KLS
Vishwanathrao Deshpande Institute of Technology
Haliyal – 581329

FIRST YEAR – CHEMISTRY CYCLE

E&CE STREAM

LAB Manual

NAME : ______________________________

Roll No./ USN : ______________________________

DIVISION : ______________________________

Semester : II			
SI.No.	**Lab Details**	**Lab Code**	**Pg. No.**
1	Engineering Chemistry	1BCHEE102/202	1 – 77
2	Introduction to C Programming	1BPLC205E	78 – 101

As prescribed by,

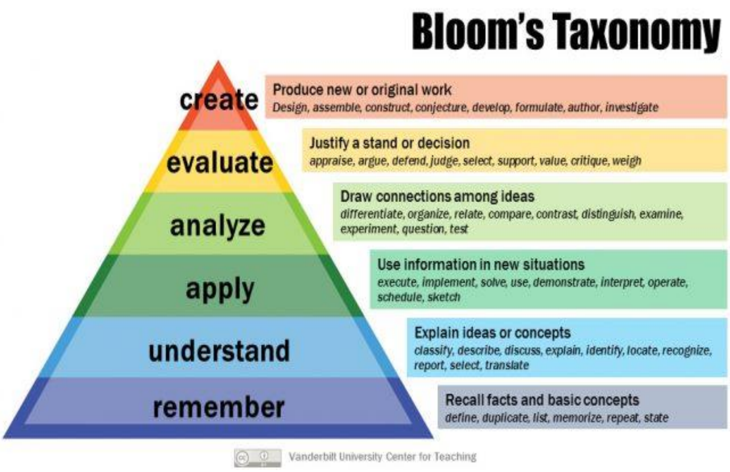
VISVESVARAYA TECHNOLOGICAL UNIVERSITY,

BELAGAVI – 590014

PROGRAM OUTCOMES(POs)

Program Outcomes as defined by NBA (PO) Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
8. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
9. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
10. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
11. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.



Vision (College)
• To nurture talent and enrich society through excellence in technical education, research and innovation.
Mission (College)
• To augment innovative pedagogy and kindle quest for interdisciplinary learning and to enhance conceptual understanding. • To build competence, professional ethics and develop entrepreneurial thinking. • To strengthen industry institute partnership and explore global collaborations. • To inculcate culture of socially responsible citizenship. • To focus on holistic and sustainable development.
Vision (Dept)
To achieve excellence in technical education, research, and innovation in computer science and Engineering by emphasizing on global trending technologies.
Mission (Dept)
• To train students with conceptual understanding through innovative pedagogies. • To imbibe professional, research, and entrepreneurial skills with a commitment to the nation's development at large. • To strengthen the industry-institute Interaction. • To promote life–long learning with a sense of societal & ethical responsibilities.

Course Outcomes
CO1: Explain the fundamental structure of a C program and primitive constructs. CO2:Apply decision-making and iterative control structures to solve simple computational problems. CO3: Develop programs using arrays and string operations to solve real-world problems.. CO4: Construct user-defined functions to modularize the solution to the given problems CO5: Build programs using structures and pointers for complex data representation and access.

Lab Manual 1

Engineering Chemistry

(1BCHEE102/202)

CO's and PO's Mapping Chart

Sl. No.	Description	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	P O9	PO 10	PO 11
1	Understand and analyze the properties, classification and applications of semiconductor materials, energy storage and conversion devices.	3	2	1	1		1					1
2	Demonstrate knowledge of nanomaterials and quantum dots including their synthesis, properties, and device applications.	3	2	1			1					1
3	Explain the role of functional polymers and composites in flexible electronic applications.	3	2	1					1			1
4	Apply experimental skills and electrochemical concepts to sensor systems and evaluate corrosion control and e-waste management techniques	3	2	1	1					1		1

Evaluation:

Integrated Lab(IPCC)		
CIE		
Particulars	**Marks**	**Total**
Conduction	04	
Performance	03	
Journal	02	
Viva Voce	01	
	10	
Total Marks	12x10	**120**
	Reduced	**15**
Lab IA		
Particulars	**Marks**	**Total**
IA	**50**	10 (Reduced)
Procedure write Up- 08 Conduction- 26 Observation and Calculation- 09 Viva- 07		
Total (CIE +Lab IA)		**25**

Mapping of Experiments with CO and PO

S.No.	Experiment Details	CO	PO
1	Estimation of total hardness of water by EDTA method	1,2,3,4	1,2,3,4,6,8, 9,11
2	Determination of chemical oxygen demand (COD) of industrial effluent sample.	1,2,3,4	1,2,3,4,6,8, 9,11
3	Estimation of iron in TMT bar by diphenyl amine indicator method.	1,2,3,4	1,2,3,4,6,8, 9,11
4	Determination of total alkalinity of given water sample.	1,2,3,4	1,2,3,4,6,8, 9,11
5	Determination of Hydrogen Peroxide in PCB Cleaner (Permanganate method)	1,2,3,4	1,2,3,4,6,8, 9,11
6	Estimation of acid mixture by conductometric sensor (Conductometry)	1,2,3,4	1,2,3,4,6,8, 9,11
7	Estimation of iron in rust sample by Potentiometric sensor (Potentiometry)	1,2,3,4	1,2,3,4,6,8, 9,11
8	Determination of pKa of vinegar using pH sensor (Glass electrode)	1,2,3,4	1,2,3,4,6,8, 9,11
9	Estimation of copper present in e-waste by optical sensor (Colorimetry).	1,2,3,4	1,2,3,4,6,8, 9,11
10	Determination of Viscosity coefficient of conductive Inks	1,2,3,4	1,2,3,4,6,8, 9,11
11	Smartphone-Based colorimetric estimation of total phenolic content in coffee products.	1,2,3,4	1,2,3,4,6,8, 9,11
12	Green synthesis of copper nanoparticles for conductive ink applications	1,2,3,4	1,2,3,4,6,8, 9,11

EXPERIMENT WISE LESSON PLAN

Experiment No.1	
Name	Estimation of total hardness of water by EDTA method
Objectives	• To enable students to understand the concept of water hardness and its significance. • To develop skills in accurate titration and endpoint detection.
Experiment No.2	
Name	Determination of chemical oxygen demand (COD) of industrial effluent sample
Objectives	• To help students understand the importance of COD in environmental monitoring. • To familiarize students with oxidation–reduction titration methods. • To develop awareness about industrial wastewater pollution.
Experiment No.3	
Name	Estimation of iron in TMT bar by diphenyl amine indicator method.
Objectives	• To enable students to determine metal content in engineering materials. • To enhance analytical skills in quantitative chemical analysis.
Experiment No.4	
Name	Determination of total alkalinity of given water sample.
Objectives	• To help students understand alkalinity and its role in water quality. • To train students in acid–base titration techniques.
Experiment No. 5	
Name	Determination of Hydrogen Peroxide in PCB Cleaner (Permanganate method)

Objectives	• To familiarize students with the analysis of industrial chemical products. • To improve students' laboratory handling and safety skills.
Experiment No. 6	
Name	Estimation of acid mixture by conductometric sensor (Conductometry)
Objectives	• To help students understand the relationship between conductivity and concentration. • To develop skills in using modern analytical instruments.
Experiment No. 7	
Name	Estimation of iron in rust sample by Potentiometric sensor (Potentiometry)
Objectives	• To help students understand corrosion analysis. • To develop competence in handling electrochemical sensors.
Experiment No. 8	
Name	Determination of pKa of vinegar using pH sensor (Glass electrode
Objectives	• To help students understand acid dissociation and pKa concepts. • To train students in the use of pH meters. • To develop skills in interpreting titration curves.
Experiment No.9	
Name	Estimation of copper present in e-waste by optical sensor (Colorimetry).
Objectives	• To introduce students to colorimetric analysis techniques. • To raise awareness about e-waste recycling and resource recovery. • To develop skills in optical measurement and data analysis
Experiment No.10	
Name	Determination of Viscosity coefficient of conductive Inks
Objectives	• To help students understand viscosity and fluid properties. • To provide practical exposure to rheological measurements. • To relate material properties to engineering applications.

Experiment No.11	
Name	Smartphone-Based colorimetric estimation of total phenolic content in coffee products.
Objectives	• To expose students to modern, low-cost analytical techniques. • To demonstrate applications of chemistry in food analysis. • To develop skills in digital data acquisition and analysis.
Experiment No.12	
Name	Green synthesis of copper nanoparticles for conductive ink applications.
Objectives	• To introduce students to green chemistry principles. • To develop awareness of sustainable material development.

LIST OF EXPERIMENTS

LAB SAFETY & USAGE INSTRUCTIONS

1. Study theory behind the experiment before attending the Laboratory.

2. Keep the work bench and sink (wash basin) neat and clean. Do not allow used filter papers, broken pieces of glass, used match sticks, etc., to lie on the work bench –throw them into the available dust bin nearby.

3. Keep the apparatus clean and arrange them properly.

4. Handle the chemicals and reagent bottles carefully.

5. Take the prescribed quantities of chemicals and reagents only.

6. Do not pour any excess reagent, taken by chance, back into the reagent bottle, as it is likely to contaminate the entire solution in the reagent bottle.

7. Close the reagent bottles with their lids and keep them in their proper places, after use.

8. Water is a precious commodity; do not waste it; close the water tap immediately after use.

9. It is said, ‘Prevention is better than cure’ - take care to prevent fire accidents in the Lab.

10. Make it a habit to record all observations in your Observation Note Book, as and when you carry out an experiment; writing observations on loose bits of paper is a bad habit.

11. Do not forget to bring your Laboratory Record while attending the lab.

12. Always wear shoes and laboratory apron while you are in the lab.

13. Wash chemical spills on your body, if any, immediately with plenty of tap water.

14. Before leaving the Laboratory, wash the apparatus clean, keep them in proper place and make your work bench tidy.

Experiment 1

Estimation of Total Hardness of Water by EDTA Method

Aim: To determine the total hardness of water

Chemicals: Na_2EDTA, Ammonia, NH_4OH-NH_4Cl buffer & Eriochrome black-T indicator

Theory: Hardness of water is the soap-consuming factor of water. Hard water does not lather well with soap. Soft water lathers well with soap. There are two types in hardness. Temporary hardness (can be removed by simply boiling the water) and permanent hardness (cannot be removed by boiling instead, can be removed by chemical methods). Hard water poses problems of excess soap consumption in domestic regions and scale & sludge formations in boilers and in industries. Soft water is most suited for many applications. Bicarbonates of calcium and magnesium cause temporary hardness. Chlorides, sulfates & nitrates of calcium and magnesium cause permanent hardness. It may be noted that hardness is due to Ca^{2+} & Mg^{2+} ions and not due to the anions such as, Cl^-, NO_3^-, SO_4^{2-}, HCO^-, etc. Total hardness is the sum of temporary hardness and permanent hardness. Though, hardness is due to different metal salts, it is expressed in equivalent amounts of $CaCO_3$ ($CaCO_3$ is chosen because, it is most insoluble in water and its molecular weight is a rounded number, 100). Hardness is expressed in terms of ppm (parts of $CaCO_3$ equivalents per million parts of water) or mg/L (milligrams of $CaCO_3$ equivalents per liter of water).

Hardness is determined by EDTA complexometric method (EDTA = Ethylene Diamine Tetra Acetic acid). The method involves the titration of known volume of hard water against standard EDTA solution using eriochrome black-T (EBT) as metal ion indicator at pH = 10 (reaction is complete at this pH and colour change happens to be sharp at the end point). The indicator forms relatively less stable wine red coloured Ca-EBT & Mg-EBT complexes. When EDTA solution is added, initially it will react with freely available Mg^{2+} & Ca^{2+} ions and towards the end point, it snatches Ca^{2+} and

Mg^{2+} ions from the less stable Ca-EBT & Mg-EBT complexes to form more stable, colourless Ca-EDTA & Mg-EDTA complexes. Free eriochrome black-T is liberated which imparts blue colour in the medium of pH =10. This marks the end of titration.

On adding indicator: Ca^{2+} + EBT □□ Ca-EBT complex

Mg^{2+} + EBT □□ Mg -EBT complex

(wine red)

At end point: Ca-EBT complex + EDTA □□ Ca-EDTA complex + EBT

(wine red) (colourless) (blue)

Mg-EBT complex + EDTA □□ Mg-EDTA complex + EBT

(wine red) (colourless) (blue)

Knowing the molarity and volume of EDTA consumed, hardness of water is calculated.

Procedure:

A. Preparation of standard Na_2EDTA solution:

Take the beaker containing about 1.0 g Na_2EDTA crystals and note down the beaker number. Add 5 mL of 1:1 ammonia solution, a little of distilled water and dissolve the crystals. Transfer the solution into a 250 mL capacity standard flask through a funnel. Rinse the beaker with little of distilled water at a time and transfer the rinsing into the standard flask. Dilute the solution up to the mark with distilled water. Shake well to make the solution uniform.

B. Determination of total hardness of water:

Take a clean burette and rinse it with distilled water and then with standard EDTA solution prepared. Now, fill the burette with standard EDTA solution. Take a clean conical flask and rinse it with distilled water. Take a clean pipette and rinse it with the given sample of hard water. Pipette out 25 mL of hard water into the conical flask. Add 2 mL of buffer solution (NH_4OH + NH_4Cl) and a pinch or 2-3 drops of eriochrome black-T indicator (it is also known as, solochrome black). Titrate this solution against standard Na_2EDTA solution adding 1.0 mL at a time until the change in colour from wine red to clear blue (pilot reading). Repeat the titration adding 0.1 mL towards the end point for two

correct readings. Let the average of burette readings be P mL. Calculate the total hardness of the given sample of water.

Result:

The total hardness of the given sample of water= ………….. ppm (or mg/L)

Observations and calculations:

A. Preparation of standard Na_2EDTA solution:

Beaker number = ………………

Weight of Na2EDTA taken *(given)* =W = ………..g

Volume of standard solution prepared from W g of Na_2EDTA = 250 ml

Molarity of Na_2EDTA solution, Y= $\frac{4 \text{ x } W}{372.25} = \frac{4 \text{ x } ....}{372.25} =$ …...........M

B. Determination of total hardness of water:

Solution taken in burette solution : Y = ………… molar Na_2EDTA

Solution taken in conical flask : 25 mL of hard water sample

+ 2 mL NH_4OH-NH_4Cl buffer solution (pH = 10)

Indicator : Eriochrome black – T (a pinch of indictor powder or 2 drops of solution)

Color change at end point : Wine red to clear blue

Burette readings:

	Trial-1 (Pilot)	Trial-2	Trial-3
Final Reading			
Initial Reading			
Difference (ml)			

Average of agreeing volumes (P) =………………ml

It is known that

1000 mL of 1 molar Na_2EDTA solution= 100 g of $CaCO_3$

(Molecular weight of $CaCO_3$ ***= 100)***

1 mL of 1 molar Na_2EDTA solution = 0.1 g of $CaCO_3$

P mL of Y molar Na_2EDTA solution = 0.1 x P x Y g of $CaCO_3$

= 0.1 x ….. x ….. g of $CaCO_3$

Z = ………………….. g of $CaCO_3$

Now, 25 mL (= 25 g) of hard water = Z = ……………….. g of $CaCO_3$

□ 10^6 mL (□ 10^6 g) of hard water= $\frac{Z X 10^6}{25}$ = $\frac{\ldots\ldots\ldots\ldots X\ 10^6}{25}$

= …………… g of $CaCO_3$

Hence, total hardness of given sample of water

= ……………. grams per million grams

= ……………. ppm or mg/ml

VIVA QUESTIONS & ANSWERS

1. What is meant by hard water?

Ans. Water not giving lather with soap is known as hard water.

2. What is the unit of hardness of water?

Ans. It is ppm of calcium carbonate.

3. What are the types of hard water?

Ans. Temporary due to the presence of bicarbonates of calcium and magnesium

Permanent hard ness is due to the presence chlorides and sulfates of calcium and magnesium.

4. What is the type of titration is carried out for the estimation of total hardness?

Ans: Complexometric titration with EDTA salt

5. What is the structural formula of EDTA?

Ans:

```
CH2COOH   CH2COOH
|              |
N-CH2-CH2-N
|              |
CH2COOH   CH2COOH
```

6.Why disodium salt of EDTA is preferred to EDTA?

Ans. Disodium salt dissolves readily in water, whereas EDTA is sparingly soluble

7. How do you calculate Molarity of EDTA?

Ans. Molarity of EDTA = Number of grams of EDTA in 1000 ml / Molecular wt. (372)

8.What is a buffer solution?

Ans. Addition small quantity of acid or alkali does not alter the pH of solution.

9. Why ammonia solution is added while preparing standard solution of EDTA?

Ans. This is to increase the rate of dissolution of EDTA in water.

10. Why is ammonia-ammonium chloride buffer added?

Ans. This buffer is added to maintain pH of 10-11

11. Why is the indicator Eriochrome Black T shows wine red at the beginning and blue color at the end?

Ans. The indicator forms weak complex with calcium and magnesium present in hard water and gives wine red color at pH 10. During titration the EDTA forms stronger complex with calcium and magnesium ions and at the end point EDTA liberates the indicator, which is blue in color at pH 10.

12. Why is titration-involving EDTA carried out slowly towards end point?

Ans. Since the formation of metal complex is very slow, the titration has to be done slowly.

13. What is importance of hardness data?

Ans. It is important in determining the suitability of water for domestic and industrial use. Determination of hardness of water serves as a basis for routine control of softening process.

14. Define ppm?

Ans: No. of parts of $CaCO_3$ equivalent to hardness causing ions present in million parts of water.

15. Why is hardness expressed only in terms of $CaCO_3$?

Ans : Because it is highly insoluble salt and its molecular weight is 100 which make the calculation easier.

16. How many bonding sites are present in EDTA?

Ans : Six bonding sites (called hexadented ligand). Namely, two nitrogen atoms and four oxygen atoms.

17. What is meant by ligand?

Ans :A species which can donate a lone pair of electrons to the metal atom is called ligand.

18. What is buffer solution?

Ans :Solution which resist the change in the pH of the solution upon the addition of small amount of acid or base.

19. How pH change takes place during the course of the reaction?

Ans :Metal ion combines with EDTA to form complex, leading to the liberation of H^+ ions which results in the change in pH of the solution.

20. Give the other name for Eriochrome black-T indicator?

Ans :Solochrome black-T.

21. What is the end point in the determination of total hardness of water?

Ans :Change of color from wine red to pure blue.

22. How does water acquire temporary hardness?

Ans : Due to the presence of bicarbonates of calcium and magnesium ions.

23. How do you remove temporary hardness?

Ans : By boiling the water sample.

24. What happens when the hard water sample is boiled?

Ans :The bicarbonates salts of calcium and magnesium get converted into insoluble carbonates. This can be removed by decantation or filtration.

25. How are the waters classified based on the degree of hardness?

Ans : Soft water	0 – 75 mg/litre
Moderately hard water	75 – 150 mg/litre
Hard water	150 – 300 mg/litre
Very hard water	> 300 mg/litre

26. What do you mean by total hardness of water?

Ans : The sum of both temporar and permanent hardness is called total hardness of water.

Experiment 2

Determination of COD of Industrial wastewater sample

Aim: To determine the COD of given waste water sample.

Chemicals: $HgSO_4$, Ag_2SO_4, H_2SO_4 reagent, $K_2Cr_2O_7$, FAS, Ferroin indicator

Theory: Chemical oxygen demand is a measure of chemically oxidisable pollutants present in water. This includes both biodegradable and non- biodegradable matter. COD is a measure of pollutional strength of the waste water. It is defined as the number of milligrams of oxygen required to oxidise the pollutants in one liter of waste water by strong chemical oxidant such as, acidified $K_2Cr_2O_7$ in the presence of Ag+ as catalyst. Some organics do not undergo easy oxidation. Therefore, Ag+ ion is used as catalyst. However, Cl^- ions in natural / waste waters will precipitate Ag+ ion as AgCl making it unavailable for catalytic activity. This is prevented by using mercuric sulfate.

A known volume of the sample water is treated with mercuric sulfate, which binds the chloride ions in water. Then, Ag_2SO_4-H_2SO_4 reagent is added followed by the addition of excess of $K_2Cr_2O_7$. The mixture is refluxed for three hours and excess $K_2Cr_2O_7$ is back titrated using standard FAS. A blank titration is carried out to know the amount of $K_2Cr_2O_7$ taken for main titration. A typical oxidation reaction with glucose as pollutant is presented below.

Addition of $HgSO_4$ $Hg^{2+} + 4Cl^-$ □□□ $[HgCl_4]^{2-}$

On adding Ag_2SO_4-H_2SO_4 Ag+ ions are released; Acidic medium is provided for dichromate.

Oxidation of $K_2Cr_2O_7 + 4H_2SO_4$ □□□ $K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3(O)$

Pollutant: $C_6H_{12}O_6 + 12(O)$ □□□ $6CO_2 + 6H_2O$

Titration of un- reacted $K_2Cr_2O_7$: $2FeSO_4 + H_2SO_4 + (O)$ □□□□ $Fe_2(SO_4)_3 + H_2O$

(from FAS) (from K2Cr2O7)

At end point: $[Fe(C_{12}H_8N_2)_3]^{3+} + e^- \rightleftharpoons [Fe(C_{12}H_8N_2)_3]^{2+}$

(pale blue) (deep red)

(ferroin in presence of $K_2Cr_2O_7$) (ferroin in absence of $K_2Cr_2O_7$)

Knowing the normality and volume of FAS consumed in main titration (back- titration) and in blank titration, COD is determined.

Procedure:

A Preparation of standard FAS solution:

Take the beaker containing about 5-7 g of FAS and note down the beaker number. Add 1 test tube full of dilute H_2SO_4 followed by about 50 mL distilled water, dissolve and transfer the solution into a 250 mL standard flask. Wash the beaker and transfer the rinsing also into the standard flask. Dilute up to the mark with distilled water. Shake the solution well to make it uniform.

B Determination of COD:

Take a clean burette and rinse it with standard FAS solution. Now, fill the burette with standard FAS solution. Take a clean pipette and rinse it with the waste water sample. Pipette out 25 mL of waste water into a clean conical flask*. Add one test tube of 1:1 dilute H_2SO_4. Pipette out 25 mL of the $K_2Cr_2O_7$ solution in the same conical flask and add 3-4 drops of ferroin indicator. Back titrate the unreacted $K_2Cr_2O_7$ in the conical flask against standard FAS solution from the burette in increments of 1.0 mL until change in colour from bluish green to reddish brown. Repeat the titration adding 0.1 mL towards the end point for two correct readings. Let the average of burette readings be P mL.

C Blank titration:

Carry out a titration similar to the main titration, taking only $K_2Cr_2O_7$ & H_2SO_4 without the sample waste water (pilot reading). Repeat the titration for two correct readings. Let the average of correct readings be Q mL. Calculate the chemical oxygen demand.

***The sample waste water given here contains only easily oxidisable pollutants. Therefore,

(i) mercuric sulphate &

(ii) Ag+ ion catalyst are not added and

(iii) refluxing the reaction mixture is avoided

Result:

Chemical oxygen demand (COD) of given waste water sample =………..ppm.

Observations and calculations:

A. Preparation of standard FAS solution:

Beaker number = ………………

Weight of FAS taken for analysis *(*ask the staff in-charge*)* = W = ... g

Volume of standard solution prepared from W g of FAS = 250 mL

Normality of FAS solution, Y= $\frac{4 \times W}{392.13} = \frac{4 \times ......}{392.13}$ = ...

(Equivalent weight of FAS = Molecular weight of FAS = 392.13)

B. Determination of COD of waste water:

Solution taken in the burette : Y = …………….. Normal FAS solution

Solution taken in the conical flask : 25 mL of waste water sample

+ 25 mL of $K_2Cr_2O_7$ solution

+ 1 test tube 1:1 H_2SO_4

Indicator : Ferroin (3-4 drops)

Color change at end : Bluish green to reddish brown

Burette readings:

	Trial-1 (Pilot)	Trial-2	Trial-3
Final Reading			
Initial Reading			
Difference (ml)			

Average of agreeing volumes (P) =……………..ml

C. Blank titre value (given)

Burette reading when 25 mL of acidified $K_2Cr_2O_7$ is titrated against

Y = ………….. Normal FAS solution

Q =………ml

Now,

Consumption of $K_2Cr_2O_7$ by

25 mL waste water in terms of FAS = (Q − P) ml of Y normal FAS

= .... – ……. mL of ………. normal FAS.

It is known that,

1000 mL of 1 normal FAS = 8 g of oxygen

(Equivalent weight of Oxygen = Atomic weight of Oxygen = 8)

1 mL of 1 normal FAS = 0.008 g of oxygen

(Q − P) mL of Y normal FAS = 0.008 x (Q − P) x Y g of oxygen

= 0.008 x ……… x.…… g of oxygen

= Z = …………… g of oxygen

Now, 25 mL of waste water requires, Z = …………… g of oxygen

10 mL of waste water requires $\frac{Z \times 10^6}{25}$

- $\frac{\text{----} \times 10^6}{25}$ = -------------g of Oxygen

The chemical oxygen demand (COD)

of the given sample of waste water = -------------ppm

VIVA QUESTIONS & ANSWERS

1. What is COD?

Ans. It is the amount of oxygen required for chemical oxidation of organic and inorganic matter present in wastewater by a strong oxidizing agent. It is expressed mg per 1000 ml of wastewater.

2. What is BOD?

Ans. It is the amount of oxygen required by the microorganisms for biological oxidation of organic matter in wastewater in five days at 20^0C at aerobic condition.

3. What are oxidisable constituents of wastewater?

Ans. The oxidisable constituents of wastewater include straight chain aliphatic compounds, aromatic compounds, alcohols, and other oxidisable materials.

4. What general groups of organic compounds are not oxidized in the COD test?

Ans. Aromatic hydrocarbons and pyridine are not oxidized in COD

5. What is the role of silver sulfate?

Ans. Silver sulfate acts as a catalyst in oxidation of straight chain aliphatic hydrocarbons and acetic acid.

6. What is the role of mercuric sulfate?

Ans. Chloride ions are present in wastewater and the same gives erroneous result. Mercuric ions bind the halide ions present in wastewater to form poorly ionized mercuric halide and prevent the reaction between silver ions and halide.

7. What are the products formed in COD analysis?

Ans. During COD analysis, organic matter is completely oxidized to carbon dioxide and water.

8. Why is sulfuric acid added during the preparation of standard FAS solution?

Ans. The sulfuric acid is added to prevent the hydrolysis of ferrous sulfate.

9. What is the indicator used?

Ans. Ferroin. It is ferrous 1, 10-phenanthroline sulfate.

10. What is the unit of COD?

Ans. COD is expressed as mg of oxygen per 1000 ml of wastewater.

11. Mention a few application s of COD.

Ans. It is extensively used in the analysis of industrial wastes

It gives an idea of substances resistant for oxidation by microorganisms

12. What is the role of 1:1 sulfuric acid added in the conical flask?

Potassium dichromate acts as oxidizing agent in acid medium

13,How is 150 ml of 6N sulfuric acid prepared with 36N sulfuric acid?

$N_1 \times V_1 = N_2 \times V_2$

6 x 150 = 36 x V_2

V_2 = 6 x 150/36 = 25 ml

25 ml of 36N sulfuric acid is added to 125 ml of water to get 6N of 150 ml of sulfuric acid.

14. Which is the oxidizing agent used in COD experiment?

Acidified potassium dichromate solution.

15. What is the full form of FAS? Give its composition?

Ferrous ammonium sulphate. $FeSO_4\ (NH_4)_2\ SO_4\ .6H_2O$

16. Why is sulphuric acid added during the preparation of std. FAS solution?

Sulphuric acid is added to prevent the hydrolysis of ferrous sulphate to ferrous hydroxide.

17. What is the end point in COD estimation?

Bluish green to reddish brown.

18. Why is COD value is higher that BOD for the same water sample?

This is because COD involves complete oxidation of both organic and inorganic compounds, where as BOD involves the oxidation of only the organic compounds.

19. What is the advantage of COD over BOD?

COD can be obtained in a short interval of time and it helps in estimation of both organic and inorganic oxidizable compounds in waste water.

20. What is meant by blank titration?

The titration, which is carried out by omitting the sample under consideration, is called blank titration.

21. What is the purpose of conducting blank titration?

To find out the amount of potassium dichromate (oxygen) consumed by the organic and inorganic wastes present in water sample.

22. What is sewage?

Sewage is commonly a cloudy dilute aqueous solution contaububg human and house hold waste water, industrial wastes, ground wastes,street washings. Sewage contains organic and inorganic matters in dissolved suspended and colloidal states.

23. What is meant by industrial sewage?

The waste water coming out of industrial establishements such as chemicals plants, fertilizer industries, leather tanneries, sugar and paper industries, breweries, textile mills, oil refineries, pharmaceutical units is called an industrial sewage.

24. What general groups of organic compounds are not oxidized in the COD test?

Aromatic hydrocarbons and pyridine are not oxidized in COD test.

25. Explain the colour changes encountered during the titration.

Ferroin indicator is red in colour in the reduced form with the composition, $[Fe(o\text{- }Phen)3]^{2+}$. When it is added to sewage containing excess of K2Cr2O7, an oxidizing agent, gets converted into its oxidized form, $[Fe(o\text{- }Phen)3]^{3+}$, which is pale blue (bluish green colour observed). The green colour observed during the course of titration is due to the reduction of K2Cr2O7 by FAS to green Cr2(So4)3. At the end point, red colour reappears as the indicator is restored to its original form, i.e. reduced form.

26. What is the limitation of COD?

One of the chief limitations of COD test is its inability to differentiate between biologically oxidisable and biologically inert organic matter. Also, it does not provide any evidence of the rate at which the biologically active material would be stabilized under conditions that exist in

Experiment 3

Estimation of iron in TMT bar by Diphenyl amine indicator method

AIM: Determination of the amount of ferrous iron present in the given volume of a solution (100ml) using a standard solution of potassium dichromate.

PRINCIPLE:

$$K_2Cr_2O_7 + 6FeSO_4 + 7H_2SO_4 \longrightarrow K_2SO_4 + 3\ Fe_2\ (SO_4)_3 + Cr_2\ (SO_4)_2 + 3H_2O$$

$$Fe^{2+} + Cr^{6+} \longrightarrow Fe^{3+} + Cr^{3+}$$

In the present experiment, ferrous iron to be determined, is oxidized to ferric iron by potassium dichromate in acid medium. The end point is determined by using a redox indicator (for e.g., DPA).

Potassium dichromate is relatively a weak oxidizing agent compared to permanganate and the reaction is slow near the end point. This is mainly due to accumulation of Fe^{+3} ions. Syrupy phosphoric acid binds these ions as ferric phosphate and removes them from the reaction sphere, which facilitates the acceleration of the main reaction. The electrode potential of Fe(III)-Fe(II) system is found to be -0.68V in acid medium (0.5M H_2SO_4) and that of the indicator DPA is -0.76V in 0.5M H_2SO_4. The reduction potential of indicator system is not sufficiently high. Hence the addition of phosphoric acid to lower the reduction potential of Fe(II)--Fe(III) couple by complexation improves end point considerably. As the titration is carried out by addition of $K_2Cr_2O_7$, blue-violet colour is obtained at the endpoint.

Procedure:

PART-A: Preparation of 0.05M potassium dichromate solution:

About 0.735g of $K_2Cr_2O_7$ is weighed accurately in a clean, dry weighing bottle and transferred into a 250ml volumetric flask through a glass funnel. The substance is dissolved completely in a minimum amount of distilled water and the solution is made up to the mark. The solution is made homogeneous by thorough shaking in the stoppered volumetric flask. The particulars of the weights used are tabulated and the concentration of potassium dichromate is calculated using the given formula.

PART-B: Determination ferrous in given iron solution

The given sample of TMT bar solution (ferrous iron solution) is made up to the mark with distilled water (in the given 100 ml volumetric flask) and shaken well to make it homogeneous in concentration. Now, 10 ml of the solution is drawn through a pipette into a 250ml clean conical flask. To this, 20ml of distilled water, 3ml of acid mixture (sulphuric acid and phosphoric acid), 2-3 drops of DPA indicator solution are added with complete mixing. This mixture is then titrated with standard potassium dichromate solution run down from the burette. The contents of the conical flask are swirled throughout the titration till the end point is reached. The end point is determined by a change in colour of the solution from colourless to blue-violet colour. The same procedure of titration is repeated until concurrent readings are obtained and all the observations are tabulated.

Burette: Std. Potassium dichromate solution

Conical flask: 10 ml of TMT bar solution + 20ml of distilled water + 3ml of acid mixture (sulphuric acid and phosphoric acid) + 2-3 drops of DPA

Indicator: 2-3 drops of Diphenyl amine (DPA)

End Point: Blue-violet colour

Result: The Amount of ferrous iron [Iron (II)] present in given 100ml solution

= ---------------- g/ml

Observation and Calculation:

Preparation of 0.05M potassium dichromate solution:

Weight of weighing bottle + $K_2Cr_2O_7$ salt =W1 =…………..g
Weight of empty bottle =W2 =…………..g
Amount of $K_2Cr_2O_7$ salt transferred = W1–W2 =……………g

Normality of $K_2Cr_2O_7$ solution is= $\dfrac{(W2-W1) \times 4}{\textit{Equivalent weight of } K_2Cr_2O_7 \ (49}$

$$= \frac{(W2-W1)\ X\ 4}{49}$$

= …………**N1**

Determination ferrous in given iron solution

Burette Reading	**I**	**II**	**III**
Initial B.R			
Final B.R			
Volume of $K_2Cr_2O_7$ solution consumed (cm^3)			

Volume of $K_2Cr_2O_7$ solution consumed =……..(V1) cm^3

(N1 X V1) $K_2Cr_2O_7$ = (N2 X V2) iron(II) solution

$$N2 = \frac{N1\ X\ V1}{V2}$$

$$= \frac{N1\ X\ V1}{10}$$

Amount of ferrous iron (II) present in given 100ml solution = $\frac{N2\ X\ 55.86\ X\ 100}{1000}$

= ---------------- g/ml

VIVA QUESTIONS & ANSWERS

1. **What is the aim of the experiment?**

   To determine the percentage of iron present in a TMT steel bar using the diphenylamine indicator method.

2. **Principle of the experiment**

   Iron in the TMT bar is converted into ferrous ions and oxidized to ferric ions using potassium dichromate. Diphenylamine indicates the end point by a color change.

3. **Why is diphenylamine used as an indicator?**

   It is a redox indicator that gives a blue-violet color at the end point.

4. **Which oxidizing agent is commonly used?**

   Potassium dichromate ($K_2Cr_2O_7$).

5. **Why potassium dichromate is preferred over potassium permanganate?**

   It is a primary standard, stable, available in pure form, and gives a sharp end point.

6. **What is the role of concentrated hydrochloric acid?**

   It dissolves iron from the TMT bar and converts it into soluble ferrous chloride.

7. **Why is phosphoric acid added during titration?**

   It complexes ferric ions and gives a sharp end point.

8. **What color change is observed at the end point?**

   Green to blue-violet.

9. **What type of titration is involved?**

   Redox titration.

10. **What is the chemical reaction involved?**

    $6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$

11. **Why is sulfuric acid preferred over nitric acid?**

    Nitric acid is an oxidizing agent and may oxidize ferrous ions prematurely.

12. **What is TMT bar?**

    Thermo-Mechanically Treated steel bars used in construction.

13. **What percentage of iron is usually present in TMT bars?**

    Approximately 98–99%.

14. **Why is the solution heated during dissolution?**

    To speed up dissolution of iron.

15. **What precautions should be taken?**

    Avoid overheating, use fresh indicator, add indicator near end point, titrate slowly.

16. **What happens if excess indicator is added?**

    It may cause early end point and inaccurate results.

17. **Is diphenylamine a self-indicator?**

    No, it is an external redox indicator.

18. **Why is the solution cooled before titration?**

    High temperature affects indicator behavior and accuracy.

Experiment 4

Determination of Total Alkalinity of given water sample

Theory: Alkalinity is due to the substances that can cause the formation of hydroxyl (OH^-) ions which in turn can react with strong acids. Alkalinity of a water sample is a measure of its capacity to neutralize acids. Substances that cause the alkalinity are of three types.

(i) Hydroxides _ NaOH, $Ca(OH)_2$, $Mg(OH)_2$;

(ii) Carbonates _ Na_2CO_3, $CaCO_3$, $MgCO_3$;

(iii) Bicarbonates _ $NaHCO_3$, $Ca(HCO_3)_2$, $Mg(HCO_3)_2$.

Total alkalinity, A_t, is the sum of the alkalinity due to hydroxides, A_h, alkalinity due to carbonates, A_c and the alkalinity due to bicarbonates, A_b.

$$A_t = A_h + A_c + A_b$$

When a sample of alkaline water is treated with a strong acid such as HCl, the following reactions occur.

(1) $NaOH + HCl \longrightarrow NaCl + H_2O$ (for hydroxides)

(2) $Na_2CO_3 + HCl \longrightarrow NaHCO_3 + NaCl$ (for carbonates)

(3) $NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$ (for bicarbonates)

Alkalinity is determined by titrating a known volume of water sample against a strong acid using a suitable indicator. Two types of alkalinity are evaluated based on the whether the indicator used is methyl orange or phenolphthalein.

(i) Alkalinity due to methyl orange, $A_{m.o}$. When methyl orange is used, the colour change at the end point is obtained only after all the three reactions given by equations (1), (2) and
(3) are complete. Hence methyl orange gives the total alkalinity.

$$A_t = A_{m.o} = A_h + A_c + A_b$$

(ii) Alkalinity due to phenolphthalein, A_{ph}. When phenolphthalein is used, the colour change at the end point is obtained after reactions given by equations (1), (2) and (3) are complete and before reaction given by equation (3) occurs. Thus the alkalinity due to phenolphthalein isdue to the hydroxides and half the carbonates as the colour change occurs before the bicarbonates react [see reactions (2) and (3)]. Therefore,

$$A_{ph} = A_h + 0.5A_c$$

Procedure:

Phenolphthalein Alkalinity

(i) Take 25 ml sample and add two drops of Phenolphthalein indicator, if a slight pink

(ii) colour appears, it means phenolphthalein alkalinity is present in the water sample.

(iii) Titrate it with standard HCl (0.02N) slowly and carefully. The pink colour of sample changes and it will become colourless and it is the end point. Record the volume of the titrant consumed as P in ml.

Methyl Orange Alkalinity

Test for methyl orange alkalinity is conducted in continuation to the phenolphthalein alkalinity test. In the same sample add two drops of methyl orange indicator. If orange colour develops in the water, it indicates the presence of methyl orange alkalinity. Titrate it with same titrant i.e. HCl (0.02N), the colour of the sample changes from orange to faint pink and that is end point. Record the final reading of burette as T in ml. Find the volume titrant consumed in methyl orange alkalinity by deducting the volume of titrant used in phenolphthalein alkalinity test from the total volume of titrant consumed in both titration. Pipette out 25 ml of water sample into a clean titration flask. Add two drops of methyl orange. Titrate against standard Hydrocholric acid till the colour of the solution changes sharply from yellow to red. Repeat for concordant values

Observations and Calculations

Burrete Reading

Trial No.	**1**	**2**	**3**
Final burette reading			
Initial burette reading			
Volume of HCl run down in cm^3			

The volume of HCl consumed =**………** V Cm^3

Normality of HCl =………N

$1000 cm^3$ of 1N HCl = 50g of $CaCO_3$ (Equivalent weight of $CaCO_3$ = 50)

$V cm^3$ of X N HCl is = $\frac{50 x V x N}{1000}$ g of $CaCO_3$

= a g

Total Alkalinity of $25 cm^3$ of water sample = a g

Total Alkalinity of 10^6(1 million parts) cm^3 of water sample = $\frac{a \times 10^6}{25}$ = z g of CaCO3

Therefore total alkalinity of the given water sample = z ppm $CaCO_3$ equivalent

Result:

Total alkalinity of the water sample = ------------- ppm $CaCO_3$ equivalent

VIVA QUESTIONS & ANSWERS

1. **What is alkalinity?**

   It is the capacity to neutralize acid. Or it is the capacity of the water to accept the protons.

2. **What are the causes of alkalinity?**

   Alkalinity of water is due to presence of OH^-, CO_3^-, HCO_3^- ions.

3. **What are the various combinations of anions, responsible for alkalinity**

   Carbonates only **CO_3^{2-}**

   Bicarbonate only **(HCO_3^-)**

   Hydroxide only **(OH^-)**

   Carbonate and Bicarbonate **(CO_3^{2-}& HCO_3^-)**

   Carbonate and Hydroxide **(CO_3 & OH^-)**

4. **Can all the three alkalinity causing ions co-exist? Justify**

   Presence of all the three combinations is not possible. Because when OH^- & HCO_3^- are present in the sample they will react and form H_2O & CO_3^- respectively.

   $$OH^- + HCO_3^- \longrightarrow H_2O + CO_3^-$$

   Name the types of alkalinity

   i) Phenolphthalein alkalinity

   ii) Methyl Orange alkalinity

5. **What are the indicators used in the determination of alkalinity**

   Phenolphthalein and Methyl Orange indicator

6. **What causes Phenolphthalein alkalinity?**

   Presence of OH^-& CO_3^- causes Phenolphthalein alkalinity

7. **<u>Phenolphthalein alkalinity of a water sample is zero. What it indicates?</u>**

   It indicates the absence of hydroxyl and carbonate ions in water

8. **<u>How do you express the total alkalinity of water?</u>**

   It is expressed in terms of ppm (parts per million) of $CaCO_3$

9. **<u>What conclusion you make when phenolphthalein alkalinity is equal to Methyl orange alkalinity?</u>**

   When Phenolphthalein alkalinity is equal to methyl orange alkalinity, the alkalinity of water is exclusively due to presence of hydroxyl ions.

10. **<u>What is the working pH of phenolphthalein and methyl orange indicators</u>**

    Phenolphthalein = $\geq$ 8.3 (pink) $\leq$ 8.3(colorless)
    Methyl orange = $\leq$ 4.3 (red) $\geq$ 4.3 (yellow)

11. **What is the desirable limit of alkalinity in drinking water according to Indian standards?**

    According to Indian standards the desirable limit is up to 200ppm

Experiment 5

Determination of H_2O_2 in PCB cleaner (Permanganate Method)

Aim: Determination of Hydrogen Peroxide using Standard Potassium Permanganate

Principle: Hydrogen peroxide reacts with permanganate ion in acidic solution according to

$$5\ H_2O_2 + 2\ MnO_4^- + 6\ H^+ \rightarrow 2\ Mn^{2+} + 5O_2 + 8\ H_2O$$

Hydrogen peroxide in a diluted portion of the sample is quantitatively oxidized by titration with a potassium permanganate solution of known strength.

Theory:

Hydrogen peroxide (H_2O_2), generally known as an oxidizer, is commonly used as a bleaching agent. It is the simplest peroxide (a compound with an oxygen-oxygen single bond). Hydrogen peroxide is a clear liquid, more viscous than water that appears colorless in dilute solution. It is also used as a disinfectant, antiseptic etc. The oxidizing capacity of hydrogen peroxide is so strong that it is considered a highly oxidizing species. Hydrogen peroxide is naturally produced in organisms as a by-product of oxidative metabolism.

Though H_2O_2 usually act as an oxidising agent, in the presence of a stronger oxidizing agent like $KMnO_4$ it behaves as a reducing agent. When $KMnO_4$ solution is added to H_2O_2 solution in presence of sulphuric acid Mn^{+7} is reduced to Mn^{+2}.

Procedure

Determination of hydrogen peroxide

Pipette 25.0 Ml of the given PCB cleaner solution into a 250-mL flask containing 10 mL of 6N H_2SO_4. Add Standard potassium permanganate solution from a 25mL burette until the first appearance of a faint pink colour that persists for 30 seconds. Record the volume delivered as **V.** Repeat the titration three times

Observation & Calculations:

Burette Reading in ml	**I**	**II**	**III**
Final burette Reading			
Initial burette Reading			
Volume of $KMnO_4$ consumed			

Concordant Value V = ------------ml.

$(N_1V_1)_{H_2O_2} = (N_2V_2)_{KMnO_4}$

$N_{H_2O_2} = \frac{N(KMnO4)\ X\ V}{25}$

$N_{H_2O_2}$=……….N

Weight of H_2O_2= $N_{H_2O_2}$ X Eq wt of H_2O_2

= …………..x 17 =……….g/L

Result: Amount of H_2O_2 present in a given sample= -----------g/L

VIVA QUESTIONS & ANSWERS

1. **What is the aim of the experiment?**
   To determine the concentration of hydrogen peroxide present in PCB cleaner using potassium permanganate method.
2. **What is the principle of the experiment?**
   Hydrogen peroxide acts as a reducing agent and is oxidized by potassium permanganate in acidic medium The amount of $KMnO_4$ consumed is proportional to the concentration of H_2O_2
3. **Which titration is involved in this experiment?**
   Redox titration.

4. **Why potassium permanganate is used?**

   Because it is a strong oxidizing agent and acts as a self-indicator.

5. **What is meant by self-indicator?**

   A reagent that shows the end point by its own color change without using an external indicator.

6. **Why dilute sulfuric acid is used?**

   Sulfuric acid provides acidic medium and does not interfere with the reaction.

7. **Why hydrochloric acid is not used?**

   HCl gets oxidized by $KMnO_4$, producing chlorine gas and causing error.

8. **Why nitric acid is avoided?**

   Nitric acid is a strong oxidizing agent and interferes with the titration.

9. **What is the color change at the end point?**

   Colorless to permanent pale pink.

10. **What is the chemical reaction involved?**

    $2KMnO_4 + 5H_2O_2 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$

11. **Why is the titration carried out in acidic medium?**

    $KMnO_4$ gives correct oxidation only in acidic medium.

12. **Why oxalic acid is not used here?**

    Oxalic acid is not required because H_2O_2 itself acts as the reducing agent.

13. **What happens if alkaline medium is used?**

    $KMnO_4$ forms manganese dioxide, giving inaccurate results.

14. **What is the equivalent weight of hydrogen peroxide?**

    Equivalent weight = Molecular weight / n = 34 / 2 = 17

15. **What is PCB cleaner?**

    A chemical solution used to clean printed circuit boards by removing oxides and contaminants.

16. **Why is H_2O_2 used in PCB cleaner?**

    Because it is an effective oxidizing agent that removes metal residues.

17. **What precautions should be taken?**

Use freshly prepared $KMnO_4$, add titrant slowly near end point, shake continuously, avoid contamination.

18. **Why $KMnO_4$ solution should be standardized?**

Because it is not a primary standard and decomposes on standing.

Experiment 6

Estimation Of Acidmixture By Conductometric Sensor

Aim: To determine the amount of HCl & CH_3COOH in the given solution.

Chemicals: 0.1 N KCl solution, Standard NaOH solution.

Theory: A titration in which the equivalence point or end point of the reaction is determined with the help of measurements of conductivity of the reaction mixture; is known as conductometric titration. The principle underlying conductometric titrations is that the specific conductivity of a solution depends on number and nature of ions, which changes gradually during the titration and lets one to know the end points. Conductivity of unit volume (1 cm^3) of the electrolytic solution at specified temperature is known as specific conductivity. It is expressed in units of milli Siemens per centimeter (mS cm^{-1}). When a mixture of HCl & CH_3COOH is titrated against NaOH, stronger acid, HCl is neutralized first followed by the neutralization of weak acid, CH_3COOH. While HCl is neutralized, highly mobile H^+ ions of acid are replaced by less mobile Na^+ ions of the base and specific conductivity decreases. This trend continues until the reach of neutralization of HCl.

$$[\ H^{\square} + Cl^{-}\ ] + [\ Na^{\square} + OH^{-}\ ] \ \square\square\square \ [\ Na^{\square} + Cl^{-}\ ] + H_2O$$

(in solution) (in solution) (in solution)

After the complete neutralization of strong acid, NaOH added will neutralize weak acid, CH_3COOH.

$$CH_3COOH + [\ Na^{\square} + OH^{-}\ ] \ \square\square\square \ [CH_3COO^{-} + Na^{\square}] + H_2O$$

(weak electrolyte; dissociates little in solution) (in solution) (strong electrolyte; dissociates nearly to completion)

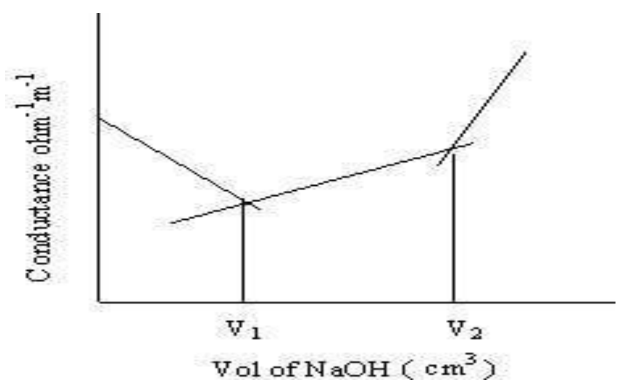
Weaker electrolyte, acetic acid is replaced by stronger electrolyte, sodium acetate. Thus, specific conductivity will tend to rise (slowly due to less mobile acetate ion and sodium ion) until the complete neutralization of acetic acid. Later, excessively added NaOH will release relatively more mobile OH^- ions, which lead to steep rise in specific conductivity.

A plot of specific conductivity against volume of NaOH added will help in knowing the neutralization points. Knowing the normality and volume of NaOH consumed for neutralization, concentration and amount of HCl & CH_3COOH are calculated.

Procedure:

Ensure calibrated condition of the conductivity meter (with the assistance of staff or laboratory instructor). Take Z mL of the given acid mixture in a clean beaker. Dip the conductivity cell in the solution (dilute if required to immerse the conductivity cell properly) and note down the specific conductivity of the solution. Now, add standard NaOH solution from the burette in increments of 0.5 mL. After each addition, stir the solution gently and note down the specific conductivity. As the titration proceeds, the specific conductivity decreases gradually until complete neutralization of HCl and then rises slowly until neutralization of CH_3COOH. After crossing the neutralization of CH_3COOH, conductivity rises steeply.

Continue the titration for at least 8-10 readings after crossing the neutralization of CH_3COOH. Plot a graph of specific conductivity against volume of NaOH as shown below. Intersecting lines represent the neutralization points of the two acids. Knowing the normality and amount of NaOH required for neutralization, amounts of HCl & CH_3COOH are calculated.



Result:

Normality of HCl solution = ……….N

Amount of HCl = …………..g/L

Normality of CH_3COOH solution =…………N

Amount of CH_3COOH =……………g/L

Observations and calculations:

Solution taken in the burette: Standard NaOH (N NaOH =……………N)

Solution taken in the beaker:

Acid mixture (HCl + CH_3COOH) = Z = ………… mL + distilled water

for proper immersion of conductivity cell

It implies that V_{HCl} = Z =....................mL; 3

V_{CH_3COOH}= Z = ……… mL

Volume of NaOH (cm^3)	**Specific conductivity,** κ (mS cm^{-1})
0.0	
0.5	
1.0	
1.5	
2.0	
2.5	
3.0	
3.5	
4.0	
4.5	
5.0	
5.5	
6.0	
6.5	
7.0	
7.5	
8.0	
8.5	
9.0	
9.5	
10.0	

Volume of NaOH (cm^3)	**Specific conductivity, κ (mS cm^{-1})**
10.5	
11.0	
11.5	
12.0	
12.5	
13.0	
13.5	
14.0	
14.5	
15.0	

Volume of NaOH required to neutralize HCl from the graph = V1 =…….. mL

Volume of NaOH required to neutralize both HCl & CH_3COOH from the graph= V2 =…… mL

∴ Volume of NaOH required to neutralize only CH_3COOH $= V_3 = V_2 - V_1$

= .... – .... =............. mL

It is known that $N_1V_1 = N_2V_2$ or $N_{HCl} \times V_{HCl} = N_{NaOH} \times V_{NaOH}$

Here, $V_{NaOH} = V_1$

∴ Normality of HCl = $N_{HCl} = \frac{N_{NaOH} \times V_1}{V_{HCl}}$ $= \frac{\text{.............} \times \text{..........}}{\text{.............}}$

3

= ....

The amount of HCl in the given solution

= N_{HCl} x Equivalent weight of HCl (36.5) g/L

= .... x 36.5 g/L

=.............................g/L

Similarly, $N_{CH_3COOH} \times V_{CH_3COOH} = N_{NaOH} \times V_{NaOH}$

Here, $V_{NaOH} = V_3$

∴ Normality of CH_3COOH $= N_{CH_3COOH} = \frac{N_{NaOH} \times V_3}{}$

$= \frac{\text{.............} \times \text{..........}}{\text{.................}}$

–

= N_{CH_3COOH} x Equivalent weight of CH_3COOH (60) g/L

=-----------X 60 g/L

The amount of CH_3COOH in the given solution = ……….g/L

VIVA QUESTIONS and ANSWER

1. **What is conductance? Mention its unit.**

   The reciprocal of resistance is called the conductance. The unit is ohm^{-1} or mho or Siemens (S).

2. **Mention the factors on which the conductance of solution depends.**

   The conductance of solution depends on

   a. Number of ions
   b. Charge on the ions
   c. Mobility of ions
   d. Temperature

3. **How does conductance of solution vary with temperature?**

   It increases with increase of temperature (unlike in the case of metallic conductors).

4. **Name the current carriers in the case of electrolytes.**

   The ions present in the solution.

5. **What is specific conductivity?**

   It is the conductivity of the solution placed between two electrodes of $1cm^2$ area of cross section, which are 1cm apart. It is expressed in $ohm^{-1}cm^{-1}$.

6. **Define cell constant.**

   It is the ratio of distance between the two electrodes to the area of cross section.

   Cell Constant = l/a Its unit is m^{-1}.

7. **What is meant by Conductometric titration?**

   The estimation of substances in solution by observing sudden change in conductance of the solution at equivalence point is known as Conductometric titration.

8. <u>Mention the types of conductivity measurements.</u>

Specific conductivity, molar conductivity and equivalent conductivity.

9. <u>What is meant by molar conductivity?</u>

It is the conductance produced by all the ions present in one litre of solution containing gram molecular weight of the electrolyte.

10. <u>What is meant by equivalent conductivity?</u>

It is the conductance produced by all the ions present in one litre of solution containing gram equivalent weight of the electrolyte.

11. <u>What is conductivity cell?</u>

It is a device used to measure the conductance of solution. It consists of two platinum foils

12. <u>Account for the followings:</u>

Conductance of the solution decreases in the beginning of titration.

It is due to the replacement of high mobile H^+ ions of HCl by less mobile Na^+ ions of NaOH solution.

<u>Conductance of the solution increases slowly in the middle of the titration (i.e. after the first equivalence point).</u>

It is due to the neutralization of acetic acid by NaOH, which leads to the formation of sodium acetate salt, which ionizes further to give CH_3COO^- and Na^+ ions.

<u>Conductance of the solution increases after the end point.</u>

It is due to the presence of excess of OH^- ions of NaOH.

The slope of the line in the beginning of titration is higher than that of the line after the end point

It is due to the high mobility of H^+ ions HCl (which are replaced by less mobile Na^+) when compared to the low mobile OH^- ions of NaOH.

13. <u>What are the advantages of Conductometric titrations?</u>

i) The method is accurate in dilute as well as more concentrated solutions.

ii)It can also be employed with colored solutions.

iii)Mixture of acids can be titrated more accurately.

14. State ohm's law.

Ohm's law states that the current, I (ampere), flowing in a conductor is directly proportional to the applied electromotive force, E (volt) and inversely proportional to the resistance, R (ohm) of the conductor.

I = E/R

15. What is conductivity?

The reciprocal of resistivity is called conductivity.

16. Which of the above conductance measured during conductometric titration?

The specific conductance is measured.

17. What is a cell?

A device which produces an electromotive force and delivers an electric current as the result of a chemical reaction is known as a cell.

18. **What is the principle involved in conductometric titration?**

In conductometric titration, there is a sudden change in conductance of solution near the end point. Hence the end point is determined graphically by plotting conductance against titre values. The principle underlying conductometric titration is the replacement of ions of a particular conductance by ions of different conductance during the titration.

19. **How is the equivalence point obtained in conductometric titration?**

During the progress of the titration, changes in conductivity occur. The conductivity is measured after each addition of a small volume of the titrant. A graph of conductivity (on Y-axis) versus volume of titrant (on X-axis) is plotted when two or more straight lines are obtained. The point of intersection of the two straight lines gives the equivalence point.

20. <u>In the titration of a mixture of acids (HCl and CH3COOH) with a strong base (NaOH), the conductance first decreases, then rises steadily and finally rises steeply. Why?</u>

Upon adding a strong base to a mixture of a strong acid and a weak acid, the conductance falls due to the replacement of highly mobile H^+ ions of the strong acid (HCL) by less mobile Na^+ ions of the base. The conductance falls till all the H^+ ions are replaced (i.e. till HCL is neutralised completely). The conductance then rises steadily as the weak acid is converted into its salt.

Finally, the conductance rises steeply as excess of alkali is introduced

Experiment 7

Estimation of Fe in Rust sample by Potentiometric sensor

Aim: To determine the amount of FAS in the given solution

Chemicals: Dilute H_2SO_4, Standard $K_2Cr_2O_7$, FAS

Theory: A titration in which the equivalence point of the reaction is determined with the help of measurements of cell potentials is known as potentiometric titration. A suitable cell made of indicator electrode and reference electrode is constructed in known volume of the test solution. For the titration of FAS against $K_2Cr_2O_7$, platinum electrode is used as indicator electrode and calomel electrode as reference electrode. Indicator electrode (Pt) potential is a function of the redox system and activities (or concentration) of the respective ionic species in the solution. Reference electrode (calomel) potential remains constant during titration. For a redox system, same metal with two oxidation states, will compete for mutual conversions,

Oxidised form + ne^- □□□ Reduced form

$$E = E^0 + 0.0591/n \log [(\text{Oxidized species}) / (\text{Reduced species})]$$

For the titration of FAS against $K_2Cr_2O_7$, Ferrous ion undergoes oxidation to ferric state:

Fe^{2+} □□□ Fe^{3+} + e^-

(reduced form) (oxidized form)

Dichromate ion undergoes reduction to chromic state:

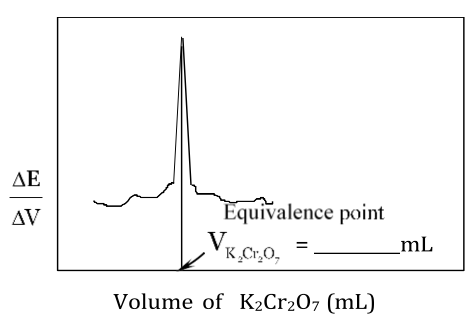
$Cr_2O_7^{2□}$ + $14H^+$ + $6e^-$ □□□ $2Cr^{3+}$ + $7H_2O$

(oxidized form) (reduced form)

Platinum electrode potential is decided by the redox system. Before the end point, the electrode is Pt|(Fe^{3+},Fe^{2+}). During the titration, Fe^{3+} ion concentration increases and that of Fe^{2+} ion decreases until the reach of equivalence point. The numerical value of the ratio, [Fe^{3+}]/[Fe^{2+}] increases and potential increases After the end point, the electrode changes as Pt|($Cr_2O_7^{2-}$,Cr^{3+}) resulting in abrupt change in electrode potential and consequently cell-potential at the end point. The cell-potential is decided by the ratio [$Cr_2O_7^{2-}$] / [Cr^{3+}] Sudden change in cell potential helps in the determination of equivalence point. With the knowledge of normality and volume of $K_2Cr_2O_7$ consumed the amount of FAS is calculated.

Procedure:

Standardize the potentiometer using electronic standard cell on the instrument (potential needs to be set to 1.018 V or 1018 mV using the calibration knob). Take suggested volume, Z mL of FAS solution from a burette into a clean beaker. Add 10 mL of dilute sulfuric acid. Wash the platinum and saturated calomel electrode assembly and place it in the solution. Add requisite amount of distilled water required for immersion of cell assembly. Measure the EMF of the experimental cell on the potentiometer. Add K2Cr2O7 solution from a burette in increments of 0.5 mL and stir the solution thoroughly. Measure the EMF after each addition. Equivalence point is recognized by sudden jump in EMF. Continue the addition of K2Cr2O7 until 6 – 8 readings beyond the equivalence point. Plot a graph of ΔE/ΔV against the volume of K2Cr2O7 (differential curve is obtained). Determine the equivalence point from the graph as shown in figure below. Calculate the strength and amount of FAS.



Result:

The normality of FAS solution = ...N;

The amount of FAS in the solution = ...g/L

Observations and calculations:

Solution taken in the burette: Standard $K_2Cr_2O_7$= N of $K_2Cr_2O_7$ = …………..N

Solution taken in the beaker: Z or V_{FAS}

= ………….. ml FAS + 10 ml of dilute H_2SO_4 + Water

Volume of K2Cr2O7 (mL)	E (mV)	ΔE (mV)	ΔV (mL)	$\frac{\Delta E}{\Delta V}$ (V/L)
0				
0.5				

$$N_{FAS} = \frac{[N_{K2Cr2O7} \text{ x } V_{K2Cr2O7} \text{ (From the graph)}]}{V_{FAS}}$$

= -------------

Weight of FAS in 1000 ml of the given solution = N_{FAS} x Equivalent wt. of FAS

=N_{FAS} x 392.14 gm

=……… gm/L

VIVA QUESTIONS & ANSWERS

1. **What is a Potentiometric titration?**

Ans. The determination of equivalence point of red-ox titration on the basis of potential measurements is known as Potentiometric titration.

2. **What are the electrodes used in Potentiometric titration?**

Ans. Platinum and calomel electrodes.

3. **What is the principle Potentiometric titration?**

Ans. The principle is the measurement of the emf between the platinum electrode (indicator electrode) and a reference electrode (calomel electrode). In this titration, the measurements of potential are made while the titration is in progress. The equivalence point is sudden change in the potential.

4. **What is an indicator electrode?**

The electrode, whose potential is dependent on the concentration of the ion being determined,.

5. **What is the determining factor in the red-ox titration?**

Ans. The determining factor is the ratio of concentrations of oxidized species to reduced species.

6. **What is the reaction-taking place between FAS and Dichromate?**

Ans. Acidified potassium dichromate oxidizes ferrous to ferric.

7. **Give the reaction between FAS and K2Cr2O7 in Potentiometric titration.Acidified K2Cr2O7 oxidizes ferrous sulphate to ferric sulphate and itself gets reduced to chromic sulphate.**

$$6FeSO_4 + 7H_2SO_4 + K_2Cr_2O_7 \rightarrow 2Fe_2(SO_4)_3 + K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O$$

8. **Mention the advantages of Potentiometric titrations.**
   1. Turbid, colored solutions can be titrated.
   2. Mixture of solutions or very dilute solutions can be titrated.
   3. The results are more accurate since the end point is determined graphically.

9. **<u>What is the purpose of adding dilute sulphuric acid?</u>**

This is because potassium dichromate acts as oxidizing agent only in acidic media.

10. **<u>What is single electrode potential?</u>**

The potential that is developed when an element is in contact with a solution containing its own ions is called single electrode potential

11. What is standard electrode potential?

The potential that is developed when an element is in contact with a solution containing its own ions of 1 M concentration at 298 K is referred to as standard electrode potential. If the gases are involved, they must be passed at a partial pressure of 1 atmosphere.

12. What is meant by e.m.f.?

E.M.F. is the potential difference required to drive a current across the electrodes.

E.M.F. = Ecathode - Eanode

13. What is a potentiometer?

It is a device or circuit used for comparing potential sources.

14. Why is the beaker solution gradually changes into green during the course of titration? When FAS in beaker reacts with K2Cr2O7, it reduces K2Cr2O7 to Cr2(SO4)3 which is a green salt solution.

15. Why is the EMF rises steeply soon after the equivalence point?

This is because, the potential of the solution before the equivalence point is determined by

$Fe^{2+} \rightarrow Fe^{3+}$ system only i.e., 0.75V, while at equivalence point, it is determined by both Fe^{3+} and $Cr_2O_7^{2-}$ ions which is = 1.04V. But beyond equivalence point, the potential of the solution is determined by $Cr_2O_7^{2-}/Cr^{3+}$ only i.e. = 1.33V. Therefore, just after the equivalence point, the potential of the solution rises steeply.

Experiment 8

Determination of pKa of vinegar using pH sensor (Glass electrode)

Aim: To determine the pKa value of the given weak acid

Chemicals: Standard buffer solutions (pH = 7.0, 4.0, 9.2), NaOH solution

Theory: p*Ka* is a measure of the strength of the acid. Higher the p*Ka*, weaker is the acid. It is defined as negative logarithm of dissociation constant, *Ka* [p*Ka* = – log*Ka*]. p*Ka* is determined by the measurement of variation in pH during titration of the acid against a base.

For the titration of weak acid against strong base, the change in pH is lesser until the reach of equivalence point. For example, pH changes slowly until neutralization point during the titration of CH3COOH against NaOH. Reaction that takes place during the titration is

$$\underset{\text{(Acid)}}{CH_3COOH} + \underset{\text{(Base)}}{NaOH} \quad □□□ \quad \underset{\text{(Salt)}}{CH_3COONa} + \underset{\text{(Water)}}{H_2O}$$

During the titration, solution will become a mixture of weak acid (unreacted CH3COOH) and its salt (CH3COONa), which represents the buffer. Therefore, pH changes slowly until the neutralization. At the equivalence point, the pH rises rapidly owing to removal of H+ ions (acid) and addition of OH^- ions (alkali) [the buffer disappears at this point of titration]. The change in pH during the titration is described by Henderson-Hasselbatch equation.

$$pH = pK_a + \log \frac{[Salt]}{[Acid]}$$

At half equivalence point, half the acid will have reacted to give salt; and half the acid will have remained unreacted. Therefore, [Salt] = [Acid] and log(1) = 0. Thus, above equation becomes, pH = pK_a i.e., pH at half equivalence point gives pK_a value of the weak acid. pH is measured on a pH meter using combined glass electrode (cell constructed by the coupling of glass electrode & Ag-AgCl electrode). The cell used is represented as

Ag-AgCl electrode | Weak acid, H^+ | Glass electrode

The cell potential evaluated is a measure of H+ ion concentration in the solution, which is read in terms of pH. The graphs ΔpH/ ΔV vs Volume of NaOH (VNaOH) and pH vs VNaOH together will assist in the evaluation of pK*a*.

Procedure:

Ensure calibrated condition of the conductivity meter *(*with the assistance of staff or laboratory instructor*)*. Take the suggested volume (Z mL) of weak acid into a clean beaker. Place the combined glass electrode in the weak acid. Add sufficient quantity of distilled water to ensure proper immersion of electrode in the solution and record the pH value. Add NaOH solution from the burette in increments of 0.5 mL every time and stir the solution well. Note down the pH after each addition. Equivalence point is recognized by sudden jump in pH. tinue the addition of NaOH until 6 – 8 readings beyond the equivalence point. Plot a graph of ΔpH/ ΔV vs Volume of NaOH (VNaOH) find out the equivalence point (Fig.1). Plot another graph of pH versus volume of NaOH, mark the position of half equivalence point and obtain pK*a* value (Fig.2).

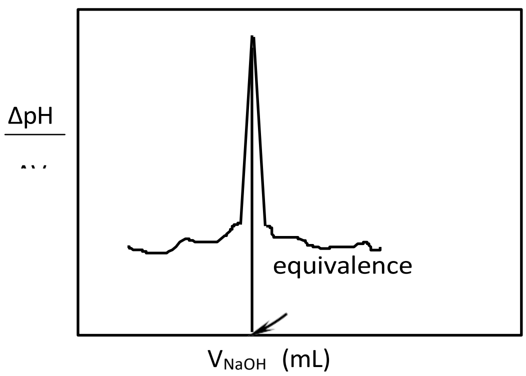


Fig.1

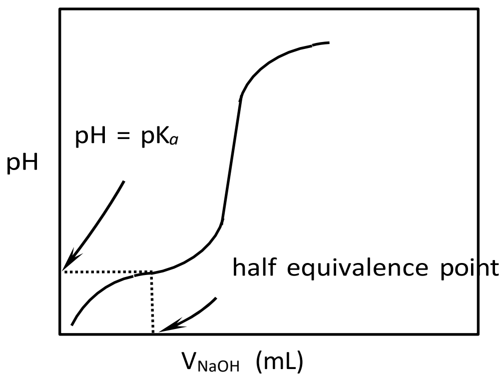


Fig.2

Result:

pK_a value of the given weak acid = ...

Observations and calculations:

Solution taken in the burette: NaOH solution

Volume of NaOH (mL)	**pH**	**ΔpH**	**ΔV**	$\frac{\Delta pH}{\Delta V}$
0				
0.5				

Solution taken in the beaker: Given volume of Weak Acid (= Z =mL) + water (if required, for immersion of combined glass electrode)

1. Equivalence point from the graph ΔpH/ ΔV vs Volume of NaOH= P= ……………ml
2. Half equivalence point P/2=…………..ml
3. pKa value of the given weak acid from the graph: pH vs Volume of NaOH=……..

Viva Questions with Answers

1. **<u>What is a weak acid?</u>**

Ans. Weak acid is one, which does not dissociate or ionize completely in aqueous solution. Example: Acetic acid, formic acid.

2. **<u>What is pKa of a weak acid?</u>**

Ans. $pKa = -\log_{10}Ka$, where Ka is dissociation constant of weak acid

3. **<u>What is meant by pH of a solution?</u>**

Ans. $Ph = -\log_{10} (H^+)$

4. **<u>What are the electrodes used in pH meter?</u>**

Ans. Glass electrode and calomel electrode.

5. **<u>Why glass electrode is known as ion selective electrode?</u>**

Ans. This is because it is able to respond to H+ ions only and develop potential while ignoring the other ions present in the solution.

6. **How is the measurement of pH made?**

Ans. Determining the EMF of the cell containing glass electrode and calomel electrode immersed in the solution makes the measurement of pH. The emf of the cell is expressed as $E = K + 0.0591pH$.

7. **How pH and pKa are related?**

Ans. $PH = pKa + \log10 \text{ (salt) / (acid)}$

The above equation is known as Henderson-Hasselbatch equation. At half Equivalence point (salt) = (acid) and therefore pH = pKa

8. **Why does pH increase suddenly after the equivalence point?**

Ans. At the equivalence point, the base neutralizes the weak acid. Afterwards, the concentration of hydroxyl ions increases, resulting in sudden increase of pH.

9. **Why is (acid) = (salt) at half equivalence point?**

Ans. At half equivalence point, half of the acid is converted into its salt.

10. **How are pKa and strength of weak acid related?**

Ans. Higher the pKa, lower will be the strength of the acid and vice versa.

11. What is the dissociation constant of weak acid?

Ans. The dissociation constant of weak acid Ka = $(H^+) (A^-) / (HA)$

Experiment 9

Estimation Of Copper Present In E-Waste By Optical Sensor

Aim: To determine the amount of copper in the given test solution

Chemicals: Standard solution of $CuSO_4$ (0.05 N), 1:1 Ammonia solution

Theory: An analysis by the way of measurements of absorbance of light in the visible range is colorimetry. It depends upon the measurement of quantity of light absorbed by a coloured solution. The wavelength of light absorbed is a function of nature (quality) of the substance and the amount of light absorbed is a function of concentration (quantity).

When certain light with intensity I_0 is passed through a transparent solution, part of it is absorbed (I_a), a part is reflected (I_r) and another part is transmitted (I_t); $I_0 = I_a + I_r + I_t$

For an interface of air and glass, the amount of light reflected is negligible;

$$I_0 = I_a + I_t$$

Quantitative measurements of absorption are based on Beer‟s law and Lambert‟s law or Beer-Lambert‟s law. **Beer's law** states that „when a monochromatic beam of light (light of single wavelength) passes through a transparent medium, the intensity of the emitted light decreases exponentially as the concentration of the medium increases arithmetically‟. **Lambert's law** states that „when a monochromatic beam of light passes through a transparent medium, the intensity of the emitted light decreases exponentially as the thickness of the medium increases arithmetically‟. Combined **Beer-Lambert's law** infers that, „when a monochromatic beam of light passes through a transparent medium, the amount of light absorbed by coloured solution is proportional to the concentration and thickness of the light absorbing medium‟. It can be expressed as $A = \log [I_o / I_t] = \varepsilon ct$ where, „I_0‟ is intensity of incident light, „I_t‟ is intensity of transmitted light, „t‟ is thickness of the light absorbing medium (cm), „c‟ is concentration of the coloured constituent in the solution (mol/L) and „□‟ is molar extinction coefficient (amount of light absorbed when „t‟ and „c‟ are 1 cm and 1 mol/L respectively). Since, □ is a constant, absorbance is proportional to the concentration of coloured constituent in solution, provided the thickness of the light absorbing medium is kept constant. Mathematically, $\mathbf{A \propto c}$

Reliability of colorimetric analysis requires appreciable colour intensity of solution. Therefore, in the estimation of copper, light blue coloured Cu^{2+} is reacted with ammonia to give intense blue coloured tetraamine copper(II) complex.

$$Cu^{2+} + 4NH_3 \quad \square\square\square \quad [Cu(NH_3)_4]^{2+}$$

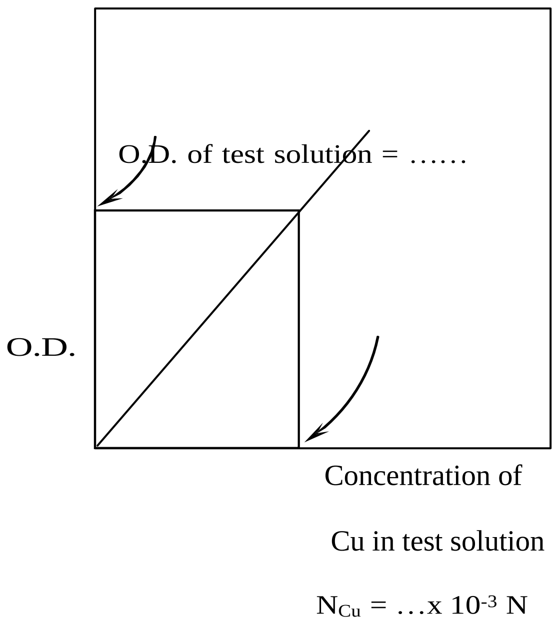
(light blue) (intense blue)

The solution absorbs light of **620 nm** wavelength. A series of standard solutions of copper complexes is used to generate a calibration curve on a graph of absorbance versus concentration of copper. Optical density of the test solution complexed with ammonia is measured and compared on the standard curve for concentration. Thus, concentration of copper in the test solution is determined.

Procedure:

Rinse and fill the burette with 0.05N $CuSO_4$ stock solution. Take 2 mL, 4 mL, 6 mL, 8 mL and 10 mL of the stock solution into 5 different 50 mL volumetric flasks. Add 4 mL of 1:1 ammonia solution to each of these flasks. Dilute with distilled water up to the mark and shake well. Prepare a blank solution by taking 4 mL of 1:1 ammonia & making it up to the mark with distilled water in a 50 mL standard flask and shaking it well. Set the light filter to measure the absorbance for 620 nm light. Measure the absorbance of the standard solutions with reference to blank (Place the cuvette with blank solution and set the absorbance to ZERO; remove it and place another identical cuvette filled with standard solution and measure the absorbance).

Plot a graph of concentration of copper against absorbance to get a calibration curve (passing through the origin). Now, complex the given volume of $CuSO_4$ with 3 mL of 1:1 ammonia and dilute to 50 mL in a volumetric flask, shake well and treat it as test solution. Measure its absorbance, compare it on the calibration curve and evaluate the concentration of copper. Calculate the amount of copper.



Concentration of Cu, N_S (N)

Result:

The concentration of copper in the test solution = N

Amount of copper in the given test solution = g/L

Observations and calculations:

Normality of $CuSO_4$ solution (given) = 0.05N

Strength of Ammonia solution used = 1:1

Sl. No.	Volume of $CuSO_4$ (V mL)	Volume of 1:1 NH_3 (mL)	Concentration of Copper $N_S = \frac{V \times 0.05}{50} = V \times 10^{-3}$ N	Absorbance (or O.D.)
1	0 (Blank solution)	4	0	0
2	2	4	2×10^{-3}	
3	4	4	4×10^{-3}	
4	6	4	6×10^{-3}	
5	8	4	8×10^{-3}	
6	10	4	10×10^{-3}	
7	Test solution	----	----	

Concentration of copper in the test solution from the graph

$= N_{Cu} = ...\times 10^{-3}$ N

Amount of copper in the test solution

$= N_{Cu}$ x Equivalent weight of copper (63.54) g/L

$= N_{Cu}$ x 63.54 g/L

= .... x 63.54 g/L

=.................................g/L

VIVA QUESTIONS & ANSWERS

1. What is colorimetry?

Ans. It is Chemical analysis through measurements of absorption of light radiation in the visible region of spectrum (400-700nm) with respect to known concentration of the substance.

2. What forms the basis for colorimetric determination?

Ans. The variation in the absorption of light with change in concentration of the substance is the basis of calorimetric determination.

3. What is photoelectric colorimeter?

Ans. It is an electric instrument, which measures the amount of light absorbed using a photocell.

4. What are filers? Why are they used?

Ans. The filters consist of thin films of gelatin containing different dyes or different colored glasses. This is used in colorimeters to select any desired spectral region. (Wavelength)

5. What is frequency?

Ans. It is the number of waves passing through a point per second. It is represented asν.

6. What is wave number?

Ans. It is reciprocal of wavelength. $1/\lambda$
represents it $1/\lambda = \nu / c$ = Frequency / velocity of
light

7. State beer's law.

Ans. The intensity of transmitted light decreases exponentially as the concentration of the absorbing substance increases arithmetically.

8. State Lambert's law.

Ans. The intensity of transmitted light decreases exponentially as the thickness of the absorbing medium increases arithmetically.

9. State Beer-Lambert law.

Ans. The amount of light absorbed is proportional to concentration and thickness of the medium. A $= \log I_0 / I_t = \varepsilon ct$

ε is Molar extinction coefficient; c is concentration; t is path length

10. Why different volumes of solutions are taken?

Ans. Different volumes are taken to get calibration graph.

11. What is blank solution?

Ans. Solution without the test solute is known as blank solution.

12. Why ammonia is added to copper solution? Why is that the same amount of ammonia added?

Ans. Ammonia is added to get cuproammonium sulfate, a dark blue complex. Same amount of ammonia is added to nullify the absorbance due to any coloring impurities present in ammonia.

13. Why is the estimation of copper done at 620 nm wavelengths?

Ans. It is done because; the complex shows a maximum absorbance at 620 nm. (λ_{Max})

14. What is meant by transmittance?

Ans. It is the ratio of intensity of transmitted light (I_t) to that of the incident light (I_o) $T = I_t / I_o$

15. What is absorbance or optical density?

Ans. It is reciprocal transmittance. $A = 1 / T = I_o / I_t$

16. How optical density is related to the concentration of the substance?

Ans The optical density is directly proportional to concentration of the substance.

17. Mention a few important criteria for satisfactory colorimetric analysis

I. The solute should not undergo salvation, association, hydrolysis or polymerization in the solvent used.
II. The color produced should be sufficiently stable
III. Clear solutions free from traces of precipitates or foreign substances in either blank or standard solutions

18. Mention a few advantages of colorimetric determinations.

Ans. Colorimetric method will often give more accurate results at low concentrations. It is more useful for biological substances.

19. How is optical density related to the concentration of the substance?

The optical density is directly proportional to the concentration of the substance.

Experiment 10

Determination of viscosity coefficient of Conducting ink

Aim: To determine the viscosity coefficient of the given organic liquid.

Chemicals: Distilled water

Theory: A liquid flowing through cylindrical tube of uniform diameter is expected to move in the forms of molecular layers. A layer close to the surface is almost stationary, while that at the axis of the tube moves faster than any other intermediate layer. A slow moving layer exerts a drag or friction on to the nearest layer. This property that retards or opposes the motion is called viscosity.

The viscosity coefficient of viscosity is defined as the tangential force per unit area required to maintain a unit velocity gradient between any two successive layers of a liquid situated a unit distance apart.

The viscosity coefficient of a liquid is given by Poiscuille's formula,

$\eta = \pi \rho r^4 t / 8lv$ where, v is volume of the liquid, r is the radius of the tube, l is length of the tube, ρ is the pressure difference between two ends of the tube, η is the coefficient of viscosity of the liquid.

If equal volumes of liquids are allowed to flow through the same tube under identical conditions, then,

$$\eta_l / \eta_w = t_l \times d_l / t_w \times d_w \qquad (1)$$

The time taken (t_l) by the test liquid to flow through the capillary is determined. The time taken (t_w) by water to flow through the same capillary is measured under identical conditions. Thus, the viscosity coefficient of test liquid is calculated from the densities (d_l, d_w) of the test liquid and water and the viscosity coefficient (η_w) of water. Viscosity is temperature dependent and hence the experiment is carried out at constant temperature.

Procedure:

Fix an Ostwald‟s viscometer vertically in a thermostat (water contained in a beaker; note down the temperature of water). Take appropriate volume (say, 25 mL) of the given liquid into wider limb of viscometer. Draw it up in the capillary limb slightly higher than the upper mark above the glass bulb

Allow the liquid to flow down. Start a stop-watch when the lower meniscus of liquid crosses the upper mark (above the bulb) and stop it when the lower meniscus crosses the lower mark (below the bulb). Read & record the flow time in seconds. Repeat the measurements for concordant values. Wash the viscometer, rinse with acetone and dry it in a hot air oven. Cool the viscometer thoroughly and fix it vertically in the thermostat. Take identical volume (25 mL) of distilled water in the viscometer and measure its flow time. Knowing the density & viscosity of water, density of liquid and flow times of water & liquid under experimental temperature, viscosity of the liquid is calculated.

Result: The viscosity coefficient of the conductive ink is --------------------- milli poise

Observations and calculations:

Temperature of the thermostat = ^{o}C

Density of test liquid (given) *dl* =…………g/cm3

Density of distilled water (given) *dw* =…………g/cm3

Viscosity of distilled water (given) ηw =…………..mP

Flow time measurement:

	Flow time (seconds)			
	Trial - 1	Trial - 2	Trial - 3	Average (S)
Test liquid				tl=
Distilled Water				tw=

Time of flow of test liquid t_l =...................... s

Time of flow of water t_w =....................... s

Viscosity coefficient of the test liquid= $\eta_l = \frac{(\eta_w \times d_l \times t_l)}{(d_w \times t_w)}$ mp

VIVA QUESTIONS & ANSWERS

1. **What is viscosity?**

   The internal friction between the moving layers of molecules of liquid is called viscosity i.e. a slow moving molecular layer will exert a backward pull on the fast moving molecular layer.

2. **Define density of liquid. Mention its unit.**

   It is defined as the ratio of mass per unit volume of the liquid.

   Density = Mass/Volume

   It is expressed in terms of Kg/m^3

3. **Define viscosity coefficient of liquid.**

   It is defined as tangential force per unit area required to maintain a unit velocity gradient between any two successive layers of liquid.

4. **Mention the CGS and SI units of viscosity coefficient.**

   CGS unit – milli poise SI
   unit – Nsm^{-2}

5. **How do you convert viscosity coefficient in CGS unit into SI unit?**

   1 milli poise = 10^{-4} Nsm^{-2}.

6. **Give the Poiseuille's equation.**

$$\eta = \frac{\pi P r^4 t}{8 V l}$$

   P = Hydrostatic pressure; r = radius of capillary tube; t = time for flow of liquid; V = volume of liquid and l = length of the tube.

7. **How does viscosity vary with temperature?**

   It decreases with increase of temperature.

8. **Why should Viscometer be dried before the time flow measurements of the liquid?**

   To avoid the formation of emulsion, which changes the time for flow of liquid.

9. **How do you dry the Viscometer?**

   It is dried first by rinsing with acetone and then keeping in oven.

10. <u>Why acetone is used for cleaning Viscometer?</u>

Since acetone is a volatile liquid, it is used to dry the Viscometer quickly.

11. <u>Why is the viscosity measurements carried out at lab temperature?</u>

Physical constants like density and viscosity of liquid vary with temperature.

12. <u>Mention the factors, which affect the viscosity of the liquid.</u>

1. Viscosity increases with increase in molecular weight.
2. Viscosity decreases with increase of temperature.
3. Polar compounds are more viscous than non polar compounds.

13. <u>The bulk of the viscometer is immersed in thermostat (beaker filled with water) during the course of the experiment. Why?</u>

To maintain a constant temperature, since the viscosity vary with change in temperature.

14. <u>What is density of a liquid?</u>

The density of a liquid is its mass divided by its volume.

15. <u>The density of a substance is expressed relative to what?</u>

The density of a substance is expressed relative to that of water at 4^{o} C.

16. <u>What is specific gravity?</u>

Specific gravity or the relative density is the weight of a given liquid divided by the weight of an equal volume of water at the same temperature

Experiment 11

Colorimetric Determination Of Total Phenolic Content In Coffee Product Using Smartphone

Aim: To determine the total phenolic content of a coffee product sample using the Folin–Ciocalteu colorimetric method using a smartphone camera.

Principle: Phenolic compounds reduce the Folin–Ciocalteu reagent under alkaline conditions to form a blue complex. A smartphone measures the color intensity (RGB). Converting a chosen channels intensity to a pseudo-absorbance ($A=\log_{10}(I0/I)$) gives a signal proportional to phenolic concentration. A calibration curve made from gallic acid standards is used to quantify unknowns.

Procedure

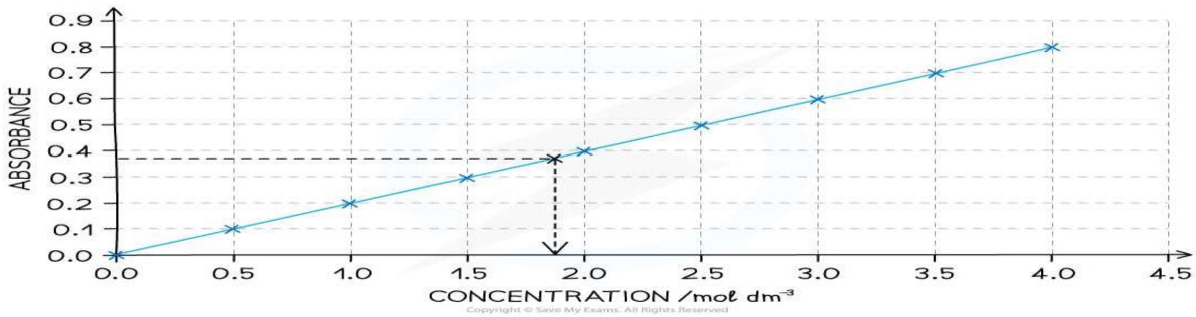
1. Preparation of Stock Solution: Prepare a standard stock solution of gallic acid by dissolving 100 mg of gallic acid in 100 mL of distilled water or 80% methanol, giving a concentration of 1000 mg/L. This serves as the reference phenolic standard for calibration.
2. Preparation of Standard Solutions: From the stock solution, pipette 2, 4, 6, 8, and 10 mL into separate 50 mL volumetric flasks. To each flask, add 2.5 mL of Folin–Ciocalteu reagent (diluted 1:10 with distilled water). After 3 minutes, add 5 mL of 7.5% sodium carbonate solution and make up the volume to 50 mL with distilled water. Mix well and incubate the flasks at room temperature for 30 minutes for color development. The blue color intensity formed is proportional to the phenolic concentration.
3. Preparation of Test and Blank Solutions:

For the test sample, take an appropriate aliquot (e.g., 1–2 mL) of the coffee extract, treat it in the same way as standards using the Folin–Ciocalteu reagent and sodium carbonate and make up to 50 mL with water.

4. For the blank, use distilled water instead of gallic acid or coffee extract, following the same procedure to correct for background absorbance.
5. Measurement and Calculation:

After incubation, place all standard, test, and blank solutions under uniform lighting conditions and photograph them using a smartphone camera (fixed ISO, exposure, and white balance).

6. Analyze the images using ImageJ or similar software to obtain RGB intensity values. Plot the calibration curve of absorbance (or inverse color intensity) versus gallic acid concentration.
7. Determine the concentration of phenolics in the coffee sample from the standard curve



SL.NO	VOLUME	CONC.	R	G	B	ABSORBANCE

8. Finally, express the Total Phenolic Content (TPC) as mg Gallic Acid Equivalents (GAE) per g or mL of coffee sample using:

$$TPC\ (mg\ GAE/g) = \frac{C \times V}{m \times 1000}$$

where C = concentration from curve (mg/L),
V = extract volume (mL), and m = sample mass (g).

VIVA QUESTIONS AND ANSWERS

1. **<u>What is the aim of the experiment?</u>**
   To determine the total phenolic content in a coffee product using a smartphone-based colorimetric method.

2. **<u>What is the principle of the experiment?</u>**

   Phenolic compounds react with Folin–Ciocalteu reagent in alkaline medium to form a blue- colored complex, whose intensity is proportional to the phenolic content.

3. **<u>Which reagent is used for phenolic estimation?</u>**

   Folin–Ciocalteu reagent.

4. **<u>Why sodium carbonate is added?</u>**

   To provide alkaline medium required for color development.

5. **<u>What color is formed during the reaction?</u>**

   Blue color.

6. **<u>Which standard is commonly used in this method?</u>**

   Gallic acid.

7. **<u>Why gallic acid is used as a standard?</u>**

   <u>It is a well-known phenolic compound and gives reproducible results</u>

8. **<u>What is meant by total phenolic content?</u>**

   The total amount of phenolic compounds present in the sample.

9. **<u>How is color intensity measured in this experiment?</u>**

   By capturing images using a smartphone and analyzing color intensity with a mobile application.

10. **<u>What is the role of smartphone in this experiment?</u>**

   It acts as a colorimeter to measure color intensity.

11. **<u>What is a calibration curve?</u>**

   A graph plotted between concentration of standard solution and corresponding color intensity.

12. **<u>In what units is total phenolic content expressed?</u>**

   As gallic acid equivalents (GAE).

13. **<u>Why controlled lighting is required?</u>**

   To avoid variations in color intensity due to external light.

14. **<u>Why the solution is allowed to stand for some time?</u>**

   For complete color development.

15. **<u>What factors affect color intensity?</u>**
    Concentration of phenolics, reaction time, pH, and lighting conditions.
16. **<u>What are phenolic compounds?</u>**
    Organic compounds containing one or more hydroxyl groups attached to an aromatic ring.
17. **<u>Why coffee contains phenolic compounds?</u>**
    Because coffee beans are rich in natural antioxidants.
18. **<u>Mention one advantage of smartphone colorimetry.</u>**
    It is simple, low-cost, and portable.
19. **<u>Mention one limitation of this method.</u>**
    Results may vary with lighting and camera quality.
20. **<u>Applications of this method</u>**
    Used in food analysis, quality control, and antioxidant studies.

Experiment - 12

Green Synthesis of copper nanoparticles for conductive ink applications

Aim: To synthesise copper nano particles by green method

Chemicals: 50 Grams of leaves of Tulsi Plant, $CuSO_4 . 5H_2O$(1mM)

Procedure

Part A: Preparation of Leaf Extract

For the synthesis of copper nanoparticles from Ocimum sanctum leaves (Holy Basil and Tulsi) were used. About 50 g of leaf was collected, washed thoroughly in distilled water, cut into small pieces and added about 50 mL of double distilled water into it. It was heated in water bath for about 10-15 minutes at 80 ^{0}C. The resultant extract was filtered using Watman filter paper No1 and stored in refrigerator for further use.

Part B: Synthesis of copper nanoparticles

About 25mL of leaf extract was added to 100 mL of 1mM copper sulphate solution in a 250 mL conical flask. Adjust pH to 8–10 slowly with 0.1 M NaOH. The solution was incubated for a period of 10 hours. The solution thus obtained was centrifuged at 12000 RPM for 15 minutes. The resultant pellet was washed with distilled water and the copper nanoparticles are dried at hot air oven at 80 ^{0}C

OBSERVSTION and CALCULATION:

Weight of empty Crucible ---------------g(W1)

Weight of Crucible and copper nanoparticles------------ g(W2)

Weight of nanoparticles= ---------- = (W2-W1) g

Result: Weight of Copper nanoparticles obtained from 1mM solution=------------------ mg

VIVA QUESTIONS AND ANSWERS

1. **What is the aim of the experiment?**

   To synthesize copper nanoparticles using a green method and apply them in conductive ink.

2. **What is meant by green synthesis?**

   Synthesis of nanoparticles using eco-friendly biological materials instead of toxic chemicals.

3. **Which biological material is used in green synthesis?**

   Plant extracts (leaves, fruits, or peels).

4. **What is the role of plant extract in this experiment?**

   It acts as both reducing and stabilizing agent.

5. **Which copper salt is commonly used?**

   Copper sulfate or copper nitrate.

6. **What indicates the formation of copper nanoparticles?**

   A visible color change in the reaction mixture.

7. **Why heating is required during synthesis?**

   To increase the rate of reduction and nanoparticle formation.

8. **What is the size range of nanoparticles?**

   Typically 1–100 nm.

9. **Why copper nanoparticles are preferred for conductive inks?**

   They have high electrical conductivity and are cost-effective.

10. **What is conductive ink?**

    An ink containing conductive materials used to print electronic circuits.

11. **How are nanoparticles separated from the solution?**

    By centrifugation.

12. **Why washing of nanoparticles is necessary?**

    To remove unreacted ions and impurities.

13. **<u>What is the role of stabilizing agents?</u>**

    To prevent agglomeration of nanoparticles.

14. **<u>Mention one advantage of green synthesis.</u>**

    It is environmentally friendly and non-toxic.

15. **<u>Mention one limitation of green synthesis.</u>**

    Difficulty in controlling particle size and shape.

16. **<u>Why copper nanoparticles easily oxidize?</u>**

    Because copper is reactive in air.

17. **<u>How can oxidation of copper nanoparticles be minimized?</u>**

    By using stabilizers or storing in inert atmosphere.

18. **<u>What property makes nanoparticles different from bulk materials?</u>**

    High surface area to volume ratio.

19. **<u>Give one application of conductive ink.</u>**

    Printed electronics, RFID tags, or flexible circuits.

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Lab Manual 2

Introduction to C Programming (CSE Stream)

(1BPLC205E)

Integrated Lab (IPCC)		
CIE		
Perticulars	**Marks**	**Total**
Performance	**07**	**15**
Journal	**05**	
Viva-voce	**03**	
Lab IA		
Perticulars	**Marks**	**Total**
IA	**50**	**10 (Reduced)**

INDEX

Sl. No.	Content	CO	PO	PSO
1	Develop a program to calculate the temperature converter from degree to Fahrenheit.	1,2	1,2,3,4,5	1
2	Develop a program to find the roots of quadratic equations.	1,2	1,2,3,4,5	1
3	Develop a program to find whether a given number is prime or not	1,2	1,2,3,4,5	1
4	Develop a program to find key elements in an array using linear search	3	2,3,5,8	1
5	Given age and gender of a person, develop a program to categorise senior citizen (male & female).	1,2	1,2,3,4,5	1
6	Generate Floyd’s triangle for given rows.	1,2	1,2,3,4,5	1
7	Develop a program to find the transpose of a matrix.	3	2,3,5,8	1
8	Develop a program to concatenate two strings, find length of a string and copy one string to other using string operations	3	2,3,5,8	1
9	Develop a modular program to find GCD and LCM of given numbers.	4	2,3	
10	Develop a program to declare the structure of employees and display the employee records with higher salary among two employees	5	2,3,5	
11	Develop a program to add two numbers using the pointers to the variables	5	2,3,5	
12	Develop a program to find the sum of digits of a given number.	1,2	1,2,3,4,5	1
13	Develop a program to perform Matrix Multiplication.	3	2,3,5,8	1
14	Develop a program to create an array of structures to store book details and check whether a specific book, as requested by the user, is available or not.	5	2,3,5	

CO's And PO's Mapping Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
1. **Explain** the fundamental structure of a C program and primitive constructs.	3	3									
2. **Apply** decision-making and iterative control structures to solve simple computational problems.		3	3	3	3						
3. **Develop** programs using arrays and string operations to solve real-world problems.		3	3		3			2			
4. **Construct** user-defined functions to modularize the solution to the given problems		3	3								
5. **Build** programs using structures and pointers for complex data representation and access.		2	2		3						

Experiment No. 01	
Name	Temperature Converter from Degree to Fahrenheit.
Objectives	Demonstrate usage of arithmetic operations and input/output functions.
Experiment No. 02	
Name	Compute the roots of a quadratic equation by accepting the coefficients.
Objectives	Demonstrating usage of decision-making statements
Experiment No. 03	
Name	Check whether a given number is prime or not.
Objectives	Demonstrate usage of loop and conditional statements
Experiment No. 04	
Name	Find key element in an array using Linear Search.
Objectives	Demonstrate usage of arrays and searching techniques.
Experiment No. 05	
Name	Categorise senior citizen (male & female) using given age and gender.

Objectives	Demonstrate usage of conditional statements and logical operators
Experiment No. 06	
Name	Generate Floyd’s Triangle for given rows.
Objectives	Demonstrate usage of nested loop statements.
Experiment No. 07	
Name	Find the transpose of a matrix.
Objectives	Demonstrate usage of two-dimensional arrays.
Experiment No. 08	
Name	Perform string operations: Concatenate two strings, find length of a string, and copy one string to another.
Objectives	Demonstrate usage of string handling functions.
Experiment No. 09	
Name	Find GCD and LCM of given numbers using modular programming.
Objectives	Demonstrate usage of functions (modular approach)..
Experiment No. 10	
Name	Declare structure for employees and display employee record with higher salary among two employees.
Objectives	Demonstrate usage of structures and decision-making
Experiment No. 11	
Name	Add two numbers using pointers to variables.
Objectives	Demonstrate usage of pointers
Experiment No. 12	
Name	Find the sum of digits of a given number.
Objectives	Demonstrate usage of loops and arithmetic operations.
Experiment No. 13	
Name	Perform Matrix Multiplication.
Objectives	Demonstrate usage of two-dimensional arrays and nested loops
Experiment No. 14	
Name	Create an array of structures to store book details and check availability of a specific book requested by the user.
Objectives	Demonstrate usage of arrays of structures and searching.

Safety and Precautions

It is necessary follow safety precautions while using the electric supply to avoid the serious problems like shocks and fire hazards.

Some of the **DO's** and **Dont's** are listed below:

Do's

- Bring observation book, manual, journal regularly.
- Wear ID card before entering into the lab.
- Read and understand how to carry out an activity thoroughly before coming to the laboratory.
- Know the location of the fire extinguisher and the first aid box and how to use them in case of an emergency.
- Report any broken plugs or exposed electrical wires to your lecturer/laboratory technician immediately

Don'ts

- Do not operate mobile phones in the lab. Keep mobile phones either in silent or switched off mode.
- Do not change system settings.
- Do not disturb your neighboring students. They may be busy in completing tasks.
- Do not remove anything from the computer laboratory without permission.
- Do not use pen drives.
- Do not misbehave in lab.

Experiment No 1: Develop a program to calculate the temperature converter from degree to Fahrenheit.

Aim: To Develop a program to calculate the temperature converter from degree to Fahrenheit.

Objective: To understand Temperature Conversion

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
int main() {
    float celsius, fahrenheit;
    printf("Enter temperature in Celsius: ");
    scanf("%f", &celsius);

    fahrenheit = (celsius * 9 / 5) + 32;
    printf("Temperature in Fahrenheit = %.2f\n", fahrenheit);

    return 0;
}
```

Sample Output:
Enter temperature in Celsius: 37
Temperature in Fahrenheit = 98.60

Experiment No 2: Develop a program to find the roots of quadratic equations.

Aim: To Develop a program to find the roots of quadratic equations.

Objective: To understand quadratic equations.

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
#include <math.h>
int main() {
    float a, b, c, d, root1, root2;
    printf("Enter coefficients a, b, c: ");
    scanf("%f %f %f", &a, &b, &c);

    d = b*b - 4*a*c;

    if(d > 0) {
        root1 = (-b + sqrt(d)) / (2*a);
        root2 = (-b - sqrt(d)) / (2*a);
        printf("Real and distinct roots: %.2f and %.2f\n", root1, root2);
    } else if(d == 0) {
        root1 = -b / (2*a);
        printf("Real and equal roots: %.2f\n", root1);
    } else {
        printf("Imaginary roots\n");
    }
    return 0;
}
```

Sample Output:

Enter coefficients a, b, c: 1 -3 2
Real and distinct roots: 2.00 and 1.00

Experiment No 3: Develop a program to find whether a given number is prime or not.

Aim: To Develop a program to find whether a given number is prime or not.

Objective: To understand how to find given number is prime or not

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
int main() {
    int n, i, flag = 0;
    printf("Enter a number: ");
    scanf("%d", &n);

    if(n <= 1) flag = 1;
    for(i = 2; i <= n/2; i++) {
        if(n % i == 0) {
            flag = 1;
            break;
        }
    }
    if(flag == 0) printf("%d is Prime\n", n);
    else printf("%d is Not Prime\n", n);

    return 0;
}
```

Sample Output:
Enter a number: 7
7 is Prime

Experiment No 4: Develop a program to find key elements in an array using linear search.

Aim: To Develop a program to find key elements in an array using linear search.

Objective: To understand linear Search concept

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
int main() {
    int n, key, i, found = 0;
    printf("Enter number of elements: ");
    scanf("%d", &n);
    int arr[n];

    printf("Enter elements: ");
    for(i = 0; i < n; i++) scanf("%d", &arr[i]);

    printf("Enter key to search: ");
    scanf("%d", &key);

    for(i = 0; i < n; i++) {
        if(arr[i] == key) {
            printf("Element found at position %d\n", i+1);
            found = 1;
            break;
        }
    }
    if(!found) printf("Element not found\n");

    return 0;
}
```

Sample Output:

Enter number of elements: 5
Enter elements: 10 20 30 40 50
Enter key to search: 30
Element found at position 3

Experiment No 5: Given age and gender of a person, develop a program to categorise senior citizen (male & female).

Aim: To Develop a program to find Given age and gender of a person, and to develop a program to categorise senior citizen (male & female).

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
int main() {
    int age;
    char gender;
    printf("Enter age: ");
    scanf("%d", &age);
    printf("Enter gender (M/F): ");
    scanf(" %c", &gender);

    if(age >= 60) {
        if(gender == 'M' || gender == 'm')
            printf("Senior Citizen (Male)\n");
        else
            printf("Senior Citizen (Female)\n");
    } else {
        printf("Not a Senior Citizen\n");
    }
    return 0;
}
```

Sample Output:

```
Enter age: 65
Enter gender (M/F): M
Senior Citizen (Male)
```

Experiment No 6: Generate Floyd’s triangle for given rows

Aim: To Develop a program to Generate Floyd’s triangle for given rows

Objective: To understand Floyd’s triangle

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
int main() {
    int n, i, j, num = 1;
    printf("Enter number of rows: ");
    scanf("%d", &n);

    for(i = 1; i <= n; i++) {
        for(j = 1; j <= i; j++) {
            printf("%d ", num++);
        }
        printf("\n");
    }
    return 0;
}
```

Sample Output:

```
Enter number of rows: 4
1
2 3
4 5 6
7 8 9 10
```

Experiment No 7: Develop a program to find the transpose of a matrix

Aim: To Develop a program to find the transpose of a matrix

Objective: To understand transpose of a matrix

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
int main() {
    int r, c, i, j;
    printf("Enter rows and columns: ");
    scanf("%d %d", &r, &c);
    int a[r][c];

    printf("Enter matrix:\n");
    for(i=0; i<r; i++)
        for(j=0; j<c; j++)
            scanf("%d", &a[i][j]);

    printf("Transpose:\n");
    for(i=0; i<c; i++) {
        for(j=0; j<r; j++)
            printf("%d ", a[j][i]);
        printf("\n");
    }
    return 0;
}
```

Sample Output:

```
Enter rows and columns: 2 3
Enter matrix:
1 2 3
4 5 6
Transpose:
1 4
2 5
3 6
```

Experiment No 8: Develop a program to concatenate two strings, find length of a string and copy one string to other using string operations

Aim: To develop a program to concatenate two strings, find length of a string and copy one string to other using string operations

Objective: To understand concatenation of two strings, find length of a string and copy one string to other using string operations

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
#include <string.h>
int main() {
   char str1[50], str2[50], str3[50];

   printf("Enter first string: ");
   scanf("%s", str1);
   printf("Enter second string: ");
   scanf("%s", str2);

   // Concatenate
   strcpy(str3, str1);
   strcat(str3, str2);
   printf("Concatenated string: %s\n", str3);

   // Length
   printf("Length of Concatenated string: %d\n", (int)strlen(str3));

   // Copy
   strcpy(str3, str1);
   printf("Copied string: %s\n", str3);

   return 0;
}
```

Sample Output:

```
Enter first string: hello
Enter second string: world
Concatenated string: helloworld
Length of first string: 5
Copied string: hello
```

Experiment No 9: Develop a modular program to find GCD and LCM of given numbers

Aim: To develop a program to find GCD and LCM of given numbers

Objective: To understand GCD and LCM of given numbers

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
int gcd(int a, int b) {
   if(b == 0) return a;
   return gcd(b, a % b);
}
int main() {
   int a, b, g, l;
   printf("Enter two numbers: ");
   scanf("%d %d", &a, &b);

   g = gcd(a, b);
   l = (a * b) / g;

   printf("GCD = %d, LCM = %d\n", g, l);
   return 0;
}
```

Sample Output:

```
Enter two numbers: 12 18
GCD = 6, LCM = 36
```

Experiment No 10: Develop a program to declare the structure of employees and display the employee records with higher salary among two employees.

Aim: To develop a program to declare the structure of employees and display the employee records with higher salary among two employees**.**

Objective: To understand structure

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
struct Employee {
    int id;
    char name[50];
    float salary;
};
int main() {
    struct Employee e1, e2;
    printf("Enter details of Employee 1 (ID Name Salary): ");
    scanf("%d%s%f", &e1.id, e1.name, &e1.salary);
    printf("Enter details of Employee 2 (ID Name Salary): ");
    scanf("%d%s%f", &e2.id, e2.name, &e2.salary);

    if(e1.salary > e2.salary)
        printf("Employee with higher salary: %s (%.2f)\n", e1.name, e1.salary);
    else
        printf("Employee with higher salary: %s (%.2f)\n", e2.name, e2.salary);

    return 0;
}
```

Sample Output:

```
Enter details of Employee 1 (ID Name Salary): 1 John 45000
Enter details of Employee 2 (ID Name Salary): 2 Alice 55000
Employee with higher salary: Alice (55000.00)
```

Experiment No 11: Develop a program to add two numbers using the pointers to the variables.

Aim: To develop a program to add two numbers using the pointers to the variables.

Objective: To understand pointers to the variables.

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
int main() {
    int a, b, sum;
    int *p, *q;

    printf("Enter two numbers: ");
    scanf("%d %d", &a, &b);

    p = &a;
    q = &b;

    sum = *p + *q;
    printf("Sum = %d\n", sum);

    return 0;
}
```

Sample Output:

Enter two numbers: 5 7
Sum = 12

Experiment No 12: Develop a program to find the sum of digits of a given number.

Aim: To develop a program to find the sum of digits of a given number.

Objective: To understand sum of digits of a given number.

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
int main() {
    int n, sum = 0;
    printf("Enter number: ");
    scanf("%d", &n);

    while(n > 0) {
        sum += n % 10;
        n /= 10;
    }
    printf("Sum of digits = %d\n", sum);
    return 0;
}
```

Sample Output:

Enter number: 1234
Sum of digits = 10

Experiment No 13: Develop a program to perform Matrix Multiplication.

Aim: To develop a program to perform Matrix Multiplication.

Objective: To understand Matrix Multiplication.

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
int main() {
    int r1, c1, r2, c2, i, j, k;
    printf("Enter rows and columns of first matrix: ");
    scanf("%d %d", &r1, &c1);
    printf("Enter rows and columns of second matrix: ");
    scanf("%d %d", &r2, &c2);

    if(c1 != r2) {
        printf("Matrix multiplication not possible!\n");
        return 0;
    }

    int a[r1][c1], b[r2][c2], result[r1][c2];

    printf("Enter first matrix:\n");
    for(i=0; i<r1; i++)
        for(j=0; j<c1; j++)
            scanf("%d", &a[i][j]);

    printf("Enter second matrix:\n");
    for(i=0; i<r2; i++)
        for(j=0; j<c2; j++)
            scanf("%d", &b[i][j]);

    for(i=0; i<r1; i++)
        for(j=0; j<c2; j++) {
            result[i][j] = 0;
            for(k=0; k<c1; k++)
                result[i][j] += a[i][k] * b[k][j];
        }

    printf("Result matrix:\n");
    for(i=0; i<r1; i++) {
        for(j=0; j<c2; j++)
            printf("%d ", result[i][j]);
```

```
        printf("\n");
    }
    return 0;
}
```

Sample Output:

Enter rows and columns of first matrix: 2 2
Enter rows and columns of second matrix: 2 2
Enter first matrix:
1 2
3 4
Enter second matrix:
5 6
7 8
Result matrix:
19 22
43 50

Experiment No 14: Develop a program to create an array of structures to store book details and check whether a specific book, as requested by the user, is available or not.

Aim: To develop a program to create an array of structures to store book details and check whether a specific book, as requested by the user, is available or not.

Objective: To understand array of structures.

Software Tool Used: Code Blocks

Program:

```
#include <stdio.h>
#include <string.h>
struct Book {
    char title[50];
    char author[50];
    int id;
};
int main() {
    int n, i, found = 0;
    char searchTitle[50];
    printf("Enter number of books: ");
    scanf("%d", &n);

    struct Book b[n];

    for(i=0; i<n; i++) {
        printf("Enter book %d details (ID Title Author): ", i+1);
        scanf("%d %s %s", &b[i].id, b[i].title, b[i].author);
    }

    printf("Enter book title to search: ");
    scanf("%s", searchTitle);

    for(i=0; i<n; i++) {
        if(strcmp(b[i].title, searchTitle) == 0) {
            printf("Book Found: %s by %s (ID: %d)\n", b[i].title, b[i].author, b[i].id);
            found = 1;
            break;
        }
    }
    if(!found) printf("Book not available\n");
    return 0;
}
```

Sample Output:
Enter number of books: 2
Enter book 1 details (ID Title Author): 1 Cprog Dennis
Enter book 2 details (ID Title Author): 2 Algo Cormen
Enter book title to search: Cprog
Book Found: Cprog by Dennis (ID: 1)

Virtual Lab Experiments

EXPERIMENT:01

Evaluation Flow of Expression

AIM: To get familiar with expression evaluation.

Procedure for the experiment is as follows.

1. Select the type of operators and the data type you want to work upon from the top most bar.
2. You can edit the values of variables by pressing the edit button.
3. Select an expression prototype from the menu.
4. You can also edit this expression.
5. You can also edit this expression.
6. Press Next to see the step by step evaluation of the selected expression in the central panel and the corresponding reasoning in the right panel.
7. Press stop if you want to abort the experiment and start over.
8. Link: https://cse02-iiith.vlabs.ac.in/exp/cp-expression-evaluation/simulation.html

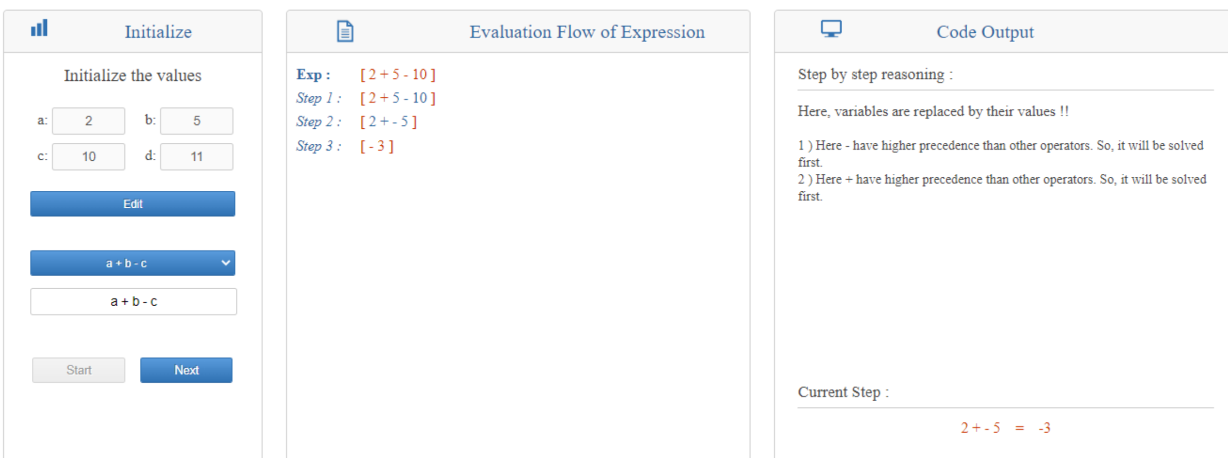

Fig1: Analysis of expression evaluation

EXPERIMENT:02

Understanding of Arrays

AIM: To get familiar with array data type.

For Experiment 1(working of 1D array):

1. Enter the size of array for selected problem and press OK.
2. Use Enter values to enter your own values in the box provided below for press Generate random values to generate a set of random values.
3. Press Start to start the experiment.
4. Click Next to get a step by step execution of the code.

Simulation Link: https://cse02-iiith.vlabs.ac.in/exp/arrays/simulation.html

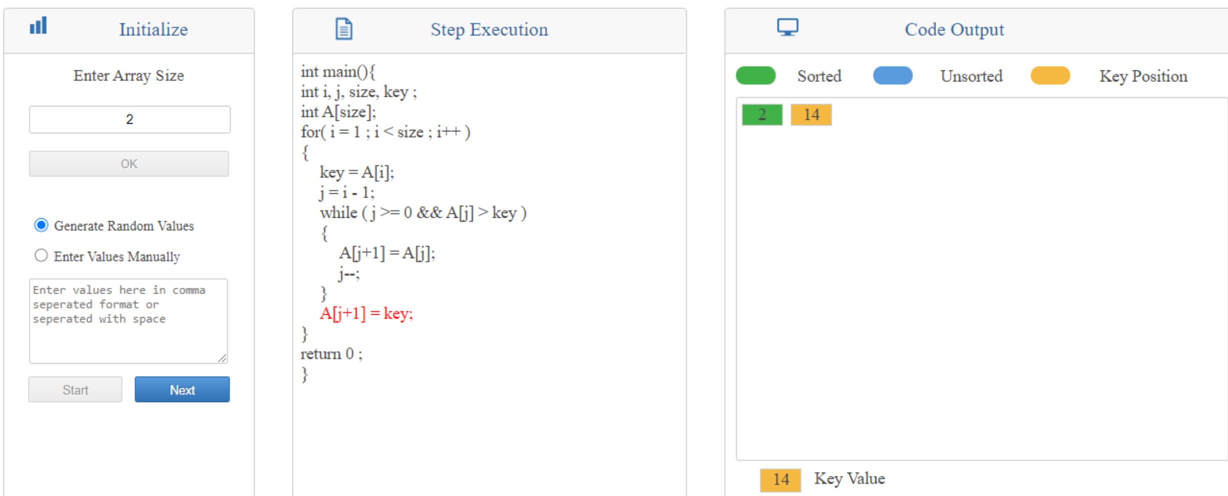

Fig1: Analysis of working of 1D array.

For Experiment 2(working of 2D array):

1. Enter the size of rows and columns for array A and press OK.
2. Press Generate random values to generate a set of random values.
3. Enter the size of columns for array B and press OK.
4. Press Generate random values to generate a set of random values.
5. Press Start to start the experiment.
6. Click Next to get a step by step execution of the code.

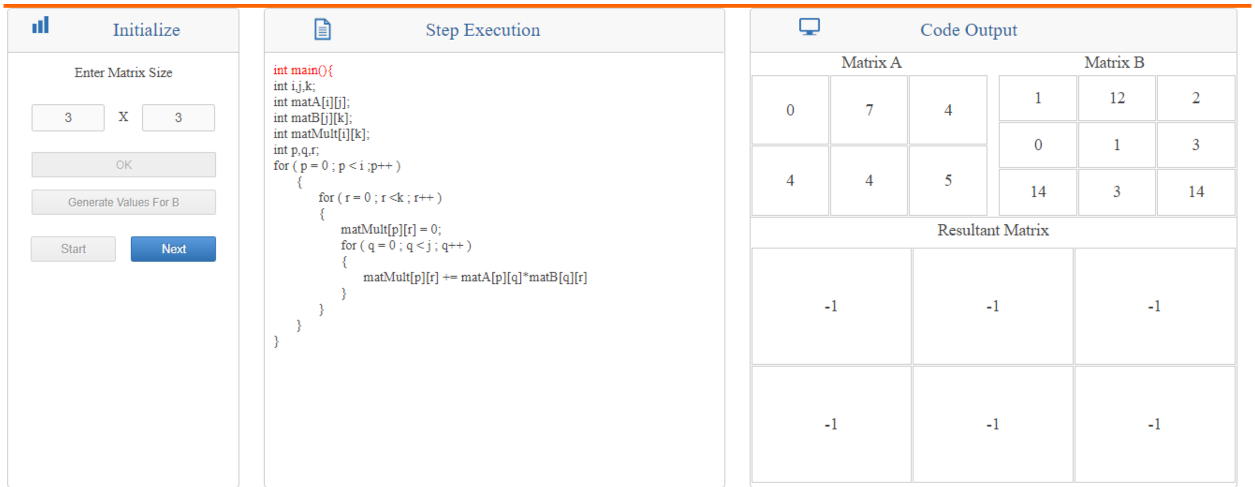

Fig2: Analysis of working of 2D array.