01

Some Basic Concepts in Chemistry

TOPIC 1

Nature of Matter, Significant Figures and Laws of Chemical Combinations

01 The number of significant figures in 0.00340 is .... **[2021, 25 July Shift-II]**

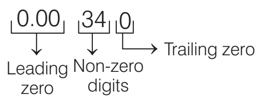
Ans. ***(3)***

Number of significant figures = 0.00340

$= 3.40 \times 10^{-3}$

So, total number of significant figure = 3.

Here,



None-zero digits and trailing zero are counted.

(Note You can convert it into simplest form first.)

02 The number of significant figures in 50000.020×10^{-3} is .... **[2021, 26 Feb Shift-I]**

Ans. ***(7)***

Non-zero digits are always significant. Any zeros between two significant digits are significant.

∴ Zero's between 5 and 2 are all significant.

50000.020×10^{-3}

(Number of significant figures = 7)

03 Among the following statements, that which was not proposed by Dalton was **[2020, 7 Jan Shift-I]**

(a) chemical reactions involve reorganisation of atoms. These are neither created nor destroyed in a chemical reaction.

(b) when gases combine or reproduced in a chemical reaction they do so in a simple ratio by volume provided all gases are at the same T and *P*.

(c) all the atoms of a given element have identical properties including identical mass. Atoms of different elements differ in mass.

(d) matter consists of indivisible atoms.

Ans. ***(b)***

The postulates given in options (a), (c) and (d) are proposed by Dalton.

Option (b) is defining the Gay-Lussac's law of combining volumes of gases.

04 0.27 g of a long chain fatty acid was dissolved in 100 cm^3 of hexane. 10 mL of this solution was added dropwise to the surface of water in a round watch glass. Hexane evaporates and a monolayer is formed. The distance from edge to centre of the watch glass is 10 cm. What is the height of the monolayer?

[Density of fatty acid = 0.9 g cm^{-3}; $\pi = 3$] **[2019, 8 April Shift-II]**

(a) 10^{-6} m (b) 10^{-4} m

(c) 10^{-8} m (d) 10^{-2} m

Ans. ***(a)***

100 mL (cm^3) of hexane contains 0.27 g of fatty acid.

In 10 mL solution, mass of the fatty acid,

$$m = \frac{0.27}{100} \times 10$$

$$= 0.027 \text{ g}$$

Density of fatty acid, $d = 0.9 \text{ g cm}^{-3}$

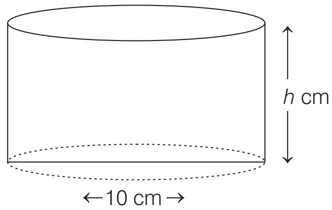
∴ Volume of the fatty acid over the watch glass,

$$V = \frac{m}{d} = \frac{0.027}{0.9}$$

$$= 0.03 \text{ cm}^3$$

Let, height of the cylindrical monolayer = *h* cm

∵ Volume of the cylinder = Volume of fatty acid



$$\Rightarrow \quad V = \pi r^2 \times h$$

$$\Rightarrow \quad h = \frac{V}{\pi r^2}$$

$$= \frac{0.03 \text{ cm}^3}{3 \times (10)^2 \text{ cm}^2}$$

$$= 1 \times 10^{-4} \text{ cm}$$

$$= 1 \times 10^{-6} \text{ m}$$

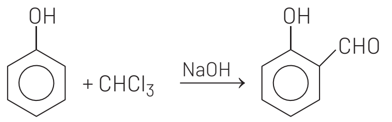
TOPIC 2

Atomic Mass, Molecular Mass and Formulae of Compounds

05 A solution of phenol in chloroform when treated with aqueous NaOH gives compound *P* as a major product. The mass percentage of carbon in *P* is ....
(to the nearest integer)
(Atomic mass: C = 12; H = 1; O = 16)
[2020, 6 Sep Shift-II]

Ans. ***(69)***

A solution of phenol in chloroform react with aqueous NaOH gives compound *P* (salicylaldehyde).



(*P*)
(Salicylaldehyde)

∴ Mass % of C in *P*(Compound)

$$= \frac{\text{Mass of C}}{\text{Mass of Compound}} \times 100$$

$$\left\{\begin{array}{l}\text{Here, mass of C} = 12 \times 7 \\ \text{mass of compound (P)} = \\ \quad \text{C} \qquad \text{H} \qquad \text{O} \\ (12 \times 7 + 6 \times 1 + 16 + 2)\end{array}\right.$$

$$= \frac{12 \times 7}{84 + 6 + 32} \times 100 = 68.85\% = 69\%$$

06 The average molar mass of chlorine is 35.5 g mol^{-1}. The ratio of ^{35}Cl to ^{37}Cl in naturally occurring chlorine is close to
[2020, 6 Sep Shift-II]

(a) 4 : 1
(b) 3 : 1
(c) 2 : 1
(d) 1 : 1

Ans. ***(b)***

Given,
Average molar mass of chlorine is 35.5 g mol^{-1}.
Naturally occurring chlorine are

	^{35}Cl	^{37}Cl
Molar ratio	x	$1-x$

Total molar ratio $= x + 1 - x = 1$
Mass average $= 35 \times x + 37 \times (1-x)$

$$35.5 = 35x + 37 - 37x$$

$$2x = 37 - 35.5; \quad x = \frac{1.5}{2} = 0.75 = \frac{3}{4}$$

For ^{35}Cl, $\quad x = \frac{3}{4}$

For ^{37}Cl; $\quad 1 - \frac{3}{4}$

$$^{35}Cl : {}^{37}Cl$$

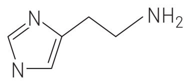
$$\frac{3}{4} : \left(1 - \frac{3}{4}\right) \Rightarrow \frac{3}{4} : \frac{1}{4}$$

On simplify this ratio, we get 3 : 1.

07 The mass percentage of nitrogen in histamine is ....
[2020, 9 Jan Shift-I]

Ans. ***(37.84)***

Histamine :



Molecular formula $= C_5H_9N_3$. Molecular mass = 111

Number of nitrogen atoms per molecule = 3

Mass due to N = 3 × 14 = 42

$$\% \text{ of N} = \frac{42}{111} \times 100 = 37.84\%$$

The value have a range from 37.80 to 38.20.

08 5 moles of AB_2 weight 125×10^{-3} kg and 10 moles of A_2B_2 weight 300×10^{-3} kg. The molar mass of $A(M_A)$ and molar mass of $B(M_B)$ in kg mol^{-1} are **[2019, 12 April Shift-I]**

(a) $M_A = 10 \times 10^{-3}$ and $M_B = 5 \times 10^{-3}$
(b) $M_A = 50 \times 10^{-3}$ and $M_B = 25 \times 10^{-3}$
(c) $M_A = 25 \times 10^{-3}$ and $M_B = 50 \times 10^{-3}$
(d) $M_A = 5 \times 10^{-3}$ and $M_B = 10 \times 10^{-3}$

Ans. ***(d)***

Key Idea To find the mass of *A* and *B* in the given question, mole concept is used.

$$\text{Number of moles } (n) = \frac{\text{given mass } (w)}{\text{molecular mass } (M)}$$

Compound	Mass of *A* (*g*)	Mass of *B* (*g*)
AB_2	M_A	$2M_B$
A_2B_2	$2M_A$	$2M_B$

We know that,
Number of moles

$$(n) = \frac{\text{given mass } (w)}{\text{molecular mass } (M)}$$

$$n \times M = w \qquad ...(A)$$

Using equation (A), it can be concluded that

$$5(M_A + 2M_B) = 125 \times 10^{-3} \text{ kg} \qquad ...(i)$$

$$10(2M_A + 2M_B) = 300 \times 10^{-3} \text{ kg} \qquad ...(ii)$$

From equation (i) and (ii)

$$\frac{1}{2}\frac{(M_A + 2M_B)}{(2M_A + 2M_B)} = \left(\frac{125}{300}\right)$$

On solving the equation, we obtain

$$M_A = 5 \times 10^{-3} \text{ and } M_B = 10 \times 10^{-3}$$

So, the molar mass of $A(M_A)$ is 5×10^{-3} kgmol^{-1} and $B(M_B)$ is 10×10^{-3} kg mol^{-1}.

09 The ratio of mass per cent of C and H of an organic compound $(C_xH_yO_z)$ is 6 : 1. If one molecule of the above compound $(C_xH_yO_z)$ contains half as much oxygen as required to burn one molecule of compound C_xH_y completely to CO_2 and H_2O. The empirical formula of compound $C_xH_yO_z$ is **[JEE Main 2018]**

(a) $C_3H_6O_3$
(b) C_2H_4O
(c) $C_3H_4O_2$
(d) $C_2H_4O_3$

Ans. ***(d)***

We can calculate the simplest whole number ratio of C and H from the data given, as

Element	Relative mass	Molar mass	Relative mole	Simplest whole no. ratio
C	6	12	$\frac{6}{12} = 0.5$	$\frac{0.5}{0.5} = 1$
H	1	1	$\frac{1}{1} = 1$	$\frac{1}{0.5} = 2$

Alternatively this ratio can also be calculated directly in the terms of *x* and *y* as

$$\frac{12x}{y} = \frac{6}{1}$$

(given and molar mass of C = 12, H = 1)

Now, after calculating this ratio look for condition 2 given in the question i.e. quantity of oxygen is half of the quantity required to burn one molecule of compound C_xH_y completely to CO_2 and H_2O. We can calculate number of oxygen atoms from this as consider the equation.

$$C_xCH_y + \left[x + \frac{y}{4}\right]O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$$

Number of oxygen atoms required

$$= 2 \times \left[x + \frac{y}{4}\right] = \left[2x + \frac{y}{2}\right]$$

$$\text{Now given, } z = \frac{1}{2}\left[2x + \frac{y}{2}\right] = \left[x + \frac{y}{4}\right]$$

Here we consider *x* and *y* as simplest ratios for C and H so now putting the values of *x* and *y* in the above equation.

$$z = \left[x + \frac{y}{4}\right] = \left[1 + \frac{2}{4}\right] = 1.5$$

Thus, the simplest ratio figures for *x*, *y* and *z* are $x = 1$, $y = 2$ and $z = 1.5$

Now, put these values in the formula given i.e.

$$C_xH_yO_z = C_1H_2O_{1.5}$$

So, empirical formula will be

$$[C_1H_2O_{1.5}] \times 2 = C_2H_4O_3$$

10 The most abundant elements by mass in the body of a healthy human adult are Oxygen (61.4%); Carbon (22.9%), Hydrogen (10.0 %); and Nitrogen (2.6%). The weight which a 75 kg person would gain if all ^1H atoms are replaced by ^2H atoms is **[JEE Main 2017]**

(a) 15 kg (b) 37.5 kg
(c) 7.5 kg (d) 10 kg

Ans. ***(c)***

Given, abundance of elements by mass oxygen = 61.4%, carbon = 22.9%, hydrogen = 10% and nitrogen = 2.6%

Total weight of person = 75 kg

$$\text{Mass due to } {}^1H = \frac{75 \times 10}{100} = 7.5 \text{ kg}$$

^1H atoms are replaced by ^2H atoms,

$$\text{Mass due to } {}^2H = (7.5 \times 2) \text{ kg}$$

$\therefore$ Mass gain by person = 7.5 kg

11 At 300 K and 1 atm, 15 mL of a gaseous hydrocarbon requires 375 mL air containing 20% O_2 by volume for complete combustion. After combustion, the gases occupy 330 mL. Assuming that the water formed is in liquid form and the volumes were measured at the same temperature and pressure, the formula of the hydrocarbon is **[JEE Main 2016]**

(a) C_3H_8 (b) C_4H_8
(c) C_4H_{10} (d) C_3H_6

Ans. ***(None)***

$$C_xH_y(g) + \left(x + \frac{y}{4}\right)O_2(g) \longrightarrow \underset{75\text{ mL}}{xCO_2(g)} + \frac{y}{2}\underset{30\text{mL}}{H_2O(l)}$$

O_2 used = 20% of 375 = 75 mL

Inert part of air = 80% of 375 = 300 mL

Total volume of gases = CO_2 + Inert part of air

$$= 30 + 300 = 330 \text{ mL}$$

$$\frac{x}{1} = \frac{30}{15} \Rightarrow x = 2 \Rightarrow \frac{x + \frac{y}{4}}{1} = \frac{75}{15}$$

$$\Rightarrow \quad x + \frac{y}{4} = 5$$

$$\Rightarrow \quad x = 2, y = 12 \Rightarrow C_2H_{12}$$

12 A gaseous hydrocarbon gives upon combustion, 0.72 g of water and 3.08 g of CO_2. The empirical formula of the hydrocarbon is **[JEE Main 2013]**

(a) C_2H_4 (b) C_3H_4 (c) C_6H_5 (d) C_7H_8

Ans. ***(d)***

18 g H_2O contain 2g H.

$\therefore$ 0.72 g H_2O contain 0.08 g H 44 g CO_2 contain 12 g C.

$\therefore$ 3.08 g CO_2 contain 0.84 g C.

$$\therefore \quad C:H = \frac{0.84}{12} : \frac{0.08}{1} = 0.07 : 0.08 = 7:8$$

$\therefore$ Empirical formula = C_7H_8

13 The mass of potassium dichromate crystals required to oxidise 750 cm^3 of 0.6 M Mohr's salt solution is (molar mass = 392) **[AIEEE 2011]**

(a) 0.49 g (b) 0.45 g
(c) 22.05 g (d) 2.2 g

Ans. ***(c)***

Mohr's salt is $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$.

Only oxidisable part Fe^{2+} is

$$[Fe^{2+} \longrightarrow Fe^{3+} + e^-] \times 6$$

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

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

$$\text{Millimoles of } Fe^{2+} = 750 \times 0.6 = 450$$

$$\text{Moles of } Fe^{2+} = \frac{450}{1000} = 0.450 \text{ mol}$$

$$6 \text{ mol } Fe^{2+} \equiv 1 \text{ mol } Cr_2O_7^{2-}$$

$$\therefore \quad 0.450 \text{ mol } Fe^{2+} \equiv \frac{0.450}{6}$$

$$= 0.075 \text{ mol } Cr_2O_7^{2-}$$

$$= 0.075 \times 294 \text{ g} = 22.05 \text{ g}$$

14 If we consider that 1/6, in place of 1/12, mass of carbon atom is taken to be the relative atomic mass unit, the mass of one mole of a substance will **[AIEEE 2005]**

(a) be a function of the molecular mass of the substance
(b) remain unchanged
(c) increase two fold
(d) decrease twice

Ans. ***(b)***

The mass of one mole of *a* substance will remain unchanged.

15 In an organic compound of molar mass 108 g mol^{-1} C, H and N atoms are present in 9 : 1 : 3.5 by weight. Molecular formula can be **[AIEEE 2002]**

(a) $C_6H_8N_2$ (b) $C_7H_{10}N$
(c) $C_5H_6N_3$ (d) $C_4H_{18}N_3$

Ans. ***(a)***

Molar mass 108 g mol^{-1}

Total part by weight = 9 + 1 + 3.5 = 13.5

$$\text{Weight of carbon} = \frac{9}{13.5} \times 108 = 72 \text{ g}$$

$$\text{Number of carbon atoms} = \frac{72}{12} = 6$$

$$\text{Weight of hydrogen} = \frac{1}{13.5} \times 108 = 8 \text{ g}$$

$$\text{Number of hydrogen atoms} = \frac{8}{1} = 8$$

$$\text{Weight of nitrogen} = \frac{3.5}{13.5} \times 108 = 28 \text{ g}$$

$$\text{Number of nitrogen atom} = \frac{28}{14} = 2$$

Hence, molecular formula = $C_6H_8N_2$.

16 Experimentally, it was found that a metal oxide has formula $M_{0.98}O$. Metal M, present as M^{2+} and M^{3+} in its oxide. Fraction of the metal which exists as M^{3+} would be **[JEE Main 2013]**

(a) 7.01% (b) 4.08%
(c) 6.05% (d) 5.08%

Ans. ***(b)***

$M_{0.98}O$

Consider one mole of the oxide.

Moles of M = 0.98 mole of O^{2-} = 1

Let moles of $M^{3+} = x$

$\Rightarrow$ Moles of $M^{2+} = 0.98 - x$

$\Rightarrow$ On balancing charge,

$$(0.98 - x) \times 2 + 3x - 2 = 0$$

$$\Rightarrow \quad 1.96 - 2x + 3x - 2 = 0$$

$$\Rightarrow \quad x = 0.04$$

$$\Rightarrow \quad \text{Percentage of } M^{3+} = \frac{0.04}{0.98} \times 100 = 4.08\%$$

TOPIC 3

Mole Concept and Concentration Terms

17 The number of atoms in 8 g of sodium is $x \times 10^{23}$. The value of x is ....

(Nearest integer)

[Given : $N_A = 6.02 \times 10^{23}$ mol^{-1}

Atomic mass of Na = 23.0 u] **[2021, 1 Sep Shift-II]**

Ans. ***(2)***

Given, mass of Na = 8g

Molar mass of Na = 23 $gmol^{-1}$

$$= \frac{\text{Weight of sodium atom}}{\text{Molecular mass of sodium atom}}$$

$$= \frac{\text{Number of atoms}}{\text{Avogadro's number}}$$

$$\frac{8\text{ g}}{23\text{ g}} = \frac{\text{Number of atoms}}{6.022 \times 10^{23}}$$

$$\text{Number of atoms} = \frac{8 \times 6.022}{23} \times 10^{23}$$

$$\text{Number of atoms} = 2.09 \times 10^{23}$$

$$x \approx 2$$

Hence, answer is 2.

18 10.0 mL of 0.05 M $KMnO_4$ solution was consumed in a titration with 10.0 mL of given oxalic acid dihydrate solution. The strength of given oxalic acid solution is ...... $\times 10^{-2}$ g/L.

(Round off to the nearest integer)

[2021, 27 July Shift-II]

Ans. ***(1575)***

For titration of $KMnO_4$ with oxalic acid,

$$n_{eq}(KMnO_4) = n_{eq}(H_2C_2O_4 \cdot 2H_2O)$$

or $$\frac{10 \times 0.05}{1000} \times 5 = \frac{10 \times M}{1000} \times 2$$

$$\Rightarrow \quad M = 0.125\text{ M}$$

Molar mass of $H_2C_2O_4 \cdot 2H_2O$

$$= 2 \times 1 + 2 \times 12 + 4 \times 16 + 2(18)$$

$$= 126\text{ g/mol}$$

Strength of oxalic acid = (126×0.125) g/L

$$= 15.75\text{ g/L}$$

$$= 1575 \times 10^{-2}\text{ g/L}$$

19 When 10 mL of an aqueous solution of Fe^{2+} ions was titrated in the presence of dil. H_2SO_4 using diphenylamine indicator, 15 mL of 0.02 M solution of $K_2Cr_2O_7$ was required to get the end point. The molarity of the solution containing Fe^{2+} ions is $x \times 10^{-2}$ M. The value of x is .... (Nearest integer)

[2021, 25 July Shift-I]

Ans. ***(18)***

For the given reaction,

$$Fe^{2+} + Cr_2O_7^{2-} \longrightarrow Fe^{3+} + Cr^{3+}$$

Volume of aqueous solution of Fe^{2+} ion $(V_1) = 10$ mL.

Volume of $K_2Cr_2O_7$ solution $(V_2) = 15$ mL

Molarity of $K_2Cr_2O_7$, $M_2 = 0.02$ M

Milliequivalent of Fe^{2+}

= Milliequivalent of $K_2Cr_2O_7$

$$n_1M_1V_1 = n_2M_2V_2$$

$$M_1 \times 10 \times 1 = 6 \times 0.02 \times 15$$

$$\Rightarrow \quad M_1 = \frac{6 \times 0.02 \times 15}{10} = 0.18$$

$$M_1 \simeq 18 \times 10^{-2}\text{ M}$$

So, value of x is 18.

20 If the concentration of glucose $(C_6H_{12}O_6)$ in blood is 0.72 gL^{-1}, the molarity of glucose in blood is ...... $\times 10^{-3}$ M. (Nearest integer)

[Given : Atomic mass of C = 12, H = 1, O = 16 u] **[2021, 22 July Shift-II]**

Ans. ***(4)***

Molar mass of glucose $(C_6H_{12}O_6)$

$$= 12 \times 6 + 12 \times 1 + 16 \times 6 = 180\text{ g mol}^{-1}$$

Concentration of glucose

$$= 0.72\text{ g L}^{-1} \quad \text{(given)}$$

$\therefore$ Molarity (M)

$$= \frac{\text{Concentration of glucose}}{\text{Molar mass of glucose}} = \frac{W_B}{M_B}$$

$$M = \frac{0.72}{180} = 0.004$$

$$= 4 \times 10^{-3}\text{ M.}$$

21 15 mL of aqueous solution of Fe^{2+} in acidic medium completely reacted with 20 mL of 0.03 M aqueous $Cr_2O_7^{2-}$. The molarity of the Fe^{2+} solution is ...... $\times 10^{-2}$ M (Round off to the nearest integer).

[2021, 17 March Shift-I]

Ans. ***(24)***

$$\underset{+6}{Cr_2O_7^{2-}} + \underset{+2}{Fe^{2+}} \longrightarrow \underset{+3}{Cr^{3+}} + \underset{+3}{Fe^{3+}}$$

Dichromate $(Cr_2O_7^{2-})$ oxidised Fe^{2+} to Fe^{3+} and itself get reduced to Cr^{3+}.

Valency factor of $Cr_2O_7^{2-} = 6$ as Cr gets reduced from +6 to +3.

Valency factor of $Fe^{2+} = 1$ as it gets oxidised from +2 to +3.

From law of equivalence,

Milliequivalent of $Cr_2O_7^{2-}$ = Milliequivalent of Fe^{2+}

$$M_1V_1n_1 = M_2V_2n_2$$

$$(M_1 \times V_1) \times 6 = (M_2 \times V_2) \times 1$$

$$(0.03 \times 20) \times 6 = (M_2 \times 15)\ 1$$

$$\Rightarrow \quad M_2 = 0.24\text{ molar}$$

$$= 24 \times 10^{-2}\text{ molar}$$

22 The mole fraction of a solute in a 100 molal aqueous solution .... $\times 10^{-2}$ (Round off to the nearest integer).

[Given, atomic masses H : 1.0 u, O : 16.0 u] **[2021, 17 March Shift-I]**

Ans. ***(64)***

Given, molality = 100

$\Rightarrow$ 100 moles of solute in 1 kg of solvent

Mole fraction of solute (χ_{Solute})

$$= \frac{\text{Moles of solute}}{\text{Total moles}} = \frac{n_{\text{Solute}}}{n_{\text{Solute}} + n_{\text{Solvent}}}$$

$$n_{\text{Solvent}} = \frac{1000}{18} = 55.5$$

$$\chi_{\text{Solute}} = \frac{100}{100 + 55.5} = \frac{100}{155.5} = 0.643$$

$$\chi_{\text{Solute}} = 64.3 \times 10^{-2} = 64 \times 10^{-2}$$

23 The $NaNO_3$ weighed out to make 50 mL of an aqueous solution containing 70.0 mg Na^+ per mL is .... g. (Rounded off to the nearest integer)

[Given : Atomic weight in g mol^{-1}, Na : 23 ; N : 14 ; O : 16].

[2021, 26 Feb Shift-II]

Ans. ***(13)***

70 mg Na^+ is present in 1 mL of $NaNO_3$ solution.

$\therefore$ 50 mL of $NaNO_3$ will contain

$$= 70 \times 50\text{ mg}$$

$$= \frac{70 \times 50}{1000} = 3.5\text{ gm}$$

Moles of Na^+ in solution = Moles of $NaNO_3$ in solution

$$[\because NaNO_3 \longrightarrow Na^+ + NO_3^-]$$

$$= \frac{3.5}{23}\text{ mol}$$

$$[\because \text{Molar mass of } Na^+ = 23\text{g mol}^{-1}]$$

Mass of $NaNO_3$ = mole × molar mass

$$[\because \text{molar mass of } NaNO_3 = 85\text{ gmol}^{-1}]$$

$$= \frac{3.5}{23} \times 85 = 12.934\text{ g} \simeq 13\text{ g}$$

24 The mole fraction of glucose $(C_6H_{12}O_6)$ in an aqueous binary solution is 0.1. The mass percentage of water in it, to the nearest integer, is ....

[2020, 3 Sep Shift-I]

Ans. ***(47.00)***

Let, for glucose :

Mass = w_B g, mole = n_B

and mole fraction = χ_B

(Molar mass, $M_B = 180$ g mol^{-1})

For water : mass = w_A g,

mole = n_A and mole fraction = χ_A

(Molar mass, $M_A = 18\text{ g mol}^{-1}$)

Where, $\chi_A + \chi_B = 1$

$$\Rightarrow \quad \frac{\chi_B}{\chi_A} = \frac{\chi_B}{1-\chi_B} = \frac{0.1}{0.9} = \frac{1}{9}$$

$$\Rightarrow \quad \frac{\dfrac{n_B}{n_A+n_B}}{\dfrac{n_A}{n_A+n_B}} = \frac{1}{9}$$

$$\Rightarrow \quad \frac{n_B}{n_A} = \frac{1}{9} \Rightarrow \frac{\dfrac{w_B}{180}}{\dfrac{w_A}{18}} = \frac{1}{9} \Rightarrow \frac{w_B}{180} \times \frac{18}{w_A} = \frac{1}{9}$$

$$\Rightarrow \quad \frac{w_B}{w_A} = \frac{10}{9} \Rightarrow \frac{w_B}{w_A} + 1 = \frac{10}{9} + 1$$

$$\Rightarrow \quad \frac{w_A}{w_A + w_B} = \frac{9}{19}$$

$$\Rightarrow \frac{w_A}{w_A + w_B}\% = \frac{9}{19} \times 100 = 47.368 \simeq 47.00$$

So, mass percentage of water (A) in the solution is 47.00.

25 6.023×10^{22} molecules are present in 10 g of a substance 'x'. The molarity of a solution containing 5 g of substance 'x' in 2 L solution is ...... $\times 10^{-3}$. **[2020, 3 Sep Shift-II]**

Ans. ***(25)***

Given, 6.023×10^{23} molecules are present in 10 g substance.

Number of moles

$$= \frac{\text{Number of molecules}}{6 \times 10^{23}} = \frac{\text{Mass (given)}}{\text{Molar mass}}$$

$$\text{Molar mass} = \frac{10 \times 6.023 \times 10^{23}}{6.023 \times 10^{22}}$$

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

We know that

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution } (l)}$$

$\left[\begin{array}{l}\text{Given, molarity of solution containing} = 5 \\ \text{of subtance, Volume} = 2\text{L}\end{array}\right]$

$$= \frac{(5/100)}{2} = \frac{5}{100 \times 2}$$

$$= 0.025 = 25 \times 10^{-3}$$

26 The strengths of 5.6 volume hydrogen peroxide (of density 1 g/mL) in terms of mass percentage and molarity (M), respectively, are

(Take molar mass of hydrogen peroxide as 34 g/mol) **[2020, 3 Sep Shift-II]**

(a) 0.85 and 0.25 (b) 0.85 and 0.5

(c) 1.7 and 0.5 (d) 1.7 and 0.25

Ans. ***(c)***

Volume of hydrogen = 5.6

Volume strength = 11.2 × molarity

$$\Rightarrow \quad \text{Molarity} = \frac{\text{Volume strength}}{11.2}$$

$$= \frac{5.6}{11.2} = 0.5$$

Suppose, that the solution taken is = 1 L

Mass of solution = 1000 mL × 1 g/mL

= 1000 g

Mass of solute = Moles × Molar mass

= 0.5 × 34

[∵ molar mass of H_2O_2 = 34]

= 17 g

$$\Rightarrow \quad \text{Mass }\% = \frac{17}{1000} \times 100 = 1.7\%$$

27 A 100 mL solution was made by adding 1.43 g of $Na_2CO_3 \cdot xH_2O$. The normality of the solution is 0.1 N. The value of x is .... **[2020, 4 Sep Shift-II]**

Ans. ***(10)***

Molar mass of $Na_2CO_3 \cdot xH_2O$.

(Atomic mass of Na = 23, C = 12, O = 16)

$= 23 \times 2 + 12 + 48 + 18x$

$= 46 + 12 + 48 + 18x =$

$(106 + 18x)$

Equivalent weight of $Na_2CO_3 \cdot xH_2O$

$$= \frac{\text{Molar mass}}{n\text{ factor}} = \frac{M}{2} = (53 + 9x)$$

[Here, m = molar mass and n factor = 2]

$$\text{Gram equivalent} = \frac{\text{Weight}}{\text{Equivalent weight}}$$

[Given, weight of $Na_2CO_3 \cdot xH_2O = 1.43$ g]

Hence, gram equivalent of

$$Na_2CO_3 \cdot xH_2O = \frac{1.43}{53 + 9x}$$

$$\text{Normality} = \frac{G_{meq}}{V_{litre}}; \; 0.1 = \frac{\dfrac{1.43}{53+9x}}{0.1}$$

{As, volume = 100 mL = 0.1 L

$$\text{So,} \quad 10^{-2} = \frac{1.43}{53 + 9x} \Rightarrow 53 + 9x = 143$$

$$9x = 90 \Rightarrow x = 10.00$$

28 Ferrous sulphate heptahydrate is used to fortify foods with iron. The amount (in grams) of the salt required to achieve 10 ppm of iron in 100 kg of wheat is ....

Atomic weight : Fe = 55.85; S = 32.00; O = 16.00 **[2020, 8 Jan Shift-I]**

Ans. ***(4.97)***

Ferrous sulphate heptahydrate $FeSO_4 \cdot 7H_2O$.

If the amount of the salt is 'x' gram.

Mass of iron contained in it

$$= \frac{x \times \text{atomic mass of Fe} (= 55.85)}{\text{Molar mass of } FeSO_4 \cdot 7H_2O (= 277.85)}$$

$$= \frac{55.85x}{277.85}$$

10 ppm of iron in 100 kg of wheat, can be acheived as,

$$= \frac{\text{mass of iron} \times 10^6}{\text{mass of wheat} (= 100\text{ kg} = 10^5\text{ g})} = 10$$

$$= \frac{55.85\,x \times 10^6}{277.85 \times 10^5} = 10 \Rightarrow x = \frac{277.85}{55.85} = 4.97\text{ g}$$

This value may vary from 4.95 to 4.99.

29 The molarity of HNO_3 in a sample which has density 1.4 g/mL and mass percentage of 63% is ....

(Molecular weight of $HNO_3 = 63$) **[2020, 9 Jan Shift-I]**

Ans. ***(14.00)***

For 100 g sample of the solution, mass of $HNO_3 = 63$ g,

$$\therefore \quad n_{HNO_3} = \frac{63}{63} = 1\text{ mol}$$

$$\text{Volume of solution} = \frac{\text{Mass}}{\text{Density}}$$

$$= \frac{100\text{ g}}{1.4\text{ g/mL}}$$

$$= \frac{100}{1.4}\text{ mL} = \frac{1}{14}\text{L}$$

$$\text{Molarity} = \frac{n}{V(\text{L})} = \frac{1}{(1/14)} = 14\text{ M}$$

30 A 10 mg effervescent tablet containing sodium bicarbonate and oxalic acid releases 0.25 mL of CO_2 at $T = 298.15$ K and $p = 1$ bar. If molar volume of CO_2 is 25.0 L under such condition, what is the percentage of sodium bicarbonate in each tablet? [Molar mass of $NaHCO_3 = 84\text{ g mol}^{-1}$] **[2019, 11 Jan Shift-I]**

(a) 8.4 (b) 0.84 (c) 16.8 (d) 33.6

Ans. ***(a)***

$$\underset{2\text{ mol}}{2NaHCO_3} + \underset{1\text{ mol}}{H_2C_2O_4} \longrightarrow \underset{2\text{ mol}}{2CO_2} + Na_2C_4O_4 + H_2O$$

⇒ In the reaction, number of mole of CO_2 produced.

$$n = \frac{pV}{RT} = \frac{1\text{ bar} \times 0.25 \times 10^{-3}\text{ L}}{0.082\text{ L atm K}^{-1}\text{mol}^{-1} \times 298.15\text{ K}}$$

$$= 1.02 \times 10^{-5}\text{ mol}$$

Number of mole of $NaHCO_3$

$$= \frac{\text{Weight of } NaHCO_3}{\text{Molecular mass of } NaHCO_3}$$

$$\therefore \; w_{NaHCO_3} = 1.02 \times 10^{-5} \times 84 \times 10^3 \text{ mg}$$

$$= 0.856 \text{ mg}$$

$$\Rightarrow NaHCO_3 \% = \frac{0.856}{10} \times 100 = 8.56\%$$

31 The hardness of a water sample (in terms of equivalents of $CaCO_3$) containing 10^{-3} M $CaSO_4$ is (Molar mass of $CaSO_4 = 136 \text{ g mol}^{-1}$) **[2019, 12 Jan Shift-I]**

(a) 100 ppm (b) 10 ppm
(c) 50 ppm (d) 90 ppm

Ans. ***(a)***

Hardness of water sample can be calculated in terms of ppm concentration of $CaCO_3$.

Given, molarity $= 10^{-3}$ M

i.e. 1000 mL of solution contains 10^{-3} mole of $CaCO_3$.

$\therefore$ Hardness of water = ppm of $CaCO_3$

$$= \frac{10^{-3} \times 1000}{1000} \times 10^6$$

$$= 100 \text{ ppm}$$

32 The ratio of masses of oxygen and nitrogen in a particular gaseous mixture is 1 : 4. The ratio of number of their molecule is **[JEE Main 2014]**

(a) 1:4 (b) 7:32
(c) 1:8 (d) 3:16

Ans. ***(b)***

The number of moles is given by

$$n = \frac{\text{weight} (w)}{\text{molecular weight } (M)}$$

Thus, ratio of moles of O_2 and N_2 is given by

$$\frac{n_{O_2}}{n_{N_2}} = \left(\frac{W_{O_2}/M_{O_2}}{W_{N_2}/M_{N_2}}\right) = \left(\frac{W_{O_2}}{W_{N_2}}\right)\left(\frac{M_{N_2}}{M_{O_2}}\right)$$

$$= \left(\frac{1}{4}\right) \times \left(\frac{28}{32}\right) = \frac{7}{32}$$

Hence, ratio of n_{O_2} and n_{N_2} is 7 : 32.

33 The molarity of a solution obtained by mixing 750 mL of 0.5 M HCl with 250 mL of 2M HCl will be **[JEE Main 2013]**

(a) 0.875 M (b) 1.00 M
(c) 1.75 M (d) 0.0975 M

Ans. ***(a)***

The molarity of a resulting solution is given by

$$M = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$$

$$= \frac{750 \times 0.5 + 250 \times 2}{750 + 250} = \frac{875}{1000}$$

$$= 0.875 \text{ M}$$

34 The density of a solution prepared by dissolving 120 g of urea (mol. mass = 60u) in 1000 g of water is 1.15 g/mL. The molarity of this solution is **[AIEEE 2012]**

(a) 0.50 M (b) 1.78 M
(c) 1.02 M (d) 2.05 M

Ans. ***(d)***

Total mass of solution = 1000 g water + 120 g urea = 1120 g

Density of solution = 1.15 g / mL

$$\text{Thus, volume of solution} = \frac{\text{mass}}{\text{density}}$$

$$= \frac{1120 \text{ g}}{1.15 \text{ g / mL}}$$

$$= 973.91 \text{ mL}$$

$$= 0.974 \text{ L}$$

$$\text{Moles of solute} = \frac{120}{60} = 2 \text{ mol}$$

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{volume (L) of solution}}$$

$$= \frac{2 \text{ mol}}{0.974 \text{ L}} = 2.05 \text{ mol L}^{-1}$$

35 The molality of a urea solution in which 0.0100 g of urea, $[(NH_2)_2CO]$ is added to 0.3000 dm^3 of water at STP is **[AIEEE 2011]**

(a) 5.55×10^{-4} M (b) 33.3M
(c) 3.33×10^{-2} M (d) 0.555 M

Ans. ***(a)***

$$\text{Molality} = \frac{\text{moles of the solute}}{\text{mass of the solvent in kg}}$$

$$\text{Moles of urea } (n_{urea}) = \frac{0.0100 \text{ g}}{60 \text{ g mol}^{-1}}$$

Mass of 1000 mL of solution

$$= \text{volume} \times \text{density}$$

$$= 300 \text{ mL} \times \frac{1 \text{ g}}{\text{mL}}$$

$$[\because 1 \text{ dm}^3 = 1000 \text{ mL}]$$

$$= 300 \text{ g}$$

Mass of solvent = 300 g − 0.0100 g

$$= 299.9 \text{ g}$$

$$= 0.2999 \text{ kg}$$

$$\text{Molality} = \frac{0.0100}{60 \times 0.2999}$$

$$= 5.55 \times 10^{-4} \text{ mol kg}^{-1}$$

36 How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms? **[AIEEE 2006]**

(a) 0.02 (b) 3.125×10^{-2}
(c) 1.25×10^{-2} (d) 2.5×10^{-2}

Ans. ***(b)***

8 moles of O-atom are contained by 1 mole $Mg_3(PO_4)_2$.

Hence, 0.25 moles of O-atom are contained by

$$= \frac{1}{8} \times 0.25 \text{ mol } Mg_3(PO_4)_2 = 3.125 \times 10^{-2}$$

37 Number of atoms in 560 g of Fe (atomic mass = 56 g mol^{-1}) is

(a) twice that of 70 g N **[AIEEE 2002]**
(b) half that of 20 g H
(c) Both (a) and (b)
(d) None of the above

Ans. ***(c)***

560 g of Fe

$$\text{Number of moles} = \frac{560 \text{ g}}{56 \text{ g mol}^{-1}} = 10 \text{ mol}$$

For 70 g of N, 14 g N = 1 mol of N-atom
70 g N = 5 mol of N-atom

For 20 g of H, 1 g H = 1 mol of H-atom
20 g H ≡ 20 mol of H-atom

TOPIC 4

Stoichiometric and Volumetric Calculations

38 Sodium oxide reacts with water to produce sodium hydroxide. 20.0 g of sodium oxide is dissolved in 500 mL of water. Neglecting the change in volume, the concentration of the resulting NaOH solution is .... $\times 10^{-1}$ M. (Nearest integer)

[Atomic mass : Na = 23.0, O = 16.0, H = 1.0] **[2021, 31 Aug Shift-II]**

Ans. ***(13)***

For the reaction,

$$\underset{\substack{1 \text{ mol} \\ \frac{20}{62} \text{ mol}}}{Na_2O} + H_2O \longrightarrow \underset{\substack{2 \text{ mol} \\ x \text{ mol}}}{2NaOH}$$

$$\text{Moles of NaOH formed} \Rightarrow x = \frac{20}{62} \times 2$$

Concentration of NaOH

$$= \frac{\text{Moles of NaOH}}{\text{Volume of solution (in litre)}}$$

$$= \frac{\frac{20}{62} \times 2}{\frac{500}{1000}} = 1.29 \text{ M} = 13 \times 10^{-1} \text{ M}$$

39 100 g of propane is completely reacted with 1000 g of oxygen. The mole fraction of carbon dioxide in the resulting mixture is $x \times 10^{-2}$. The value of x is .... (Nearest integer) [Atomic weight : H = 1.008, C = 12.00, O = 16.00]

[2021, 27 Aug Shift-II]

Ans. ***(19)***

For the reaction,

$$CH_3CH_2CH_3(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(g)$$
$$1 \quad : \quad 5 \qquad\qquad 3 \quad : \quad 4$$

1 mole of propane reacts completely with 5 moles
of oxygen to form 3 moles of carbon dioxide and
4 moles of steam.

44 g of propane = 1 mole of propane

$$100 \text{ g of propane} = \frac{1}{44} \times 100 = 2.27 \text{ mol}$$

32 g of O_2 = 1 mole of O_2

$$1000 \text{ g of } O_2 = \frac{1}{32} \times 1000 = 31.25 \text{ moles}$$

$\therefore$ 2.27 moles of propane requires $5 \times 2.27 = 11.35$ moles of O_2

moles of CO_2 formed

$= 3 \times 2.7 = 6.681$ mol of CO_2

	$CH_3CH_2CH_3$	+ $5O_2$	$\longrightarrow 3CO_2$	+ $4H_2O$
	1	: 5	3	: 4
at $t = 0$	2.27 mol	31.25 mol	0	0
at $t = t$	0	31.25 − (5 × 2.27) 19.90 mol	3 × 2.27 6.81 mol	4 × 2.27 9.08 mol

When reaction is completed 19.90 moles of O_2,
6.81 moles of CO_2 and 9.08 moles of steam are left in the flask.

$$\text{Mole fraction of } CO_2 = \frac{\text{Moles of } CO_2(g)}{\text{Total number of moles}}$$

$$= \frac{6.81}{19.90 + 6.81 + 9.08} = 0.19$$

$$x \times 10^{-2} = 0.19 \Rightarrow x = 19$$

40 A chloro compound A,

(i) Forms aldehydes on ozonolysis followed by the hydrolysis.

(ii) When vaporised completely, 1.53 g of A gives 448 mL of vapour at STP.

The number of carbon atoms in a molecule of compound A is ....

[2021, 26 Aug Shift-II]

Ans. ***(3)***

Given, 448 mL of A gives 1.53 g of vapours.

$$\therefore 22400 \text{ mL of } A \text{ gives} = \frac{1.53}{445} \times 22400$$
$$= 76.50 \text{ g of } A$$

$\therefore$ Molecular mass is 76.5.

$\therefore$ The possible compound is

$$CH_3—CH{=}CH—Cl$$

On ozonolysis followed by hydrolysis, it gives aldehyde as follows.

$$H_3CHC{=}CH—Cl \xrightarrow[\text{Zn}/H_2O]{O_3} \underset{\text{Aldehyde}}{CH_3—CH{=}O} + Cl—\underset{\underset{H}{|}}{C}{=}O$$

The compound (A) $CH_3—CH{=}CH—Cl$ (chloropropene) has 3 carbon atoms.

41 4g equimolar mixture of NaOH and Na_2CO_3 contains x g of NaOH and y g of Na_2CO_3. The value of x is ...... g. (Nearest integer)

[2021, 20 July Shift-II]

Ans. ***(1)***

Total mass = 4 g (given)

Mass of NaOH = x g

Mass of Na_2CO_3 = y g

$$x + y = 4$$

$$\frac{\text{Mass of NaOH}}{\text{Molar mass of NaOH}} = \frac{\text{Mass of } Na_2CO_3}{\text{Molar mass of } Na_2CO_3}$$

$$\frac{x}{40} = \frac{y}{106} \quad \text{(Equimolar)}$$

$$y = \left(\frac{106}{40}\right)x \Rightarrow x + \frac{106}{40}x = 4$$

$$x + 2.065x = 4 \Rightarrow 3.065x = 4$$

$$x = 1.096 \text{ g} \Rightarrow x \simeq 1$$

42 250 mL of 0.5 M NaOH was added to 500 mL of 1 M HCl. The number of unreacted HCl molecules in the solution after complete reaction is .... × 10^{21}. (Nearest integer) $(N_A = 6.022 \times 10^{23})$

[2021, 20 July Shift-I]

Ans. ***(226)***

We know that, number of moles

$= V_L \times$ molarity

and number of millimoles

$= V_{mL} \times$ molarity

So, millimoles of

NaOH = 250 × 0.5 = 125

Millimoles of HCl = 500 × 1 = 500

Now, reaction is

	NaOH	+ HCl	$\longrightarrow$ NaCl	+ H_2O
At $t = 0$,	125	500	0	0
At $t = t$,	0	375	125	125

125 millimoles of NaOH reacts with 125 millimoles of HCl.

So, millimoles of HCl left = 375

Moles of HCl = 375×10^{-3}

Number of HCl molecules

= Avogadro's constant (N_A) × moles of HCl

$= 6.022 \times 10^{23} \times 375 \times 10^{-3}$

$= 225.8 \times 10^{21} = 226 \times 10^{21}$

Therefore, answer is 226.

43 10.0 mL of Na_2CO_3 solution is titrated against 0.2 M HCl solution. The following titre values were obtained in 5 readings. 4.8 mL, 4.9 mL, 5.0 mL, 5.0 mL and 5.0 mL based on these readings and convention of titrimetric estimation of concentration of Na_2CO_3 solution is .... mM (Round off to the nearest integer).

[2021, 18 March Shift-II]

Ans. ***(50)***

10.0 mL of Na_2CO_3 solution is titrated against 0.2 M HCl.

Volume of Na_2CO_3 solution (mL)	Volume of 0.2 M HCl solution (mL)	Mean volume of HCl (mL)
10	4.8	
10	4.9	
10	5.0	5.0
10	5.0	
10	5.0	

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$$
$$10 \text{mL} \qquad 0.2\text{M}_{HCl}$$
$$M_{Na_2CO_3} = ? \quad 5 \text{ mL}$$

M_{eq} of Na_2CO_3 = M_{eq} of HCl

$$M_{Na_2CO_3} \times 10 \times 2 = 0.2 \times 5 \times 1$$
$$M_{Na_2CO_3} = 5 \times 10^{-2} \text{M} = 50 \times 10^{-3} \text{ M}$$
$$= 50 \text{ mM}$$

44 Complete combustion of 750 g of an organic compound provides 420 of CO_2 and 210 g of H_2O. The percentage composition of carbon and hydrogen in organic compound is 15.3 and ...... respectively (Round off to the nearest integer).

[2021, 16 March Shift-I]

Ans. *(3)*

$$C_xH_y + \left(x+\frac{y}{4}\right)O_2 \longrightarrow x\,CO_2 + \frac{y}{2}H_2O$$

Any hydrocarbon, on combustion gives CO_2 and H_2O. This is Liebig's method for estimation of 'C' and 'H' percentage.

Mass of water formed $= 210$ g

18 g of H_2O contains $= 2$ g of hydrogen

210 g of H_2O contains $= \left(\frac{2}{18}\times 210 = \frac{70}{3}\right)$ g of hydrogen.

Given, mass of organic compound $= 750$ g

Percentage of hydrogen

$$= \frac{\text{Mass of hydrogen}}{\text{Mass of organic compound}} \times 100$$

$$= \frac{70}{3\times 750}\times 100 = 3.11\%$$

Nearest integer $= 3$

45 Complete combustion of 1.80 g of an oxygen containing compound ($C_xH_yO_z$) gave 2.64 g of CO_2 and 1.08 g of H_2O. The percentage of oxygen in the organic compound is **[2021, 25 Feb Shift-I]**

(a) 50.33 (b) 53.33
(c) 63.53 (d) 51.63

Ans. *(b)*

$$\underset{1.8\text{ g}}{C_xH_yO_z} + O_2 \longrightarrow \underset{2.64\text{ g}}{CO_2} + \underset{1.08\text{ g}}{H_2O}$$

$$n_C = \underset{\text{(Moles)}}{n_{CO_2}} = \frac{2.64\,(\text{Given mass})}{44\,(\text{Molecular mass})} = 0.06$$

$$n_H = 2\times n_{H_2O} = \frac{1.08}{18}\times 2 = 0.12$$

Weight of oxygen in $C_xH_yO_z$

$$= 1.80 - 12\times\frac{2.64}{44} - \frac{1.08}{18}\times 2$$

$$= 1.80 - 0.72 - 0.12 = 0.96\text{ g}$$

% of oxygen by weight

$$= \frac{0.96}{1.80}\times 100 = 53.33\%$$

46 The formula of a gaseous hydrocarbon, which requires 6 times of its own volume of O_2 for complete oxidation and produces 4 times its own volume of CO_2 is C_xH_y. The value of y is .... **[2021, 24 Feb Shift II]**

Ans. *(8)*

Combustion reaction :

$$C_xH_y(g) + \left(x+\frac{y}{4}\right)O_2(g) \longrightarrow xCO_2(g) + \frac{y}{z}H_2O(l)$$

Suppose, volume of C_xH_y is V and volume of O_2 is 6 times greater than $C_xH_y = 6V$

then volume of $xCO_2 \Rightarrow Vx = 4V$

$$x = 4$$

Since, $V_{O_2} = 6\times V_{C_xH_y}$

$$V\left(x+\frac{y}{4}\right) = 6V$$

$$\left(x+\frac{y}{4}\right) = 6 \qquad \ldots\text{(i)}$$

Put value of $x = 4$ in Eq. (i)

We get, $4 + \frac{y}{4} = 6 \Rightarrow y = 8$

47 1.86 g of aniline completely reacts to form acetanilide. 10% of the product is lost during purification. Amount of acetanilide obtained after purification (in g) is .... $\times 10^{-2}$. **[2021, 24 Feb Shift-II]**

Ans. *(432)*

Reaction

$$\underset{\substack{\text{Aniline}\\ \text{Mol. wt} = 98}}{C_6H_5NH_2} \xrightarrow[\text{Efficiency}]{90\%} \underset{\substack{\text{Acetanilide}\\ \text{(mol. wt. = 135)}}}{C_6H_5-\underset{H}{\underset{|}{N}}-\overset{O}{\overset{\|}{C}}-CH_3}$$

Given, weight $= 1.86$ g

Here, 1 mole of aniline gives 1 mole of acetanilide

$\therefore$ mole of aniline $=$ mole of acetanilide

$$\Rightarrow \frac{1.86}{93} = \frac{W_{\text{Acetanilide}}}{135}$$

$$W_{\text{Acetanilide}} = \frac{1.86\times 135}{93}\text{ g} = 2.70\text{ g}$$

But efficiency of reaction is 90% only.

Hence, mass of acetanilide produced

$$= 2.70\times\frac{90}{100}\text{ g} = 2.43\text{ g} = 243\times 10^{2}\text{ g}$$

$$x = 243$$

48 The ratio of the mass percentages of 'C' and H' and 'C and O' of a saturated acyclic organic compound 'X' are 4 : 1 and 3 : 4 respectively. Then, the moles of oxygen gas required for complete combustion of two moles of organic compound 'X' is .... **[2020, 2 Sep Shift-II]**

Ans. *(5)*

For the molecular formula, $C_nH_{2n+2}O_2$ (M=Molar mass)

$$C\% = \frac{12n}{M}\times 100,\ H\% = \frac{2n+2}{M}\times 100,$$

$$O\% = \frac{32}{M}\times 100$$

To be saturated and alicyclic, $n = 2$, is,

$$C\% = \frac{24}{M}\times 100,\ H\% = \frac{6}{M}\times 100 \text{ and}$$

$$O\% = \frac{32}{M}\times 100$$

$$\Rightarrow \quad C\% : H\% = 24 : 6 = 4 : 1$$

$$C\% : O\% = 24 : 32 = 3 : 4$$

So, X is $C_2H_6O_2$ and its combination equation is

$$C_2H_6O_2 + \left(2+\frac{6}{4}-\frac{1}{2}\right)O_2 \longrightarrow 2CO_2 + \frac{6}{2}H_2O$$

$$\Rightarrow \underset{1\text{ mol}}{C_2H_6O_2} + \underset{\frac{5}{2}\text{ mol}}{\frac{5}{2}O_2} \longrightarrow 2CO_2 + 3H_2O$$

2 mol $\frac{5}{2}\times 2 = 5$ mol of O_2 will be required.

49 The volume (in mL) of 0.1 N NaOH required to neutralise 10 mL of 0.1 N phosphonic acid is .... **[2020, 3 Sep Shift-II]**

Ans. *(10)*

$$\text{Base} + \text{Acid} \longrightarrow \text{Salt} + H_2O$$

$$\underset{\text{Base}}{NaOH} + \underset{\text{Phosphonic acid}}{H_3PO_3} \longrightarrow \underset{\text{Salt}}{NaH_2PO_3} + \underset{\text{Water}}{H_2O}$$

$$\text{Given}\begin{cases} 0.1\text{ N} & 0.1\text{ N} \\ V = ? & 10\text{ mL}\end{cases}$$

On dilution $(N_1V_1)_{NaOH} = (N_2V_2)_{H_3PO_3}$

$$0.1V_1 = 0.1\times 10\text{ mL} \Rightarrow V_1 = \frac{0.1\times 10\text{ mL}}{0.1}$$

$$V_1 = 10\text{ mL}$$

Volume of NaOH $= 10$ mL

50 The mass of ammonia in grams produced when 2.8 kg of dinitrogen quantitatively reacts with 1 kg of dihydrogen is .... **[2020, 4 Sep Shift-I]**

Ans. *(3400)*

$$\underset{1\text{ mol}}{N_2} + \underset{3\text{ mol}}{3H_2} \longrightarrow \underset{2\text{ mol}}{2NH_3}$$

Molecular weight of N_2(kg) $= 0.028$ kg/mol

Mass of 'N' atom $= 14$ g

Then, mass of N_2 molecule $= 28$ g $= 0.028$ kg/mol

Molecular weight of $H_2 = 2$ g

Here, $3H_2$ is $= 3\times 2 = 6$ g $= 0.006$ kg/mol

Molecular weight of NH_3 is $= 17$ g

Molecular weight of $2NH_3$(kg) $= 0.034$ kg/mol

0.028 kg N_2 require hydrogen $= 0.006$ kg

$$1\text{ kg }N_2\text{ require} = \frac{0.006}{0.028}$$

2.8 kg N_2 (limiting reagent) require

$$= \frac{0.006}{0.028} \times 2.8 = 0.6 \text{ kg } H_2 \text{(Excess)}$$

Then 0.6 kg H_2 is present in excess and N_2 will be limiting reagent.

$$0.028 \text{ kg } N_2 \xrightarrow{\text{Excess}} 0.034 \text{ kg of } NH_3$$

$$1 \text{ kg } N_2 \longrightarrow \frac{0.034}{0.028}$$

$$2.8 \text{ kg } N_2 \longrightarrow \frac{0.034}{0.028} \times 2.8$$

$$= 3.4 \text{ kg or } 3400 \text{ g}$$

Amount of $NH_3 = 3400$ g

51 The minimum number of moles of O_2 required for complete combustion of 1 mole of propane and 2 moles of butane is ....

[2020, 5 Sep Shift-I]

Ans. ***(18)***

Combustion of propane

$$\underset{\text{Propane}}{C_3H_8(g)} + 5\,O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$$

For 1 mole propane combustion 5 mole O_2 is required.

Combustion of butane

$$\underset{\substack{\text{Butane}\\ \text{2 mol}}}{C_4H_{10}(g)} + \frac{13}{2}\,O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

For 2 moles of butane 13 moles of O_2 is required.

Hence, minimum number of moles of O_2 required to oxidise 1 mole of propane and 2 moles of butane $= 5 + 2 \times \frac{13}{2} = 18$

52 The volume, in mL, of 0.02 M $K_2Cr_2O_7$ solution required to react with 0.288 g of ferrous oxalate in acidic medium is ....

(Molar mass of Fe $= 56$ g mol^{-1})

[2020, 5 Sep Shift-II]

Ans. ***(50)***

m eq. of $K_2Cr_2O_7 = m$ eq. FeC_2O_4

$$K_2Cr_2O_7 + 7H_2SO_4 + FeCrO_4 \rightarrow Fe_2(SO_4)_3 + K_2SO_4 + Cr_2(SO_4)_3 + 4CO_2 + 7H_2O$$

$$FeC_2O_4 + Cr_2O_7^{2-} \longrightarrow Fe^{3+} + CO_2 + Cr^{3+}$$

$$V \times 0.02 \times 6 = \frac{0.288 \times 3 \times 1000}{144}$$

$\Rightarrow V = 50$ mL

53 The ammonia (NH_3) released on quantitative reaction of 0.6 g urea (NH_2CONH_2) with sodium hydroxide (NAOH) can be neutralised by **[2020, 7 Jan Shift-II]**

(a) 100 mL of 0.2 N HCl
(b) 200 mL of 0.4 N HCl
(c) 200 mL of 0.2 N HCl
(d) 100 mL of 0.1 N HCl

Ans. ***(a)***

$$\underset{(M=60)}{NH_2CONH_2} + 2\,NaOH \longrightarrow 2\,NH_3 + Na_2CO_3$$

No. of moles of urea

$$= \text{Given mass/molar mass}$$

$$= \frac{0.6}{60} = 0.01 \text{ mol } NH_2CONH_2$$

$\therefore$ It gives 0.02 mol NH_3 as per the equation.

To neutralise it, 0.02 equivalents of HCl needed.

As we know, no. of equivalents of HCl $=$ Normality $\times$ Volume

Therefore,

(a) $100 \times 10^{-3} \times 0.2 = 0.02.$

(b) $200 \times 10^{-3} \times 0.4 = 0.08$

(c) $200 \times 10^{-3} \times 0.2 = 0.04$

(d) $100 \times 10^{-3} \times 0.1 = 0.01$

Thus, option (a) is correct.

54 The volume (in mL) of 0.125 M $AgNO_3$ required to quantitatively precipitate chloride ions in 0.3 g of $[Co(NH_3)_6]Cl_3$ is ....

$M_{[Co(NH_3)_6]Cl_3} = 267.46$ g/mol

$M_{AgNO_3} = 169.87$ g/mol

[2020, 8 Jan Shift-I]

Ans. ***(26.92)***

Given, Mass of $[Co(NH_3)_6]Cl_3 = 0.3$ g

Molar mass $= 267.46$ g mol^{-1}

$$\therefore \quad n = \frac{0.3}{267.46} \text{ mol}$$

From the formula, 1 mol complex will give 3 mol Cl^-.

$$\therefore \quad n_{Cl^-} = \frac{0.3}{267.46} \times 3$$

$$= \frac{0.9}{267.46}$$

The precipitation reaction is takes place as follows :

$$\underset{(0.3g)}{[Co(NH_3)_6]Cl_3} + \underset{(VmL, 0.125g)}{3AgNO_3} \longrightarrow 2AgCl$$

$$\therefore \quad \frac{0.3 \times 3}{267.46} = 0.125 \times V \times 10^{-3}$$

$\therefore$ Volume of $AgNO_3$ (in mL)

$$= \frac{0.9 \times 1000}{0.125 \times 267.46}$$

$$= 26.92 \text{ mL.}$$

This value may vary from 26.60 to 27.00.

55 $NaClO_3$ is used, even in spacecrafts, to produce O_2. The daily consumption of pure O_2 by a person is 492 L at 1 atm 300 K. How much amount of $NaClO_3$, in grams, is required to produce O_2 for the daily consumption of a person at 1 atm, 300 K .... ?

$$NaClO_3(s) + Fe(s) \rightarrow O_2(g) + NaCl(s) + FeO(s)$$

$R = 0.082$ L atm mol^{-1}K^{-1}

[2020, 8 Jan Shift-II]

Ans. ***(2130)***

Volume of $O_2 = 492$ L

$$\therefore \quad n = \frac{pV}{RT}$$

$$= \frac{1 \text{ atm} \times 492 \text{ L}}{0.082 \text{ L atm K}^{-1} \text{ mol}^{-1} \times 300 \text{ K}}$$

$$= \frac{492}{8.2 \times 3} \text{ mol}$$

From the reaction,

$$NaClO_3(s) + Fe(s) \longrightarrow O_2(g) + NaCl(s) + FeO(s)$$

$$n_{NaClO_3} = n_{O_2} = \frac{492}{8.2 \times 3} = 20 \text{ mol}$$

$m_{NaClO_3} = n \times$ molar mass of $NaClO_3$ ($= 106.5$)

$$= 20 \times 106.5 = 2130 \text{ g}$$

The value in different situations may range from 2120 to 2140.

56 The strength of 11.2 volume solution of H_2O_2 is [Given that molar mass of $H = 1$ g mol^{-1} and $O = 16$ g mol^{-1}]

[2019, 8 April Shift-II]

(a) 1.7% (b) 34%
(c) 13.6% (d) 3.4%

Ans. ***(d)***

11.2 volume of H_2O_2 means that 1 mL of this H_2O_2 will give 11.2 mL of oxygen at STP.

$$\underset{2 \times 34 \text{ g}}{2H_2O_2(l)} \longrightarrow \underset{22.4 \text{ L at STP}}{O_2(g)} + 2H_2O(l)$$

22.4 L of O_2 at STP is produced from $H_2O_2 = 68$ g

$\therefore$ 11.2 L of O_2 at STP is produced from

$$H_2O_2 = \frac{68}{22.4} \times 11.2$$

$$= 34 \text{ g}$$

$\therefore$ 34 g of H_2O_2 is present in 1000 g of solution

$$\therefore \quad \% \, w/w = \frac{34}{1000} \times 100 = 3.4\%.$$

57 For a reaction,

$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$,

identify dihydrogen (H_2) as a limiting reagent in the following reaction mixtures.

[2019, 9 April Shift-I]

(a) 56 g of N_2 + 10 g of H_2
(b) 35 g of N_2 + 8 g of H_2
(c) 14 g of N_2 + 4 g of H_2
(d) 28 g of N_2 + 6 g of H_2

Ans. ***(a)***

Key Idea The reactant which is present in the lesser amount, i.e. which limits the amount of product formed is called limiting reagent.

When 56 g of N_2 + 10 g of H_2 is taken as a combination then dihydrogen (H_2) act as a limiting reagent in the reaction.

$$\underset{\substack{2\times14\,g\\28\,g}}{N_2(g)} + \underset{\substack{3\times2\,g\\6\,g}}{3H_2(g)} \longrightarrow \underset{\substack{2(14+3)\\34\,g}}{2NH_3(g)} \quad ...(i)$$

28 g N_2 requires 6 g H_2 gas.

56 g of N_2 requires $\frac{6\,g}{28\,g} \times 56\,g = 12$ g of H_2

12 g of H_2 gas is required for 56 g of N_2 gas but

only 10 g of H_2 gas is present in option (a).

Hence, H_2 gas is the limiting reagent.

In option (b), i.e. 35 g of N_2 + 8 g of H_2.

As 28 g N_2 requires 6 g of H_2.

35 g N_2 requires $\frac{6\,g}{28\,g} \times 35$ g H_2

$\Rightarrow$ 7.5 g of H_2

Here, H_2 gas does not act as limiting reagent since 7.5 g of H_2 gas is required for 35 g of N_2 and 8 g of H_2 is present in reaction mixture. Mass of H_2 left unreacted = 8 − 7.5 g of H_2. = 0.5 g of H_2.

Similarly, in option (c) and (d), H_2 does not act as limiting reagent.

For 14g of N_2 + 4 g of H_2.

As we know 28g of N_2 reacts with 6 g of H_2.

14 g of N_2 reacts with $\frac{6}{28} \times 14$g of H_2

3 g of H_2

For 28 g of N_2 + 6 g of H_2, i.e. 28 g of N_2 reacts with 6 g of H_2 [by equation (i)].

58 At 300 K and 1 atmospheric pressure, 10 mL of a hydrocarbon required 55 mL of O_2 for complete combustion and 40 mL of CO_2 is formed. The formula of the hydrocarbon is **[2019, 10 April Shift-I]**

(a) C_4H_7Cl (b) C_4H_6
(c) C_4H_{10} (d) C_4H_8

Ans. ***(b)***

In eudiometry,

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \xrightarrow[1\,atm]{300\,K} x\,CO_2 + \frac{y}{2}H_2O$$

1 mol	$\left(x+\frac{y}{4}\right)$mol	x mol
1 mL	$\left(x+\frac{y}{4}\right)$mL	x mL
10 mL	$\left(x+\frac{y}{4}\right)\times 10$ mL	$10x$ mL

Given, (i) $V_{CO_2} = 10x = 40$ mL $\Rightarrow x = 4$

(ii) $V_{O_2} = 10\left(x + \frac{y}{4}\right)$mL = 55 mL

$\Rightarrow \quad 10\left(4 + \frac{y}{4}\right) = 55 \qquad [\because x = 4]$

$\Rightarrow \quad 40 + \frac{y \times 10}{4} = 55$

$\Rightarrow \quad y \times \frac{10}{4} = 15 \Rightarrow y = 15 \times \frac{4}{10} = 6$

So, the hydrocarbon (C_xH_y) is C_4H_6.

59 The minimum amount of $O_2(g)$ consumed per gram of reactant is for the reaction (Given atomic mass : Fe = 56, O = 16, Mg = 24, P = 31, C = 12, H = 1) **[2019, 10 April Shift-II]**

(a) $C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$
(b) $P_4(s) + 5O_2(g) \longrightarrow P_4O_{10}(s)$
(c) $4Fe(s) + 3O_2(g) \longrightarrow 2Fe_2O_3(s)$
(d) $2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$

Ans. ***(b)***

(a) $\underset{44g}{C_3H_8(g)} + \underset{160g}{5O_2(g)} \longrightarrow 3CO_2(g) + 4H_2O(l)$

$\Rightarrow$ 1g of reactant = $\frac{160}{44}$ g of O_2 consumed = 3.64 g

(b) $\underset{124g}{P_4(s)} + \underset{160g}{5O_2(g)} \longrightarrow P_4O_{10}(s)$

$\Rightarrow$ 1g of reactant $\frac{160}{124}$ g of O_2 consumed = 1.29 g

(c) $\underset{244g}{4Fe(s)} + \underset{96g}{3O_2(g)} \longrightarrow 2Fe_2O_3(s)$

$\Rightarrow$ 1 g of reactant $\frac{96}{224}$ g of O_2 consumed = 0.43 g

(d) $\underset{48\,g}{2Mg(s)} + \underset{32\,g}{O_2(g)} \longrightarrow 2MgO(s)$

$\Rightarrow$ 1 g of reactant $\frac{32}{48}$ g of O_2 consumed = 0.67 g

So, minimum amount of O_2 is consumed per gram of reactant (Fe) in reaction (c).

60 25 g of an unknown hydrocarbon upon burning produces 88 g of CO_2 and 9 g of H_2O. This unknown hydrocarbon contains **[2019, 12 April Shift-II]**

(a) 20 g of carbon and 5 g of hydrogen
(b) 22 g of carbon and 3 g of hydrogen
(c) 24 g of carbon and 1 g of hydrogen
(d) 18 g of carbon and 7 g of hydrogen

Ans. ***(c)***

Hydrocarbon containing C and H upon burning produces CO_2 and water vapour respectively. The equation is represented as

$$C_xH_y + (x + y/4)O_2 \longrightarrow xCO_2 + (y/2)H_2O$$

Mass of carbon = $\frac{12}{44} \times$ mass of CO_2

$= \frac{12}{44} \times 88\,g = 24\,g$

Mass of hydrogen = $\frac{2}{18} \times$ mass of H_2O

$= \frac{2}{18} \times 9 = 1\,g$

So, the unknown hydrocarbon contains 24 g of carbon and 1g of hydrogen.

61 For the following reaction, the mass of water produced from 445 g of $C_{57}H_{110}O_6$ is :

$$2C_{57}H_{110}O_6(s) + 163O_2(g) \longrightarrow 114CO_2(g) + 110H_2O(l)$$

[2019, 10 Jan Shift-II]

(a) 490 g (b) 495 g (c) 445 g (d) 890 g

Ans. ***(b)***

$$2\,C_{57}H_{110}O_6(s) + 163\,O_2(g) \longrightarrow 110\,H_2O(l) + 114\,CO_2(g)$$

Molecular mass of $C_{57}H_{110}O_6$

$= 2 \times (12 \times 57 + 1 \times 110 + 16 \times 6)$ g

= 1780 g

Molecular mass of 110 H_2O

= 110 (2 + 16) = 1980 g

1780 g of $C_{57}H_{110}O_6$ produced = 1980 g of H_2O.

445g of $C_{57}H_{110}O_6$ produced = $\frac{1980}{1780} \times 445$ g of H_2O = 495 of H_2O

62 A mixture of 100 mmol of $Ca(OH)_2$ and 2 g of sodium sulphate was dissolved in water and the volume was made upto 100 mL.

The mass of calcium sulphate formed and the concentration of OH^- in resulting solution, respectively, are :

(Molar mass of $Ca(OH)_2$, Na_2SO_4 and $CaSO_4$ are74, 143 and 136 g mol^{-1}, respectively; K_{sp} of $Ca(OH)_2$ is 5.5×10^{-6})

[2019, 10 Jan Shift-I]

(a) 13.6 g, 0.28 mol L^{-1}
(b) 1.9 g, 0.28 mol L^{-1}
(c) 13.6 g, 0.14 mol L^{-1}
(d) 1.9 g, 0.14 mol L^{-1}

Ans. ***(b)***

The reaction involved is as follows :

	$Ca(OH)_2$	$+ Na_2SO_4 \longrightarrow$	$CaSO_4$	$+ 2OH^-$	$+ 2Na^+$
Millimoles	100	$\frac{2 \times 1000}{142} = 14$	0	0	0
at $t=0$ Milimoles	86	0			
at $t=t$		[Limiting reagent]	14	28	

$$\text{No. of moles} = \frac{\text{Weight}}{\text{Molecular mass}}$$

$$\therefore \text{Mass of } CaSO_4 = \frac{14}{1000} \times 136 = 1.9 \text{ g}$$

Also,

$$\text{Molarity} = \frac{\text{No. of moles of solute}}{\text{Volume of solution (in L)}}$$

$\therefore$ Molarity of OH^-,

$$[OH^-] = \frac{28}{1000} \times \frac{1000}{100}$$
$$= 0.28 \text{mol } L^{-1} = 0.28 \text{ M}$$

63 1 g of a carbonate (M_2CO_3) on treatment with excess HCl produces 0.01186 mole of CO_2. The molar mass of M_2CO_3 in g mol^{-1} is **[JEE Main 2017]**

(a) 1186 (b) 84.3 (c) 118.6 (d) 11.86

Ans. ***(b)***

$$\underset{1\text{ g}}{M_2CO_3} + 2HCl \rightarrow 2MCl + H_2O + \underset{0.01186 \text{ mole}}{CO_2}$$

Number of moles of M_2CO_3 reacted
= Number of moles of CO_2 evolved

$$\frac{1}{M} = 0.01186 \quad [M = \text{molar mass of } M_2CO_3]$$

$$M = \frac{1}{0.01186} = 84.3 \text{ g mol}^{-1}$$

64 The molecular formula of a commercial resin used for exchanging ions in water softening is $C_8H_7SO_3Na$ (mol. wt. = 206). What would be the maximum uptake of Ca^{2+} ions by the resin when expressed in mole per gram resin? **[JEE Main 2015]**

(a) $\frac{1}{103}$ (b) $\frac{1}{206}$ (c) $\frac{2}{309}$ (d) $\frac{1}{412}$

Ans. ***(d)***

We know the molecular weight of $C_8H_7SO_3Na$

$= 12 \times 8 + 1 \times 7 + 32 + 16 \times 3 + 23 = 206$

We have to find, mole per gram of resin.

$\therefore$ 1 g of $C_8H_7SO_3Na$ has number of mole

$$= \frac{\text{Weight of given resin}}{\text{Molecular weight of resin}} = \frac{1}{206} \text{ mol}$$

Now, reaction looks like

$$2C_8H_7SO_3Na + Ca^{2+} \longrightarrow (C_8H_7SO_3)_2Ca + 2Na^+$$

$\because$ 2 moles of $C_8H_7SO_3Na$ combines with 1 mol Ca^{2+}

$\therefore$ 1 mole of $C_8H_7SO_3Na$ will combine with $\frac{1}{2}$ mol Ca^{2+}

$\therefore \frac{1}{206}$ mole of $C_8H_7SO_3Na$ will combine with

$$\frac{1}{2} \times \frac{1}{206} \text{ mol } Ca^{2+} = \frac{1}{412} \text{ mol } Ca^{2+}$$

65 3 g of activated charcoal was added to 50 mL of acetic acid solution (0.06 N) in a flask. After an hour it was filtered and the strength of the filtrate was found to be 0.042 N. The amount of acetic acid adsorbed (per gram of charcoal) is **[JEE Main 2015]**

(a) 18 mg (b) 36 mg
(c) 42 mg (d) 54 mg

Ans. ***(a)***

Given, initial strength of acetic acid
= 0.06N
Final strength = 0.042 N
Volume given = 50 mL

$\therefore$ Initial m moles of CH_3COOH
$= 0.06 \times 50 = 3$

Final m moles of CH_3COOH
$= 0.042 \times 50 = 2.1$

$\therefore$ m moles of CH_3COOH adsorbed
$= 3 - 2.1 = 0.9$ m mol

Hence, mass of CH_3COOH absorbed per gram of charcoal

$$= \frac{0.9 \times 60}{3}$$
($\because$ molar mass of $CH_3COOH = 60 \text{ gmol}^{-1}$)
$$= \frac{54}{3} = 18 \text{ mg.}$$

66 Amount of oxalic acid present in a solution can be determined by its titration with $KMnO_4$ solution in the presence of H_2SO_4. The titration gives unsatisfactory result when carried out in the presence of HCl because HCl **[AIEEE 2008]**

(a) gets oxidised by oxalic acid to chlorine
(b) furnishes H^+ ions in addition to those from oxalic acid
(c) reduces permanganate to Mn^{2+}
(d) oxidises oxalic acid to carbon dioxide and water

Ans. ***(c)***

Titration of oxalic acid by $KMnO_4$ in the presence of HCl gives unsatisfactory result because HCl is a better reducing agent than oxalic acid and HCl reduces preferably MnO_4^- to Mn^{2+}.

67 In the reaction,

$$2Al(s) + 6HCl(aq) \longrightarrow 2Al^{3+}(aq) + 6Cl^-(aq) + 3H_2(g)$$

[AIEEE 2007]

(a) 6L HCl (aq) is consumed for every 3L $H_2(g)$ produced
(b) 33.6 L $H_2(g)$ is produced regardless of temperature and pressure for every mole Al that reacts
(c) 67.2 L $H_2(g)$ at STP is produced for every mole Al that reacts
(d) 11.2 L $H_2(g)$ at STP is produced for every mole HCl (aq) consumed

Ans. ***(d)***

$$2Al(s) + 6HCl(aq) \rightarrow 2Al^{3+}(aq) + 6Cl^-(aq) + 3H_2(g)$$

From the equation, it is clear that,
6 mol of HCl produces 3 mol of H_2

or 1 mole of $HCl = \frac{3 \times 22.4}{6}$ L of H_2
$= 11.2$ L of H_2

68 What volume of hydrogen gas, at 273 K and 1 atm pressure will be consumed in obtaining 21.6 g of elemental boron (atomic mass = 10.8) from the reduction of boron trichloride by hydrogen? **[AIEEE 2003]**

(a) 89.6 L (b) 67.2 L
(c) 44.8 L (d) 22.4 L

Ans. ***(b)***

$$\underset{2\text{ mol}}{2BCl_3} + \underset{3\text{ mol}}{3H_2} \longrightarrow \underset{\substack{2\text{ mol}\\21.6\text{ g}}}{2B} + 6HCl$$

$21.6 \text{ g B} = 2 \text{ mol B} \equiv 3 \text{ mol } H_2$

$pV = nRT$

$$\Rightarrow V = \frac{nRT}{p}$$

$$= \frac{3 \times 0.0821 \times 273}{1} = 67.2 \text{ L}$$