EXPERIMENT No-1

Standardize the Given Solution Of NaOH By Volumetric Method.

Principle:

It is an acid-base titration HCl is a strong acid and can be titrated with a base.

Standard Solution: 0.1 M HCl

Indicator: Phenolphthalein

End Point: Just Colourless

Equation: $HCl + NaOH \longrightarrow NaCl + H_2O$

Mole Ratio: 1 : 1

Procedure:

Take the given HCl solution in burette with the help of funnel and note the initial reading. Pipette out $10.0cm^3$ of NaOH in conical flask. Add 1-2 drops of phenolphthalein as an indicator. The solution becomes pink. Titrate this solution against HCl solution taken in burette. The end point is just colourless. Note the final reading. Take at least three concordant readings to calculate the exact volume of acid used.

Observations and Calculations:

i. Vol. of NaOH taken in conical flask for each titration = $10.0cm^3$.

ii. Vol. of HCl used from bulette for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of HCl used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0\ cm^3$

NaOH HCl

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

$$\frac{M_1 \times 10.0}{1} = \frac{0.1 \times 10.0}{1}$$

$$M1 = \frac{0.1 \times 10.0}{10.0} = 0.1\ M\ NaOH$$

Result:

Given solution of NaOH is $0.1\ mol/dm^3$

Exercise:

Standardize the given solution of H_2SO_4 by volumetric method.

Experiment No-2

Standardize The Given Solution Of HCl By Volumetric Method. Calculate The Volume Of This Solution Required To Make 500cm³ Of 0.01 M HCl.

Principle:

It is an acid-base titration. HCl is a strong acid and can be titrated with a strong base NaOH.

Standard Solution: 0.1 M NaOH

Indicator: Phenolphthalein

End Point: Just Colourless

Equation: $HCl + NaOH \longrightarrow NaCl + H_2O$

Mole Ratio: 1 : 1

Procedure:

Take the given HCl solution in burette with the help of funnel and note the initial reading. Pipette out $10.0 cm^3$ of NaOH in conical flask. Add 1-2 drops of phenolphthalein as an indicator. The solution becomes pink. Titrate this solution against HCl solution taken in burette. The end point is just colourless. Note the final reading. Take at least three concordant readings to calculate the exact volume of acid used.

Observations and Calculations:

(i) Vol. of NaOH taken in conical flask for each titration = $10.0 cm^3$.

(ii) Vol. of HCl used from bulette for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of HCl used
1.	0.0	10.0	$10.0 cm^3$
2.	10.0	20.0	$10.0 cm^3$
3.	20.0	30.0	$10.0 cm^3$

Concordant Reading = $10.0 cm^3$

HCl		NaOH
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M \times 10}{1}$	=	$\frac{0.1 \times 10}{1}$
M_1	=	$\frac{0.1 \times 10}{10} = 0.1\ mol/dm^3\ HCl$

Calculation for volume to make 500 cm^3 of 0.01 M HCl:
(Dilution method)

Known concentration = conc.to be prepared

$$M_1V_1 = M_2V_2$$

$$0.1 \times V_1 = 0.01 \times 500$$

$$V_1 = \frac{0.01 \times 500}{0.1}$$

$$V_1 = 50cm^3 \text{ of HCl}$$

Result:

The given HCl solution is 0.1M and 50cm^3 of this solution is mixed with 450cm^3 of water to make 500cm^3 of 0.01 M HCl solution.

Exercise:

(i) Standardize the given solution of HCl by volumetric method. calculate the volume of this solution required to make 250cm^3 of 0.05 M HCl.

(ii) Standardize the given solution of H_2SO_4 by volumetric method. calculate the volume of this solution required to make 100cm^3 of 0.05 M H_2SO_4.

MIXTURE ANALYSIS

Experiment No-3

The Given Solution Contains 5 Grams Of A Mixture Of NaOH And Na_2SO_4 Dissolved Per $500cm^3$. Determine Volumetrically Percentage Of Each In The Mixture.

Principle:

It is an acid-base titration. In the mixture NaOH is reactive against standard solution of HCl.

Standard Solution: 0.05 M HCl

Indicator: Phenolphthalein

End Point: Just Colourless

Equation: $HCl + NaOH \longrightarrow NaCl + H_2O$

Mole Ratio: 1 : 1

Procedure:

Take the given HCl solution in burette with the help of funnel and note the initial reading. Pipette out $10.0cm^3$ of NaOH and Na_2SO_4 mixture in conical flask. Add 1-2 drops of phenolphthalein as an indicator. The solution becomes pink. Titrate this solution against HCl. The end point is just colourless. Note the final reading. Take at least three concordant readings to calculate the exact volume of acid used.

Observations and Calculations:

(i) Vol. of mixture taken in conical flask for each titration = $10.0cm^3$.

(ii) Vol. of HCl used from bulette for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of HCl used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0\ cm^3$

NaOH		HCl
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M_1 \times 10.0}{1}$	=	$\frac{0.05 \times 10}{1}$
M_1	=	$0.05\ mol/dm^3$ of NaOH

Amount in g/dm^3 = molarity × mol. mass of NaOH

$= 0.05 \times 40$

$= 2\ g/dm^3$

$500cm^3$ solution contain mixture $= 5g$

$1000cm^3$ solution contain mixture $= \frac{5}{500} \times 1000$

$= 10\ g/dm^3$

%age of NaOH $= \frac{2}{10} \times 100 = 20\%$

%age of Na_2SO_4 $= 100 - 20 = 80\%$

Result:

The given mixture contains 20% NaOH and 80% Na_2SO_4.

Experiment No-4

The Given Solution Contains 2.5g Of A Mixture Of Oxalic acid and Sodium Oxalate Per 250cm³. Find Out % age Composition Of Mixture.

Principle:

It is an acid-base titration. In the mixture, oxalic acid will react with a standard base.

Standard Solution: 0.1 M NaOH

Indicator: Phenolphthalein

End Point: Just Colourless

Equation:

$$\begin{matrix} COOH \\ | \\ COOH \end{matrix} + 2NaOH \longrightarrow \begin{matrix} COONa \\ | \\ COONa \end{matrix} + 2H_2O$$

Mole Ratio: 1 : 2

Procedure:

Take the given mixture of solution in burette with the help of funnel and note the initial reading. Pipette out 10.0cm³ of NaOH in conical flask. Add 1-2 drops of phenolphthalein as an indicator. The solution becomes pink. Titrate this solution against acidic mixture taken in burette. The end point is just colourless. Note the final reading. Take at least three concordant readings to calculate the exact volume of acid used.

Observations and Calculations:

(i) Vol. of NaOH used for each titration = 10.0cm³.

(ii) Vol. of acid used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of Oxalic acid used
1.	0.0	10.0	10.0cm³
2.	10.0	20.0	10.0cm³
3.	20.0	30.0	10.0cm³

Concordant Reading = 10.0 cm³

$$\text{Oxalic acid} \qquad \text{NaOH}$$

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

$$\frac{M_1 \times 10.0}{1} = \frac{0.1 \times 10}{2}$$

$M_1 = 0.05$ M oxalic acid

$250cm^3$ solution contain mixture $= 2.5g$

$1000cm^3$ solution contain mixture $= \frac{2.5}{250} \times 1000$

$= 10.0$ g

Amount per dm^3 of oxalic acid $=$ molarity $\times$ mol. mass

$= 0.05 \times 126$

$= 6.3\ g/dm^3$

10.0 g mixture contain oxalic acid $= 6.3$ g

100 g mixture contain oxalic acid $= \frac{6.3}{10} \times 100 = 63g$

% age of $H_2C_2O_4.2H_2O$ $= 63\%$

% age of $Na_2C_2O_4$ $= 100 - 63 = 37\%$

Result:

The given mixture contains 63% oxalic acid and 37% sodium oxalate.

Exercise:

(i) The given solution contains 8g mixture of KOH and K_2SO_4 dissolved /dm^3. Calculate the % age of KOH volumetrically.

(ii) The given solution contains 2.5g mixture of HCl and NaCl dissolved/$250cm^3$. Calculate % age composition of each volumetrically.

Experiment No-5

The Given Solution Contains 10g Mixture Of H_2SO_4 and Na_2SO_4 dissolved Per dm^3. Determine % age composition of the Mixture.

Principle:

It is an acid-base titration. In the mixture H_2SO_4 is reactive against standard NaOH Solution.

Standard Solution: 0.1 M NaOH

Indicator: Phenolphthalein

End Point: Just colourless

Equation: $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$

Mole Ratio: 2 : 1

Procedure:

Take the given mixture of acid solution in burette with the help of funnel and note the initial reading. Pipette out $10.0cm^3$ of NaOH in conical flask. Add 1-2 drops of phenolphthalein as an indicator. The solution becomes pink. Titrate this solution against mixture taken in burette. The end point is just colourless. Note the final reading. Take at least three concordant readings to calculate the exact volume of H_2SO_4 used.

Observations and Calculations:

(i) Vol. of NaOH taken for each titration = $10.0cm^3$.

(ii) Vol. of H_2SO_4 used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of H_2SO_4 used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0\ cm^3$

$$\begin{array}{ccc} H_2SO_4 & & NaOH \\ \frac{M_1V_1}{n_1} & = & \frac{M_2V_2}{n_2} \\ \frac{M_1 \times 10.0}{1} & = & \frac{0.1 \times 10.0}{2} \end{array}$$

$$M_1 = \frac{0.1 \times 10.0}{2} \times \frac{1}{10.0} = 0.05 \text{ M of } H_2SO_4$$

Amount in g/dm^3 of H_2SO_4 $= \text{Molarity} \times \text{mol. mass}$

$= 0.05 \times 98$

$= 4.9\ g/dm^3$

% age of H_2SO_4 $= \frac{4.9}{10} \times 100 = 49\%$

% age of Na_2SO_4 $= 100 - 49 = 51\%$

Result:

The given mixture contains 49% H_2SO_4 and 51% of Na_2SO_4.

DETERMINATION OF MOLECULAR AND ATOMIC MASSES

Experiment No-6

The Given Solution Contain 4.0g of a Metal Hydroxide MOH Dissolved Per dm^3. determine The Atomic Mass of the Metal 'M'.

Principle:

It is an acid-base titration. MOH is strong base and can be titrated with a strong acid.

Standard Solution: 0.05 M H_2SO_4

Indicator: Phenolphthalein

End Point: Just colourless

Equation: $2MOH + H_2SO_4 \longrightarrow M_2SO_4 + 2H_2O$

Mole Ratio: 2 : 1

Procedure:

Take the given H_2SO_4 solution in burette with the help of funnel and note the initial reading. Pipette out $10.0cm^3$ of MOH solution in conical flask. Add 1-2 drops of phenolphthalein as an indicator. The solution becomes pink. Titrate this solution against standard solution taken in burette. The end point is just colourless. Note the final reading. Take at least three concordant readings to calculate the exact volume of acid used.

Observations and Calculations:

(i) Vol. of MOH taken for each titration = $10.0cm^3$

(ii) Vol. of H_2SO_4 used from burette for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of H_2SO_4 used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0\ cm^3$

$$\begin{aligned} &MOH && H_2SO_4 \\ &\frac{M_1V_1}{n_1} &=& \frac{M_2V_2}{n_2} \\ &\frac{M_1 \times 10.0}{2} &=& \frac{0.05 \times 10.0}{1} \end{aligned}$$

$$M_1 = \frac{0.05 \times 10.0}{1} \times \frac{2}{10.0} = 0.1\ M$$

$$= 0.1\ mol/dm^3\ MOH$$

Amount in g/dm^3 of MOH = molarity × mol. mass of MOH

$$4.0 = 0.1 \times \text{mol. mass of MOH}$$

$$\text{Mol. mass of MOH} = \frac{4.0}{0.1} = 40.0g$$

At mass of M = mol mass of MOH − Formula mass of OH^-

$$= 40.0 - 17$$

$$= 23\ g/mol.$$

Result:

The atomic mass of metal 'M' is 23 so the metal is sodium Na (Natrium).

Experiment No-7

The given solution contains 5.6g of an alkali metal hydroxide MOH per dm^3. Find out atomic mass of the metal and also the name of the metal.

Principle:

It is an acid-base titration. The alkali metal hydroxide can be titrated against an acid.

Standard Solution: 0.1 M HCl

Indicator: Phenolphthalein

End Point: Just colourless

Equation: $MOH + HCl \longrightarrow MCl + H_2O$

Mole Ratio: 1 : 1

Procedure:

Take the given HCl solution in burette with the help of funnel and note the initial reading. Pipette out $10.0cm^3$ of MOH solution in conical flask. Add 1-2 drops of indicator. The solution becomes pink. Titrate this solution against standard solution taken in burette. The end point is just colourless. Note the final reading. Take at least three concordant readings to calculate the accurate volume of acid used.

Observations and Calculations:

(i) Vol. of MOH taken for each titration = $10.0cm^3$.

(ii) Vol. of acid used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of HCl used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0\ cm^3$

$$\begin{array}{ccc} MOH & & HCl \\ \frac{M_1V_1}{n_1} & = & \frac{M_2V_2}{n_2} \\ \frac{M_1 \times 10.0}{1} & = & \frac{0.1 \times 10.0}{1} \\ M_1 & = & 0.1\ mol/dm^3 \text{ of MOH} \end{array}$$

Amount of MOH in g/dm^3 = Molarity × mol. mass of MOH

5.6 = 0.1 × mol. mass of MOH

(i) Mol. mass of MOH = $\frac{5.6}{0.1}$ = 56g

(ii) At mass of M = mol mass of MOH − Formula mass of OH^-

= 56 − 17

= 39 g/mol.

Result:

The molecular mass of MOH is 56 and the atomic mass of metal 'M' is 39. So the given metal hydroxide is KOH. The metal is kalium K (Potassium).

Exercise:

The given solution contains 0.4g of MOH dissolved per $100cm^3$. Determine the equivalent weight of MOH.

Experiment No-8

The given solution contains 10 g dm^{-3} of caustic soda (NaOH). Find the % purity of the sample.

Solution:

Standard reagent = 0.1 M HCl

Indicator = Phenolphthalein

Principle of titration = Acid – Base neutralization

Equation = $NaOH + HCl \longrightarrow NaCl + H_2O$

End point = Just colourless

Mole ratio = 1 : 1

Procedure:

Take HCl in the burette and 10 cm^3 of caustic soda solution in the titration flask with the help of pipette. Add one or two drops of phenolphthalein as on indicator. The solution turned pink. Now titrate it against HCl from the bruette drop wise till colourless end point is obtained. Take three concordant readings.

Observations and Calculations:

No.	Initial Reading	Final Reading	Volume of HCl Used
1	0.0	10.0	10.0 cm^3
2	10.0	20.0	10.0 cm^3
3	20.0	30.0	10.0 cm^3

C.R = 10.0 cm^3

NaOH HCl

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

$$\frac{M1 \times 10}{1} = \frac{0.1 \times 10}{1}$$

$$M_1 = 0.1$$

$$\text{Amount / } dm^3 \text{ of NaOH} = \text{Molarity} \times \text{Molar mass}$$

$$= 0.1 \times 40$$

$$= 4.0 \text{ g } dm^{-3}$$

10 grams of the solution gives pure NaOH $= 4\ g$

1 gram of the solution gives pure NaOH $= \frac{4}{10}$

100 grams of the solution gives pure NaOH $= \frac{4}{10} \times 100 = 40\%$

$\therefore$

% purity $= 40\%$

% impurity $= 100 - 40 = 60\%$

Result:

% purity $= 40\%$

Experiment No-9

6.3g Of Organic Dibasic Acid Have Been dissolved Per dm^3. Calculate Relative Molecular Mass Of Organic Dibasic Acid.

Principle:

It is an acid-base titration. Oxalic acid is a weak organic dibasic acid as it furnishes two protons its aqueous solution.

Standard Solution: 0.1 M NaOH

Indicator: Phenolphthalein

End Point: Just colourless

Equation:

$$\begin{matrix} COOH \\ | \\ COOH \end{matrix} \quad 2H_2O + 2NaOH \longrightarrow \begin{matrix} COONa \\ | \\ COONa \end{matrix} + 4H_2O$$

Mole Ratio: 1 : 2

Procedure:

Take the given acid in burette and note the initial reading. Pipette out $10.0cm^3$ of NaOH in conical flask. Add 1-2 drops of indicator in it. Solution becomes pink. Titrate this solution against acid taken in burette. The end point is just colourless. Take at least three concordant readings to calculate the accurate volume of acid used.

Observations and Calculations:

(i) Vol. of NaOH used for each titration = $10.0cm^3$.

(ii) Vol. of oxalic acid used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of Oxalic acid used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0\ cm^3$

$$H_2C_2O_4.2H_2O \qquad NaOH$$

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

$$\frac{M_1 \times 10.0}{1} = \frac{0.1 \times 10.0}{2}$$

$$M_1 = \frac{0.1 \times 10.0}{2} \times \frac{1}{10.0}$$

$$M_1 = 0.05M \text{ of } H_2C_2O_4.2H_2O$$

Amount in g/dm^3 of $H_2C_2O_4.2H_2O$ = molarity × relative mol. mass

6.3 = 0.05 × relative mol. mass

Relative molar mass = $\frac{6.3}{0.05} = 126 \text{ g.mol}^{-1}$

Result:

The relative molar mass is $126 g.mol^{-1}$

DETERMINATION OF WATER OF CRYSTALLIZATION

Experiment No-10

The Given Solution Contains 6.3g Of $\begin{matrix} COOH \\ | \\ COOH \end{matrix}$ xH_2Odissolved Per dm^3.Find Out The Value Of 'x'.

Principle:

It is an acid-base titration. Oxalic acid is a weak organic dibasic acid. It can be titrated with a strong base such as NaOH.

Standard Solution: 0.1 M NaOH

Indicator: Phenolphthalein

End Point: Just colourless

Equation:

$$2NaOH + \begin{matrix} COOH \\ | \\ COOH \end{matrix} xH_2O \longrightarrow \begin{matrix} COONa \\ | \\ COONa \end{matrix} + (x+2)H_2O$$

Mole Ratio: 2 : 1

Procedure:

Take the given oxalic acid solution in burette with the help of funnel and note the initial reading. Pipette out $10.0cm^3$ of NaOH in conical flask. Add 1-2 drops of phenolphthalein as an indicator. The Solution becomes pink. Titrate this solution against acid solution taken in burette. The end point is just colourless. Note the final reading. Take at least three concordant readings to get the exact volume used.

Observations and Calculations:

(i) Vol. of NaOH taken for each titration = $10.0cm^3$.

(ii) Vol. of $H_2C_2O_4.xH_2O$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of Oxalic acid used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0\ cm^3$

Oxalic acid		NaOH
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M_1 \times 10.0}{1}$	=	$\frac{0.1 \times 10.0}{2}$
M_1	=	$\frac{0.1 \times 10.0}{2} \times \frac{1}{10.0}$
M_1	=	0.05 M
Amount in g/dm^3	=	molarity $\times$ relative molecular

$$6.3 = 0.05 \times (90 + 18x)$$

$$\frac{6.3}{0.05} = 90 + 18x$$

$$126 = 90 + 18x$$

$$126 - 90 = 18x$$

$$36 = 18x$$

$$x = \frac{36}{18} = 2$$

$$x = 2$$

Result:

Water of crystallization in hydrated oxalic acid is = 2

DETERMINATION OF SOLUBILITY

Experiment No-11

Determine The Solubility Of Oxalic Acid Volumetrically At Room Temperature.

Principle:

It is an acid-base titration. Oxalic acid is a weak acid and can be titrated with a base.

Standard Solution: 0.1 M NaOH

Indicator: Phenolphthalein

End Point: Just colourless

Equation:

$$\begin{array}{c}COOH\\|\\COOH\end{array}.2H_2O + 2NaOH \longrightarrow \begin{array}{c}COONa\\|\\COONa\end{array} + 4H_2O$$

Mole Ratio: 1 : 2

Procedure:

Prepare a saturated solution of oxalic acid at room temperature. Take $10.0cm^3$ of this saturated solution and dilute it to $100cm^3$. Take this dilute solution in the burette with the help of funnel and note the initial reading. Pipette out $10.0cm^3$ of NaOH in conical flask. Add 1-2 drops of indicator in it. The Solution becomes pink. Titrate this solution against acid taken in burette. The end point is just colourless. Take at least three concordant readings to get the exact volume of acid used.

Observations and Calculations:

(i) Vol. of NaOH taken for each titration = $10.0cm^3$.

(ii) Vol. of oxalic acid used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of Oxalic acid used
1.	0.0	5.0	$5.0cm^3$
2.	5.0	10.0	$5.0cm^3$
3.	10.0	15.0	$5.0cm^3$

Concordant Reading = $5.0\ cm^3$

Oxalic acid		NaOH
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M_1 \times 5.0}{1}$	=	$\frac{0.1 \times 10.0}{2}$
M_1	=	$\frac{0.1 \times 10.0}{2} \times \frac{1}{5.0}$
M_1	=	$0.1\ mol/dm^3$ of oxalic acid

Amount in $H_2C_2O_4$ in g/dm^3 = Molarity × mol. mass

$= 0.1 \times 126$

$= 12.6\ g/dm^3$

$1000cm^3$ solution contain $H_2C_2O_4.2H_2O$ = 12.6g

$100cm^3$ dilute solution contain $H_2C_2O_4.2H_2O$ $= \frac{12.6}{1000} \times 100$

= 1.26g

$10cm^3$ of saturated solution = $100cm^3$ of dilute solution

10g of saturated solution contain oxalic acid = 1.26g ($d = 1g/cm^3$)

100g of saturated solution contain oxalic acid $= \frac{1.26}{10} \times 100 = 12.6g$

Result:

The solubility of oxalic acid at room temperature is = 12.6g

Experiment No-12

The Given Solution Contain 5g Of Soap Dissolved Per 500cm^3 Solution. Determine The Percentage Of Free Alkali In Soap.

Principle:

Soap is formed by the reaction of oil and caustic soda. Washing soap contains NaOH as free Alkali. The soap solution may be titrated against a standard solution of HCl in presence of phenolphthalein as an indicator.

Standard Solution: 0.1 MHCl

Indicator: Phenolphthalein

End point: Just colourless

Equation: $NaOH + HCl \longrightarrow NaCl + H_2O$

Mole ratio: 1 : 1

Procedure:

Take the given HCl in burette with the help of funnel and note the initial reading. Weigh 5g of toilet soap pieces and put them in hot water. Dissolve the soap and convert solution into 500cm^3 measuring flask. Make up the volume upto mark. Take 50cm^3 of soap solution in conical flask with the help of pipette. Add 1-2 drops of indicator in it. Titrate this solution against standard acid in burette. The end point is just colourless. Note the final reading. Take at least three concordant readings to calculate the exact volume of acid used.

Observations and Calculations:

(i) Vol. of soap solution taken for each titration = 50.0cm^3.

(ii) Vol. of HCl used for each titration

No. of Obs.	Initial Reading	Final Reading	Vol. of HCI used
1.	0.0	8.0	8.0cm^3
2.	8.0	16.0	8.0cm^3
3.	16.0	24.0	8.0cm^3

Concordant reading = 8.0cm^3

NaOH		HCl
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M1 \times 50.0}{1}$	=	$\frac{0.1 \times 8.0}{1}$
M_1	=	0.016M

Amount in g/dm^3 of NaOH = Molarity × Mol. mass

= 0.016×40

= $0.64\ g/dm^3$

$500cm^3$ solution contain soap = 5g.

$1000cm^3$ solution contain soap = $\frac{5}{500} \times 1000$ = 10g.

10g soap contain free alkali = 0.64g.

100g soap contain free alkali = $\frac{0.64}{10} \times 100$ = 6.4%

Result:

The given soap solution contain 6.4% free alkali.

Experiment No-13

The Given Solution Contains 40g Of Vinegar Per 200 Cm^3 Of Solution. Calculate The % age Of Acetic Acid (CH_3 COOH) In This Vinegar Sample.

Principle:

Vinegar is a mixture containing 3-6% CH_3 COOH, Ethyl acetate, Ethyl for mate and a number of fermentation products. The amount of acetic acid can be determine by titrating it against some base. So, it is an acid base titration.

Standard Solution: 0.1 M NaOH

Indicator: Phenolphthalein

End point: Just colourless

Equation: $NaOH + CH_3COOH \longrightarrow CH_3COONa + H_2O$

Mole ratio: 1 : 1

Procedure:

Take the given vinegar solution in burette with the help of funnel and note the initial reading. Only CH_3COOH in vinegar will react with NaOH. Pipette out $10.0cm^3$ of NaOH in conical flask. Add 1-2 drops of indicator in it.

The solution becomes pink. Titrate this solution against the acid taken in burette. The end point is just colourless. Note the final reading. Take at least three concordant readings to get the exact volume of acid used.

Observations and Calculations:

(i) Vol. of NaOH taken for each titration = 10.0 cm^3

(ii) Vol. of CH_3COOH used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of Acetic acid used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = **$10.0cm^3$**

$$\begin{array}{ccc} CH_3COOH & & NaOH \\ \frac{M_1V_1}{n_1} & = & \frac{M_2V_2}{n_2} \\ \frac{M_1 \times 10.0}{1} & = & \frac{0.1 \times 10.0}{1} \\ M_1 & = & 0.1\ mol/dm^3 \text{ of } CH_3COOH \end{array}$$

Amounting g/dm^3 of CH_3COOH = Molarity × Molecular mass

= 0.1×60

= $6.0\ g/dm^3$

$200cm^3$ solution contain vinegar = 40g

$1000cm^3$ solution contain vinegar = $\frac{40}{200} \times 1000$

= $200g/dm^3$

200g vinegar contain CH_3COOH = 6g

100g vinegar contain CH_3COOH = $\frac{6}{200} \times 100 = 3\%$

% age of CH_3COOH = 3%

Result:

The given vinegar sample contains 3%. CH_3 COOH

Experiment No-14

The Given Solution Contain 16g Of Na_2CO_3 And NaCl Dissolved $/dm^3$. Calculate the Composition Of each in 80g Of Mixture Volumetrically.

Principle:

It is an acid-base titration. In this mixture Na_2CO_3 is reactive against standard acid like HCl.

Standard Solution: 0.1 M HCl

Indicator: Methyl Orange

End Point: Just light pink / orange red

Equation: $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$

Mole Ratio: 1 : 2

Procedure:

Take the given HCl solution in burette and note the initial reading. Pipette out $10.0cm^3$ of basic mixture in conical flask. Add 1-2 drops of methyl orange as an indicator. The solution becomes yellow. Titrate this solution against HCl solution taken in burette. The end point is just light pink/orange red. Note the final reading. Take at least three concordant readings to calculate the exact volume of acid used.

Observations and Calculations:

(i) Vol. of mixture taken for each titration = $10.0cm^3$.

(ii) Vol. of acid used from burette for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of HCl used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0\ cm^3$

$$\begin{array}{ccc} Na_2CO_3 & & HCl \\ \frac{M_1V_1}{n_1} & = & \frac{M_2V_2}{n_2} \\ \frac{M_1 \times 10.0}{1} & = & \frac{0.1 \times 10.0}{2} \\ M_1 & = & 0.05\ mol/dm^3 \text{ of } Na_2CO_3 \end{array}$$

Amount per dm^3 of Na_2CO_3 = molarity × mol. mass

= 0.05×106

= $5.3\ g/dm^3$

16g mixture contain Na_2CO_3 = 5.3g

80g mixture contain Na_2CO_3 = $\frac{5.3g}{16} \times 80 = 26.5\ g$

Amount in NaCl = 80 - 26.5

= 53.5 g

Result:

The given 80 g mixture contains 26.5g of Na_2CO_3 and 53.5g of NaCl.

Exercise:

(i) The given solution contains 15g of a mixture of NaOH and Na_2SO_4 dissolved per dm^3. Calculate the amount of NaOH in 50g of the mixture.

(ii) The given solution contains 2.0g of HCl and NaCl dissolved in $500cm^3$. Calculate % age of NaCl.

Experiment No-15

The Given Solution Contains 0.84g Of Alkali Metal Bicarbonate dissolved Per 100cm³ Of Solution. Calculate Atomic Mass Of Metal 'M'.

Principle:

It is an acid-base titration. $MHCO_3$ is a weak base. It can be titrated with a strong acid.

Standard Solution: 0.1 M HCl

Indicator: Methyl Orange

End Point: Just light pink / orange red

Equation: $MHCO_3 + HCl \longrightarrow MCl + H_2O + CO_2$

Mole Ratio: 1 : 1

Procedure:

Take the given HCl solution in burette with the help of funnel and note the initial reading. Pipette out $10.0cm^3$ of $MHCO_3$ in conical flask. Add 1-2 drops of methyl orange in it. The solution becomes yellow. Titrate this solution against HCl taken in burette. The end point is just light pink/orange red. Note the final reading. Take at least three concordant readings to calculate the accurate volume of acid used.

Observations and Calculations:

(i) Vol. of $MHCO_3$ taken for each titration = $10.0cm^3$.

(ii) Vol. of HCl used from burette for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of HCl used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0\ cm^3$

$MHCO_3$		HCl
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M_1 \times 10.0}{1}$	=	$\frac{0.1 \times 10.0}{1}$

$M_1 = 0.1\ mol/dm^3$ of $MHCO_3$

$100cm^3$ solution contain $MHCO_3 = 0.84$ g

$1000\ cm^3$ solution contain $MHCO_3 = \frac{0.84}{100} \times 1000$

$= 8.4\ g/dm^3$

Amount of $MHCO_3$ in g/dm^3 = molarity $\times$ mol. mass of $MHCO_3$

$8.4 = 0.1 \times$ mol. mass of $MHCO_3$

Mol. mass of $MHCO_3 = \frac{8.4}{0.1} = 84$

Atomic mass of M = mol mass of $MHCO_3$ – Formula mass of HCO_3^-

$= 84 - 61$

Atomic mass of M = 23

Result:

The atomic mass of metal 'M' is 23 so, the metal is sodium Na (Natrium).

Experiment No-16

The Given Solution Contains 2.5g Of Impure Baking Soda ($NaHCO_3$) dissolved per $250cm^3$. Calculate The %age Purity Of Sample Volumetrically:

Principle:

It is an acid -base titration. Baking soda $NaHCO_3$ being weak Base can be titrated against a strong acid.

Standard Solution: 0.1 MHCl

Indicator: Methyl orange

End point: Just light pink / orange red

Equation: $NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$

Mole ratio: 1 : 1

Procedure:

Take the given acid in the burette with the help of funnel and note the initial reading. Pipette out $10.0cm^3$ of baking soda sample in conical flask. Add 1-2 drops of indicator in it. The solution becomes yellow. Titrate this solution against the solution taken in burette. The end point is just light pink/orange red. Take at least three concordant readings to calculate the exact volume of acid used.

Observations and Calculations:

(i) Vol of $NaHCO_3$ taken for each titration = $10.0 cm^3$

(ii) Vol. of Acid used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of HCl used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant reading = $10.0cm^3$

$NaHCO_3$		HCl
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M_1 \times 10.0}{1}$	=	$\frac{0.1 \times 10.0}{1}$
M_1	=	0.1 mol/dm^3 of $NaHCO_3$

Amount of $NaHCO_3$ (Pure) in g/dm^3 = Molarity $\times$ Mol. mass

$= 0.1 \times 84$

$= 8.4$ g/dm^3

250 cm^3 solution contains impure sample = 2.5g.

1000 cm^3 solution contain impure sample $= \frac{2.5}{250} \times 1000$

= 10.0g.

10.0g baking soda contain pure $NaHCO_3$ = 8.4g

100.0g backing soda contain pure $NaHCO_3$ =

$= \frac{8.4}{10} \times 100$

= 84%

% age purity = 84%

Result:

The given impure sample of baking soda contains pure $NaHCO_3$ = 84%

Exercise:

The given soln contains 7.5g of impure baking soda $NaHCO_3$ dissolved per 500 cm^3. Calculate % purity of the sample.

Experiment No-17

The Given Solution Contains 8.0g Of Impure Na_2CO_3 (soda Ash) dissolved per dm^3. Calculate The % age Of Pure Na_2CO_3 Volumetrically.

Principle:

It is an acid base titration. Na_2CO_3 being a weak base can be titrated with a strong acid.

Standard Solution: 0.05M H_2SO_4

Indicator : Methyl orange

End point : • Just light pink / orange red

Equation : $Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + CO_2 + H_2O$

Mole ratio : 1 : 1

Procedure:

Take the given H_2SO_4 in the burette with the help of funnel and note the initial reading. Pipette out $10.0cm^3$ of Na_2CO_3 in the conical flask. Add 1-2 drops of Methyl orange as an indicator in conical flask. The solution becomes yellow. Titrate this solution against acid taken in burette. The end point is just light pink/orange red colour. Note the final reading. Take at least three concordant readings to calculate the exact volume of acid used.

Observations and Calculations:

(i) Vol. of Na_2CO_3 taken for each titration = $10.0cm^3$.

(ii) Vol. of Acid used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of H_2SO_4 used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant reading = $10.0cm^3$

$$\begin{array}{ccc} Na_2CO_3 & & H_2SO_4 \\ \frac{M_1V_1}{n_1} & = & \frac{M_2V_2}{n_2} \\ \frac{M_1 \times 10.0}{1} & = & \frac{0.05 \times 10.0}{1} \\ M_1 & = & 0.05M\ Na_2CO_3 \end{array}$$

Amount of Na_2CO_3 in sample = Molarity × Mol. mass

= 0.05 × 106

= $5.3g/dm^3$

8g impure sample contain Na_2CO_3 (Pure) = 5.3g

100g impure sample contain Na_2CO_3(Pure) =

$= \frac{5.3}{8} \times 100$

= 66.25%

Result:

The given impure sample of soda ash contain 66.25% pure Na_2CO_3.

Exercise:

(i) The given solution contains 5g of impure sample of soda ash Na_2CO_3 dissolved per $500cm^3$. Calculate the %age purity of sample.

(ii) The given solution contains 2g of washing soda dissolved per $250cm^3$ of solution. Calculate the %age purity of Na_2CO_3 in the sample.

SECTION-II
REDOX ($KMnO_4$ Titration)

Redox Reaction:

A reaction in which both oxidation and reduction reactions occur simultaneously is called redox reaction.

Oxidation:

Oxidation may be defined in a number of way as if the reactant.

(1) Gains oxygen.
(2) Losses electrons.
(3) Losses hydrogen.
(4) Increase in oxidation number, then the process of oxidation occurs.

Reduction:

Reduction is the opposite of oxidation. In this reaction, if the reactant.

(1) Gains hydrogen.
(2) Gains electrons.
(3) Losses oxygen.
(4) There is a decrease in oxidation number.

The process of oxidation and reduction are opposite to each other. They take place simultaneously. No reaction occurs alone.

Consider The Followwing Reaction:

$2KMnO_4 + 10FeSO_4 . 7H_2O + 8H_2SO_4$

$\downarrow$

$K_2SO_4 + 2MnSO_4 + 5\ Fe_2(SO_4)_3 + 78H_2O$

Since $FeSO_4$ is converted into $Fe_2(SO_4)_3$ there is a loss of electrons.

We can calculate it by the following method.

$FeSO_4$	$Fe_2(SO_4)_3$
$Fe + (+6) + 4(-2) = 0$	$2Fe + 3(+6) + 3(-8) = 0$
$Fe + 6 - 8 = 0$	$2Fe + 18 - 24 = 0$
$Fe - 2 = 0$	$2Fe - 6 = 0$
$Fe = +2$	$2Fe = +6$
	$Fe = +6/2$
	$Fe = +3$

$Fe^{+2} \rightarrow Fe^{+3} + 1e^-$

Since there is loss of e^-, So oxidation take place in the above reaction.

Similarly

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{+2} + 4H_2O$$

OR

$$KMnO_4 \longrightarrow MnSO_4$$

$(+1) + Mn + 4(-2) = 0$	$Mn + (+6) + 4(-2) = 0$
$Mn + 1 - 8 = 0$	$Mn + 6 - 8 = 0$
$Mn - 7 = 0$	$Mn - 2 = 0$
$Mn = +7$	$Mn = +2$

Since $Mn^{+7} + 5e^- \longrightarrow Mn^{+2}$

There is a gain of electrons so reduction take place.

The branch of volumetric analysis in which an oxidizing agent is titrated against a reducing agent or vice versa is called Redox titration.

A substance that gains electrons during a chemical reaction is called oxidizing agent e.g. $KMnO_4$. The positive charge of an oxidizing agent is reduced during a chemical reaction. Oxidizing agent is always reduced in the reaction.

A substance that losses or donates electrons in a chemical reaction is called a reducing agent e.g $FeSO_4$ $7H_2O$. The positive charge of reducing agent is increased during the chemical reaction. Reducing agent is always oxidized in a chemical reaction.

List of Oxidizing Agents:

(1) $KMnO_4$

(2) $K_2Cr_2O_7$

(3) Conc. HNO_3

List of Reducing Agents:

(1) $FeSO_4 . 7H_2O$

(2) $FeSO_4 . (NH_4)_2 SO_4 . 6H_2O$ (Mohr's Salt)

(3) $H_2C_2O_4 . 2H_2O$

(4) $Na_2C_2O_4$.

(5) $K_2C_2O_4$.

(6) $(NH_4)_2 C_2O_4 . H_2O$

Indicator:

$KMnO_4$ itself acts as an indicator in these reaction because it is a colour substance. Oxidation-reduction reaction is a colourless reaction. At the end point one drop of $KMnO_4$ indicates the end point by changing the colour of solution pink.

Reaction of KMnO4 with $FeSO_4 . 7H_2O$.

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$
$$[2FeSO_4 + H_2SO_4 + [O] \longrightarrow Fe_2(SO_4)_3 + H_2O] \times 5$$
$$2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$$

Reduction of $KMnO_4$ with Mohr's Salt:

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5(O)$$
$$[2(FeSO_4(NH_4)_2SO_4 . 6H_2O) + H_2SO_4 + (O) \longrightarrow Fe_2(SO_4)_3 + 2(NH_4)_2SO_4 + 13H_2O] \times 5$$
$$2KMnO_4 + 8H_2SO_4 + 10FeSO_4(NH_4)_2SO_4 . 6H_2O \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 10(NH_4)_2SO_4 + 68H_2O$$

Reaction of $KMnO_4$ with Oxalic Acid:

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5(O)$$
$$\left[\begin{matrix}COOH\\COOH\end{matrix} + (O) \longrightarrow 2CO_2 + H_2O\right] \times 5$$
$$2KMnO_4 + 3H_2SO_4 + 5\begin{matrix}COOH\\COOH\end{matrix} \longrightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O$$

Reaction of $KMnO_4$ with Salts of Oxalic Acid:

GENERAL INSTRUCTIONS FOR $KMnO_4$ TITRATIONS:

(1) Always take $KMnO_4$ in the burette $KMnO_4$ being a coloured liquid, its upper meniscus is read.

(2) $KMnO_4$ itself acts as an indicator so no other indicator is used in $KMnO_4$ titration.

(3) As indicated in the above equations, all redox reactions take place in presence of dilute. H_2SO_4, Therefore always add half test tube of dilute H_2SO_4 in conical flask.

(4) When titrations with oxalic acid are carried out, 60 - 70C temperature is needed.

(5) If the temperature falls below 60C, brown ppt must appear which tells about incomplete reaction, so always titrate hot solution while carrying out titration with oxalic acid.

(6) In case of Ferrous ions, heating is not necessary because on heating Fe^{+2} are easily converted into Fe^{3+} ions, by atmospheric oxygen.

(7) Sometimes a brownish black colour or brown precipitates are obtained at the end point which may be due to the following reasons.

- (i) Due to abrupt addition of $KMnO_4$ solution in form of continuous stream.
- (ii) Due to insufficient amount of dil. H_2SO_4 added.
- (iii) Due to incomplete reactions MnO_2 ppt settle down.

(8) The burette should not be filled upto zero mark because upper meniscus is to be read in the reaction.

(9) Due to green colour of iron salts solution, during their volume measurement, upper meniscus must be read.

EXPERIMENT No-18

Standardize The Given Solution Of $KMnO_4$ By Volumetric Method.

Principle:

It is a redox titration. $KMnO_4$ is an oxidizing agent and can be reduced by some reducing agent e.g $FeSO_4.7H_2O$ in presence of dil. H_2SO_4.

Standard Solution: 0.1M $FeSO_4 . 7H_2O$

Indicator: $KMnO_4$ (itself)

End point: Just light pink

Equation: $2KMnO_4 + 10FeSO_4.7H_2O + 8H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 78H_2O$

Mole Ratio: 2 : 10

Procedure:

Take $KMnO_4$ solution in the burrette with the help of funnel and remove the funnel. Note the initial reading. Pipette out $10.0cm^3$ of $FeSO_4 . 7H_2O$ in conical flask. Add half test tube of dil H_2SO_4 in it. Titrate this solution against $KMnO_4$ solution taken in burette. End point is just light pink. Take at least three concordant readings to get the exact volume of $KMnO_4$ used.

Observation and Calculations:

(i) Vol. of $FeSO_4 . 7H_2O$ solution taken in conical flask for each titration = $10.0cm^3$.

(ii) Vol. of $KMnO_4$ used from burette for each titration

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Cancordant reading = $10.0\ cm^3$

$$KMnO_4 \qquad FeSO_4 . 7H_2O$$

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

$$\frac{M_1 \times 10.0}{2} = \frac{0.1 \times 10.0}{10}$$

$$M_1 = \frac{0.1 \times 10.0}{10} \times \frac{2}{10.0} = 0.02M$$

$$\text{Amount in g/dm}^3 = \text{Molarity} \times \text{Mol mass of } KMnO_4$$

$$= 0.02 \times 158$$

$$= 3.16g$$

Result:

The given $KMnO_4$ solution is 0.02M having 3.16 g/dm^3.

Experiment No-19

Standardize The Given Solution Of $KMnO_4$. Also Calculate The Volume Of $KMnO_4$ Required To Prepare $400cm^3$ Of 0.005M $KMnO_4$.

Principle:

It is a redox-titration $KMnO_4$ is an oxidizing agent and can be reduced with some reducing agent.

Standard Solution: 0.1M Mohr's salt

Indicator: $KMnO_4$ (itself)

End point: Just light pink

Equation:

$$2KMnO_4 + 10FeSO_4 (NH_4)_2 SO_4 . 6H_2O + 8H_2SO_4$$
$$\downarrow$$
$$K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 10(NH_4)_2 SO_4 + 68H_2O$$

Mole Ratio: $KMnO_4$: Mohr's salt
2 : 10

Procedure:

Take given $KMnO_4$ solution in the burette with the help of funnel, then remove the funnel and note the initial reading. Take $10.0cm^3$ of Mohr's salt in conical flask with the help of pipette. Add half test tube of dil H_2SO_4 in it. Titrate this solution against $KMnO_4$ taken in burette. The end point is just light pink colour.

Note the final reading. Take at least three concordant readings to calculate the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of Mohr's salt soln taken for each titration = $10.0cm^3$
(ii) Vol. of $KMnO_4$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Cancordant reading = $10.0\ cm^3$

KMnO$_4$		Mohr's salt

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

$$\frac{M_1 \times 10.0}{2} = \frac{0.1 \times 10.0}{10}$$

$$M_1 = \frac{0.1 \times 10.0}{10} \times \frac{2}{10.0} = 0.02M$$

$$M_1 = 0.02 \text{ mol/dm}^3 \text{ of } KMnO_4$$

Dilution Formula:

$$M_1V_1 = M_2V_2$$

$$\text{Given } KMnO_4 = \text{Required } KMnO_4$$

$$M_1V_1 = M_2V_2$$

$$0.02 \times V_1 = 0.005M \times 400$$

$$V_1 = \frac{0.005M \times 400}{0.02}$$

$$V_1 = 100cm^3$$

Result:

Molarity of given $KMnO_4$ soln is 0.02 mol/dm^3. 100cm^3 of this solution is required to mix with 300cm^3 of water to get 0.005M soln of 400cm^3 volume.

MIXTURE ANALYSIS

Experiment No-20

The Given Solution Contain 8.0 Grams Of A Mixture Of $KMnO_4$ And K_2SO_4 dissolved Per dm^3. Calculate The Amount Of K_2SO_4 In The Mixture Solution.

Principle:

It is a redox titration. $KMnO_4$ is an oxidizing agent and can be titrated against reducing agent like $FeSO_4 . 7H_2O$ in the presence of dil H_2SO_4. In the give mixture, only $KMnO_4$ is reactive.

Standard Solution : 0.1M $FeSO_4 . 7H_2O$

Indicator : $KMnO_4$ (itself)

End Point : Just light pink

Equation:

$$2KMnO_4 + 10FeSO_4.7H_2O + 8H_2SO_4 \downarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 78H_2O$$

Mole Ratio : $KMnO_4$: $FeSO_4 . 7H_2O$

2 : 10

Procedure:

Take mixture solution in the burette and note the initial reading. Pipette out $10.0cm^3$ of $FeSO_4 . 7H_2O$ solution in conical flask. Then add half test take of dil . H_2SO_4 in it. Titrate this solution against mixture taken in burette. The end point is just light pink. Note the final reading. Take at least three concordant reading to calculate the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of $FeSO_4 . 7H_2O$ soln taken for each titration = $10.0cm^3$.

(ii) Vol. of $KMnO_4$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of KMnO4 used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Cancordant reading = $10.0\ cm^3$

$$KMnO_4 \qquad\qquad FeSO_4 . 7H_2O$$

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

$$\frac{M_1 \times 10.0}{2} = \frac{0.1 \times 10.0}{10}$$

$$M_1 = \frac{0.1 \times 10.0}{10} \times \frac{2}{10} = 0.02M$$

Amount of $KMnO_4$ in g/dm^3 = Molarity × Mol. mass

$= 0.02 \times 158$

$= 3.16\ g/dm^3$

8.0g mixture contain $KMnO_4$ = 3.16g

Amount of K_2SO_4 = $8 - 3.16$

$= 4.84g$

Result:

In the given mixture of $KMnO_4$ and K_2SO_4, the amount of K_2SO_4 is = 4.84g

Exercise:

(i) The given solution contains 5.0g of a mixture of $KMnO_4$ and K_2SO_4 dissolved per $500cm^3$ soln. Determine the % age of each component in the mixture.

(ii) The given solution contain 8.0g of mixture of $KMnO_4$ and K_2SO_4 dissolved per dm^3. Find out composition of each in 200g of the mixture.

Experiment No-21

The Given Solution Contains 6.0g Of Hydrated Oxalic Acid And Sulphuric Acid dissolved per 500 Cm^3 Of Solution. Find The % age Composition Of each.

Principle:

It is a redox titration. In this mixture oxalic acid reacts with $KMnO_4$ in the presence of dil. H_2SO_4.

Standard Solution: 0.02M $KMnO_4$

Indicator: $KMnO_4$ (itself)

End Point: Light pink

Equation:

$$2KMnO_4 + 5\begin{array}{c}COOH\\|\\COOH\end{array} 2H_2O + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 18H_2O$$

Mole Ratio:

$KMnO_4$	:	Oxalic acid
2	:	5

Procedure:

Take given $KMnO_4$ solution in the burette and note the initial reading. Pipette out given mixture of oxalic acid and sulphuric acid in the conical flask and then add half test tube of dil. H_2SO_4 in it. Heat the solution upto 60-70C and then titrate this hot solution against $KMnO_4$. The end point is just light pink. Note the final reading. Take at least three concordant readings to calculate the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of mixture taken for each titration = 10.0cm^3

(ii) Vol. of $KMnO_4$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	10.0	10.0cm^3
2.	10.0	20.0	10.0cm^3
3.	20.0	30.0	10.0cm^3

Cancordant reading = 10.0 cm^3

$$\text{Oxalic acid} \qquad KMnO_4$$

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

$$\frac{M_1 \times 10.0}{5} = \frac{0.02 \times 10.0}{2}$$

$$M_1 = \frac{0.02 \times 10.0}{2} \times \frac{5}{10.0}$$

$$M_1 = 0.05M \text{ oxalic acid}$$

Amount is g/dm^3 of oxalic acid = Molarity × Molar mass

= 0.05 × 126

= 6.3 g/dm^3

500cm^3 solution contain mixture = 6.0g

1000cm^3 solution contain mixture = $\frac{6}{500} \times 1000 = 12g$

12g mixture contain oxalic acid = 6.3g

100g mixture contain oxalic acid = $\frac{6.3}{12} \times 100 = 52.5\%$

% age of H_2SO_4 = 100 − 52.5 = 47.5%

Result:

The given mixture contains 52.5% oxalic acid and 47.5% of H_2SO_4.

EXPERIMENT No-22

The Given Solution Contain 10 Grams Of A Mixture Of Ammonium Oxalate And Ammonium Sulphate dissolved Per dm^3. Find Out % age Of each By Volumetric Method.

Principle:

It is a redox titration. In the given mixture, Ammonium oxalate contain $C_2O_4^{2-}$ ions and can be titrated against oxidizing agent in the presence of dil. H_2SO_4.

Standard Solution: 0.02M $KMnO_4$

Indicator: $KMnO_4$ (itself)

End point: Just light pink

Equation:

$$2KMnO_4 + 5(NH_4)_2C_2O_4 . H_2O + 8H_2SO_4 \downarrow$$

$$K_2SO_4 + 2MnSO_4 + 5(NH_4)_2 SO_4 + 10CO_2 + 13H_2O$$

Mole Ratio:

$KMnO_4$: $(NH_4)_2 C_2O_4 . H_2O$

2 : 5

Procedure:

Take $KMnO_4$ solution in the burette and note the initial reading. Pipette out $10.0cm^3$ of mixture in the conical flask and add half test tube of dil. H_2SO_4 in it. Heat the solution of conical flask upto 60-70C. Now titrate this hot solution against $KMnO_4$. The end point is just light pink. Note the final reading. Take at least three concordant readings to get the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of Mixture, taken for each titration $= 10.0cm^3$

(ii) Vol. of $KMnO_4$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Cancordant reading = $10.0\ cm^3$

$$(NH_4)_2C_2O_4 \cdot H_2O \qquad KMnO_4$$

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

$$\frac{M_1 \times 10.0}{5} = \frac{0.02 \times 10.0}{2}$$

$$M_1 = \frac{0.02 \times 10.0}{2} \times \frac{5}{10.0}$$

$$= 0.05M \text{ Amm . Oxalate.}$$

Amount in g/dm^3 of $(NH_4)_2C_2O_4 \cdot H_2O$ $=$ Molarity × Mol. mass

$= 0.05 \times 142$

$= 7.1\ g/dm^3$

10g mixture contain $(NH_4)_2C_2O_4 \cdot H_2O$ $= 7.1g$

100g mixture contain $(NH_4)_2C_2O_4 \cdot H_2O$ $= \frac{7.1}{10} \times 100$

$= 71\%$

% age of $(NH_4)_2SO_4$ $= 100 - 71$

$= 29\%$

Result:

In the given mixture 71% $(NH_4)_2C_2O_4 \cdot H_2O$ and 29% $(NH_4)_2SO_4$ is present.

Exercise:

The given solution contains 12g mixture of potassium oxalate and potassium sulphate dissolved per dm^3. Find out % age of ecah volumetrically.

Experiment No-23

The Given Solution Contains 6.3g Of Hydrated Oxalic Acid $\begin{array}{c}COOH\\|\\COOH\end{array} \times H_2O$ dissolved Per dm^3. Find Out Value Of 'x'.

Principle:

It is a redox titration. Oxalic acid is a reducing agent and can be oxidized to CO_2 by an oxidizing agent such as $KMnO_4$ in the presence of dil. H_2SO_4 at 60-70 C.

Standard Solution: 0.02M $KMnO_4$

Indicator: $KMnO_4$ (itself)

End Point: Just light pink

Equation:

$$2KMnO_4 + 5\begin{array}{c}COOH\\|\\COOH\end{array}.xH_2O + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + (5x+8)H_2O$$

Mole Ratio:

$KMnO_4$:	Oxalic acid
2 :	5

Procedure:

Take given $KMnO_4$ solution in the burette with the help of funnel and then remove the funnel. Note the initial reading. Pipette out $10.0cm^3$ of oxalic acid in conical flask.

Add half test tube of dil . H_2SO_4 in it. Heat the solution upto 60-70C and then titrate this hot solution against standard $KMnO_4$ solution. End point is just light pink. Note the final reading. Take at least three concordant readings to calculate the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of oxalic acid taken for each titration = $10.0cm^3$

(ii) Vol. of $KMnO_4$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading $= 10.0cm^3$

Oxalic acid KMnO$_4$

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

$$\frac{M_1 \times 10.0}{5} = \frac{0.02 \times 10.0}{2}$$

$$M_1 = \frac{0.02 \times 10.0}{2} \times \frac{5}{10.0}$$

$$M_1 = 0.05M \text{ oxalic acid}$$

Mol. mass of $H_2C_2O_4 . xH_2O$ = 90 + 18x.

Amount in g/dm^3 of oxalic acid = Molarity × Mol. mass

$$6.3 = 0.05 \times (90+18x)$$

$$\frac{6.3}{0.05} = (90 + 18x)$$

$$126 = (90 + 18x)$$

$$126 - 90 = 18x$$

$$36 = 18x$$

$$x = \frac{36}{18} = 2$$

Result:

$$x = 2$$

The number of water molecules associated with one mole of $H_2C_2O_4$ is = 2

Experiment No-24

The Given Solution Contains 13.9g Of $FeSO_4.XH_2O$ dissolved Per 500cm^3 Solution. Find Out Value Of 'x' By Volumetric Method.

Principle:

It is a redox titration. $FeSO_4$ is a reducing agent and can be titrated against standard $KMnO_4$ solution in the presence of dil. H_2SO_4.

Standard Solution : 0.02M $KMnO_4$

Indicator : $KMnO_4$ (itself)

End Point : Just light pink

Equation :

$$2KMnO_4 + 10FeSO_4 . xH_2O + 8H_2SO_4 \downarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + (10x + 8)H_2O$$

Mole Ratio:

$KMnO_4$: $FeSO_4 . xH_2O$

2 : 10

Procedure:

Take given $KMnO_4$ solution in the burette and note the initial reading. Pipette out 10.0cm^3 of $FeSO_4 . xH_2O$ solution in conical flask. Then add half test tube of dilute H_2SO_4 in it. Titrate this solution against $KMnO_4$ solution taken in burette. The end point is just light pink. Note the final reading. Take at least three concordant readings to get the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of $FeSO_4 . xH_2O$ taken for each titration = 10.0cm^3.

(ii) Vol. of $KMnO_4$ used for each titration =

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	10.0	10.0cm^3
2.	10.0	20.0	10.0cm^3
3.	20.0	30.0	10.0cm^3

Concordant Reading = 10.0cm^3

$$FeSO_4 . xH_2O \qquad KMnO_4$$

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

$$\frac{M_1 \times 10.0}{10} = \frac{0.02 \times 10.0}{2}$$

$$M_1 = \frac{0.02 \times 10.0}{2} \times \frac{10}{10.0}$$

$$M_1 = 0.1 \text{ mol/dm}^3$$

$500cm^3$ solution contain $FeSO_4 . xH_2O$ = 13.9g.

$1000cm^3$ solution contain $FeSO_4 . xH_2O = \frac{13.9}{500} \times 1000$

$= 27.8 \text{ g/dm}^3$

Amount in g/dm^3 = Molarity × mol. mass of $FeSO_4 . xH_2O$.

$$27.8 = 0.1 \times (152 + 18x)$$

$$\frac{27.8}{0.1} = 152 + 18x$$

$$278 = 152 + 18x$$

$$278 - 152 = 18x$$

$$126 = 18x$$

$$x = \frac{126}{18} = x$$

$$x = 7$$

Result:

No. of water molecule in hydrated $FeSO_4$ is = 7

Experiment No-25

The Given Solution Contains 3.92g Of $FeSO_4 (NH_4)_2 SO_4.xHO_2$ dissolved Per $100cm^3$ Of Solution. Determine Value Of 'x' By Volumetric Method:

Principle:

It is a redox titration. Mohr's salt is a reducing agent and can be titrated with some oxidizing agent like $KMnO_4$.

Standard Solution : $0.02M\ KMnO_4$

Indicator : $KMnO_4$ (itself)

End Point : Just light pink

Equation :

$$2KMnO_4 + 10FeSO_4 . (NH_4)_2 SO_4 . xH_2O + 8H_2SO_4 \downarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 10(NH_4)_2 SO_4 + (10x + 8)H_2O$$

Mole Ratio:

$KMnO_4$	:	Mohr's Salt
2	:	10

Procedure:

Take the given $KMnO_4$ solution in burette and note the initial reading. Pipette out $10.0cm^3$ of Mohr's salt solution in the conical flask and then add half test tube of dil. H_2SO_4 in it. Titrate this solution against standard solution taken in burette. The end point is just light pink. Note the final reading. Take at least three concordant readings to calculate the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of Mohr's salt taken for each titration = $10.0cm^3$

(ii) Vol. of $KMnO_4$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Cancordant reading = $10.0\ cm^3$

Mohr's Salt		$KMnO_4$
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M_1 \times 10.0}{10}$	=	$\frac{0.02 \times 10.0}{2}$

$$M_1 = \frac{0.02 \times 10.0}{2} \times \frac{10}{10.0}$$

$$M_1 = 0.1M$$

$100cm^3$ solution contain Mohr's salt = 3.92

$$1000cm^3 \text{ solution contain Mohr's salt} = \frac{3.92}{100} \times 1000$$

$$= 39.2 \text{ g/dm}^3$$

Mol. mass of $FeSO_4 . (NH_4)_2 SO_4 . xH_2O$ = 284 + 18x.

Amount in g/dm^3 = Molarity × Mol. mass of Mohr's salt.

$$39.2 = 0.1 \times (284 + 18x)$$

$$\frac{39.2}{0.1} = 284 + 18x$$

$$392 = 284 + 18x$$

$$392 - 284 = 18x$$

$$108 = 18x$$

$$x = \frac{108}{18} = 6$$

$$x = 6$$

Result:

No. of water molecules in hydrated Mohr's Salt is = 6

Experiment No-26

To determine The Solubility Of Mohr's Salt At Room Remperature:

Principle:

It is a redox-titration. Mohr's salt is a reducing agent and can be titrated with standard oxidizing agent e.g $KMnO_4$ in the presence of dil . H_2SO_4.

Standard Soln : $0.02M\ KMnO_4$

Indicator : $KMnO_4$ (itself)

End Point : Just light pink

Equation : $2KMnO_4 + 10FeSO_4 (NH_4)_2 SO_4 . 6H_2O + 8H_2SO_4$

$$\downarrow$$

$K_2SO_4 + 2MnSO_4 + 5Fe_2 (SO_4)_3 + 10(NH_4)_2 SO_4 + 68H_2O$

Mole Ratio: $KMnO_4$: Mohr's Salt

2 : 10

Procedure:

Take the given $KMnO_4$ solution in burette and note the initial reading. Prepare a saturated soln of Mohr's Salt at room temperature. Now take $10.0cm^3$ of this saturated solution and dilute it upto $200cm^3$ of solution. Now pipette out $10.0cm^3$ of this dilute solution in conical flask. Then add half test tube of dil. H_2SO_4 in it. Titrate this solution against $KMnO_4$. The end point is just light pink. Note the final reading. Take at least three concordant readings to calculate the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of Mohr's Salt taken for each titration = $10.0cm^3$.

(ii) Vol. of $KMnO_4$ used for each titration =

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	5.0	$5.0cm^3$
2.	5.0	10.0	$5.0cm^3$
3	10.0	15.0	$5.0cm^3$

Concordant Reading= $5.0cm^3$

Mohr's Salt		$KMnO_4$
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M_1 \times 10.0}{10}$	=	$\frac{0.02 \times 5.0}{2}$

$$M_1 = \frac{0.02 \times 5.0}{2} \times \frac{10}{10.0}$$

$$M_1 = 0.05 \text{ mol/dm}^3$$

$$\text{Amount in g/dm}^3 = \text{Molarity} \times \text{Mol. mass of Mohr's Salt}$$

$$= 0.05 \times 392$$

$$= 19.6 \text{ g/dm}^3$$

$1000cm^3$ solution contain Mohr's Salt = 19.6g

$200cm^3$ solution contain Mohr's Salt =

$$= \frac{19.6}{1000} \times 200 = 3.92g$$

$200cm^3$ dilute soln contain Mohr's Salt = 3.92g

$10cm^3$ of water = 10g of water

$200cm^3$ of dilute soln = $10cm^3$ of saturated solution.

$10cm^3$ of saturated solution contain Mohr's Salt = 3.92g.

$100cm^3$ of saturated solution contain Mohr's Salt = $\frac{3.92}{10} \times 100$

$$= 39.2 \text{ g/100g}$$

Solubility of Mohr's Salt = 39.2g/100g of H_2O.

Result:

The solubility of Mohr's Salt at room temperature is = 39.2g

EXPERIMENT No-27

Determine The Solubility Of Oxalic acid at room temperature.

Principle:

It is a redox titration. Oxalic acid is a reducing agent and can be titrated with some oxidizing agent like $KMnO_4$ at 60-70C°.

Standard Solution	:	0.02M $KMnO_4$
Indicator	:	$KMnO_4$ (itself)
End Point	:	Just light pink
Equation	:	$2KMnO_4 + 5H_2C_2O_4 \; 2H_2O + 3H_2SO_4 \xrightarrow{\Delta} K_2SO_4 + 2MnSO_4 + 10CO_2 + 18H_2O$

Mole Ratio: $KMnO_4$: Oxalic acid

2 : 5

Procedure:

Take the given $KMnO_4$ solution in the burette and Note the initial reading. Prepare a saturated solution of oxalic acid at room temperature. Take 10.0cm^3 of this saturated solution and dilute it upto 250cm^3 in a measuring flask. Take 10.0cm^3 of this dilute oxalic acid solution in conical flask and then add half test tube of dil. H_2SO_4 in it. Heat the solution of conical flask upto 60-70C°. Titrate this hot solution against $KMnO_4$. The end point is just light pink. Note the final reading. Take at least three concordant readings to calculate the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of oxalic acid taken for each titration = 10.0cm^3.

(ii) Vol. of $KMnO_4$ used for each titration =

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	8.0	8.0cm^3
2.	8.0	16.0	8.0cm^3
3.	16.0	24.0	8.0cm^3

concordant reading = 8.0cm^3

Oxalic acid		KMnO$_4$
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M_1 \times 10.0}{5}$	=	$\frac{0.02 \times 8.0}{2}$

$$M_1 = \frac{0.02 \times 8.0}{2} \times \frac{5}{10.0}$$

$$M_1 = 0.04M$$

Amount in g/dm^3 = Molarity × Mol. mass

= 0.04 × 126

= 5.04 g/dm^3

1000cm^3 solution contain oxalic acid = 5.04

250cm^3 solution contain oxalic acid = $\frac{5.04}{1000} \times 250$

= 1.26g

250cm^3 dilute solution contain oxalic acid = 1.26g.

∴ 10cm^3 of water = 10g of water

250cm^3 of dilute solution = 10cm^3 of saturated solution.

10.0cm^3 saturated solution contain oxalic acid = 1.26g.

100cm^3 of saturated solution contain oxalic acid = $\frac{1.26}{10} \times 100$

= 12.6 g/100g of H_2O

Solubility of $H_2C_2O_4 . 2H_2O$ = 12.6g/100g of H_2O.

Result:

Hence the solubility of oxalic acid at room temperature is = 12.6 g

Experiment No-28

6.5g Of An Impure Sample Of $KMno_4$ Is dissolved Per dm^3. Determine %age Of Mn Present In The Given Solution:

Principle:

It is a redox titration. $KMnO_4$ is an oxidizing agent and can be reduced to Mn^{2+} ions by a suitable reducing agent such as Mohr's Salt.

Standard Solution : 0.1M Mohr's Salt

Indicator : $KMnO_4$ (itself)

End Point : Just light pink

Equation :

$$2KMnO_4 + 10\ FeSO_4 . (NH_4)_2\ SO_4 . 6H_2O + 8H_2SO_4 \downarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 10(NH_4)_2\ SO_4 + 68H_2O$$

Mole Ratio: $KMnO_4$: Mohr's Salt

2 : 10

Procedure:

Take the given $KMnO_4$ solution in burette and Note the initial reading. Pipette out $10.0cm^3$ of Mohr's Salt in conical flask and add half test tube of dilute H_2SO_4 in it. Titrate this solution against $KMnO_4$. The end point is just light pink. Note the final reading. Take at least three concordant Reading. to calculate the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of Mohr's salt taken for each titration = $10.0cm^3$

(ii) Vol. of $KMnO_4$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0cm^3$

KMnO$_4$		Mohr's Salt
$\frac{M_1V_1}{n_1}$	=	$\frac{M_2V_2}{n_2}$
$\frac{M_1 \times 10.0}{2}$	=	$\frac{0.1 \times 10.0}{10}$
M_1	=	$\frac{0.1 \times 10.0}{10} \times \frac{2}{10.0} = 0.02M$

Amount in g/dm^3 = Molarity × relative Atomic mass of Mn.

$= 0.02 \times 55$

$= 1.1\ g/dm^3$

6.5 g of the sample contains Mn = 1.1 g

1 g of the sample contains Mn $= \frac{1.1}{6.5}$

100 g of the sample contains Mn $= \frac{1.1}{6.5} \times 100 = 16.92\%$

Result:

The given sample of KMnO$_4$ contain 16.92% Mn.

Exercise:

Find out the % age of Mn in the given sample of KMnO$_4$,1.65g of which has been dissolved per 500c

Experiment No-29

The Given Solution Contain 30.0g Per dm^3 Of A partially Oxidized Ferrous Sulphate Calculate The Percentage Oxidation By Volumetric Method:

Principle:

It is a redox titration. $FeSO_4$ is a reducing agent and get oxidized easily in atmosphere. It can be titrated against some standard oxidizing agent like $KMnO_4$ in the presence of dil . H_2SO_4.

Standard Solution : 0.02M $KMnO_4$

Indicator : $KMnO_4$ (itself)

End Point : Just light pink

Equation :

$$2KMnO_4 + 10FeSO_4 . 7H_2O + 8H_2SO_4 \downarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 78H_2O$$

Mole Ratio: $KMnO_4$: $FeSO_4 . 7H_2O$

2 : 10

Procedure:

Take the given $KMnO_4$ solution in the burette and note the initial reading. Pipette out $10.0cm^3$ of $FeSO_4$ (Partially Oxidized) in conical flask and then add half test tube of dil . H_2SO_4 in it. Titrate this solution against $KMnO_4$. The end point is just light pink.

Note the final reading. Take at least three concordant readings to calculate the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of $FeSO_4$ taken for each titration = $10.0cm^3$.

(ii) Vol. of $KMnO_4$ used for each titration =

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0cm^3$

$FeSO_4 . 7H_2O$ $\qquad$ $KMnO_4$

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

$$\frac{M_1 \times 10.0}{10} = \frac{0.02 \times 10.0}{2}$$

$$M_1 = \frac{0.02 \times 10.0}{2} \times \frac{10}{10.0} =$$

$$M_1 = 0.1 \text{ mol/dm}^3 \ FeSO_4 . 7H_2O$$

Amount in g/dm^3 of $FeSO_4 .7H_2O$ = Molarity × Mol. mass

= 0.1 × 278

= 27.8 g/dm^3

30g sample contain pure $FeSO_4 . 7H_2O$ = 27.8g

Amount of oxidized $FeSO_4 .7H_2O$ = 30 – 27.8 = 2.2

% of partially oxidised $FeSO_4$ $= \frac{2.2}{30} \times 100 = 7.33$ %

Result:

The given impure sample contains 7.33% partially oxidized $FeSO_4 .7H_2O$.

Experiment No-30

The Given Solution Contains 27.8g Of $FeSO_4.7H_2O$ Dissolved per dm^3. Find The Amount Of Iron In The Given Sample By Volumetric Method:

Principle:

It is redox titration . $FeSO_4 . 7H_2O$ is a reducing agent and can be titrated against $KMnO_4$ in the presence of dil . H_2SO_4.

Standard Solution : 0.02M $KMnO_4$

Indicator : $KMnO_4$ (itself)

End Point : Just light pink

Equation :

$$2KMnO_4 + 10FeSO_4 . 7H_2O + 8H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 78H_2O$$

Mole Ratio: $KMnO_4 : FeSO_4 . 7H_2O$

2 : 10

Procedure:

Take the given $KMnO_4$ in the burette and Note the initial reading. Pipette out $10.0cm^3$ of $FeSO_4 . 7H_2O$ solution in the conical flask. Then add half test tube of dil. H_2SO_4 in the flask. Titrate this solution against $KMnO_4$ in the burette. The end point is just light pink. Note the final reading. Take at least three concordant readings to calculate the exact volume of $KMnO_4$ used.

Observations and Calculations:

(i) Vol. of $FeSO_4 . 7H_2O$ solution taken = $10.0cm^3$

(ii) Vol. of $KMnO_4$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $KMnO_4$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0cm^3$

$$\begin{array}{ccc} FeSO_4 . 7H_2O & & KMnO_4 \\ \frac{M_1V_1}{n_1} & = & \frac{M_2V_2}{n_2} \\ \frac{M_1 \times 10.0}{10} & = & \frac{0.02 \times 10.0}{2} \\ M_1 & = & \frac{0.02 \times 10.0}{2} \times \frac{10}{10.0} \\ M_1 & = & 0.1M\ FeSO_4 . 7H_2O \end{array}$$

$$\begin{aligned} \text{Amount of Fe in g/dm}^3 &= \text{Molarity} \times \text{Atomic mass of Fe} \\ &= 0.1 \times 56 \\ &= 5.6\ g/dm^3 \end{aligned}$$

Result:

The given solution of $FeSO_4 . 7H_2O$ contain 5.6g iron per dm^3.

SECTION-III
IODINE TITRATION (REDOX TITRATIONS)

IODINE TITRATION:

Iodine titration is the type of redox titration. Iodinine acts as an oxidizing agent and can be titrated against reducing agent like $Na_2S_2O_3$.

OXIDIZING AGENT:

Iodine (I_2) itself acts as an oxidizing agent and in the reaction itself reduced.

REDUCING AGENT:

$Na_2S_2O_3.5H_2O$ (sodium thiosulphate) acts as a reducing agent and in the reaction itself oxidized.

INDICATOR:

Mostly starch is used as an indicator in Iodimetry. Although Iodine can be used as an indicator because it has an intense yellow to brown colour. But during Titration it is difficult to detect the disappearance of yellow colour, so starch is used near the end point. Starch produces a deep blue complex with iodine. The complex is visible at low concentration of iodine. It gives water insoluble complex with iodine, so that is why we use indicator near to the end point.

Types of Iodine Titrations:

There are two types of Iodine titration.

(1) Iodimetry (2) Iodometry

(1) Iodimetry (Direct Titration):

Iodine is an oxidizing agent. Its standard solution is directly titrated with sodium thiosulphate, which is a reducing agent.

$$I_2 + Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$$

In this iodine solution is taken in iodine flask. (stopper conical flask). Iodine is slightly soluble in water but when some KI is added, its solubility increase due to formation of I_3^-. Volatility of iodine also decreases by KI due to formation of I^-.

$$I_2 + KI \longrightarrow I_3^- + K^+$$

$$I_3^- + 2S_2O_3^{2-} \longrightarrow 3I^- + S_4O_6^{2-}$$

(2) Iodometry (Indirect Titration):

In this titration some oxidizing agent liberate iodine from KI and this liberated I_2 is titrated against standard solution of reducing agent i.e $Na_2S_2O_3$. The amount of I_2 liberated from KI is equivalent to the quantity of oxidizing agent present. Some oxidizing agents are $K_2Cr_2O_7$, $CuSO_4$, $KMnO_4$, H_2O_2, Ferric ions, MnO_2, bromine and chlorine.

(I) $2CuSO_4 + 4KI \longrightarrow Cu_2I_2 + 2K_2SO_4 + I_2$.

(ii) $K_2Cr_2O_7 + 6KI + 7H_2SO_4 \longrightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 3I_2 + 7H_2O$.

(iii) $2KMnO_4 + 10KI + 8H_2SO_4$

$$\downarrow$$

$6K_2SO_4 + 2MnSO_4 + 5I_2 + 8H_2O$

In above reactions, liberated iodine is titrated against standard $Na_2S_2O_3$ solution.

$$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$$

GENERAL INSTRUCTIONS FOR IODINE TITRATIONS:

(1) Always add sodium thiosulphate solution in burette.

(2) In iodometry titration; add oxidizing agent in the conical flask or iodine flask.

(3) The medium of solution should be acidic.

(4) Add KI solution in excess because volatility of I_2 decreases.

(5) In iodimetry make solution of I_2 in potassium iodide.

(6) Add indicator near the end point when colour of solution is light yellow.

(7) Always use fresh solutions of starch indicator and sodium thiosulphate. Prepare solution of $Na_2S_2O_3.5H_2O$ with recently boiled water because CO_2 present in water an bacteria decompose the solution.

(8) Do not expose the solution of $Na_2S_2O_3$ to light for long time.

(9) Perform this titration in iodine flask or stopper flask.

(10) Use sucker pipette to transfer iodine solution into iodine flask. Do not use ordinary pipette.

Experiment No-31

Standardize The Given Solution Of Iodine. You Are Provided With 0.1M $Na_2S_2O_3$ Solution:

Principle:

It is redox titration. I_2 is an oxidizing agent and can be titrated against some reducing agent like $Na_2S_2O_3$. (Iodimetry)

Standard Solution : $0.1M\ Na_2S_2O_3$

Indicator : Starch solution

End Point : Blue to colourless

Equation : $I_2 + 2Na_2S_2O_3 \longrightarrow Na_2S_4O_6 + 2NaI$

Mole Ratio : 1 : 2

Procedure:

Take $Na_2S_2O_3$ solution in burette with the help of funnel and then remove the funnel. Note the initial reading. Pipette out $10.0cm^3$ of I_2 solution in a conical flask with the help of pipette sucker. Add $20cm^3$ of distilled water in flask. Titrate this I_2 solution against standard $Na_2S_2O_3$ solution. When the solution becomes pale yellow, add 1-2 drops of starch as an indicator. The solution becomes blue. Now titrate further till the blue colour disappears. This is the end point. Note the final reading. Take at least three concordant reading to calculate the exact volume of $Na_2S_2O_3$ used.

Observations and Calculations:

(i) Vol. of I_2 solution taken for each titration = $10.0cm^3$.

(ii) Vol. of $Na_2S_2O_3$ soln used for each titration =

No.	Initial Reading	Final Reading	Volume of $Na_2S_2O_3$
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0cm^3$

$$I_2 \qquad Na_2S_2O_3$$

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

$$\frac{M_1 \times 10.0}{1} = \frac{0.1 \times 10.0}{2}$$

$$M_1 = \frac{0.1 \times 10.0}{2} \times \frac{1}{10}$$

$$M_1 = 0.05M$$

$$\text{Amount in g/dm}^3 \text{ of } I_2 = \text{Molarity} \times \text{Molecular mass}$$

$$= 0.05 \times 254$$

$$= 12.7 \text{ g/dm}^3$$

Result:

The given I_2 solution is 0.05M having 12.7 g/dm^3 strength.

Exercise:

Standardize the given solution of I_2 you are provided with 0.05M $Na_2S_2O_3$ solution.

Experiment No-32

Standardize The Given Solution Of I_2 And Find Out Volume Of This Iodine Solution Required To Prepare 400cm³ Of 0.025m I_2 Solution:

Principle:

It is redox titration. I_2 is an oxidizing agent and can be titrated with some standard reducing agent like $Na_2S_2O_3$ directly. (Iodimetry).

Standard Solution : 0.1M $Na_2S_2O_3$

Indicator : Starch solution

End Point : Blue to colourless

Equation : $I_2 + 2Na_2S_2O_3 \longrightarrow Na_2S_4O_6 + 2NaI$

Mole Ratio : 1 : 2

Procedure:

Take the given $Na_2S_2O_3$ solution in burette and note the initial reading. Pipette out 10.0cm³ of I_2 solution in conical flask with pipette sucker. Add 20cm³ of water in it. Titrate this solution against $Na_2S_2O_3$ solution in burette. When the solution becomes pale yellow, add 1-2 drops of indicator in it. The solution becomes blue. Further titrate the solution till the blue colour disappears. This is the end point. Note the final reading. Take at least three concordant readings to calculate the exact volume of $Na_2S_2O_3$ used

Observations and Calculations:

(i) Vol. of I_2 taken for each titration = 10.0cm³.

(ii) Vol. of $Na_2S_2O_3$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $Na_2S_2O_3$ used
1.	0.0	10.0	10.0cm³
2.	10.0	20.0	10.0cm³
3.	20.0	30.0	10.0cm³

Concordant Reading = 10.0cm³

I_2		$Na_2S_2O_3$

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

$$\frac{M_1 \times 10.0}{1} = \frac{0.1 \times 10.0}{2}$$

$$M_1 = \frac{0.1 \times 10.0}{2} \times \frac{1}{10.0}$$

$$M_1 = 0.05M$$

Dilution Formula:

$$I_2 \text{ Soln given} = I_2 \text{ soln required}$$

$$M_1V_1 = M_2V_2$$

$$0.05 \times V_1 = 0.025 \times 400$$

$$V_1 = \frac{0.025 \times 400}{0.05}$$

$$V_1 = 200cm^3$$

Result:

The given I_2 solution is 0.05M and the volume required to prepare $400cm^3$ of 0.025 MI_2 solution is $200cm^3$ mixed with $200cm^3$ water.

Exercise:

Standardize the given solution of I_2 and calculate the volume of this solution required to make $500cm^3$ of $0.025MI_2$ solution. Given 0.1M $Na_2S_2O_3$ solution.

Experiment No-33

24.8g Sample Of Alkali Metal Thiosulphate $M_2S_2O_3 . 5H_2O$ Have Been Dissolved Per dm^3 Of Solution. Calculate The Atomic Mass Of Metal 'M' By Volumetric Method.

Principle:

It is a redox titration. I_2 is an oxidizing agent and can be titrated with some reducing agent like $Na_2S_2O_3$ (Iodimetry).

Standard Solution	:	0.05 M I_2 solution
Indicator	:	**Starch solution**
End Point	:	**Blue to colourless**
Equation	:	$I_2 + 2M_2S_2O_3 \longrightarrow 2MI + M_2S_4O_6$

Procedure:

Take $M_2S_2O_3$ solution in burette and note the initial reading. Pipette out $10.0cm^3$ of I_2 solution in conical flask with pipette sucker. Add $20cm^3$ of water in it. Titrate this solution against solution in burette. When the solution becomes pale yellow, add 1-2 drops of indicator in it. The solution becomes blue. Further titrate the solution till the blue colour disappears. It is the end point Note the Final reading. Take at least three concordant readings to calculate the exact volume of $M_2S_2O_3$ used.

Observations and Calculations:

(i) Vol. of I_2 taken for each titration = $10.0cm^3$.

(ii) Vol. of $M_2S_2O_3$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $M_2S_2O_3$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant reading = $10.0cm^3$

$$M_2S_2O_3 \qquad I_2$$

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

$$\frac{M_1 \times 10.0}{2} = \frac{0.05 \times 10.0}{1}$$

$$M_1 = \frac{0.05 \times 10.0}{1} \times \frac{2}{10.0}$$

$$M_1 = 0.1M\ M_2S_2O_3$$

Molar mass of $M_2S_2O_3 . 5H_2O$ = $M_2 + 202$

Amount in g/dm^3 of $M_2S_2O_3$ = Molarity × Mol. mass

$$24.8 = 0.1 \times (2M + 202)$$

$$\frac{24.8}{0.1} = 2M + 202$$

$$248 = 2M + 202$$

$$2M = 248 - 202$$

$$2M = 46$$

$$M = \frac{46}{2} = 23$$

$$M = 23\ g/mol$$

Result:

So the atomic mass of metal M in $M_2S_2O_3 . 5H_2O$ is 23g/mol which is sodium Na (Natrium).

Exercise:

12.4g of $M_2S_2O_3 . 5H_2O$ have been dissolved per $500m^3$ of solution. Find out the atomic mass of 'M' by volumetric method.

Experiment No-34

Calculate The Percentage Purity Of Given Sample Of Hypo, 7g Of Which Have Been dissolved Per 250cm³ Of Solution:

Principle:

It is redox titration. Hypo ($Na_2S_2O_3 \cdot 5H_2O$) is a reducing agent and can be titrated with I_2 solution directly (Iodimetry).

Standard Solution	:	0.05M I_2 solution
Indicator	:	Starch solution
End Point	:	Blue to colourless
Equation	:	$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$
Mole Ratio	:	1 : 2

Procedure:

Take hypo solution in burette and note the initial reading. Take 10.0cm^3 of I_2 solution in conical flask with pipette sucker. Add 20cm^3 of distilled water in it. Titrate this solution against the solution in burette. When the solution becomes pale yellow, add 1-2 drops of starch solution it. The solution becomes blue in colour. Further titrate the solution till the blue colour disappears. This is the end point. Note the final reading. Take at least three concordant readings to calculate the exact volume of hypo used.

Observations and Calculations:

(i) Vol. of I_2 taken for each titration = 10.0cm^3

(ii) Vol. of hypo used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $Na_2S_2O_3$ used
1.	0.0	10.0	10.0cm^3
2.	10.0	20.0	10.0cm^3
3.	20.0	30.0	10.0cm^3

Concordant Reading = **10.0cm^3**

$NaS_2O_3 . 5H_2O$ $\qquad$ I_2

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

$$\frac{M_1 \times 10.0}{2} = \frac{0.05 \times 10.0}{1}$$

$$M_1 = \frac{0.05 \times 10.0}{1} \times \frac{2}{10.0}$$

$$M_1 = 0.1M$$

Amount in g/dm^3 = Molarity × Mol. mass of hypo

= 0.1 × 248

= 24.8 g/dm^3

$250cm^3$ solution contain hypo = 7.0g

$1000cm^3$ solution contain hypo $= \frac{7}{250} \times 1000$

= 28

28g impure sample contain pure $Na_2S_2O_3$ = 24.8g

100g of impure sample contain pure $Na_2S_2O_3$ =

$$= \frac{24.8}{28} \times 100$$

= 88.75%

Result:

% age purity = 88.75%

The given impure sample of hypo contains 88.75% pure $Na_2S_2O_3 . 5H_2O$.

Experiment No-35

20g Of $Na_2S_2O_3 \cdot 5H_2O$ Have Been dissolved per dm^3 Of Solution. Find Out The %age Of Sulphur In The Sample By Volumetric Method:

Principle:

It is a redox titration. I_2 is an oxidizing agent and can be titrated with a reducing agent like $Na_2S_2O_3$. (Iodimetry).

Standard Solution : 0.05 M I_2 solution

Indicator : Starch solution

End Point : Blue to colourless

Equation : $I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$

Mole Ratio : 1 : 2

Procedure:

Take hypo solution in burette and note the initial reading. Take $10.0cm^3$ of I_2 solution in conical flask with pipette sucker. Add $20cm^3$ of distilled water in it. Titrate this solution against the solution in burette. When the solution becomes pale yellow, add 1-2 drops of starch solution it. The solution becomes blue in colour. Further titrate the solution till the blue colour disappears. This is the end point. Note the final reading. Take at least three concordant readings to calculate the exact vol

No. of Obs.	Initial Reading	Final Reading	Vol. of $Na_2S_2O_3$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading $= 10.0cm^3$

$$Na_2S_2O_3 . 5H_2O \qquad\qquad I_2$$

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

$$\frac{M_1 \times 10.0}{2} = \frac{0.05 \times 10.0}{1}$$

$$M_1 = \frac{0.05 \times 10.0}{1} \times \frac{2}{10.0}$$

$$M_1 = 0.1 \text{ mol/dm}^3 \text{ of } Na_2S_2O_3$$

Amount in g/dm^3 of sulphur = Molarity × atomic mass

= 0.1 × (32 × 2)

= 6.4g/dm^3

20g sample contain sulphur(S) = 6.4g

100g sample contain sulphur(S) =

$$= \frac{6.4}{20} \times 100$$

= 32%

% age of S = 32%

Result:

The given sample of $Na_2S_2O_3$ contain 32% sulphur (S).

EXPERIMENT No-36

24.8g Of $Na_2S_2O_3 . XH_2O$ Have Been dissolved Per Dm^3 Of Solution. Find Out Value Of 'x'.

Principle:

It is a redox titration I_2 is an oxidizing agent and can be titrated against some reducing agent like sodium thiosulphate directly (Iodimetry).

Standard Solution : **0.05M I_2**
Indicator : **Starch solution**
End Point : **Blue to colourless**
Equation : $I_2 + 2Na_2S_2O_3 . xH_2O \longrightarrow 2NaI + Na_2S_4O_6 . 2XH_2O$
Mole Ratio : **1 : 2**

Procedure:

Take the given $Na_2S_2O_3$ solution in burette and note the initial reading. Pipette out $10.0cm^3$ of I_2 solution in conical flask and then add $20cm^3$ of distilled water in it. Titrate this solution against solution in burette. When the solution becomes pale yellow, add 1-2 drops of indicator in it. The solution becomes blue. Further titrate the solution till the blue colour just disappear. This is the end point. Note the final reading. Take at least three concordant readings to calculate the exact volume of $Na_2S_2O_3$ used.

Observations and Calculations:

(i) Vol. of I_2 taken for each titration = $10.0cm^3$.

(ii) Vol. of $Na_2S_2O_3$ used for each titration.

No. of Obs.	Initial Reading	Final Reading	Vol. of $Na_2S_2O_3$ used
1.	0.0	10.0	$10.0cm^3$
2.	10.0	20.0	$10.0cm^3$
3.	20.0	30.0	$10.0cm^3$

Concordant Reading = $10.0cm^3$

$$Na_2S_2O_3 . xH_2O \qquad I_2$$

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

$$\frac{M_1 \times 10.0}{2} = \frac{0.05 \times 10.0}{1}$$

$$M_1 = \frac{0.05 \times 10.0}{1} \times \frac{2}{10.0}$$

$$M_1 = 0.1M$$

Molecular mass of $Na_2S_2O_3 . XH_2O$ = 158 + 18x

Amount in g/dm^3 = Molarity × Mol. mass

$$24.8 = 0.1 \times (158 + 18x)$$

$$\frac{24.8}{0.1} = 158 + 18x$$

$$248 = 158 + 18x$$

$$248 - 158 = 18x$$

$$90 = 18x$$

$$x = \frac{90}{18} = 5$$

$$x = 5$$

Result:

No. of water of crystallization in $Na_2S_2O_3$ is = 5

Exercise:

2.48g of $Na_2S_2O_3 . xH_2O$ have been dissolved per $100cm^3$ of solution calculate the value of 'x'.