ARJUNA

JEE 2.0 2025

Some basic concepts of chemistry

Chemistry | Lecture - 12

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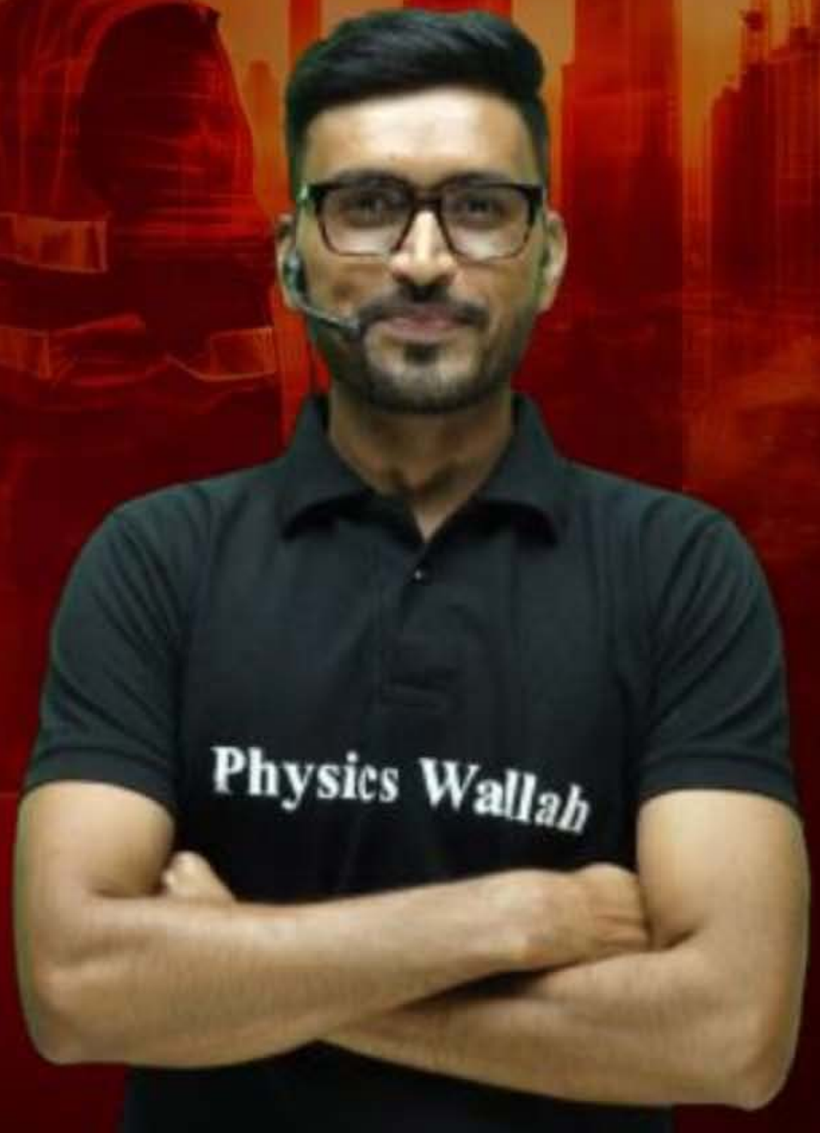


TOPICS to be covered

1. Ppm, ppb
2. Formality (F)
3. % labelling of oleum
4. POAC

Concentration Terms

Molality (m)

- The number of moles of solute dissolved in 1000 gm (1 kg) of a solvent is known as the molality of the solution.

$$m = \frac{n}{(\text{Mass})\text{solvent (in kg)}}$$

$$m = \frac{\chi_B}{\chi_A} \times \frac{1000}{M_A}$$

QUESTION

molar mass = 60 g/mol

solute ka mol / mass of solvent

Density of 2 M CH_3COOH solution is (1.2 g/mL). Calculate molality of the solution.

Ans :- 2M CH_3COOH solution → 2 moles of CH_3COOH in 1 litre of solution.

Moles of CH_3COOH = 2

Mass of CH_3COOH = mol × molar mass
= 2 × 60 = 120 g

$V_{sol.}$ = 1 litre = 1000 ml

$d_{sol.} = M_{sol}/V_{sol}$

$M_{sol.}$ = 1.2 × 1000
= 1200 g

(Mass) solvent = (Mass) solution − (Mass) solute
= 1200 − 120 = 1080 g

$$m = \frac{n_{CH_3COOH}}{\text{(Mass) solvent (in gm)}} \times 1000$$

$$m = \frac{2}{1080} \times 1000$$

$$m = \frac{2000}{108}\ m. = 1.85\ m.$$

* Relationship b/w density (gm/ml), Molarity (M) and molality (m) :⇒

$$\underset{\sim}{d} = M\left[\frac{1}{m} + \frac{M_B}{1000}\right]$$

M_B → Molar mass of solute.

Done

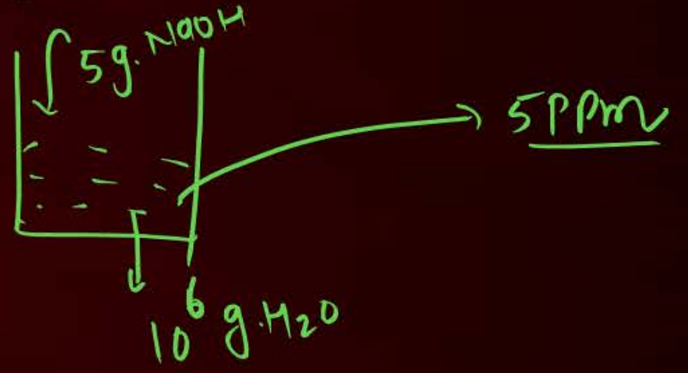
PPM (Parts per million)

Done

- PPM or Parts Per Million is a unit used to describe very small concentrations of a substance in a larger solution.
- It is the number of parts of solute present in 10^6 parts of solution.

$$PPm = \frac{\text{Parts of solute}}{\text{Total Parts of solution}} \times 10^6$$

$$PPm = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$$



QUESTION

2 gm of oxygen is dissolved in 10^4 gm of water. Find the concentration of oxygen in ppm.

Ans :-> $$PPm = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$$

$$= \frac{2}{(10^4 + 2)} \times 10^6 \quad \text{→ neglect}$$

$$= \frac{2}{10^4} \times 10^6$$

$$= 200 \text{ PPm}$$

Done

Ans

QUESTION

Calculate the parts per million of SO_2 gas in 250 ml water (density 1 g cm^{-3}) containing 5×10^{-4} g of SO_2 gas.

$V_{H_2O} = 250\ ml.$ $\quad 1\ g/ml.$

$d_{H_2O} = 1\ gm/ml.$

$M_{H_2O} = 250\ g$

A 1

B 2

C 20

D 10

$$PPm = \frac{5 \times 10^{-4}}{250} \times 10^6$$

$$= \frac{50}{25} = 2\ PPm.$$ Ans

ppb (Parts Per billion)

$$ppb = \frac{\text{Parts of solute}}{\text{Total Parts of Solution}} \times 10^{9}$$

Formality (F)

→ for ionic compounds ↳ formula units
↳ formula mass

Ex. NaCl.
formula mass = 23 + 35.5 = 58.5.

Ex :→ $CaCl_2$
formula mass = 40 + 2(35.5) = 111.

→ It is the gram formula units of solute present in 1 litre of solution.

$$\text{formality (f)} = \frac{\text{Mass of solute}}{\left(\begin{matrix}\text{formula mass} \\ \text{of solute}\end{matrix}\right) \times \text{Vol of solution (in litre)}}$$

* Temperature dependent.

QUESTION

Calculate the formality of NaCl solution, 5.85 g of which have been dissolved to form 250 ml of the given solution.

Ans :> Vol of solution = 250 ml.

mass of NaCl = 5.85 g.

formula mass of NaCl = 23 + 35.5 = 58.5

$$f = \frac{\text{Mass of NaCl}}{\text{formula mass of NaCl} \times \text{Vol of sol (in ml)}} \times 1000$$

$$= \frac{5.85}{58.5} \times \frac{1000}{250} = \frac{100}{250} = 0.4\ f.$$

Strength :

$$\text{Strength of solution} = \frac{\text{Mass of solute (gm)}}{\text{Vol of solution (litre)}}$$

→ It is the mass of solute present in 1 litre of solution.

↳ Unit :→ gm/litre

↳ Temperature dependent

Done

QUESTION

What will be the formality of KNO_3 solution having strength equal to 2.02 g per litre ?

Ans :→ Strength = 2·02 gm/litre. [2·02 g of KNO_3 in 1 litre of solution].

* formula mass of KNO_3 = 39 + 14 + 48 = 101 g/mol.

$$\text{formality} = \frac{\text{Mass of } KNO_3}{\text{formula mass} \times \text{Vol. of sol (in litre)}}$$

$$= \frac{2·02}{101 \times 1} = 0·02 \text{ f}$$

Done

Ans

→ Normality

→ Equivalent weight

→ No. of Equivalence

→ Law of Equivalence

→ Redox

Titration

Percentage labelling of oleum :

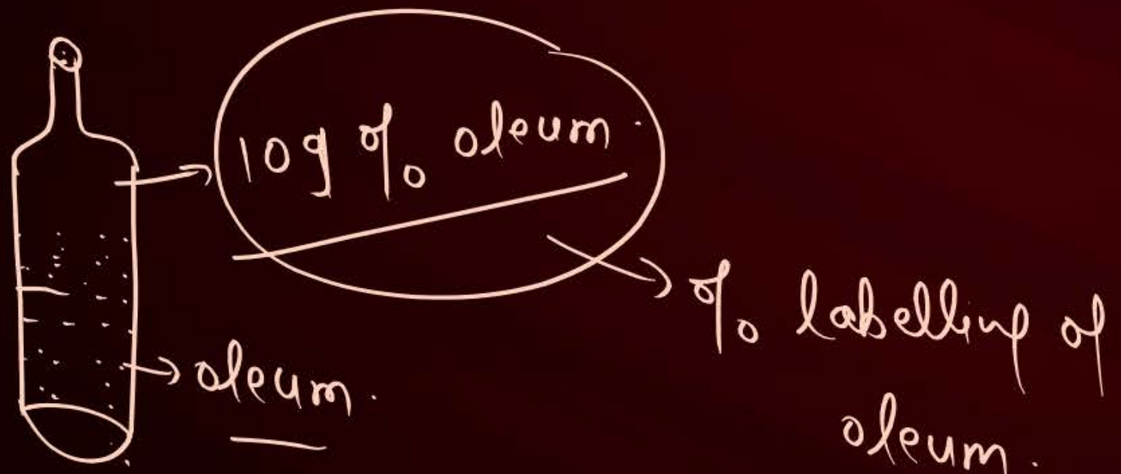
- Oleum is fuming sulphuric acid which contains extra SO_3 dissolved in H_2SO_4.
- To convert this extra SO_3 into H_2SO_4, water has to be added.
- The amount of sulphuric acid obtained when just sufficient water is added into 100 g of oleum so that all SO_3 present in it is converted into H_2SO_4, is called percentage labelling of oleum.

* fuming H_2SO_4

[$H_2SO_4 + SO_3$]

↓

Oleum ($H_2S_2O_7$)



Percentage labelling of oleum :

Ex. 109 % Oleum :

→ 100 g of oleum reacts with H_2O to form 109 gm of H_2SO_4.

$$[H_2SO_4 + SO_3] + H_2O \longrightarrow H_2SO_4$$

free (x) 109

100 g

$$SO_3 + H_2O \rightarrow H_2SO_4$$

0.5 mol 0.5 mol

$100 + x = 109$

$x = 9$ gm (mass of H_2O)

$$n_{H_2O} = \frac{w}{Mw} = \frac{9}{18} = 0.5 \text{ mol}$$

moles of $SO_3 = 0.5$ mol

molar mass of $SO_3 = 32 + 48 = 80$ g/mol

Mass of SO_3 = moles × molar mass
$= 0.5 \times 80 = 40$ gm

% of free SO_3 in oleum $= \frac{40}{100} \times 100\% = 40\%$

Ans

QUESTION

Calculate the % of free SO_3 in an oleum, that is labelled 118%.

Ans :- 118 % oleum => 100 g of oleum reacts with water to form 118 g of H_2SO_4

$$\underset{100}{H_2SO_4 + SO_3} + \underset{(x)}{H_2O} \longrightarrow \underset{(118\ gm)}{H_2SO_4}$$

$x \rightarrow 18\ g$

moles of $H_2O = \frac{18}{18} = 1\ mol$

$$SO_3 + H_2O \rightarrow H_2SO_4$$
$$(1\ mol)\ (1\ mol)$$

$\downarrow$

$80\ gm$

% of free $SO_3 = \frac{80}{100} \times 100\% = 80\%$ Ans

% free $SO_3 = \frac{80(y-100)}{18}$ % labelling

$= \frac{80(118-100)}{18}$

$= 80\%$ Ans

* % of free SO_3 in oleum $= \frac{80(y-100)}{18}$ %.

% labelling of oleum.

QUESTION

Which of the following percentage strength is not possible for a sample of oleum ?

A. 104 %

B. 127 %

C. 118 %

D. 109 %

$\%$ of free $SO_3 = \frac{80(y-100)}{18}\ \%$

$= \frac{80(127-100)}{18}\ \%$

$= \frac{80 \times 27^{3}}{18_{2}} \Rightarrow 40 \times 3 = 120\%$ free SO_3

QUESTION

If in a sample of oleum, mole fraction of SO_3 is 0.5. Label the oleum sample.

Ans :⇒ $\chi_{SO_3} = \frac{n_{SO_3}}{n_{SO_3} + n_{H_2SO_4}} = \frac{0.5}{1}$

moles of SO_3 = 0.5

mass of SO_3 = $0.5 \times \underbrace{80}_{\text{molar mass}} = 40$ gm

Balanced $SO_3 + H_2O \longrightarrow H_2SO_4$

0.5 mol 0.5 mol

n_{H_2O} = 0.5 mol

Mass of $H_2O = 0.5 \times 18 = 9$ gm

$n_{H_2SO_4}$ = 0.5 mol

Mass of $H_2SO_4 = 0.5 \times \underbrace{98}_{\text{molar mass}}$

= 49 gm.

Mass of oleum = (mass)$_{SO_3}$ + (mass) H_2SO_4

= 40 + 49 = 89 gm

∵ 89 gm oleum ⟶ 9 gm H_2O

∴ 100 g. oleum ⇒ $\frac{9}{89} \times 100$ g. H_2O

→ 10.11 g. H_2O

% labelling

= 100 + 10.11

⇒ 110.11 %.

Ans

Principle of Atom Conservation (POAC)

- The **Principle of Atom Conservation** (POAC) states that the total number of atoms of reactants must equal the number of atoms of products.
- Number of atoms of element in reactant = Number of atoms of element in product
- Moles of atoms of element in reactant = moles of atoms of element in product

PoAC for H-atom *

$HCl + NaOH \longrightarrow NaCl + H_2O$

← moles of H atom reactant side = moles of H-atom Product side.

PoAC for Cl atom :=>

moles of Cl atom reactant side = moles of Cl atom Product side.

* $KClO_3 \longrightarrow KCl + O_2$.

POAC for K-atom.

moles of K atom in $KClO_3$ = moles of K atom in KCl.

$1 \times$ moles of $KClO_3$ = $1 \times$ moles of KCl.

POAC for O-atoms :>

moles of O-atom in $KClO_3$ = moles of O-atom in O_2.

$3 \times$ moles of $KClO_3$ = $2 \times$ moles of O_2

QUESTION

Find out the moles of CO_2 formed from combustion of 60 moles of butane.

Ans:- $C_4H_{10} + O_2 \longrightarrow CO_2 + H_2O$

POAC for C-atom.

moles of C-atom in C_4H_{10} = moles of C-atom in CO_2

$4 \times$ moles of $C_4H_{10} = 1 \times$ moles of CO_2

$4 \times 60 =$ moles of CO_2

240 mol = moles of CO_2

Ans

C_4H_{10}.

$C_4H_{10} + \frac{13}{2} O_2 \rightarrow 4CO_2 + 5H_2O$

1 mol — 4 mol

6 mol — 60×4 mol.

QUESTION

What mass of O_2 is produced by 1.23 g of $KClO_3$?

→ molar mass = 39 + 35.5 + 48 = 122.5

Ans :⇒

$$KClO_3 \longrightarrow KCl + O_2$$

Balanced

$$2KClO_3 \rightarrow 2KCl + 3O_2$$

2 mol → 3 mol

PoAC for O-atoms :⇒

3 × moles of $KClO_3$ = 2 × moles of O_2

$$3 \times \frac{1.23}{122.5} = 2 \times \frac{\text{mass of } O_2}{32}$$

2 mol $KClO_3$ → 3 mol O_2

$\frac{1.23}{122.5}$ mol → $\frac{3}{2} \times \frac{1.23}{122.5}$ mol O_2

$$\text{Mass of } O_2 = \frac{3 \times 16 \times 1.23}{122.5} \text{ gm.}$$

Ans

QUESTION

A mixture of KBr and NaBr weighing 0.560 gm was treated with aq. Ag^+ ion and all bromide ion was recovered as 0.970 gm of pure AgBr. What was the fraction by weight of KBr in the sample?

QUESTION

27.6 gm of K_2CO_3 was treated by a series of reagents so as to convert all of its carbon to $K_2Zn_3[Fe(CN)_6]_2$. Calculate the weight of the product. [mol. Wt. of K2CO3 = 138 and that of $K_2Zn_3[Fe(CN)_6]_2$ is 698]

Ans :-> K_2CO_3 + (Series of Reagents) ⟶ $K_2Zn_3[Fe(CN)_6]_2$

(27.69m) mass = ?

POAC for C-atoms :->

moles of C-atom in K_2CO_3 = moles of C atom in $K_2Zn_3[Fe(CN)_6]_2$

1 × moles of K_2CO_3 = 12 × moles of $K_2Zn_3[Fe(CN)_6]_2$

$$\frac{27.6}{138} = 12 \times \frac{\text{mass}}{698}$$

Mass = ? (Ans)

Homework

Train your brain (examples):-

Q. No. - Complete

Concept application :

Q. No. – Complete

Prarambh (Topic wise) :-

Q. No. Complete

DPP


THANK
YOU