T.U.
4. The turbidity of sample 4 is………… N.T.U.

XVI. Interpretation of Result: (Give meaning of above results)

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XVII. Conclusion and Recommendation

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XVIII. Practical Related Questions:

1. Write the safe level turbidity of drinking water.
2. Explain the N.T.U.
3. State the causes due to which turbidity goes to high level.
4. Mention the various units for measurement of turbidity.

XIX. References/ Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Practical Chemistry	Dr. N.K. Verma	Laxmi publications New Delhi, 2011 ISBN: 7008-594-2
2.	Applied Chemistry :Theory and practice	O.P.Vermani, A.K.Narula	New age International Publication New Delhi 2005 ISB-8122408141
3.	A Manual of Practical Engineering Chemistry	Sudha Jain, Shradha Sinha	S. Chand Limited, 2002 ISBN : 8121921929, 9788121921923
4.	Polytechnic Chemistry	Ved Prakash Mehta	Jain Brothers

XX. Assessment Scheme:

Performance Indicators		Weightage %
Process related: 15 Marks		**60%**
1	Calibration of Nephelometer.	30%
2	Measurement of turbidity of water sample	30%
Product related: 10 Marks		**40%**
3	Practical related questions	20%
4	Submitting the journal in time	20%
	Total	100%

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

List of Student Team Members

1 ……………………………

2 ……………………………

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Practical No. 07 Dissolved Oxygen in water

I. Practical Significance

Dissolved oxygen (DO) is the amount of oxygen that is present in water. Water bodies receive oxygen from the atmosphere and from aquatic plants. Running water, such as that of a swift moving stream, dissolves more oxygen than the still water of a pond or lake. A high DO level in a community water supply is good because it makes drinking water taste better. However, high DO levels speed up corrosion in water pipes in industries. For this reason, industries use water with the least possible amount of dissolved oxygen. Healthy water should generally have dissolved oxygen concentrations above 6.5-8 mg/L and between about 80-120 %. DO is considered an important measure of water quality as it is a direct indicator of an aquatic resource's ability to support aquatic life. For the National Aquatic Resource Surveys (NARS), levels of DO are measured with a calibrated water quality probe meter, usually in conjunction with measurements for temperature and pH. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills.

Dissolved Oxygen test is the basis for BOD test which is an important parameter to evaluate organic pollution potential of a waste. It is necessary for all aerobic biological wastewater treatment processes to control the rate of aeration. Dissolved Oxygen can be measured either by titrimetric or electrometric method.

II. Industry / Employer Expected Outcomes

1. Use the techniques and procedures required to prepare standard solutions
2. Measurement Skills
3. Handling of glassware
4. Able to interpret the results obtained and give decisions or actions to be taken for further treatment.

III. Relevant Course Outcome

CO5: Use relevant water treatment processes to solve industrial problems.

IV. Practical Learning Outcome

Determination of dissolved oxygen in the given water sample.

V. Laboratory Learning Outcome:

1. Set up titration Apparatus
2. Record the observations.
3. Calculate dissolved oxygen.

VI. Relevant Affective Domain Outcome:

1. Follow safe practices.
2. Demonstrate working as a leader/a team member.
3. Maintain tools and equipment.
4. Practice good housekeeping.

VII. Relevant Theoretical Background

Dissolved oxygen is absolutely essential for the survival of all aquatic organisms. Moreover, oxygen affects a vast number of other water indicators, not only biochemical but aesthetic ones like the odour, clarity and taste. Consequently, oxygen is perhaps the most well-established indicator of water quality. The experiment is based on oxidation of potassium iodide. The liberated iodine is titrated against standard hypo solution using starch as a final indicator. Since oxygen in water is in molecular state and not capable to react with KI, an oxygen carrier manganese hydroxide is used to bring about the reaction between KI and O_2. Manganous hydroxide is produced by the action of potassium hydroxide and manganous sulphate.

Chemical reactions:

$$2KOH + MnSO_4 \longrightarrow Mn(OH)_2 + K_2SO_4$$

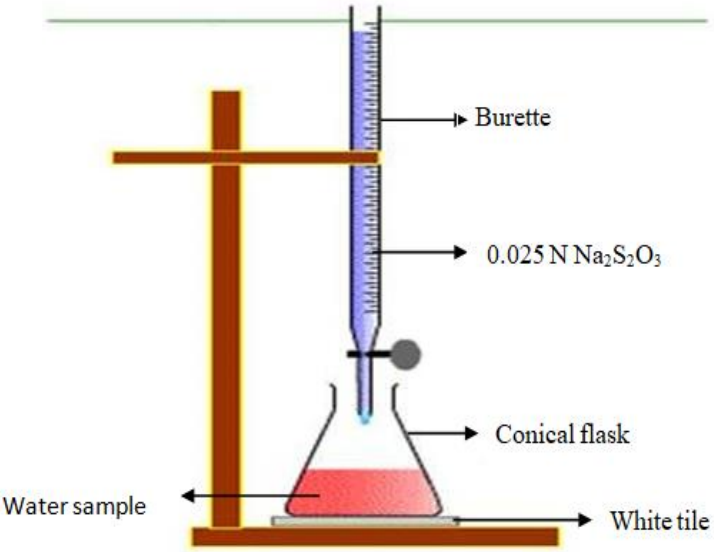
$$2Mn(OH)_2 + O_2 \longrightarrow 2\,MnO(OH)_2$$

$$MnO(OH)_2 + H_2SO_4 \longrightarrow MnSO_4 + 2H_2O + [O]$$

$$2KI + H_2SO_4 + [O] \longrightarrow K_2SO_4 + H_2O + I_2$$

$$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + \underset{\text{Sodium tetrathionate}}{Na_2S_4O_6}$$

VIII. Circuit diagram / Experimental set-up / Work Situation:



IX. Resources Required

Sr. No.	Name of Resource	Specification	Quantity	Remark
1.	Burette	Borosil glass , Capacity 50 ml	One per group	
2.	Conical flask	Borosil glass, Capacity 250 ml		
3.	Beaker	Borosil glass, Capacity 250 ml		
4.	Pipette/Measuring flask	Borosil glass, Capacity 25ml / 100ml		
5.	Stopper bottle	Glass bottles, Capacity 500 ml		
6.	Sodium thiosulphate	0.025 N	As per Require -ment	
7.	Alkaline Iodine Azide(AIA)	15g KI + 70 g KOH dissolve anddiluted to 100 ml + 4 g NaN_3 dissolved in 4ml distilled water		
8.	Manganese sulphate	400 g $MnSO_4$ in 1 lit. distilled water		
9.	Water sample			
10	Sulphuric acid	Concentrated		
11	Starch indicator			

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. Remove an air bubbles if present in the nozzle of the burette before taking an initial reading.
3. Place the conical flask on white tile to identify the color change at the end point.
4. Volume of indicator should be same in all titrations.
5. Shaking of the titration flask should be continuous during addition of the solution from burette.

XI. Procedure

1. Take 500 ml of water in a stopper bottle.
2. Add 10 ml of alkaline KI and 10 ml of $MnSO_4$ into it.
3. Stopper the bottle and shake it well
4. Wash the burette with water.
5. Keep the bottle in dark for 5 min and add conc. H_2SO_4 till the brown precipitates are dissolved.
6. Take 100 ml of the above solution in a conical flask.
7. Rinse the burette with 0.025 N sodium thiosulphate, and fill it.
8. Titrate the water sample against 0.025 N sodium thiosulphate solution till the colour changes to light yellow.
9. Add 3-4 drops of starch in to it and the colour changes to blue

10. Continue titration till blue colour disappears.
11. At the end point blue colour changes to colourless.
12. Repeat this process till to get three constant reading.

$$\text{Starch} + I_2 \xrightarrow{\qquad\qquad} \text{Starch iodide complex (Blue colour)}$$

XII. Observation

Solution in Burette: ___________________
Solution in Conical Flask: _________________
Indicator: ______________________________
End Point: ________________Procedure

XIII. Observation Table

Sr. No.	Burette Reading (ml)	Average Burette Reading
1.		V = ……….. ml
2.		
3.		

XIV. Calculations:

1000 ml of 1N $Na_2S_2O_3$ = 8 g of O_2

V ml of 0.025 N $Na_2S_2O_3$ = $\frac{(V \times 0.025 \times 8)}{1000}$ **g** of O_2 per 100 mL of water sample

= V × 0.025 × 8 **mg** oxygen per 100 mL water sample

= V × 0.025 × 8 × 10 mg oxygen per 1000 mL water sample

= ………× 0.025 × 8 × 10 mg oxygen per 1000 mL water sample

= ………. ppm Dissolved oxygen

XV. Results:

Dissolved oxygen in given water sample =.............................ppm

XVI. Interpretation of Result: (Give meaning of above results)

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XVII. Conclusion and Recommendation

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XVIII. Practical Related Questions:

1. Solution turns blue after addition of starch. Explain.
2. Write the colour of change at the end point.
3. Write the balanced chemical reaction between alkaline KI and Manganese sulphate.
4. Write the balanced chemical reaction between liberated iodine and sodium thiosulphate. Give the name of product.

XIX. References/ suggestions for further reading

Sr. No.	Title of Book	Author	Publication
1.	Practical Chemistry	Dr. N.K. Verma	Laxmi publications New Delhi, 2011 ISBN: 7008-594-2
2.	Applied Chemistry :Theory and practice	O.P.Vermani, A.K.Narula	New age International Publication New Delhi 2005 ISBN : 8122408141
3.	A Manual of Practical Engineering Chemistry	Sudha Jain, Shradha Sinha	S. Chand Limited, 2002 ISBN : 8121921929, 9788121921923
4.	Polytechnic Chemistry	Ved Prakash Mehta	Jain Brothers

XX. 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	Cleaning and filling burette	10 %
2	Measurement of water sample	10%
3	Accurate burette reading	20 %
4	Working in team	20 %
Product related: 10 Marks		**40%**
5	Dissolved oxygen in water sample	20 %
6	Answer to sample questions	10 %
7	Submission of report in time	10 %
Total		**100 %**

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

List of Student Team Members

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2. ....
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Practical No. 08 Chloride content of water sample

I. Practical Significance

Chlorides are present in water usually as NaCl, $MgCl_2$ and $CaCl_2$. Although chlorides are not harmful as such, their concentrations over 250 ppm impart a peculiar taste to the water, thus rendering the water unacceptable for drinking purposes from aesthetic point of view. Further, existence of chloride in a of unusually high concentrations water sample indicates pollution from domestic sewage or from industrial waste-waters. Presence of chlorides is also undesirable in boiler feed water. Salts like $MgCl_2$ may undergo hydrolysis under the high pressure and temperature prevailing in the boiler, generating hydrochloric acid which causes corrosion in boiler parts.

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 embrittelment, 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. Industry / Employer Expected Outcomes

1. Use the techniques and procedures required to prepare standard solutions
2. Measurement Skills
3. Handling of Glassware
4. Calculation
5. Interpretation of result and conclusion to be drawn for further process.

III. Relevant Course Outcome

CO5: Use relevant water treatment processes to solve industrial problems.

IV. Practical Learning Outcome

Determination of chloride content in the given water sample by Mohr's method.

V. Laboratory Learning Outcome:

1. Prepare $AgNO_3$ Solution of known concentration
2. Calculate chloride content in water sample

VI. Relevant Affective domain Outcome:

1. Follow safety practices.
2. Demonstrate working as a leader/a team member.
3. Practice good housekeeping.

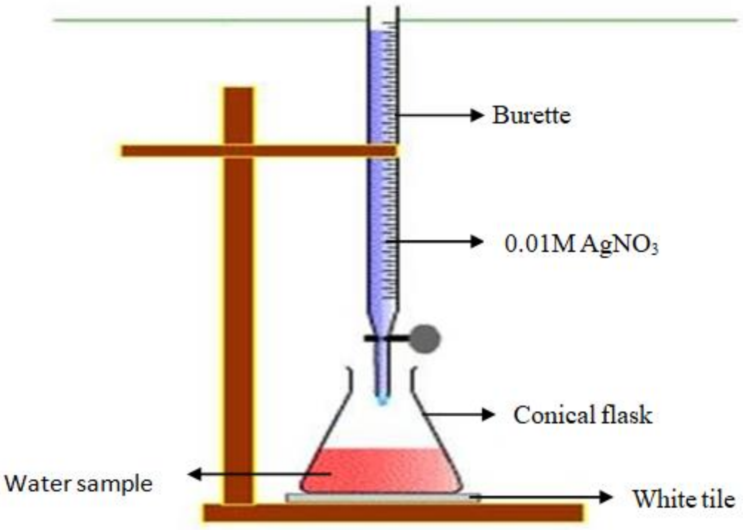
VII. Relevant Theoretical Background

Chloride ions can be determined by titration with standard silver nitrate solution, using potassium chromate as indicator (Mohr's method). As the titration proceeds, the chloride ions present react with $AgNO_3$ forming insoluble white precipitate of AgCl. As soon as all the chloride ions are removed in the form of AgCl, the extra drop of $AgNO_3$ reacts with the indicator forming brick red silver chromate. Thus, the change of colour from bright yellow to faint but distinct brick red colour marks the end-point.

$$AgNO_3 + Cl^- \longrightarrow \underset{\text{White ppt}}{AgCl\downarrow} + NO_3^-$$

$$2AgNO_3 + K_2CrO_4 \longrightarrow \underset{\text{Brick red ppt}}{Ag_2CrO_4\downarrow} + 2KNO_3$$

VIII. Circuit diagram / Experimental set-up / Work Situation:



IX. Resources Required

Sr. No.	Resources	Specification	Quantity	Remark
1.	Burette	Borosil glass , Capacity 25 ml /50ml	One per group	
2.	Conical flask	Borosil glass, Capacity 250 ml/100ml	One per group	
3.	Beaker	Borosil glass, Capacity 250 ml/100ml	One per group	
4.	Pipette	Borosil glass, Capacity 25ml / 10ml	One per group	
5.	Silver nitrate	0.01M	As per Requirement	
6.	Potassium chromate indicator			
7.	Water sample			

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. Remove an air bubbles if present in the nozzle of the burette before taking an initial reading.
3. Place the conical flask on white tile to identify the color change at the end point.
4. Volume of indicator should be same in all titrations.
5. Shaking of the titration flask should be continuous during addition of the solution

XI. Procedure

1. Wash the burette with water.
2. Rinse the burette with 0.01 M $AgNO_3$ solution. Fill it with 0.01 M $AgNO_3$

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 potassium chromate indicator into the water sample in conicalflask. Color of the solution becomes yellow.
6. Add 0.01 M $AgNO_3$ solution from burette into the conical flask very slowly, till yellow color changes to brick red.
7. Note down the reading, repeat the procedure to get constant reading.

XII. Observation

Solution in Burette: ___________________

Solution in Conical Flask: ________________

Indicator: _____________________________

End Point: _____________________________

XIII. Observation Table for

Sr. No.	Burette Reading (ml)	**Constant Burette Reading** (Volume of 0.01M $AgNO_3$)
1.		Z =............ (ml)
2.		
3.		

XIV. Calculations:

STEP 1:

$$1000 \text{ ml of } 1M\ AgNO_3 \equiv 35.5 \text{ g of } Cl^-$$

$$\text{'Z' ml of } 0.01\,M\ AgNO = \frac{(35.5 \times Z \times 0.01)}{1000}$$

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

STEP 2:

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

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

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

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

XV. Results:

Chloride content in given water sample = ------------- ppm

XVI. Interpretation: (Give meaning to result obtained)

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XVII. Conclusion: (Action/decision to be taken)

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XVIII. Practical Related Questions:

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

XIX. References/ Suggestions for further Reading

Sr. No.	Title of Book	Author	Publication
1.	Practical Chemistry	Dr. N.K. Verma	Laxmi publications New Delhi, 2011 ISBN: 7008-594-2
2.	Applied Chemistry :Theory and practice	O.P.Vermani , A.K.Narula	New age International Publication New Delhi 2005 ISBN : 8122408141
3.	Experiments and calculations in engineering chemistry	Dr. S.S. Dara	S.Chand. Publication, New Delhi, 2011, ISBN:8121908647
4	A Manual of Practical Engineering Chemistry	Sudha Jain, Shradha Sinha	S. Chand Limited, 2002 ISBN : 8121921929, 9788121921923

XX. 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		**100 %**

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

List of Student Team Members

1. ……………………………………
2. ……………………………………
3. ……………………………………
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Space for Answer

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Practical No. 09 Determination of pH Value

I. Practical Significance

Determination of pH values of different solutions will make the student enable to identify the process of optimization of water treatment processes, equipment maintenance, disinfection understanding, chemical dosage calculation etc. that help in solving various broad based Engineering problems related to water treatment.

II. Industry or employer expected outcomes

1. Use pH data to optimize water treatment processes.
2. Use pH information to ensure the effectiveness of disinfection processes.
3. Measurement skills
4. Compare colour formations
5. Calibration skills

III. Relevant Course Outcome

CO5-Use relevant water treatment processes to solve industrial problems.

IV. Practical Outcome

Determination of pH value of given solution using pH meter and universal indicator.

V. Laboratory Learning Outcomes

1. Use universal indicator for pH values.
2. Calculate pH value by using pH meter.

VI. Relevant Affective Domain related outcomes

1. Demonstrate working as leader or a team member.
2. Follow Good housekeeping.

VII. Relevant Theoretical Background

The pH (potential of hydrogen) is a measure of the acidity or alkalinity of a solution. It is defined as the negative logarithm (base 10) of the concentration of hydrogen ions (H^+) in a solution. The pH scale ranges from 0 to 14, with 7 considered neutral. Values below 7 are acidic, and values above 7 are alkaline or basic.

VIII. Experimental set-up / Circuit diagram / Work Situation

IX. Required Resources/ apparatus/ equipment with specifications

Sr. No.	Resources	Specifications	Quantity	Remarks
1	pH meter	pH meter reading upto pH 14 ambient 40 to 700 C pH/mV resolution 13 bit	02	
2	Universal Indicator	Colour strips specifically for pH 1 to 14, mixture of methyl red , methyl orange, bromothymol blue , Phenolphthalein in ethanol or water		
3	Chemicals	Any acid, distilled water, alkali and salt solution.		
4	Test Tubes	15 ml	20	
5	Beaker	100 ml	05	

X. Precautions to be Followed

1. Every time wash the test tube with distilled water, when you will change the solution**.**
2. Every time clean the glass electrode with distilled water.
3. Glass electrode should be properly deep in sample solution.

XI. Procedure

Part I: Determination of pH by using pH meter.

1. Turn on the pH meter & make sure the pH meter is calibrated. Calibration should be performed using standard buffer solutions (pH 4.01, pH 7.00, and pH 10.01 are common choices).
2. Clean the glass electrode with distilled or deionized water to remove any residue.
3. Take test solution A in beaker.
4. Immerse the glass electrode into the sample solution & note down the pH value in the observation table.
5. Remove the glass electrode & clean it with distilled water.
6. Repeat the same procedure for remaining test solutions.

Part II: Determination of pH by using universal Indicator.

1. Add a few drops of universal indicator solution to the each sample solutions.
2. Observe the color change in the sample.
3. Match the color of the solution to the corresponding pH range with standard colour strip.
4. Note down the pH value of sample solution written on colour strips against that colour

XII. Observation table

Sr. No.	Test Solution	pH by Universal Indicator	pH by pH meter
1	**A**		
2	**B**		
3	**C**		
4	**D**		
5	**E**		
6	**F**		
7	**G**		

XIII. Results

a) Solutions with less than 7pH=…………

b) Solutions with more than 7pH=…………

c) Solutions with exact than 7pH=…………

XIV. Interpretation Results

a) Solution having pH less than 7: Acidic solution

b) Solution having pH more than 7: Alkaline solution

c) Solution having pH 7: Neutral solution

XV. Conclusions & Recommendations (Acidic/ Alkaline/ Neutral)

1. Solution A is _______
2. Solution B is _______
3. Solution C is _______
4. Solution D is _______
5. Solution E is _______
6. Solution F is _______
7. Solution G is _______

XVI. Practical Related Questions:

1) Name the electrode used in method of finding pH value.

2) State the composition of universal Indicator.

3) Describe the standardization process of pH meter.

XVII. References/ Suggestions for further Reading

Sr. No.	Title	Author	Publisher
1	Engineering Chemistry	Jain and Jain	National Council of Education Research and Training, New Delhi, 2010, ISBN : 8174505083
2	Engineering Chemistry	Dara, S. S.	National Council of Education Research and Training, New Delhi, 2015, ISBN : 8174505660
3	Fundamental of Electrochemistry	Bagotsky V.S.	National Council of Education Research and Training, New Delhi, 2013, ISBN : 8174506314.
4	Chemistry for Engineers	Agnihotri Rajesh	Wiley India Pvt. Ltd. New Delhi, 2014, ISBN: 9788126550784.

5	Applied Chemistry with Lab Manual	Anju Rawlley, DevdattaV.Saraf	Khanna Book Publishing Co. (P) Ltd. New Delhi, 2021, ISBN- 978-93-91505-44-8
6	Engineering Chemistry	Vairam S.	Wiley India Pvt. Ltd. New Delhi, 2013, ISBN: 978812654334
7.	You-Tube link		https://www.youtube.com/watch?v=6BJlmA0M4Jo

XVIII. Assessment Scheme

Sr. No.	**Process Related**	**Weightage (60%)**
1	Washing Glass Electrode	15%
2	Assemble the instrument	15%
3	Addition of Indicator	15%
4	Standardization of instrument	15%
	Product Related	**40%**
5	Identification of pH by digital pH meter	20%
6	Identification of pH by digital Universal Indicator	20%
	Total (25 Marks)	**100 %**

Marks Obtained

Process Related (15)	**Product Related (10)**	**Total(25)**	**Dated Signature of Faculty**

List of Student Team Members

1. ……………………………………
2. ……………………………………
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Practical No. 10 Moisture & Ash Content in Coal Sample.

I. Practical Significance

The evaluation of solid fuel materials like coal and coke relies on determining key parameters such as moisture content, volatile matter, ash, and fixed carbon. These parameters are crucial for assessing the quality and combustion characteristics of the fuel. Moisture content significantly influences the calorific value of coal, impacting its efficiency as a source of energy. The percentage of ash in coal holds importance in industrial settings, especially in boilers, where it contributes to calculations related to ash load and material balance. Additionally, the determination of ash content is vital in the ultimate analysis for calculating the oxygen content. Fixed carbon, obtained by subtracting the sum of ash, moisture, and volatile matter from 100, serves as a key indicator in understanding the composition of the fuel. Diploma engineers play a pivotal role in analyzing and providing comprehensive data on the combustion properties of fuel materials. This information serves as a basis for decision-making in the procurement and sale of solid fuel materials, ensuring that the quality and suitability of these materials meet the required standards for various industrial applications.

II. Industry or employer expected outcomes

1. Measurement skill
2. Handling of instrument
3. Calculation

III. Relevant Course Outcome

CO6- Use appropriate fuel and electrolyte for engineering applications.

IV. Practical Outcome

Determination of the moisture and ash content in a given coal sample using proximate analysis.

V. Laboratory Learning Outcomes

1. Use of oven for appropriate temperature settings.
2. Calculate moisture and ash content in coal samples.

VI. Relevant Affective Domain related outcomes

1. Follow safe practices.
2. Demonstrate working as a leader/a team member.
3. Maintain tools and equipment.
4. Practice good housekeeping.
5. Practice energy conservation

VII. Relevant Theoretical Background

Analyzing and monitoring the moisture content in coal is crucial due to its significant impact on the coal's properties. While external moisture can be easily removed through evaporation at room temperature, inherent moisture trapped within the coal structure poses a challenge to extraction. Laboratory tests are employed to assess the level of inherent moisture, typically involving heating the coal in an electric oven at 105 °C under a nitrogen atmosphere or drying it in air within the temperature range of 100 to 105 °C. The ash content of coal is another key parameter that greatly influences its quality. Ash contributes to a reduction in the calorific value of coal, making it essential to understand the ash content when burning coal on a large scale. Determining ash content involves heating and burning a coal sample in the presence of air and measuring the subsequent weight loss. This information is critical for industries relying on coal as a fuel source, ensuring efficient combustion processes and optimal energy output.

VIII. Experimental set-up / Circuit diagram / Work Situation

IX. Required Resources/ apparatus/ equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Electronic balance	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
2	Electric oven	Inner size 18"x 1 8"x 18"; temperature range 100 to 250° C with the capacity of 40 lit	One per batch
3	Muffle furnace	Temperature up to 900° C, digital temperature controller with an accuracy of +/- 30 ° C	One per batch
4	Pair of tongs		One per group
5	Silica crucible		One per group
6	Coal sample		As per requirement

X. Precautions to be Followed

1. Exercise caution when operating the oven and furnace.
2. Utilize a pair of tongs exclusively for the removal of the silica crucible from the oven and furnace.

XI. Procedure

Part A: Procedure for Moisture Determination

1. Carefully weigh around 1 g of coal sample that has been air-dried in a silica crucible.
2. Place the crucible in an electric oven maintained at 105°C for 1 hour.
3. After the heating process, ascertain the variance between the initial weight and the ultimate weight of the coal. This discrepancy in weight signifies the moisture content, as the moisture is vaporized during the heating procedure.

Part B: Procedure for Ash Determination

1. Precisely weigh the moisture-free coal sample obtained from Part A and place it in a silica crucible.
2. Introduce the crucible into a muffle furnace held at a consistent temperature of 750°C. Allow the sample to undergo heating for a duration of 1 hour.
3. After the heating process, determine the weight of the ash that has been formed as a result of the combustion.

XII. Observation table& calculations

Observation Table I Part A: Determination of moisture content

Sr. No.	Description	Weights in gm
1.	Weight of empty silica crucible(W_1)	
2.	Weight of silica crucible and coal sample before heating(W_2)	
3.	Weight of coal taken($W_3 = W_2 - W_1$)	
4.	Weight of silica crucible and coal sample after heating(W_4)	
5.	Weight of moisture removed ($W_5 = W_2 - W_4$)	

Calculation: Part A: Determination of moisture content

$$\%\text{ of Moisture Content} = \frac{\text{Weight of moisture removed } (W_5)}{\text{Weight of Coal taken } (W_3)} \times 100$$

$$\%\text{ of Moisture Content} = \frac{\dots\dots\dots\dots}{\dots\dots\dots\dots} \times 100$$

$$\%\text{ of Moisture Content} = \dots\dots\dots\dots\dots\%$$

Observation table II: Part B: Determination of ash content

Sr. No.	Description	Weights in grams
1.	Weight of empty silica crucible(W_1)	
2.	Weight of silica crucible and coal sample before burning(W_2)	
3.	Weight of coal taken($W_3 = W_2 - W_1$)	
4.	Weight of silica crucible and ash (W_4)	
5.	Weight of ash formed ($W_5 = W_4 - W_1$)	

Calculation: Part B: Determination of ash content

$$\%\ \text{of Ash Content} = \frac{\text{Weight of Ash formed } (W_5)}{\text{Weight of Coal taken } (W_3)} \times 100$$

$$\%\ \text{of Ash Content} = \frac{\ldots\ldots\ldots\ldots\ldots\ldots}{\ldots\ldots\ldots\ldots\ldots\ldots} \times 100$$

$$\%\ \text{of Ash Content} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\%$$

XIII. Results

1. Percentage of moisture content in coal = _________%

2. Percentage of ash content in coal = ___________ %

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

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

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XVI. Practical Related Questions:

1. Determine the temperature required to eliminate moisture and ash from a coal sample.
2. Identify the elements in fuel that undergo combustion.
3. Highlight the critical factor influencing the choice of fuel.

XVII. References/ Suggestions for further Reading

Sr. No.	Title	Author	Publisher
1	Engineering Chemistry	Jain and Jain	National Council of Education Research and Training, New Delhi, 2010, ISBN : 8174505083
2	Engineering Chemistry	Dara, S. S.	National Council of Education Research and Training, New Delhi, 2015, ISBN : 8174505660
3	Fundamental of Electrochemistry	Bagotsky V.S.	National Council of Education Research and Training, New Delhi, 2013, ISBN : 8174506314.

4	Chemistry for Engineers	Agnihotri Rajesh	Wiley India Pvt. Ltd. New Delhi, 2014, ISBN: 9788126550784.
5	Applied Chemistry with Lab Manual	Anju Rawlley, DevdattaV.Saraf	Khanna Book Publishing Co. (P) Ltd. New Delhi, 2021, ISBN- 978-93-91505-44-8
6	Engineering Chemistry	Vairam S.	Wiley India Pvt. Ltd. New Delhi, 2013, ISBN: 978812654334
7.	You-Tube link		https://www.youtube.com/watch?v=DtSH8n1jbyM https://www.youtube.com/watch?v=n2Qwb8Pw8YE

XVIII. Assessment Scheme

Performance Indicators		
Sr. No.	**Process Related (15 Marks)**	**Weightage (60%)**
1	Weight of silica crucible & coal sample after heating	15%
2	Weight of moisture removed	15%
3	Weight of silica crucible & ash	15%
4	Weight of the ash formed	15%
	Product Related (10 Marks)	**40%**
5	Percentage of moisture content	10%
6	Percentage of ash content	10%
7	Practical related questions	10%
8	Submitting the manual in time	10%
	Total (25 Marks)	**100 %**

Marks Obtained

Process Related (15)	**Product Related (10)**	**Total (25)**	**Dated Signature of Faculty**

List of Student Team Members

1…………………………………

2…………………………………

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Space for Answers

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Practical No. 11 Calorific Value of Solid Fuel.

I. Practical Significance

The calorific value of a fuel, representing the energy released per kilogram when the fuel is burned, is a crucial characteristic that influences its selection for specific applications and pricing. Determining the calorific value is essential for both selling and procuring fuel materials. Diploma engineers are tasked with analyzing and providing comprehensive data on the combustion properties of fuel materials, utilizing tools such as bomb calorimeters to measure the calorific value of solid and liquid fuels. This data forms the foundation for informed decisions in the procurement and utilization of fuel resources.

II. Industry or employer expected outcomes

1. Measurement skills
2. Handling instrument
3. Calculations

III. Relevant Course Outcome

CO6-Use appropriate fuel and electrolyte for engineering applications.

IV. Practical Outcome

Determination of calorific value of given solid fuel using Bomb calorimeter.

V. Laboratory Learning Outcomes

1. Set up a Bomb Calorimeter.
2. Calculate calorific value.

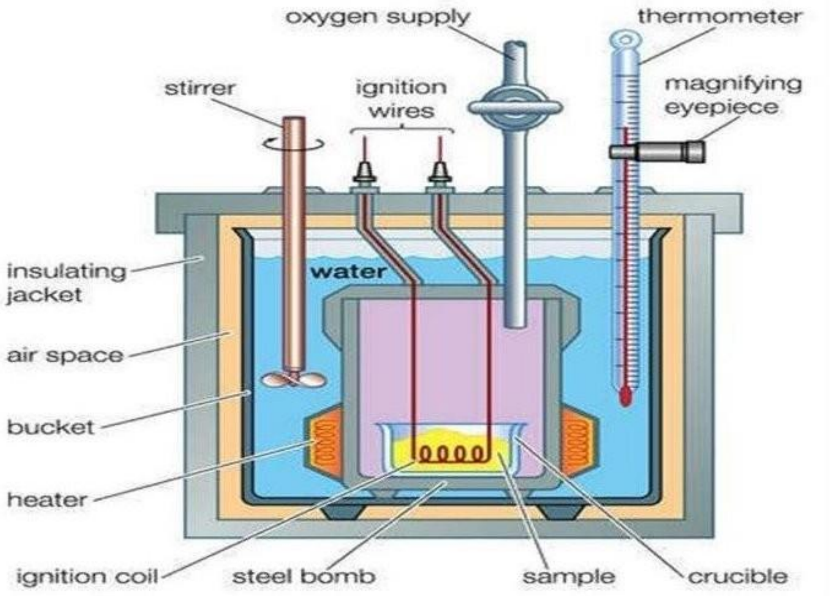
VI. Relevant Affective Domain related outcomes

1. Demonstrate working as leader or a team member.
2. Follow safe practices.
3. Maintain equipment’s or instruments.
4. Practice energy conservation.

VII. Relevant Theoretical Background

The bomb calorimeter is a device employed to measure the calorific value of both solid and liquid fuels. It comprises a sturdy cylindrical vessel with a lid supporting two electrodes connected to a fuse wire and a known-weight fuel sample. The lid includes an oxygen inlet valve, facilitating the introduction of high-pressure oxygen gas (typically around 25 to 30 atm.). This entire assembly, including the lid and fuel sample, is placed within a copper calorimeter filled with a known amount of water. To ensure even heating, a mechanical stirrer is provided, and a thermometer is used to gauge the water temperature change resulting from the combustion of the fuel in the lid. To determine the water equivalent of a specific bomb calorimeter, engineers conduct experiments using a known fuel sample with a predetermined calorific value. This value is often specific to the bomb calorimeter's manufacturer. Notably, bomb calorimeters find applications beyond fuel analysis; they are instrumental in energy balance studies within ecology and are utilized in the examination of Nano-materials, ceramics, and zeolites. These devices contribute to the understanding of the thermodynamics of various combustible materials. The unit of calorific value is measured in Joules per kilogram (J/kg).

VIII. Experimental set-up / Circuit diagram / Work Situation



IX. Required Resources/ apparatus/ equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Electronic balance	Range of 0.001gm to 500g. pan size 100mm; response time3-5 sec.; power requirement 90-250 V, 10	One per batch
2.	Electric oven	Inner size18"x18"x18"; temperature range 100 to 250°C with the capacity of 40 lit	One per batch
3.	Bomb calorimeter	Standard	One per batch
4.	Pair of tongs		One per group
5.	Silica crucible		One per group
6.	Coal sample		As per requirement

X. Precautions to be Followed

1. Handle the bomb calorimeter with care.
2. Use a pair of tongs to remove the nickel or steel crucible.
3. Avoid approaching the top of the bomb to prevent the risk of explosion.

XI. Procedure

1. Begin by placing a measured quantity of air-dried coal sample, approximately 1 gram, into a nickel or steel crucible. Introduce this crucible into the bomb.

2. Introduce a known volume of distilled water into this system, initiate the stirrer, and record the initial water temperature.
3. Introduce oxygen gas at a pressure of approximately 25 to 30 atmospheres.
4. Initiate an electric current through the crucible, allowing the fuel sample to combustion in the presence of oxygen.
5. The heat generated during the combustion process is absorbed by the water, leading to an increase in its temperature.
6. Record the final steady-state temperature of the water as the combustion reaction

XII. Observation & Calculations.

Sr. No.	Description	Weights in grams
1	Water equivalent of Bomb calorimeter (m_1)	
2	Mass of water in copper calorimeter (m_2)	
3	Specific heat of water (Cw)	
4	Weight of empty silica crucible(W_1)	
5	Weight of silica crucible and solid fuel(coal sample) before burning (W_2)	
6	Weight of solid fuel (coal sample) (m_f taken = W_2-W_1)	
7	Initial temperature of water (t_1)	
8	Final temperature of water (t_2)	

Calculations

Calorific value of fuel is determined by following formula

$$\text{Calorific Value} = \frac{(m_1 + m_2) \times (t_2 - t_1) \times C_w}{m_f}$$

$$= \frac{(\ldots\ldots\ldots\ldots\ldots\ldots\ldots) \times (\ldots\ldots\ldots\ldots\ldots\ldots) \times \ldots\ldots\ldots}{\ldots\ldots\ldots\ldots\ldots}$$

Calorific Value = ………………. cal/gm

Calorific Value = ………………. ×4.183 x 10^3 J/kg =…………………J/Kg

XIII. Results

Calorific value of given solid fuel (coal sample)=…………………..J/Kg

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

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

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XVI. Practical Related Questions:

1. State type of fuel does the Bomb calorimeter analyze to determine its calorific value.
2. Clarify why the Bomb calorimeter is positioned inside a water jacket.
3. Explain the importance or relevance of determining the calorific value.

XVII. References/ Suggestions for further Reading

Sr. No.	Title	Author	Publisher
1	Engineering Chemistry	Jain and Jain	National Council of Education Research and Training, New Delhi, 2010, ISBN : 8174505083
2	Engineering Chemistry	Dara, S. S.	National Council of Education Research and Training, New Delhi, 2015, ISBN : 8174505660
3	Fundamental of Electrochemistry	Bagotsky V.S.	National Council of Education Research and Training, New Delhi, 2013, ISBN : 8174506314.
4	Chemistry for Engineers	Agnihotri Rajesh	Wiley India Pvt. Ltd. New Delhi, 2014, ISBN: 9788126550784.
5	Applied Chemistry with Lab Manual	Anju Rawlley, DevdattaV.Saraf	Khanna Book Publishing Co. (P) Ltd. New Delhi, 2021, ISBN- 978-93-91505-44-8
6	Engineering Chemistry	Vairam S.	Wiley India Pvt. Ltd. New Delhi, 2013, ISBN: 978812654334
7.	You-Tube link	Ministry of Steel (You tube Channel - Govt. of India Ministry of Steel)	https://www.youtube.com/watch?v=wwJG2JVg6qM

XVIII. Assessment Scheme

Performance Indicators		
Sr. No.	**Process Related (15 Marks)**	**Weightage (60%)**
1	Accurately measure the weight of the sample fuel	10%
2	Operation of Bomb calorimeter	30%
3	Measurement of initial & final temperature of water	20%
Product Related (10 Marks)		**40%**
4	Formula of Calorific value	10%
5	Calculation	10%
6	Practical related questions	10%
7	Submitting the manual in time	10%
Total (25 Marks)		**100 %**

Marks Obtained

Process Related (15)	Product Related (10)	Total(25)	Dated Signature of Faculty

List of Student Team Members

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Space for Answers

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Practical No. 12 Sulphur Content in Coal

I. Practical Significance

Sulphur emissions resulting from coal combustion not only contribute to atmospheric pollution but also pose hazards to living organisms. The corrosive impact on chimneys and various equipment, including air heaters and machinery parts, further emphasizes the undesirable consequences of sulphur presence. Beyond these detrimental effects, sulphur can influence clinkering and slagging tendencies. Therefore, measuring the sulphur content in coal samples becomes crucial for assessing the fuel's potential. The ultimate analysis, a valuable tool for coal classification, aids in determining the elemental composition, with a particular focus on sulphur content. In metallurgical coal, the presence of sulphur is detrimental to its suitability for metallurgical processes, adversely affecting metal properties. The oxidation products of sulphur, especially SO_2 and SO_3 formed in the presence of moisture, exhibit a corrosive effect, leading to the formation of sulphuric acid. Given these considerations, diploma engineers play a pivotal role in analyzing and furnishing comprehensive data on the combustion properties of fuel materials. This information serves as a foundational basis for both selling and procuring fuel resources.

II. Industry or employer expected outcomes

1. Measurement skills
2. Preparation of solutions
3. Sample Handling
4. Calculations
5. Monitor Processes CO6-Use appropriate fuel and electrolyte for engineering applications.

III. Relevant Course Outcome

CO6-Use appropriate fuel and electrolyte for engineering applications.

IV. Practical Outcome.

Calculate the percentage of Sulphur in a given coal sample by ultimate analysis. (Gravimetric analysis)

V. Laboratory Learning Outcomes

1. Use gravimetric analysis method
2. Calculate the percentage of Sulphur.

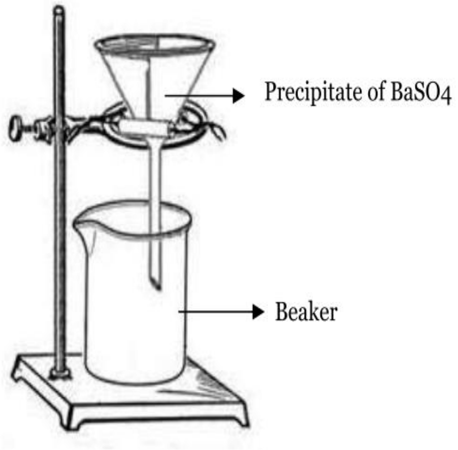
VI. Relevant Affective Domain related outcomes

1. Demonstrate working as leader or a team member.
2. Follow Good housekeeping.
3. Maintain equipment’s or instruments

VII. Relevant Theoretical Background

The ultimate analysis is a technique employed to ascertain the composition of coal, specifically determining the levels of carbon, hydrogen, oxygen, sulphur, and nitrogen. In the context of sulphur, it typically manifests in three distinct forms within coal—sulphates, iron pyrites (FeS_2), and organic compounds. These forms are referred to as 'sulphate,' 'pyritic,' and 'organic,' respectively. To quantify sulphate sulphur, coal is extracted using dilute hydrochloric acid, and the determination involves gravimetric analysis. This entails precipitating sulphate sulphur as barium sulphate with the addition of barium chloride. On the other hand, pyritic sulphur, insoluble in dilute hydrochloric acid, undergoes quantitative dissolution with nitric acid under specific experimental conditions, converting it into sulphate. The separation of sulphates from nitric acid is achieved through evaporation. The sulphates are then extracted with hydrochloric acid and subjected to gravimetric analysis by precipitating as barium sulphate with barium chloride. Remarkably, organic sulphur content in coal is not directly determined through analytical methods. Instead, it is calculated by subtracting the combined values of pyritic and sulphate sulphur from the total sulphur content. This comprehensive approach provides insights into the diverse forms of sulphur present in coal, offering valuable information for various applications in chemical analysis.

VIII. Experimental set-up / Circuit diagram / Work Situation



IX. Required Resources/ apparatus/ equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Remark
1	Electronic balance	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
2	Electric oven	Inner size 18"x18"x18"; temperature range 100 to 250° C with the capacity of 40 lit	One per batch
3	Bomb calorimeter		One per batch
4	Pair of tongs		One per group
5	Silica crucible		One per group
6	Beaker	Borosil glass,250m1	Two per group
7	Funnel	Borosil glass	
8	Chemicals	Coal sample, HC1, $BaC1_2$	As per requirement

X. Precautions to be Followed

1. Exercise caution when dealing with the bomb calorimeter.

2. Utilize a pair of tongs to carefully extract the nickel or steel crucible.
3. Handle the glassware with care.
4. Ensure precision in drying and weighing the precipitate.
5. Avoid approaching the upper part of the bomb to mitigate the risk of an explosion.

XI. Procedure

1. Begin by placing a 1-gram sample of coal, devoid of moisture and volatile matter, into a nickel or steel crucible.
2. Introduce the crucible into the bomb of the bomb calorimeter, allowing for complete combustion in the presence of oxygen.
3. The resulting ash comprises coal sulphur in the form of a sulphate, which is then extracted using diluted hydrochloric acid (HCl).
4. Treat the acid extract with a barium chloride ($BaCl_2$) solution to induce the precipitation of sulphate as barium sulphate ($BaSO_4$).
5. After filtration, thorough washing, and drying, measure the weight of the obtained precipitate.

XII. Observations & Calculations

Sr. No.	Description	Weights in grams
1	Weight of $BaSO_4$ formed (y)	
2	Atomic weight of sulphur	32
3	Molecular weight of $BaSO_4$	233

.

XIII. Calculations:

Sulphur in coal is determined as,

233 g of $BaSO_4$ contains 32 g of sulphur

$$\text{y gm of } BaSO_4 \text{ contains} = \frac{(32) \times (y)}{233} \text{ gm of sulphur}$$

$$\text{y gm of } BaSO_4 \text{ contains} = \frac{(32) \times (\ldots\ldots\ldots\ldots..)}{233} \text{ gm of sulphur}$$

=…………………..gm of Sulphur

Hence % of Sulphur in coal is =………………….x 100 %

XIV. Results

The percentage of sulphur content in coal sample =……………%.

XV. Interpretation Results(Give meaning of the above obtained results)

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

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XVII. Practical Related Questions:

1. Provide the balanced chemical equation for the reaction that occurs when the acid extract is treated with a $BaCl_2$ solution.
2. Explain the importance of estimating the sulphur content in a coal sample.
3. In this experiment, identify the particular form of sulphur that is being determined.

XVIII. References/ Suggestions for further Reading

Sr. No.	Title	Author	Publisher
1	Engineering Chemistry	Jain and Jain	National Council of Education Research and Training, New Delhi, 2010, ISBN : 8174505083
2	Engineering Chemistry	Dara, S. S.	National Council of Education Research and Training, New Delhi, 2015, ISBN : 8174505660
3	Fundamental of Electrochemistry	Bagotsky V.S.	National Council of Education Research and Training, New Delhi, 2013, ISBN : 8174506314.
4	Chemistry for Engineers	Agnihotri Rajesh	Wiley India Pvt. Ltd. New Delhi, 2014, ISBN: 9788126550784.
5	Applied Chemistry with Lab Manual	Anju Rawlley, DevdattaV. Saraf	Khanna Book Publishing Co. (P) Ltd. New Delhi, 2021, ISBN- 978-93-91505-44-8
6	Engineering Chemistry	Vairam S.	Wiley India Pvt. Ltd. New Delhi, 2013, ISBN: 978812654334

XIX. Assessment Scheme

Performance Indicators		
Sr. No.	**Process Related (15 Marks)**	**Weightage (60%)**
1	Determination of weight of coal sample	10%
2	Preparation of acid extract solution	30%
3	Separation, Dehydration, and Quantification.	20%
	Product Related (10 Marks)	**Weightage 40%**
4	Calculation for percentage of sulphur	20%
5	Practical related quotations.	10%
6	Submitting the manual in time	10%
	Total (25 Marks)	**100 %**

Marks Obtained

Process Related (15)	Product Related (10)	Total(25)	Dated Signature of Faculty

List of Student Team Members

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2…………………………………

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Practical No.13 Conductance of Electrolyte

I. Practical Significance

Electrolytes are substances that dissociate into ions when dissolved in a solvent, and their ability to conduct electric current is vital in several applications, such as Batteries, Electroplating, Chemical Analysis, Electrolysis and Medical Applications

II. Industry or employer expected outcomes

1. Optimized Electrolyte Formulations
2. Enhanced Battery Performance
3. Measurement skills
4. Calibration of instrument

III. Relevant Course Outcome

CO6-Use appropriate fuel and electrolyte for engineering applications.

IV. Practical Outcome

Determination of conductance of given electrolyte by using a conductivity meter.

V. Laboratory Learning Outcomes

1.Standardize conductivity meter.
2.Measure the conductance of given solutions.

VI. Relevant Affective Domain related outcomes

1. Demonstrate working as leader or a team member.
2. Follow Good housekeeping.
3. Maintain equipment's or instruments.

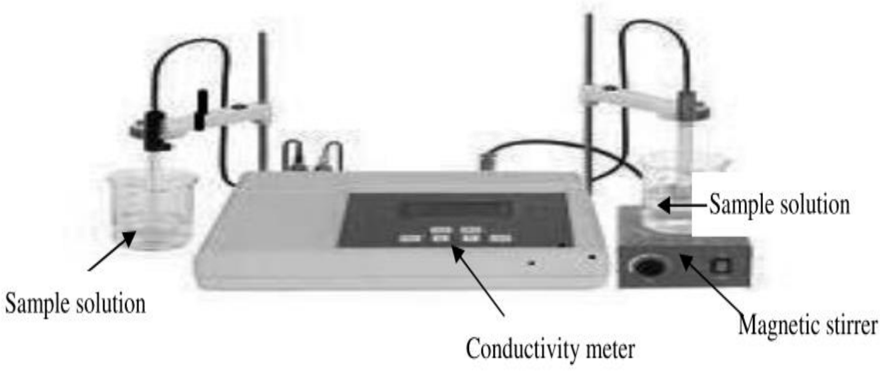
VII. Relevant Theoretical Background

The conductance of electrolyte solutions involves principles of electrochemistry, particularly those related to ion movement and electrical conductivity. Electrolytic Dissociation, Ions & their mobility. The conductance is the property of the metallic & electrolytic conductor.

Conductance = 1/ Resistance = 1/R

Units of conductance: Ω-

VIII. Experimental set-up / Circuit diagram / Work Situation



IX. Required Resources/ apparatus/ equipment with specifications

Sr. 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°C	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, 100m1 / 250 ml	One per group
4.	Measuring cylinder	Borosil glass, 50 ml ,100m1	One per group
5.	Volumetric flask	Borosil glass,100m1,250m1	One per group
6.	Solutions strong electrolyte , Weak electrolyte , Non electrolyte.	Prepare different solutions of different concentration	As per requirement

X. Precautions to be Followed

1. Calibrate and check the accuracy of your conductivity meter regularly using standard solutions to ensure reliable and accurate measurements.
2. Handle electrodes with care to avoid damage.
3. Conductivity cell must be kept clean & standardized with KCl solution.
4. Use conductivity water for preparation of solution.
5. 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 as shown in diagram.
2. Weigh exactly 0.745 gm of KC1. Transfer in to 200 ml beaker and dissolved in 50 ml conductivity or distilled water.
3. Transfer the dissolved KC1 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 KC1 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. Observation table: Room Temperature______°C.

Sr. No.	Salt Solution	Observed conductance
A		
B		
C		
D		
E		

XIII. Results

1. Conductance of solution A =__________________
2. Conductance of solution B =___________________
3. Conductance of solution C =___________________
4. Conductance of solution D =___________________
5. Conductance of solution E =___________________

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

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

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XVI. Practical Related Questions:

1) Write unit of conductance.
2) Calculate the amount of KCl required to prepare 0.1 N KCl
3) Describe the Calibration process of conductivity meter.

XVII. References/ Suggestions for further Reading

Sr. No.	Title	Author	Publisher
1	Engineering Chemistry	Jain and Jain	National Council of Education Research and Training, New Delhi, 2010, ISBN : 8174505083
2	Engineering Chemistry	Dara, S. S.	National Council of Education Research and Training, New Delhi, 2015, ISBN : 8174505660
3	Fundamental of Electrochemistry	Bagotsky V.S.	National Council of Education Research and Training, New Delhi, 2013, ISBN : 8174506314.
4	Chemistry for Engineers	Agnihotri Rajesh	Wiley India Pvt. Ltd. New Delhi, 2014, ISBN: 9788126550784.
5	Applied Chemistry with Lab Manual	Anju Rawlley, DevdattaV.Saraf	Khanna Book Publishing Co. (P) Ltd. New Delhi, 2021, ISBN- 978-93-91505-44-8
6	Engineering Chemistry	Vairam S.	Wiley India Pvt. Ltd. New Delhi, 2013, ISBN: 978812654334
7.	You-Tube	NITTTR Chandigarh Technology Enabled Learning	https://www.youtube.com/watch?v=WhyMOVvAu3s

XVIII. Assessment Scheme

Performance Indicators		
Sr. No.	**Process Related (15 Marks)**	**Weightage (60%)**
1	Preparation of 0.1 N KCl	10%
2	Calibration of conductivity cell	10%
3	Conductance of solutions	30%
4	Working in Team	10%
Product Related (10 Marks)		**40%**
5	Identification of type of electrolyte	20%
6	Submitting the manual in time	20%
Total (25 Marks)		**100 %**

Marks Obtained

Process Related (15)	Product Related (10)	Total (25)	Dated Signature of Faculty

List of Student Team Members

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Practical No. 14 Specific Conductance & Equivalent Conductance of Salt Solution

I. Practical Significance

Specific conductance and equivalent conductance are essential in various scientific and industrial applications like providing insights into the composition, quality, and behavior of electrolyte solutions. Their measurement and analysis contribute to advancements in engineering fields ranging from water treatment to fundamental research in electrochemistry.

II. Industry or employer expected outcomes

i. Measurement skills
ii. Calibration of instrument
iii. Calculations Optimization & monitor of Treatment Processes

III. Relevant Course Outcome

CO6-Use appropriate fuel and electrolyte for engineering applications.

IV. Practical Outcome

Determination of specific conductance and equivalence conductance of given salt sample solution.

V. Laboratory Learning Outcomes

i. Set up conductometric titration assembly.
ii. Record conductance.
iii. Determine specific conductance and equivalence conductance.

VI. Relevant Affective Domain related outcomes

i. Demonstrate working as leader or a team member.
ii. Follow Good housekeeping.
iii. Maintain equipment’s or instruments.

VII. Relevant Theoretical Background

The conductance of electrolyte solutions involves principles of electrochemistry, particularly those related to ion movement and electrical conductivity. Electrolytic Dissociation, Ions & their mobility. The conductance is the property of the metallic & electrolytic conductor.

Conductance = 1/ Resistance = 1/R

Units of conductance: Ω-

Specific conductance = Conductance x 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^{-} cm^{-}

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,

$\lambda = k \times V$

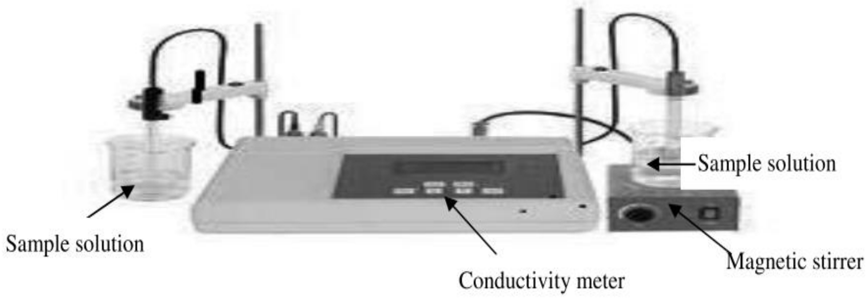
Where V is the volume in ml containing 1 g equivalent of the electrolyte.

$\lambda = k \times 1000 / N$

Where N is the normality of solution

Unit of equivalent conductance: Ω^{-} cm^{-2}equiv^{-}

VIII. Experimental set-up / Circuit diagram / Work Situation



IX. Required Resources/ apparatus/ equipment with specifications

Sr. 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°C	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, 100m1 / 250 ml	One per group
4.	Measuring cylinder	Borosil glass, 50 ml ,100m1	One per group
5.	Volumetric flask	Borosil glass,100m1,250m1	One per group
6.	Solutions strong electrolyte , Weak electrolyte , Non electrolyte.	Prepare different solutions of different concentration	As per requirement

X. Precautions to be Followed

1. Calibrate and check the accuracy of your conductivity meter regularly using standard solutions to ensure reliable and accurate measurements.
2. Handle electrodes with care to avoid damage.
3. Conductivity cell must be kept clean & standardized with KCl solution.
4. Use conductivity water for preparation of solution.
5. 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 as shown in diagram.
2. Weigh exactly 0.745 gm of KC1. Transfer in to 200 ml beaker and dissolved in 50 ml conductivity or distilled water.
3. Transfer the dissolved KC1 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 KC1 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. Observation table: Room Temperature______^{o}C.

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

XIII. Results

1. Specific Conductance ______Ω^{-} cm^{-}& equivalent conductance _______Ω^{-} cm^{-2} equiv^{-} of solution A.
2. Specific Conductance ______Ω^{-} cm^{-}& equivalent conductance ________Ω^{-} cm^{-2} equiv^{-} of solution B.
3. Specific Conductance ______Ω^{-} cm^{-}& equivalent conductance ________Ω^{-} cm^{-2} euiv^{-} of solution C.

4. Specific Conductance ______Ω^{-} cm^{-}& equivalent conductance ________Ω^{-} cm^{-2} equiv^{-} of solution D.
5. Specific Conductance ______Ω^{-} cm^{-}& equivalent conductance ________Ω^{-} cm^{-2} equiv^{-} of solution E.

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

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

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XVI. **Practical Related Questions:**

1) Write unit of conductance.
2) Calculate the amount of KCl required to prepare 0.1 N KCl
3) Describe the Calibration process of conductivity meter.

XVII. **References/ Suggestions for further Reading**

Sr. No.	Title	Author	Publisher
1	Engineering Chemistry	Jain and Jain	National Council of Education Research and Training, New Delhi, 2010, ISBN : 8174505083
2	Engineering Chemistry	Dara, S. S.	National Council of Education Research and Training, New Delhi, 2015, ISBN : 8174505660
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7.	You-Tube link	NITTTR Chandigarh Technology Enabled Learning	https://www.youtube.com/watch?v=WhyMOVvAu3s

XVIII. Assessment Scheme

Performance Indicators		
Sr. No.	**Process Related (15 Marks)**	**Weightage (60%)**
1	Preparation of 0.1 N KCl	10%
2	Calibration of conductivity cell	10%
3	Conductance of solutions	30%
4	Working in Team	10%
Product	**Related (10 Marks)**	**40%**
5	Calculations for Specific conductance	10%
6	Calculations for Equivalent conductance	10%
7	Practical related questions	10%
8	Submitting the manual in time	10%
Total (25 Marks)		**100 %**

Marks Obtained

Process Related (15)	Product Related (10)	Total(25)	Dated Signature of Faculty

List of Student Team Members

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Practical No. 15 . Determination of Equivalence Point Using Conductivity Meter.

I. Practical Significance

The determination of the equivalence point using a conductivity meter holds practical significance in various analytical and experimental contexts, particularly in titrations. Conductivity meters contribute to ensuring the accuracy and reliability of titration results in these industries, meeting regulatory requirements. Conductivity meters can be adapted for use in non-aqueous solutions, providing a versatile tool for a broader range of titrations. Conductivity meters overcome this limitation by offering a sensitive and quantitative method for determining the equivalence point in titrations involving weak acids or bases.

II. Industry or employer expected outcomes

1. Measurement skills
2. Calibration of instrument
3. Calculations
4. Monitor Processes
5. Plotting Graph

III. Relevant Course Outcome

CO6-Use appropriate fuel and electrolyte for engineering applications.

IV. Practical Outcome

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

V. Laboratory Learning Outcomes

1. Set up conductometric titration assembly.
2. Record conductance.
3. Determine equivalence point.

VI. Relevant Affective Domain related outcomes

1. Demonstrate working as leader or a team member.
2. Follow Good housekeeping.
3. Maintain equipment’s or instruments.

VII. Relevant Theoretical Background

Conductometric titration is suitable for weak acid-base titrations where visual indicators may not provide clear endpoints. Conductometric titration involves monitoring changes in conductance during a titration.

Conductance is related to the concentration of ions in the solution. The determination of the equivalence point in the titration of acetic acid (a weak acid) and ammonium hydroxide (a weak base) using a conductivity meter involves understanding key concepts related to weak acid-base equilibria and conduct metric titrations. Acetic acid is a weak acid. Ammonium hydroxide is a weak base. The ionization equilibrium reactions influence the conductance behavior during titration.

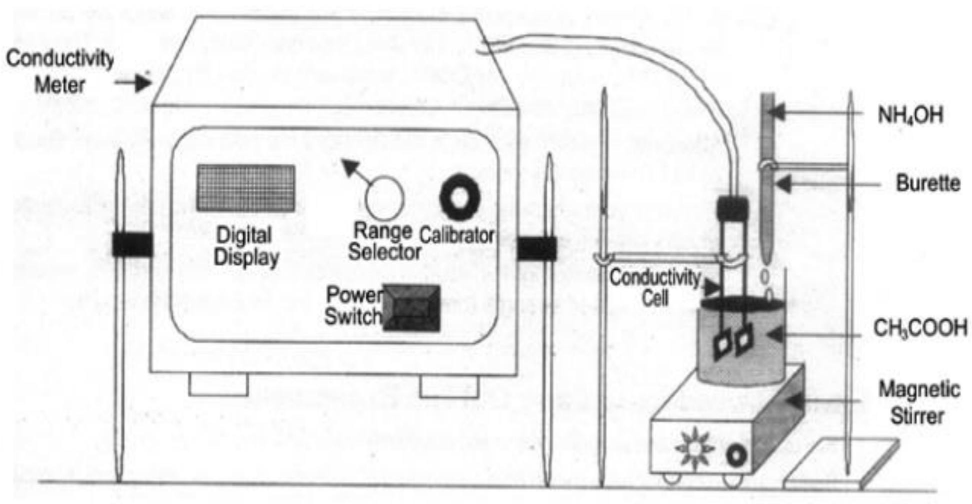
Acetic acid ionization: $CH_3COOH \rightleftharpoons CH_3COOH^- + H^+$

Ammonium hydroxide ionization: $NH_4OH \rightleftharpoons NH_4^+ + OH^-$

Acetate ion (CH_3COO^-) is formed from acetic acid. Ammonium ion (NH_4^+) is formed from ammonium hydroxide. In a titration between CH_3COOH and NH_4OH, initially, the conductance of the CH_3COOH solution is low since it is a weak acid. As NH_4OH is added from the burette, the conductance increases due to the formation of the salt CH_3COONH_4, which has a higher degree of ionization. Upon reaching neutralization, the conductance of the solution remains constant because further addition of NH_4OH is offset by the common ion effect. The presence of CH_3COONH_4 suppresses the dissociation of NH_4OH, preventing additional ions from contributing to the conductance.

The conductivity cell comprises two platinum electrodes sealed into a glass tube, spaced 1 cm apart with a cross-sectional area of 1 cm². The cell constant is the ratio of the electrode length (in cm) to the cross-sectional area (in cm²) in a conductivity cell.

VIII. Experimental set-up / Circuit diagram / Work Situation



IX. Required Resources/ apparatus/ equipment with specifications.

Sr. 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°C	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, 100m1 / 250 ml	One per group
4	Measuring cylinder	Borosil glass, 50 ml ,100m1	One per group
5	Burette	Borosil glass 25 ml / 50m1	One per group
6	Pipette / Measuring cylinder	Borosil glass 25m1 / 10 n¯11	One per group
7	Acetic acid solution	0.01 M	
8	Ammonium hydroxide solution	pH = 10	

XI. Precautions to be Followed

1. Calibrate and check the accuracy of your conductivity meter regularly using standard solutions to ensure reliable and accurate measurements.
2. Handle electrodes with care to avoid damage.
3. Conductivity cell must be kept clean & standardized with KCl solution.
4. Use conductivity water for preparation of solution.
5. Make sure that instrument is giving stable reading.

XII. Procedure

1. Arrange the experimental setup by assembling the conductivity meter, conductivity cell, beaker containing the electrolyte solution, and a burette, following the configuration outlined in the accompanying diagram.
2. Power on the conductivity meter and perform calibration procedures according to the guidelines specified in the instrument's manual to ensure accurate measurements.
3. Clean the conductivity cell thoroughly using distilled water to eliminate any residual impurities.
4. Wash and meticulously clean the burette, conical flask, and beaker with distilled water, maintaining a contamination-free environment for the experiment.
5. Measure 50 ml of acetic acid solution using a measuring cylinder, transfer it to the beaker, and position the beaker on the magnetic stirrer.
6. Introduce the conductivity cell and a magnetic needle into the acetic acid solution, initiating the magnetic stirrer to ensure homogeneity.
7. Activate the electric current and measure the conductivity of the acetic acid solution, recording the initial data.
8. Fill the burette with NH_4OH solution up to the zero mark, ensuring precision in the titration process.

9. Begin the titration by adding 1 ml increments of NH_4OH solution from the burette to the acetic acid solution after each addition, stirring the solution thoroughly.
10. Record the conductance of the acetic acid solution in the beaker following each addition of NH_4OH solution, documenting the observations in the provided table.
11. Continue noting down conductance values until a consistent conductance level is achieved, signifying the completion of the titration.
12. Construct a graphical representation of the experiment by plotting conductance (Y-axis) against the volume of NH_4OH added from the burette (X-axis). This graph provides a visual depiction of the titration process and aids in determining the equivalence point.

XIII. Observations

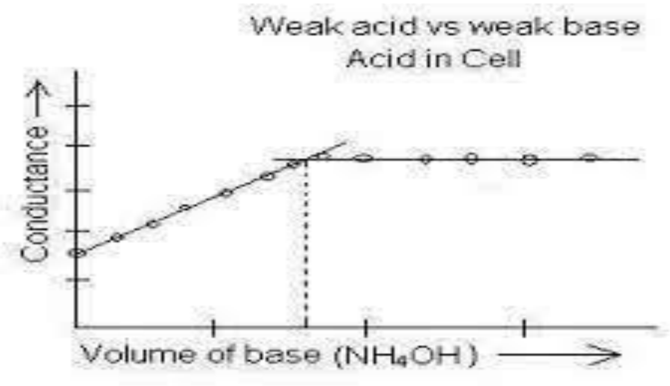
1. Solution in conical flask:______________
2. Solution in burette: ___________________
3. End Point:_____________________

XIV. Observation table:

Sr. No.	Volume of NH_4OH added	Conductance in mhos	Sr. 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	
9	8 ml		22	21 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	

- **Plotting of Graph Conductance V/s Volume of NH_4OH**

Create a graphical representation by plotting conductance (Y-axis) against the volume of NH_4OH added (X-axis). The graph exhibits a consistent pattern wherein conductance rises with successive additions of NH_4OH, culminating in a distinct peak value. Beyond this peak, the conductance levels off and remains constant. The volume of NH_4OH, represented on the X-axis, corresponding to the point of constant conductance signifies the neutralization point or equivalence point of the titration.



XV. Results

The equivalence point of acetic acid and ammonium hydroxide reaction =____ml

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

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

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XVIII. Practical Related Questions:

1. Name the ions which Cause conductivity in this experiment.
2. Write down balanced chemical reaction in this experiment.
3. Neutralization point of weak acid and weak base is determined by conductometric titration. Give reason.

XIX. References/ Suggestions for further Reading

Sr. No.	Title	Author	Publisher
1	Engineering Chemistry	Jain and Jain	National Council of Education Research and Training, New Delhi, 2010, ISBN : 8174505083
2	Engineering Chemistry	Dara, S. S.	National Council of Education Research and Training, New Delhi, 2015, ISBN : 8174505660

3	Fundamental of Electrochemistry	Bagotsky V.S.	National Council of Education Research and Training, New Delhi, 2013, ISBN : 8174506314.
4	Chemistry for Engineers	Agnihotri Rajesh	Wiley India Pvt. Ltd. New Delhi, 2014, ISBN: 9788126550784.
5	Applied Chemistry with Lab Manual	Anju Rawlley, DevdattaV. Saraf	Khanna Book Publishing Co. (P) Ltd. New Delhi, 2021, ISBN- 978-93-91505-44-8
6	Engineering Chemistry	Vairam S.	Wiley India Pvt. Ltd. New Delhi, 2013, ISBN: 978812654334

XX. Assessment Scheme

Performance Indicators		
Sr. No.	**Process Related (15 Marks)**	**Weightage (60%)**
1	Calibration of conductivity cell	10%
2	Accurate 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 equivalence point by plotting graph	20%
5	Practical related quotations.	10%
6	Submitting the manual in time	10%
	Total (25 Marks)	**100 %**

Marks Obtained

Process Related (15)	**Product Related (10)**	**Total(25)**	**Dated Signature of Faculty**

List of Student Team Members

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