IIT CHEMISTRY

PHYSICAL CHEMISTRY

CONCENTRATION TERMS

SOLUTIONS :

A mixture of two or more substances can be a solution. We can also say that a solution is a homogeneous mixture of two or more substances 'Homogeneous' means 'uniform throughout'. Thus a homogeneous mixture, i.e., a solution, will have uniform composition throughout.

1. CONCENTRATION TERMS:

The following concentration terms are used to express the concentration of a solution. These are :

1 . Molarity (M)
2 . Molality (m)
3 . Mole fraction (x)
4 . % calculation
5 . ppm

* Remember that all of these concentration terms are related to one another. By knowing one concentration term you can also find the other concentration terms. Let us discuss all of them one by one.

1.1. Molarity (M): The number of moles of a solute dissolved in 1 L (1000 ml) of the solution is known as the molarity of the solution.

That is, Molarity of solution $= \dfrac{\text{number of moles}}{\text{volume of solution in litre}}$

Let a solution is prepared by dissolving w g of solute of mol. wt. M in V mL water.

$\therefore$ Number of moles of solute dissolved $= \dfrac{w}{M}$

$\therefore$ V mL water have $\dfrac{w}{M}$ mole of solute

$\therefore$ 1000 mL water have $\dfrac{w \times 1000}{M \times V(\text{in mL})} \Rightarrow \therefore$ Molarity (M) $= \dfrac{w \times 1000}{(\text{Mol. wt of solute}) \times V(\text{in mL})}$

Some other relations may also useful.

Number of millimoles $= \dfrac{\text{mass of solute}}{(\text{Mol. wt. of solute})} \times 1000$ = (Molarity of solution × V_{ml})

Molarity of solution may be also given as: $\dfrac{\text{Number of millimole of solute}}{\text{Total volume of solution in ml}}$

Molarity is a unit that depends upon temperature. It decreases as temperature increases.

Ex.1 Find the mass of solute and solvent in 100 mL, 1 M NaOH solution having density 1.5 g/mL.

(A) 40 g, 110 g (B) 4 g, 150 g (C) 4 g, 146 g (D) 40 g, 150 g

Ans. (C)

Sol. Mole of NaOH = molarity × volume (l) = 1 × 0.1 = 0.1

Mass of NaOH = 0.1 × 40 = 4gm

Mass of solution = volume × density = 100 × 1.5 = 150gm

Hence: mass of solvent = 150 – 4 = 146 g.

Ex.2 Molality of pure water if its density is 0.936 gm/ml

(A) 50 (B) 55.56 (C) 57.56 (D) 56.56

Ans. (B)

Sol. $m = \frac{1000}{M.W.} = \frac{1000}{18} = 55.56$

1.2 **Molality (m) :** The number of moles of solute dissolved in 1000 g (1 kg) of a solvent is known as the molality of the solution.

That is, molality $= \frac{\text{number of moles of solute}}{\text{mass of solvent in gram}} \times 100$

Let y g of a solute is dissolved in x g of a solvent. The molecular mass of the solute is m. Then y/m mole of the solute are dissolved in x g of the solvent. Hence

Molality $= \frac{y}{m \times x} \times 1000$

Ex.3 225 gm of an aqueous solution contains 5 gm of urea. What is the concentration of the solution in terms of molality. (Mol. wt. of urea = 60)

Ans. 0.332.

Sol. Mass of urea = 5 gm

Molecular mass of urea = 60

Number of moles of urea $= \frac{5}{60}$ = 0.083

Mass of solvent = (255 – 5) = 250 gm

$\therefore$ Molality of the solution $= \frac{\text{Number of moles of solute}}{\text{Mass of solvent in gram}} \times 1000$

$= \frac{0.083}{250} \times 1000 = 0.332.$

Ex.4 A solution is made by dissolving $CaBr_2$ in water (solvent) such that mass fraction of solute and solvent is same in the solution. The molality of solution is -

(A) 2.5 m (B) 55.55 m (C) 2 m (D) 5 m

Ans. (D)

Sol. $m = \frac{w / 200 \times 1000}{w} = 5$ $m = \frac{w / 200 \times 1000}{w} = 5$

1.3 Mole fraction (x):

The ratio of number of moles of the solute or solvent present in the solution and the total number of moles present in the solution is known as the mole fraction of substances concerned.

Let number of moles of solute in solution = n

Number of moles of solvent in solution = N

$\therefore$ Mole fraction of solute (x_1) = $\dfrac{n}{n + N}$

$\therefore$ Mole fraction of solvent (x_2) = $\dfrac{N}{n + N}$ $\Rightarrow$ also $x_1 + x_2 = 1$

1.4 % Calculation: The concentration of a solution may also express in terms of percentage in the following ways.

(i) % weight by weight (%w/w): It is given as mass of solute present in per 100 g of solution.

i.e. % w/w = $\dfrac{\text{mass of solute in g}}{\text{mass of solution in g}} \times 100$

[X % by mass means 100 g solution contains X g solute ;

$\therefore$ (100 – X) g solvent]

(ii) % weight by volume (%w/V) : It is given as mass of solute present in per 100 mL of solution.

i.e. % w/v = $\dfrac{\text{mass of solute in g}}{\text{volume of solution in mL}} \times 100$

[X % $\left(\dfrac{w}{V}\right)$ means 100 mL solution contains X g solute]

(iii) % volume by volume (%V/V): It is given as volume of solute present in per 100 mL solution.

i.e. % V/V = $\dfrac{\text{Volume of solute}}{\text{Volume of solution in mL}} \times 100$

Ex.5 0.25 of a substance is dissolved in 6.25 g of a solvent. Calculate the percentage amount of the substance in the solution.

Ans. 3.8%.

Sol. wt. of solution = 0.25 + 6.25 = 6.50.

so % (w/w) = $\dfrac{0.25}{6.50} \times 100 = 3.8\%$.

Ex.6 0.5 g of a substance is dissolved in 25 g of a solvent. Calculate the percentage amount of the substance in the solution.

Ans. 1.96

Sol. Mass of substance = 0.5 g

Mass of solvent = 25 g

$\therefore$ Percentage of the substance (w/w) = $\dfrac{0.5}{0.5 + 25} \times 100 = 1.96$

1.5 Parts per million (ppm) : $\dfrac{\text{Mass of solute}}{\text{Mass of solvent}}\times 10^6 \cong \dfrac{\text{Mass of solute}}{\text{Mass of solution}}\times 10^6$

Do yourself-1:

1. Calculate the molarity when:
(a) 4.9 g H_2SO_4 acid dissolved in water to result 500 mL solution.
(b) 2 gram-molecules of KOH dissolved in water to result 500 mL solution.
(A) (a) 0.1 M (b) 0.07 M
(B) (a) 0.4 M (b) 4 M
(C) (a) 0.4 M (b) 0.07 M
(D) (a) 0.1 M (b) 4 M

2. Calculate the volume in litre of 0.1 M solution of HCl which contains 0.365 g HCl?
(A) 10^{-2} L (B) 0.1 L (C) 1 L (D) 10 L

3. What volume of a 0.8 M solution contains 100 millimoles of the solute?
(A) 80 mL (B) 125 mL (C) 125 L (D) 80 L

4. Which of the following methods of expressing concentration of a solution is/are independent of temperature ?
(A) Molality
(B) % w/w
(C) Mole fraction of solute
(D) All of these

5. 20 cm^3 of an alcohol is dissolved in 80 cm^3 of water. Calculate the percentage of alcohol in solution.

6. Calculate the amount of 75% pure NaI required to prepare 5 litre of 0.5 M solution.
(A) 281.25 g (B) 500 g (C) 923.33 g (D) 519.375 g

2. DILUTION AND INTERMIXING OF SOLUTIONS

Dilution: Whenever a given solution of known concentration i.e. normality and molarity (known as standard solution) is diluted (adding solvent), the number of millimoles (or milli equivalents) of solute remain unchanged. The concentration of solution however changes. In such a case if :

M_1 = Mormality of original solution; V_1 = volume of original solution and

M_2 = normality of diluted solution; V_2 = total volume of diluted solution

Since the number of millimoles remains same,

$\Rightarrow M_1V_1 = M_2V_2$

Ex.7 Calculate the resultant molarity of following:

(a) 200 ml 1M HCl + 300 ml water (b) 1500 ml 1M HCl + 18.25 g HCl

(c) 200 ml 1M HCl + 100 ml 0.5 M H_2SO_4 (d) 200 ml 1M HCl + 100 ml 0.5 M HCl

Ans. (A) 0.4 M (B) 1.33 M (C) 1 M (D) 0.83 M.

Sol. (a) Final molarity = $\dfrac{200\times1+0}{200+300}$ = 0.4 M.

(b) Final molarity = $\dfrac{1500\times1+\dfrac{18.25\times1000}{36.5}}{1500} = 1.33\,M$

(c) Final molarity of H^+ = $\dfrac{200\times1+100\times0.5\times2}{200+100}$ = 1 M.

(d) Final molarity = $\dfrac{200\times1+100\times0.5}{200+100}$ = 0.83 M.

Ex.8 The molarity of Cl^- in an aqueous solution which was (w/V) 2% NaCl, 4% $CaCl_2$ and 6% NH_4Cl will be:

(A) 0.342 (B) 0.721 (C) 1.12 (D) 2.18

Ans. (D)

Sol. Moles of Cl^- in 100 ml of solution = $\dfrac{2}{58.5}+\dfrac{4}{111}\times 2+\dfrac{6}{53.5}$ = 0.2184

Molarity of Cl^- = $\dfrac{0.2184}{100}\times 1000$ = 2.184.

Ex.9 How many milli-litres of 0.2 M $AlCl_3$ solution is required to precipitate all the Ag^+ from 45 ml of a 0.2 M $AgNO_3$ solution:

$AlCl_3 + 3AgNO_3 \rightarrow 3AgCl\downarrow + Al(NO_3)_3$

(A) 15 ml (B) 30 ml (C) 45 ml (D) 60 ml

Ans. (A)

Sol. $AlCl_3 \;+\; 3AgNO_3 \rightarrow 3AgCl\downarrow + Al(NO_3)_3$

45×0.2 milli moles

$\dfrac{1}{3}\times 45\times 0.2$ milli mol

$\dfrac{1}{3}\times 0.45\times 0.2 = 0.2\times V$

$\Rightarrow$ V = 15 ml

Ex.10 The specific gravity of a solution is 1.8, having 62% by weight of acid. It is to be diluted to specific gravity of 1.2. What volume of water should be added to 100 ml of this solution?

Ans. 300 mL

Sol. Let, to 100 ml of given acid solution (sp. gr 1.8) x ml. of water is added.

$\therefore$ the total volume of resulting solution

$= (100 + x)$ ml

$\therefore$ the total weight of resulting solution

$= (100 + x) \times 1.2$ gm.

weight of acid present in the given acid solution (per 100 ml) $= 100 \times 1.8 \times 0.62$

$\therefore$ the amount of water present in 100 ml of given acid solution $= 1.8 \times 100 \times 0.38$

$\therefore$ total wt of acid present in the diluted solution $= (100 + x)\, 1.2 - x - 180 \times 0.38$

$= 1.8 \times 100 \times 0.62$

$\therefore$ $120 + 0.2x = 180$ or $x = 300$

$\therefore$ to lower sp. gravity of the given acid solution to 1.2, we are to add 300 ml of water per 100 ml of acid solution (sp gr. 1.2).

Ex.11 How would you prepare exactly 3 L of 1 M NaOH solution by mixing proportions of stock solutions of 2.5 M NaOH and 0.4 M NaOH, if no water is to be used? Find the ratio of the volume (v_1/v_2).

(A) 1 : 3 (B) 3 : 7 (C) 2 : 5 (D) Data insufficient

Ans. (C)

Sol. $M_1V_1 + M_2V_2 = M_TV_T$

$2.5\ V_1 + 0.4\ V_2 = 3 \times 1$

$2.5\ V_1 + 0.4\ (3 - V_1) = 3 \quad \Rightarrow 2.5\ V_1 + 1.2 - 0.4\ V_1 = 3$

$2.1\ V_1 = 1.8$

$$V_1 = \frac{1.8}{2.1} = \frac{6}{7}$$

$$V_2 = 3 - \frac{6}{7} = \frac{15}{7}$$

$$\frac{V_1}{V_2} = \frac{6}{7} \times \frac{7}{15} = 2 : 5$$

3. INTERCONVERSION OF CONCENTRATION TERMS:

Comprehension # (Q.51 to Q.52)

	Molarity(mol/L)	Molality(mol/Kg)	Density (g/mL)	Gram molecular mass of solute
Solution-1	a	-	d_1	P
Solution-2	-	b	d_2	Q
Solution-3	1	-	1.060	60

Now answer the following questions :

Ex.12 What is molality of solution-1 :

(A) $\frac{(1000\times a)}{(1000\times d_1)-aP}$ (B) $\frac{1000\ d_1}{1000\ a-P}$ (C) $\frac{a}{1000\ d_1-aP}$ (D) None of these

Ans. (A)

Sol. For solution 1 'a' moles of solute are present in 1000 ml of solution.

wt. of solution = 1000 × d_1 g

wt. of solute = aP g

So, Molality = $\left[\frac{a\times1000}{1000\times d_1-aP}\right]$

Ex.13 What is the molarity of solution-2 :

(A) $\frac{b\times d_2}{1000+bQ}$ (B) $\frac{b\times1000\times d_2}{1000+bQ}$ (C) $\frac{1000\times bQ}{1000+bd_2}$ (D) None of these

Ans. (B)

Sol. For solution 2 'b' moles of solute are present in 1000 g of solvent.

wt. of solution = 1000 + bQ

vol. of solution = $\frac{1000+bQ}{d_2}$

Molality = $\frac{b\times1000}{\frac{1000+bQ}{d_2}}$ = $\frac{b\times1000\times d_2}{1000+bQ}$

Ex.14 The molarity of the solution containing 2.8%(mass / volume) solution of KOH is : (Given atomic mass of K = 39) is :

(A) 0.1 M (B) 0.5 M (C) 0.2 M (D) 1 M

Sol. Weight of KOH = 2.8 gram

Volume of solution = 100 ml

$$M = \frac{2.8\times1000}{56\times100} = \frac{5}{49} = 0.5\ M$$

Ex.15 What is the mole fraction of ethanol in 20% by weight solution in water?

(A) 0.095 (B) 0.089 (C) 0.9 (D) 1.2

Ans. (B)

Sol. 100 gm of solution contain 20 gm C_2H_5OH and 80 gm of water

$\therefore$ moles of ethanol present = $\frac{20}{46}$ = 0.435

(mol. wt of ethanol = 46)

$\therefore$ moles of water present = $\frac{80}{18}$ =4.444

Total no. of moles = 0.435 + 4.444 = 4.879

$\therefore$ mole fraction of C_2H_5OH

$$= \frac{0.435}{4.879} = 0.089$$

Do yourself-2:

1. What volume of water is required to make 0.2 M solution from 16 mL of a 0.5 M solution?

(A) 24 mL (B) 40 mL (C) 6.4 mL (D) 20 mL

2. What approximate volume of 0.40 M $Ba(OH)_2$ solution must be added to 50.0 mL of 0.30 M NaOH solution to get a solution in which the molarity of the OH^- ions is 0.50 M ?

(A) 33 mL (B) 66 mL (C) 133 mL (D) 100 mL

3. 100 mL 30% (w/v) NaOH solution is mixed with 100 ml 90% (w/v) NaOH solution. The molarity of final solution is-

(A) 30M (B) 15M (C) 7.5M (D) 2M

4. Molality (m) of a sulphuric acid solution in which the mol fraction of water is 0.85 is :

(A) 4.9 (B) 9.8 (C) 19.6 (D) Can't be determined

5. The molality of a sulphuric acid solution is 0.2. Total weight of the solution having 100 g of solvent is about :

(A) 119.6 g (B) 109.8 g (C) 104.9 g (D) 102 g

6. For a mixture of 100 mL of 0.3 M $CaCl_2$ solution and 400 mL of 0.1 M HCl solution, select the correct option:

(A) Total concentration of cations = 0.14 M (B) $[Cl^-]$ = 0.2 M

(C) Both (A) and (B) (D) None of these

7. What volume of water should be added to 50 ml of HNO_3 having density 1.5 g ml^{-1} and 63.0% by weight to have one molar solution.

3. SOME SPECIAL CONCENTRATION TERMS

3.1 VOLUME STRENGTH OF H_2O_2:

Strength of H_2O_2 is represented as 10V , 20 V , 30 V etc.

20V H_2O_2 means **one litre** of this sample of H_2O_2 on decomposition gives **20L of O_2** gas at **STP.**

Decomposition of H_2O_2 is given as :

$$H_2O_2 \longrightarrow H_2O + \frac{1}{2}O_2$$

1 mole $\qquad \frac{1}{2} \times 22.7$ L O_2 at STP

= 34g $\qquad$ = 11.35 L O_2 at STP

Molarity of H_2O_2 (M) = $\dfrac{\text{Volume strength of } H_2O_2}{11.35}$

Strength (in g/L) =Molarity × Mol. Wt = Molarity × 34

Ex.16 A fresh H_2O_2 solution is labeled 11.35 V at STP. This solution has the same concentration as a solution which is :

(A) 3.4% (w / w) (B) 3.4% (v / v) (C) 3.4% (w / v) (D) None of these

Ans. (C)

Sol. Molarity of H_2O_2 = $\dfrac{\text{vol.strength}}{11.2} = \dfrac{11.35}{11.35} = 1$

Now, $\%(w/v) = \dfrac{\text{wt. of solute in g}}{\text{wt. of solution in mL}} \times 100$

$= \text{Molarity} \times \text{Mol. wt. of solute} \times \dfrac{1}{10}$

$= 1 \times 34 \times \dfrac{1}{10} = 3.4\%$

3.2. PERCENTAGE LABELING OF OLEUM:

Oleum is SO_3 dissolved in 100% H_2SO_4. Sometimes, oleum is reported as more than 100% by weight, say y% (where y > 100). This means that (y – 100) grams of water, when added to 100 g of given oleum sample, will combine with all the free SO_3 in the oleum to give 100% sulphuric acid.

Hence, weight % of free SO_3 in oleum = 80(y –100)/18

Ex.17 What volume of water is required (in mL) to prepare 1 L of 1 M solution of H_2SO_4 (density = 1.5g/mL) by using 109% oleum and water only (Take density of pure water = 1 g/mL).

Ans. 1410.09 mL

Sol. 1 mole H_2SO_4 in 1L solution = 98 g H_2SO_4 in 1500 g solution = 98 g H_2SO_4 in 1402 g water.

Also, in 109% oleum, 9 g H_2O is required to form 109 g pure H_2SO_4& so, to prepare 98 g H_2SO_4, water needed is 9/109 × 98 = 8.09 g.

Total water needed = 1402 + 8.09 = 1410.09 g = 1410.09 mL

Ex.18 A 50 gm oleum sample contains $\left(\frac{400}{49}\right)$ gm of combined SO_3. Find percent label of the oleum sample.

Ans. (118)

Sol. Combined SO_3 = $\left(\frac{400}{49}\right)$g is present in H_2SO_4

mole of SO_3 = $\frac{\frac{400}{49}}{80} = \frac{5}{49}$

mole of H_2SO_4 in oleum = $\frac{5}{49}$

In 50 g oleum mass of H_2SO_4 = $\frac{5}{49} \times 98 = 10$ g

100 g oleum mass of H_2SO_4 = 20 g

mass of SO_3 = 100 – 20 = 80 g

$SO_3 + H_2O$

mass 80 g

mol $= \frac{80}{80}$ =1 mol = 18 g

% labeling = (100 + 18) % = 118 %

4. EUDIOMETRY OR GAS MIXTURE ANALYSIS:

Gaseous reactions are carried out in a special type of tube known as eudiometer tube. The tube is graduated in millimeters for volume measurement. The reacting gases taken in the eudiometer tube are exploded by sparks. T he volume s of the pro duct s of a gases are determined by absorbing them in suitable reagents,

Eg.

Solvent	**gas(es) absorb**
KOH	CO_2, SO_2, Cl_2
AmmonicalCu_2Cl_2	CO
Turpentine oil	O_3
Alkaline pyrogallol	O_2
Water	NH_3, HCl
$CuSO_4$	H_2O

Eudiometry is mainly bases on Avogadro's law i.e. $V \propto n$ at the same temperature and pressure.

$\therefore$ The mole concept may be applied in solving the problems, keeping in mind that in a gaseous reaction the relative volumes (measured under identical conditions) of each reactant and product represent their relative numbers of moles.

eg :	A(g) +	B(g) $\rightarrow$	C(g) +	D(g)
	a volumes	b volumes	c volumes	d volumes
	a moles	b moles	c moles	d moles

* Generally, explosions are carried out at STP and H_2O is assumed to be in liquid state, means its volume is negligible as compared to product gases.

Burning of hydrocarbon :

1. Hydrocarbon containing carbon and hydrogen only.

$$C_xH_y(g) + \left(x+\frac{y}{4}\right)O_2\,(g) \longrightarrow xCO_2\,(g) + \frac{y}{2}H_2O\,(\ell)$$

2. Hydrocarbon containing carbon and hydrogen and oxygen.

$$C_xH_yO_z\,(g) + \left(x+\frac{y}{2}-\frac{z}{2}\right)(g) \longrightarrow xCO_2\,(g) + \frac{y}{2}H_2O\,(\ell)$$

Ex.19 A gaseous hydrocarbon requires 6 times its own volume of O_2 for complete oxidation and produces4 times its volume of CO_2. What is its formula?

Ans. C_4H_8

Sol. The balanced equation for combustion

$$C_xH_y + \left(x+\frac{y}{4}\right)O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$$

1 volume $\left(x+\frac{y}{4}\right)$volume

$\therefore\ x + \frac{y}{4} = 6$ (by equation)

or $4x + y = 24$ ....(1)

Again x = 4 since evolved CO_2 is 4 times that of hydrocarbon

$\therefore\ 16 + y = 24$ or $y = 8$ $\therefore$ formula of hydrocarbon C_4H_8

Ex.20 7.5 ml of a gaseous hydrocarbon was exploded with 36 ml of oxygen. The volume of gases on cooling was found to be 28.5 ml, 15 ml of which was absorbed by KOH and the rest was absorbed in a solution of alkaline pyrogallol. If all volumes are measured under same conditions, the formula of hydrocarbon is

(A) C_3H_4 (B) C_2H_4 (C) C_2H_6 (D) C_3H_6

Ans. (B)

Sol. $\mathbf{C_xH_y} + \left(x+\frac{y}{4}\right)\mathbf{O_2} \longrightarrow XCO_2 + H_2O$

7.5 ml 36 ml

$36 - 7.5\left(x+\frac{y}{4}\right) + 7.5\,x = 28.5$

$36 - 7.5\left(15+\frac{y}{4}\right) + 7.5\,x = 28.5$

y = 4

x = 2

So formula = C_2H_4

Ex.21 A 30 mL mixture of CO, CH_4 and He gases is exploded by an electric discharge at room temperature with excess of oxygen. The decrease in volume is found to be 13 mL. A further contraction of 14 mL occurs, when the residual gas is treated with KOH solution. Find out the composition of the gaseous mixture in terms of volume percentage.

Ans. Percentage composition of CO = 33.33 %; CH_4 =13.33 % : He =53.33 %

Sol. Let the volume of CO be 'a' mL and CH_4 be 'b' mL

$\therefore$ Volume of He = (30 – a – b)

on explosion with oxygen

$$CO\,(g) + \frac{1}{2}O_2\,(g) \longrightarrow CO_2(g)$$

$$CH_4\,(g) + 2O_2\,(g) \longrightarrow CO_2\,(g) + 2H_2O\,(\ell)$$

'a' mL of CO give 'a' mL of CO_2 and 'b' mL of CH_4 gives 'b' mL of CO_2.

Therefore the volume decrease is due to the consumption of O_2. O_2 consumed for 'a' mL of CO is $\frac{a}{2}$ mL and O_2 consumed for 'b' mL of CH_4 is '2b' mL

$$\therefore \quad \frac{a}{2} + 2b = 13$$

The further contraction occurs because of the absorption of CO_2 by KOH, a + b = 14

$\therefore$ b = 4 mL

$\therefore$ a = 10 mL

$\therefore$ Percentage composition of CO $= \frac{10}{30} \times 100 = 33.33$ %

Percentage composition of $CH_4 = \frac{4}{30} \times 100 = 13.33$

Percentage composition of He $= \frac{(30-10-4)}{30} \times 100 = 53.33$ %

Do yourself-3:

1. A gaseous alkane is exploded with oxygen. The volume of O_2 for complete combustion to CO_2 formed is in the ratio 7/4. The molecular formula of alkane is :

(A) C_2H_4 (B) C_2H_6 (C) CH_4 (D) C_4H_{12}

2. 10 ml of gaseous hydrocarbon is exploded with 100 ml O_2. The residual gas on cooling is found to measure 95 ml of which 20 ml is absorbed by KOH and the reminder by alkaline pyrogallol. The formula of the hydrocarbon is :

(A) CH_4 (B) C_2H_6 (C) C_2H_4 (D) C_2H_2

ANSWER KEY

DO YOURSELF

Do yourself-1:

1. (D)

Sol. (a) $M = \dfrac{\frac{4.9}{98}}{\frac{500}{1000}} = 0.1\ M$

(b) $M = \dfrac{2\ \text{mole}}{500} \times 1000 = 4\ M.$

2. (B)

Sol. $\text{Volume} = \dfrac{\text{No.of moles}}{\text{Molarity}} = \dfrac{0.365/36.5}{0.1} = 0.1$

3. (B)

Sol. $M = \dfrac{n_{solute}}{V_{solution}}$

$\dfrac{0.8}{1000} = \dfrac{100\times10^{-3}}{\text{vol. of solution}}$

vol. of solution = 125 ml

(Here n_{solute}= mole of solute, $V_{solution}$ = vol. of solution).

4. (D)

Sol. Only Molarity depend on temperature molality, mole -fracction& % w/w do not depend on temperature.

5. 20%

Sol. Volume of alcohol = 20 cm^3

Volume of water = 80 cm^3

Percentage of alcohol = $\dfrac{20}{20+80}\times100 = 20\%$

6. (B)

Do yourself-2:

1. (A)

Sol. $M_1V_1 = M_2V_2$

$0.5 \times 16 = 0.2 \times V_2$

$V_2 = 40$ ml

Volume of water = 40 – 16 = 24 mL

2. (A)

Sol. Molarity of $OH^{-} = \dfrac{\text{Total moles of } OH^{-}}{\text{Total Vol. of solution}}$

$0.50 = \dfrac{(2\times 0.40\times V_{ml})+0.30\times 50}{V_{ml}+50}$

So V = 33 ml.

3. (B)

Sol. Total NaOH in 100 ml (1st solution) = 30 gm

Total NaOH in 100 ml (2nd solution) = 90 gm

$\therefore$ Molarity = $\left(\dfrac{120/40}{200/1000}\right) = 15M$

4. (B)

Sol. $X_{H_2O} = 0.85$ $X_{H_2SO_4} = 0.15$

$m = \dfrac{0.15}{0.85\times 18} \times 1000 = 9.8$

5. (D)

6. (C)

Sol. Molarity of cation $= \dfrac{M_1V_1 + M_2V_2}{V_1+V_2} = \dfrac{0.6}{5} = 0.12$ M

Molarity of $Cl^{-} = \dfrac{3(0.2)100 + 0.1\times 400}{500} = 0.2$ M.

7. 700 ml.

Sol. Volume of HNO_3 = 50 ml, density = 1.5

$d = \dfrac{M}{V}$, mass of solution = 50 × 1.5

weight of $HNO_3 = \dfrac{75\times 63}{100} = \dfrac{3}{4} \times 63$

Mole of $HNO_3 = \dfrac{3}{4}\times\dfrac{63}{63} = \dfrac{3}{4}$ Mole

$M = \dfrac{\text{Mole of } HNO_3}{\text{Volume of solution}} = 1 = \dfrac{3}{4\times V_{lit}} = 1$

$V = \dfrac{3}{4}$ L = 750 ml

Do yourself-3:

1. (B)

Sol. $\mathbf{C_xH_y} + \left(x + \frac{y}{4}\right)\mathbf{O_2} \longrightarrow XCO_2 + H_2O$

$$\frac{x + \frac{y}{4}}{x} = \frac{7}{4}$$

$$\frac{y}{4x} = \frac{3}{4} \qquad \frac{y}{x} = \frac{3}{1}$$

2. (D)

Sol. Volume of CO_2 = 20 ml (absorbed gas by KOH)

Volume of air unreacted = 95 – 20 = 75 (gas abosrbed by pyrogallol)

O_2 reacted = 100 + 75 = 25 ml

10 ml hydrocarbon libarates 20 ml CO_2.

2 atoms of 'C' are present in the compound.

	C_2H_x +	yO_2	$2CO_2$ +	H_2O
initial	10 ml	25 ml		
final	0	0	20	10 ml

volume of water vapours = (25 – 20) × 2 = 10 ml

10 ml hydrocarbon gives 10 ml water vapours.

No. of Hydrogen atoms in compounds are 2.

Compound will be C_2H_2.

EXERCISE # (S-I)

DEFINATIONS OF CONCENTRATION TERS

1. Calculate the molarity of the following solutions:

(a) 4g of caustic soda is dissolved in 200 mL of the solution.

(b) 5.3 g of anhydrous sodium carbonate is dissolved in 100 mL of solution.

(c) 0.365 g of pure HCl gas is dissolved in 50 mL of solution.

2. 0.115 gm of sodium metal was dissolved in 500 ml of the solution in distilled water. Calculate the molarity of the solution?

3. The average concentration of Na^+ ion in human body is 3 to 4 gm per litre. The molarity of Na^+ ion is about.

4. What is the concentration of chloride ion, in molarity, in a solution containing 10.56 gm $BaCl_2.8H_2O$ per litre of solution? (Ba = 137)

5. How much $BaCl_2$ (in gm) would be needed to make 250 ml of a solution having the same concentration of Cl^- as one containing 1.825 gm HCl per 100 ml ? (Ba = 137)

6. Equal moles of H_2O and NaCl are present in a solution. Find molality of solution?

7. What is the quantity of water (in g) that should be added to 16 g. methanol to make the mole fraction of methanol as 0.25:

8. If 0.5 M methanol undergo self dissociation like $CH_3OH \rightleftharpoons CH_3O^- + H^+$ & if concentration of H^+ is 2.5×10^{-4} M then calculate % dissociation of methanol.

INTERCONVERSION OF CONCENTRATION TERMS

9. Density of a solution containing 13% by mass of sulphuric acid is 0.98 g/mL. Then molarity of solution will be

10. The density of a solution containing 40% by mass of HCl is 1.2 g/mL. Calculate the molarity of the solution.

11. 15 g of methyl alcohol is present in 100 mL of solution. If density of solution is 0.90 g mL^{-1}. Calculate the mass percentage of methyl alcohol in solution

12. A 6.90 M solution of KOH in water contains 30% by mass of KOH. What is density of solution in gm/ml.

13. The concentration of a solution of NaOH is 8% (w/w) and 10% (w/v). Calculate density (in gm/mℓ) of solution?

14. The mole fraction of solute in aqueous urea solution is 0.2. Calculate the mass percent of solute?

15. Calculate molality (m) of each ion present in the aqueous solution of 2M NH_4Cl assuming 100% dissociation according to reaction.

$$NH_4Cl\ (aq) \longrightarrow NH_4^+\ (aq) + Cl^-\ (aq)$$

Given : Density of solution = 3.107 gm / ml.

16. The concentration of $Ca(HCO_3)_2$ in a sample of hard water is 405 ppm. The density of water sample is 1.0 gm/ml. Calculate the molarity of solution ?

17. Units of parts per million (ppm) or per billion (ppb) are often used to describe the concentrations of solutes in very dilute solutions. The units are defined as the number of grams of solute per million or per billion grams of solvent. Bay of Bengal has 1.9 ppm of lithium ions. What is the molality of Li^+ in this water ?

PROBLEMS RELATED WITH MIXING & DILUTION

18. Find molarity of Na^+ ions if 500 mL of 0.2 M $NaCl_{(aq)}$ solution is mixed with 500 mL 0.5 M $Na_2SO_{4\ (aq)}$ solution ?

19. Find out the volume of 98% w/w H_2SO_4 (density = 1.8 gm/ ml), must be diluted to prepare 12.5 litres of 2.5 M sulphuric acid solution

20. Determine the volume (in mℓ) of diluted nitric acid 20% w/v HNO_3 that can be prepared by diluting 50 mL of conc. HNO_3 with water 69.8% w /v.

21. 500 gm of urea solution of mole fraction 0.2 is diluted to 1500 gm. Calculate the mole fraction of solute in the diluted solution ?

22. When V ml of 2.2 M H_2SO_4 solution is mixed with 10 V ml of water, the volume contraction of 2% take place. Calculate the molarity of diluted solution ?

23. 500 ml of 2 M NaCl solution was mixed with 200 ml of 2 M NaCl solution. Calculate the final volume and molarity of NaCl in final solution if final solution has density 1.5 gm/ml.

24. Calculate the amount of the water "in $m\ell$"which must be added to a given solution of concentration of 40 mg silver nitrate per ml, to yield a solution of concentration of 16 mg silver nitrate per ml ?

25. What volume (in $m\ell$) of 0.8 M $AlCl_3$ solution should be mixed with 50 ml of 0.2M $CaCl_2$ solution to get solution of chloride ion concentration equal to 0.6 M ?

26. A mixture containing equimolar amounts of $Ca(OH)_2$ and $Al(OH)_3$ requires 0.5 L of 4.0 M HCl to react with it completely. Total moles of the mixture are :

27. How would you prepare exactly 3.0 litre of 1.0 M NaOH by mixing proportions of stock solution of 2.50 M NaOH and 0.40 M NaOH. No water is to be used. Find the ratio of the volume (v_1/v_2).

28. 20 mL of 0.2M $Al_2(SO_4)_3$ is mixed with 30 mL of 0.6 M $BaCl_2$. Calculate the mass of $BaSO_4$ formed in solution.

$$BaCl_2 + Al_2(SO_4)_3 \longrightarrow BaSO_4 + AlCl_3$$

SOME TYPICAL CONCENTRATION TERMS

29. 50 ml of '20V' H_2O_2 is mixed with 200 ml, '10V' H_2O_2. Find the volume strength of resulting solution?

30. 500 ml of a H_2O_2 solution on complete decomposition produces 2 moles of H_2O. Calculate the volume strength of H_2O_2 solution? **[Given: Volume of O_2 is measured at 1atm and 273 K]**

31. An oleum sample is labeled as 118 %, Calculate

(i) Mass of H_2SO_4 in 100 gm oleum sample.

(ii) Maximum mass of H_2SO_4 that can be obtained if 30 gm sample is taken.

(iii) Composition of mixture (mass of components) if 40 gm water is added to 30 gm given oleum sample.

32. A mixture is prepared by mixing 10 gm H_2SO_4 and 40 gm SO_3 calculate,

(a) mole fraction of H_2SO_4 (b) % labeling of oleum

ANALYSIS OF GAS MIXTURE

33. When 100 ml of a $O_2 - O_3$ mixture was passed through turpentine, there was reduction of volume by 20 ml. If 100 ml of such a mixture is heated, what will be the increase in volume?

34. 60 ml of a mixture of nitrous oxide and nitric oxide was exploded with excess of hydrogen. If 38 ml of N_2 was formed, calculate the volume of NO gas in the mixture.

35. 20 ml of a mixture of C_2H_2 and CO was exploded with 30 ml of oxygen. The gases after the reaction had a volume of 34 ml. On treatment with KOH, 8 ml of oxygen remained. Calculate the volume of C_2H_2 in the mixture.

36. 10 ml of CO is mixed with 25 ml air having 20% O_2 by volume. What would be the final volume if none of CO and O_2 is left after the reaction?

37. Calculate the volume of CO_2 evolved by the combustion of 50 ml of a mixture containing 40% C_2H_4 and 60% CH_4 (by volume)

38. 10 ml of a mixture of CH_4, C_2H_4 and CO_2 were exploded with excess of air. After explosion and further cooling, there was contraction of 17 ml and after treatment with KOH, there was further reduction of 14 ml. What is the composition of the mixture?

39. Find the hydrocarbon for which volume of oxygen required is 1.5 times volume of carbon dioxide produced.

40. 10 moles of a mixture of CO (g) and CH_4(g) was mixed with 22 moles of O_2 gas and subjected to sparking. Find the moles of gas absorbed when the residual gases are passed through alc. KOH.

EXERCISE # (S-II)

1. What volume of 0.2 M NaOH (in ml) solution should be mixed to 500 ml of 0.5 M NaOH solution so that 300 ml of final solution is completely neutralised by 20 ml of 2 M H_3PO_4 solution.
[Assuming 100% dissociation]

2. How much minimum volume (in mℓ) of 0.1 M aluminium sulphate solution should be added to excess calcium nitrate to obtain atleast 1 gm of each salt in the reaction.

$$Al_2(SO_4)_3 + 3Ca(NO_3)_2 \longrightarrow 2Al(NO_3)_3 + 3CaSO_4$$

3. One litre of milk weighs 1.035 kg. The butter fat is 10% (v/v) of milk has density of 875 kg/m^3. The density (in gm/mℓ) of fat free skimed milk is ?

4. 100 ml of 0.1 M solution of AB (d = 1.5 gm/ml) is mixed with 100 ml of 0.2 M solution of CB_2 (d = 2.5 gm/ml). Calculate the molarity of B^- in final solution if the density of final solution is 4 gm/ml. Assuming AB and CB_2 are non reacting & dissociates completely into A^+, B^-, C^{+2}.

5. 60 ml of a "x" % w/w alcohol by weight (d = 0.6 g/cm^3) must be used to prepare 200 cm^3 of 12% alcohol by weight (d = 0.90 g/cm^3). Calculate the value of "x"?

6. 1120 gm of 2 'm' urea solution is mixed with 2480 gm of 4 'm' urea solution. Calculate the molality of the resulting solution?

7. To 100 ml of 5 M NaOH solution (density 1.2 g/ml) were added 200 ml of another NaOH solution which has a density of 1.5 g/ml and contains 20 mass percent of NaOH. What will be the volume of the gas (at STP) in litres liberated when aluminium reacts with this (final) solution.

The reaction is $Al + NaOH + H_2O \longrightarrow NaAlO_2 + H_2$

8. 500 ml of 2M CH_3COOH solution is mixed with 600 ml 12% w/v CH_3COOH solution then calculate the final molarity of solution.

9. 120 gm of solution containing 40% by mass of NaCl are mixed with 200 gm of a solution containing 15% by mass NaCl.

(a) Determine the mass percent of sodium chloride in the final solution.

(b **)** What is the molality of the above solution.

(c) What is the mole fraction of the solute.

(d) What is the molarity of solution if density of solution in 1.6 gm/ml.

(e) %c w/ v of NaCl present in the solution.

EXERCISE # (O-I)

DEFINATIONS OF CONCENTRATION TERMS

1. 8 g NaOH is dissolved in one litre of solution, its molarity is :
(A) 0.8 M (B) 0.4 M (C) 0.2 M (D) 0.1 M

2. The molarity of asolution of sodium chloride (mole wt. = 58.5) in water containg 5.85 gm of sodium chloride in 500 ml of solution is :
(A) 0.25 (B) 2.0 (C) 1.0 (D) 0.2

3. For preparing 0.1 M solution of H_2SO_4 in one litre, we need H_2SO_4 :
(A) 0.98 g (B) 4.9 g (C) 49.0 g (D) 9.8 g

4. H_2O_2 solution used for hair bleaching is sold as a solution of approximately 5.0 g H_2O_2 per 100 mL of the solution. The molecular mass of H_2O_2 is 34. The molarity of this solution is approximately:-
(A) 0.15 M (B) 1.5 M (C) 3.0 M (D) 3.4 M

5. 171 g of cane sugar ($C_{12}H_{22}O_{11}$) is dissolved in 1 litre of water. The molarity of the solution is :
(A) 2.0 M (B) 1.0 M (C) 0.5 M (D) 0.25 M

6. How much grams of CH_3OH should be dissolved in water for preparing 150 ml. of 2.0 M CH_3OH solution
(A) 9.6 (B) 2.4 (C) 9.6×10^3 (D) 4.3×10^2

7. Equal weight of NaCl and KCl are dissolved separately in equal volumes of solutions molarity of the two solutions will be –
(A) Equal
(B) That of NaCl will be less than that of KCl
(C) That of NaCl will be more than that of KCl Solution
(D) That of NaCl will be half of that of KCl solution

8. The molarity of pure water is :
(A) 100 M (B) 55.5 M (C) 50 M (D) 18M

9. Molarity of liquid HCl if density of solution is1.17 g/cc. :
(A) 36.5 (B) 18.25 (C) 32.05 (D) 42.10

10. If 18 g of glucose is present in 1000 g of solvent, the solution is said to be :
(A) 1 molar (B) 0.1 molar (C) 0.5 molar (D) 0.1 molal

11. A molal solution is one that contains one mole of a solute in
(A) 1000 g of the solvent (B) one litre of the solution
(C) one litre of the solvent (D) 22.4 litres of the solution

12. Which of the following solution has maximum mass of pure NaOH ?

(I) 50 g of 40% (W/W) NaOH

(II) 50 mL of 40% (W/V) NaOH (d_{sol} = 1.2 g/ml).

(III) 50 g of 12 M NaOH (d_{sol} = 1 g/ml).

(A) I (B) II (C) III (D) III = II = I.

13. Mole fraction of $C_3H_5(OH)_3$ (glycerine) in a solution of 36 g of water and 46 g of glycerine is :

(A) 0.46 (B) 0.36 (C) 0.20 (D) 0.40

14. The mole fraction of oxygen in a mixture of 7g of nitrogen and 8g of oxygen is :

(A) $\frac{8}{15}$ (B) 0.5 (C) 0.25 (D) 1.0

15. 1000 g aqueous solution of $CaCO_3$ contains 10 g of calcium carbonate concentration of the solution is :

(A) 10 ppm (B) 100 ppm (C) 1000 ppm (D) 10,000 ppm

16. Which one of the following modes of expressing concentration of solution is independent of temperature–

(A) Molarity (B) Molality (C) % w/v (D) Grams per litre

17. One mole mixture of CH_4 & air (containing 80% N_2 20% O_2 by volume) of a composition such that when underwent combustion gave maximum heat (assume combustion of only CH_4). Then which of the statements are correct, regarding composition of initial mixture.(X presents mole fraction)

(A) $X_{CH_4} = \frac{1}{11}$, $X_{O_2} = \frac{2}{11}$, $X_{N_2} = \frac{8}{11}$ (B) $X_{CH_4} = \frac{3}{8}$, $X_{O_2} = \frac{1}{8}$, $X_{N_2} = \frac{1}{2}$

(C) $X_{CH_4} = \frac{1}{6}$, $X_{O_2} = \frac{1}{6}$, $X_{N_2} = \frac{2}{3}$ (D) Date insufficient

INTERCONVERSION OF CONCENRATION TERMS

18. The molarity of 98% by wt. H_2SO_4 (d = 1.8 g/ml) is

(A) 6 M (B) 18 M (B) 10 M (D) 4 M

19. Mole fraction of A in H_2O is 0.2. The molality of A in H_2O is :

(A) 13.9 (B) 15.5 (C) 14.5 (D) 16.8

20. The molarity of the solution containing 2.8%(mass / volume) solution of KOH is : (Given atomic mass of K = 39) is :

(A) 0.1 M (B) 0.5 M (C) 0.2 M (D) 1 M

21. Calculate the mass percent (w/w) of sulphuric acid in a solution prepared by dissolving 4 g of sulphur trioxide in a 100 ml sulphuric acid solution containing 80 mass percent (w/w) of H_2SO_4 and having a density of 1.96 g/ml. (molecular weight of H_2SO_4 = 98). Take reaction $SO_3 + H_2O \rightarrow H_2SO_4$

(A) 80.8% (B) 84% (C) 41.65% (D) 20%

PROBLEMS RELATED WITH MIXING & DILUTION

22. How much volume of 3.0 M H_2SO_4 is required for the preparation of 1.0 litre of 1.0 M solution?

(A) 300 ml (B) 320 ml (C) 333.3 ml (D) 350.0 ml

23. How much water should be added to 200 cc of semi molar solution of NaOH to make it exactly deci molar:

(A) 1000 cc (B) 400 cc (C) 800 cc (D) 600 cc

24. The molarity of a solution made by mixing 50 ml of conc. H_2SO_4 (18 M) with 50 ml. of water, is:

(A) 36 M (B) 18 M (C) 9 M (D) 6M

25. 100 ml of 0.3 M HCl solution is mixed with 200 ml of 0.3 M H_2SO_4 solution what is the molarity of H^+ in resultant solution.

(A) 0.9 (B) 0.6 (C) 0.4 (D) 0.5

26. 60 g of solution containing 40% by mass of NaCl are mixed with 100 g of a solution containing 15% by mass NaCl. Determine the mass percent of sodium chloride in the final solution.

(A) 24.4% (B) 78% (C) 48.8% (D) 19.68%

27. 125 ml of 8% w/w NaOH solution (sp. gravity 1) is added to 125 ml of 10% w/v HCl solution. The nature of resultant solution would be ________.

(A) basic (B) neutral (C) acidic (D) can't be predicted.

28. Equal volumes of 10% (v/v) of HCl is mixed with 10% (v/v) NaOH solution. If density of pure NaOH is 1.5 times that of pure HCl then the resultant solution be.

(A) basic (B) neutral (C) acidic (D) can't be predicted.

29. What volumes should you mix of 0.2 M NaCl and 0.1 M $CaCl_2$ solution so that in resulting solution the concentration of positive ion is 40% lesser than concentration of negative ion. Assuming total volume of solution 1000 ml.

(A) 400 ml NaCl , 600 ml $CaCl_2$ (B) 600 ml NaCl, 400 ml $CaCl_2$

(C) 800 ml NaCl, 200 ml $CaCl_2$ (D) None of these

30. Assuming complete precipitation of AgCl, calculate the sum of the molar concentration of all the ions if 2 lit of 2M Ag_2SO_4 is mixed with 4 lit of 1 M NaCl solution is :

(A) 4M (B) 2M (C) 3 M (D) 2.5 M

SOME TYPICAL CONCENTRATION TERMS

31. A fresh H_2O_2 solution is labeled as 11.35 V. Calculate its concentration in %w/v ?

(A) 2.5% (B) 3.4% (C) 4.2% (D) 5.4%

32. 100 ml each of 2M H_2O_2 and 11.35 V H_2O_2 solution are mixed then find the strength of final solution in g/L.

(A) 25 (B) 51 (C) 42 (D) 54

33. 12.5gm of fuming H_2SO_4 (labelled as 112%) is mixed with 100 lit water. Molar concentration of H^+ in resultant solution is :

[Note : Assume that H_2SO_4 dissociate completely and there is no change in volume on mixing]

(A) $\frac{2}{700}$ (B) $\frac{2}{350}$ (C) $\frac{3}{350}$ (D) $\frac{3}{700}$

34. Similar to the % labelling of oleum, a mixture of H_3PO_4 and P_4O_{10} is labelled as (100 + x) % where x is the maximum mass of water which can react with P_4O_{10} present in 100 gm mixture of H_3PO_4 and P_4O_{10}. If such a mixture is labelled as 127 %. Mass of P_4O_{10} in 100 gm of mixture, is

(A) 71 gm (B) 47 gm (C) 83 gm (D) 35 gm

35. If 50 gm oleum sample rated as 118% is mixed with 18 gm water, then the correct option is

(A) The resulting solution contains 18 gm of water and 118 gm H_2SO_4

(B) The resulting solution contains 9 gm water and 59 gm H_2SO_4

(C) The resulting solution contains only 118 gm pure H_2SO_4

(D) The resulting solution contains 68 gm of pure H_2SO_4

ANALYSIS OF GAS MIXTURE

36. $C_6H_5OH\ (g) + O_2\ (g) \longrightarrow CO_2\ (g) + H_2O\ (l)$

Magnitude of volume change if 30 ml of C_6H_5OH (g) is burnt with excess amount of oxygen, is

(A) 30 ml (B) 60 ml (C) 20 ml (D) 10 ml

37. 10 ml of a compound containing 'N' and 'O' is mixed with 30 ml of H_2 to produce H_2O (l) and 10 ml of N_2 (g). Molecular formula of compound if both reactants reacts completely, is

(A) N_2O (B) NO_2 (C) N_2O_3 (D) N_2O_5

38. When 20 ml of mixture of O_2 and O_3 is heated, the volume becomes 29 ml and disappears in alkaline pyragallol solution. What is the volume percent of O_2 in the original mixture?

(A) 90% (B) 10% (C) 18% (D) 2%

39. The % by volume of C_4H_{10} in a gaseous mixture of C_4H_{10}, CH_4 and CO is 40. When 200 ml of the mixture is burnt in excess of O_2. Find volume (in ml) of CO_2 produced.

(A) 220 (B) 340 (C) 440 (D) 560

40. The percentage by volume of C_3H_8 in a mixture of C_3H_8, CH_4 and CO is 36.5. Calculate the volume of CO_2 produced when 100 mL of the mixture is burnt in excess of O_2.

(A) 173 mL (B) 106.5 mL (C) 206.5 mL (D) 156.5 mL

41. 4 gm of C_3H_8 and 14 gm of O_2 are allowed to react maximum possible extent to forms only CO & H_2O. In final gaseous mixture which of the given relation is incorrect-

(A) $\frac{n_{CO}}{n_{O_2}} = \frac{16}{7}$ (B) $\%w_{CO} = \frac{200}{3}$ (C) $W_{CO} = 7.636$ gm (D) $W_{CO} = 14$ gm

42. One litre of CO_2 passed over hot coke the volume becomes 1.4 litres then the composition of products will not be (At STP)

(A) $V_{CO_2} : V_{CO} = 3 : 4$ (B) $V_{CO_2} = 1.6$ ltr. (C) $n_{CO_2} : n_{CO} = 3 : 4$ (D) % V of CO $= \frac{400}{7}$

43. 25 moles of mixture of SO_2 & O_2 was passed over a catalyst 8 moles of SO_3 was formed. After reaction the final mixture composition is/are -

(A) 17 mole of O_2, 8 mole of SO_3 (B) 13 mole of SO_2, 8 mole of O_2

(C) 9 mole of O_2, 12 mole of SO_3 (D) 15 mole of O_2, 10 mole of SO_3

44. A definite amount of gaseous hydrocarbon was burnt with just sufficient amount of O_2. The volume of all reactants was 600 ml, after the explosion the volume of the products [CO_2(g) and H_2O(g)] was found to be 700 ml under the similar conditions. The molecular formula of the compound is

(A) C_3H_8 (B) C_3H_6 (C) C_3H_4 (D) C_4H_{10}

45. For a chemical reaction occurring at constant pressure and temperature.

$$2A(g) + 5B(g) \longrightarrow C(g) + 2D(g)$$

(A) Contraction in volume is double the volume of A taken if B is taken in excess.

(B) Contraction in volume is more than the volume of B taken if A is in excess.

(C) Volume contracts by 20 mL if 10 mL A is reacted with 20 mL B.

EXERCISE # (O-II)

1. **Statement–1** : Molality of pure ethanol is lesser than pure water.
Statement–2 : As density of ethanol is lesser than density of water.
[Given : $d_{ethanol}$ = 0.789 gm/ml; d_{water} = 1 gm/ml]
(A) Statement–1 is true, statement–2 is true and statement–2 is correct explanation for statement–1.
(B) Statement–1 is true, statement–2 is true and statement–2 is NOT the correct explanation for statement–1.
(C) Statement–1 is false, statement–2 is true.
(D) Statement–1 is true, statement–2 is false.

2. **Statement -1 :** Mass of a solution of 1 litre of 2M H_2SO_4 [$d_{solution}$ = 1.5 gm/ml] is greater than the mass of solution containing 400 gm MgO which is labelled as 40% (w/w) MgO.
Statement -2 : Mass of H_2SO_4 in 1 litre 2M H_2SO_4 [$d_{solution}$ = 1.5 gm/ml] is greater than the mass of MgO in 1 litre 40% (w/w) MgO [$d_{solution}$ =2 gm /ml] solution.
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(C) Statement-1 is false, statement-2 is true.
(D) Statement-1 is true, statement-2 is false.

ONE OR MORE THAN ONE MAY BE CORRECT

3. Solution(s) containing 40 gm NaOH is/are
(A) 50 gm of 80% (w/w) NaOH
(B) 50 gm of 80% (w/v) NaOH [$d_{soln.}$ = 1.2 gm/ml]
(C) 50 gm of 20 M NaOH [$d_{soln.}$ = 1 gm/ml]
(D) 50 gm of 5m NaOH

4. The incorrect statement(s) regarding 2M $MgCl_2$ aqueous solution is/are ($d_{solution}$ = 1.09 gm/ml)
(A) Molality of Cl^- is 4.44 m
(B) Mole fraction of $MgCl_2$ is exactly 0.035
(C) The conc. of $MgCl_2$ is 19% w/v
(D) The conc. of $MgCl_2$ is 19×10^4 ppm

5. A sample of H_2O_2 solution labelled as 56 volume has density of 530 gm/L. Mark the correct option(s) representing concentration of same solution in other units. (Solution contains only H_2O and H_2O_2)
(A) $M_{H_2O_2} = 6$
(B) $\% \frac{w}{v} = 17$
(C) Mole fraction of H_2O_2 = 0.25
(D) $m_{H_2O_2} = \frac{1000}{72}$

6. 100 mL of 0.06 M $Ca(NO_3)_2$ is added to 50 mL of 0.06 M $Na_2C_2O_4$. After the reaction is complete (CaC_2O_4 is precipitated)

(A) 0.003 moles of calcium oxalate will get precipitated

(B) 0.003 M Ca^{2+} will remain in excess

(C) $Na_2C_2O_4$ is the limiting reagent

(D) Oxalate ion ($C_2O_4^{2-}$) concentration in final solution is 0.003 M

MATCH THE COLUMN

7.

	Column I		**Column II**
(A)	10 M MgO ($d_{solution}$= 1.20 gm/ml) Solute : MgO Solvent: H_2O	(P)	$W_{solvent}$ = 120 gm per 100 ml of solution
(B)	40% w/v NaOH ($d_{solution}$ = 1.6 gm/ml) Solute : NaOH Solvent: H_2O	(Q)	$W_{solution}$ = 150 gm per 100 gm solvent
(C)	8 m $CaCO_3$ Solute : $CaCO_3$ Solvent: H_2O	(R)	W_{solute} = 120 gm per 100 gm of solvent
(D)	0.6 mol fraction of 'X' (molecular mass = 20) in 'Y' (molecular mass 25) Solute : X Solvent : Y	(S)	$W_{solvent}$ = 125 gm per 100 gm of solute

8.

	Column-I		**Column-II**
(A)	120 g CH_3COOH in 1 L solution d_{sol} = 1.2 g/mL	(P)	M = 2
(B)	120 g glucose dissolved in 1 L solution (d_{sol} = 1.2 g/mL)	(Q)	10% w/w solution
(C)	$x_{NH_2CONH_2}$ = 1/31 (aqueous solution)	(R)	12% w/v solution
(D)	19.6% (w/v) H_2SO_4 solution $\rightarrow$ ($d_{solution}$ = 1.2 g/mL)	(S)	m = 1.85
		(T)	m = 0.617

9. Match the column:

	Column I		**Column II**
(A)	20 V H_2O_2	(P)	2.5 M
(B)	24.5 % w/v H_2SO_4	(Q)	1.78 M
(C)	Pure water	(R)	1.5 M
(D)	5% w/w NaOH ($d_{solution}$= 1.2 gm/ml)	(S)	55.5 M

MATCHING LIST TYPE

10. Gaseous alkane (C_nH_{2n+2}) exploded with oxygen. Ratio of the mol of O_2 for complete combustion to the mole of CO_2 formed is given in column-I & in column II formula is given.

	Column-I		**Column-II**
(P)	7 : 4	(1)	C_3H_8
(Q)	2 : 1	(2)	C_4H_{10}
(R)	5 : 3	(3)	C_2H_6
(S)	13 : 8	(4)	CH_4

Code:

	P	Q	R	S
(A)	3	2	1	2
(B)	2	4	1	3
(C)	3	4	1	2
(D)	2	3	1	4

11.

	Column-I (solvent)		**Column-II (gases absorbed)**
(P)	Turpentine oil	(1)	H_2O
(Q)	$CuSO_4/CaC_2$	(2)	O_2
(R)	KOH	(3)	CO_2, SO_2,Cl_2
(S)	Alkaline pyrogallol	(4)	O_3

Code:

	P	**Q**	**R**	**S**
(A)	3	2	1	2
(B)	2	4	1	3
(C)	4	1	3	2
(D)	2	3	1	4

COMPREHENSION

Comprehension 12 and 13 (2 questions)

2 litre of 9.8 % w/w H_2SO_4 (d = 1.5 gm/ml) solution is mixed with 3 litre of 1 M KOH solution.

12. The number of moles H_2SO_4 added are
(A) 1 (B) 2 (C) 3 (D) 0.5

13. The concentration of H^+ if solution is acidic or concentration of OH^- if solution is basic in the final solution is
(A) 0 (B) $\frac{3}{10}$ (C) $\frac{3}{5}$ (D) $\frac{2}{5}$

Comprehension 14 and 15 (2 questions)

30 gm H_2SO_4 is mixed with 20 gram SO_3 to form mixture.

14. Find mole fraction of SO_3 .
(A) 0.2 (B) 0.45 (C) 0.6 (D) 0.8

15. Determine % labelling of oleum solution.
(A) 104.5 (B) 106 (C) 109 (D) 110

Comprehension 16 and 17 (2 questions)

Estimation of halogens :
Carius method : A known mass of compound is heated with conc. HNO_3 in the presence of $AgNO_3$contained in a hard glass tube known as carius tube in a furnce. C and H are oxidised to CO_2 and H_2O. The halogen forms the corresponding AgX. It is filtered, dried, and weighed.
Estimation of sulphur : A known mass of compound is heated with fuming HNO_3 or sodium peroxide (Na_2O_2) in the presence of $BaCl_2$ solution in Carius tube. Sulphur is oxidised to H_2SO_4 and precipitated as $BaSO_4$. It is filtered, dried and weighed.

16. 0.15gm of an organic compound gave 0.12 gm of silver bromide by the Carius method. Find the percentage of bromine in the compound.
(A) 34.0 (B) 40 (C) 17 (D) 68

17. 0.2595 gm of an organic substance when treated by Carius method gave 0.35gm of $BaSO_4$. Calculate the percentage of sulphur in the compound.
(A) 9 (B) 30.4 (C) 18.52 (D) 40.52

Comprehension 18 and 19 (2 questions)

Estimation of phosphorous :
A known mass of compound is heated with fuming HNO_3 or sodium peroxide (Na_2O_2) in Carius tube which converts phosphorous to H_3PO_4. Magnesia mixture ($MgCl_2$ + NH_4Cl) is then added, which gives the precipitate of magnesium ammonium phosphate ($MgNH_4.PO_4$) which on heating gives magnesium pyrophosphate ($Mg_2P_2O_7$), which is weighed.

18. 0.12 gm of an organic compound containing phosphorus gave 0.22 gm of $Mg_2P_2O_7$ by the usual analysis. Calculate the percentage of phosphorous in the compound.

(A) 25 (B) 9.25 (C) 80.1 (D) 51.20

19. An organic compound has 6.2% of phosphorus. On sequence of reaction the phosphorous present in the 10gm of organic compound is converted to $Mg_2P_2O_7$. Find wt. of $Mg_2P_2O_7$ formed.

(A) 2.22 (B)10.2 (C) 15 (D) 20

Comprehension 20 and 23 (4 questions)

Estimation of nitrogen : There are two methods for the estimation of nitrogen (i) Dumas method and (ii) Kjedahl's method.

Dumas method : A known mass of compound is heated with copper oxide (CuO) in an atomsphere of CO_2, which gives free nitrogen along with CO_2 and H_2O.

$C_xH_yN_z + (2x + y/2)\,CuO \rightarrow xCO_2 + y/2\,(H_2O) + z/2\,(N_2) + (2x + y/2)\,Cu.$

The gaseous mixture is passed over a heated copper gauze which converts traces of nitrogen oxides formed to N_2. The gaseous mixture is collected over an aqueous solution of KOH which absorbs CO_2, and nitrogen is collected in the upper part of the graduated tube.

ii. Kjeldahl's method : A known mass of organic compound (0.5 gm) is mixed with K_2SO_4 (10 gm) and $CuSO_4$. (1.0 gm) or a drop of mercury (Hg) and conc. H_2SO_4 (25 ml) , and heated in Kjeldahl's flask. $CuSO_4$ or Hg acts as a catalyst, while K_2SO_4 raises the boiling point of H_2SO_4. The nitrogen in the organic compound is quantitatively converted to ammonium sulphate. The resulting mixture is then distilled with excess of NaOH solution and the NH_3 evolved is passed into a known but excess volume of standard HCl or H_2SO_4. The acid left unused is estimated by titration with some standard alkali. The amount of acid used against NH_3 can thus be known and from this the percentage of nitrogen is calculated.

(a) $C + H + S \xrightarrow[H_2SO_4]{conc.} CO_2 + H_2O + SO_2$

(b) $N \xrightarrow[H_2SO_4]{conc.} (NH_4)_2SO_4$

(c) $(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2NH_3 + 2H_2O$

(d) $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

iii. This method is not applicable to compounds containing N in nitro and azo groups, and N present in the ring (e.g. , pyridine) as N of these compounds does not change to $(NH_4)_2SO_4$ (ammonium sulphate) under these reaction condtions.

20. 0.30 gm of an organic compound gave 50 ml of nitrogen collected at 300K and 715 mm pressure in Dumas method. Calculate the percentage of nitrogen in the compound. (Vapour pressure of water or aqueous tension of water at 300K is 15 mm.

(A) 10.2 (B) 17.46 (C) 24 (D) 34

21. 0.50 gm of an organic compound was treated according to Kjeldahl's method. The ammonia evolved was absorbed in 50 ml of 0.5M H_2SO_4. The residual acid required 60 ml of M/2 NaOH solution. Find the percentage of nitrogen in the compound.

(A) 50 (B) 56.0 (C) 66 (D) 40

22. 0.4 gm of an organic compound was treated according to Kjeldahl's method. The ammonia evolved was absorbed in 50 ml of 0.5M M H_3PO_3. The residual acid required 30 ml of 0.5M $Ca(OH)_2$. Find the percentage of N_2 in the compound.

(A) 20 (B) 50 (C) 70 (D) 90

23. 0.002 gm of an organic compound was treated according to Kjeldahl's method. 0.2×10^{-4} mol of H_2SO_4 was required to neutralise NH_3. Calculate the percentage of N_2.

(A) 50 (B) 28 (C) 70 (D) 18

COMPREHENSION 24 TO 27

A 10 ml mixture of N_2, Alkane & O_2 undergo combustion in Eudiometry tube. There was contraction of 2 ml, when residual gases are passed through KOH. To the remaining mixture comprising of only one gas excess H_2 was added & after reaction the gas produced is absorbed by water, causing a reduction in volume of 8 ml.

24. Gas produced after introduction of H_2 in the mixture?

(A) H_2O (B) CH_4 (C) CO_2 (D) NH_3

25. Volume of N_2 present in the mixture?

(A) 2 ml (B) 4 ml (C) 6 ml (D) 8 ml

26. Volume of O_2 remained after the first combustion?

(A) 4 ml (B) 2 ml (C) 0 (D) 8 ml

27. Identify the hydrocarbon.

(A) CH_4 (B) C_2H_6 (C) C_3H_8 (D) C_4H_{10}

EXERCISE # (JEE-MAINS)

1. 6.02×10^{21} molecules of urea are present in 100 ml of its solution. The concentration of urea solution is **[AIEEE-2004]**

(1) 0.001 M (2) 0.01 M (3) 0.02 M (4) 0.1 M

2. A 5.2 molal aqueous solution of methyl alcohol, CH_3OH, is supplied. What is the mole fraction of methyl alcohol in the solution ? **[AIEEE-2011]**

(1) 0.086 (2) 0.050 (3) 0.100 (4) 0.190

3. The concentrated sulphuric acid that is peddled commercially is 95% H_2SO_4 by weight. If the density of this commerical acid is 1.834 g cm^{-3}, the molarity of this solution is :– **[AIEEE-2012]**

(1) 17.8 M (2) 15.7 M (3) 10.5 M (4) 12.0 M

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

(1) 2.05 M (2) 0.50 M (3) 1.78 M (4) 1.02 M

5. 10 mL of 2(M) NaOH solution is added to 200 mL of 0.5 (M) of NaOH solution. What is the final concentration ? **[JEE(Main-online)-2013]**

(1) 0.57 M (2) 5.7 M (3) 11.4 M (4) 1.14 M

6. The density of 3M solution of sodium chloride is 1.252 g mL^{-1}. The molality of the solution will be (molar mass, NaCl = 58.5 g mol^{-1}) **[JEE(Main-online)-2013]**

(1) 2.18 m (2) 3.00 m (3) 2.60 m (4) 2.79 m

7. The amount of $BaSO_4$ formed upon mixing 100 mL of 20.8% $BaCl_2$ solution with 50 mL of 9.8% H_2SO_4 solution will be : **[JEE(Main-online)-2014]**

(Ba = l37, Cl = 35.5, S=32, H = l and O = 16)

(1)33.2 g (2) 11.65 g (3) 23.3 g (4) 30.6 g

8. For the estimation of nitrogen, 1.4 g of an organic compound was digested by Kjeldahl method and the evolved ammonia was absorbed in 60 mL of sulphuric acid. The unreacted acid required 20 mL of sodium hydroxide for complete neutralizaton. The percentage of nitrogen in the compound is : **[JEE(Main-online)-2014]**

(1) 3% (2) 5% (3) 6% (4) 10%

9. 3g of activated charcoal was added to 50 mL of acetic acid solution (0.06N) in a flask. After an hour it was filtered and the strength of the filtrate was found to be 0.042N. The amount of acetic acid adsorbed (per gram of charcoal) is: **[JEE(Main)-2015]**

(1) 18 mg (2) 36 mg (3) 42 mg (4) 54 mg

10. On treatment of 100 mL of 0.1 M solution of $CoCl_3 . 6H_2O$ with excess $AgNO_3$; 1.2×10^{22} ions are precipitated. The complex is : **[JEE(Main)-2017]**

(1) $[Co(H_2O)_4 Cl_2]Cl.2H_2O$ (2) $[Co(H_2O)_3Cl_3].3H_2O$

(3) $[Co(H_2O)_6]Cl_3$ (4) $[Co(H_2O)_5Cl]Cl_2.H_2O$

11. The mole fraction of a solvent in aqueous solution of a solute is 0.8. The molality (in mol kg^{-1}) of the aqueous solution is: **[JEE(Main)-April 2019]**

(1) 13.88×10^{-1} (2) 13.88×10^{-3} (3) 13.88×10^{-2} (4) 13.88

12. What would be the molality of 20% (mass/mass) aqueous solution of KI ? **[JEE(Main)-April 2019]**

(molar mass of KI = 166 g mol^{-1})

(1) 1.48 (2) 1.35 (3) 1.08 (4) 1.51

13. 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}] **[JEE(Main)-April 2019]**

(1) 3.4% (2) 34% (3) 1.7% (4) 13.6%

14. The volume strength of 1M H_2O_2 is: **[JEE(Main)-January 2019]**

(Molar mass of H_2O_2 = 34 g mol^{-1})

(1) 16.8 (2) 11.35 (3) 22.4 (4) 5.6

15. 8g of NaOH is dissolved in 18g of H_2O. Mole fraction of NaOH in solution and molality (in mol kg^{-1}) of the solutions respectively are : **[JEE(Main)-January 2019]**

(1) 0.2, 22.20 (2) 0.167,22.20 (3) 0.167, 11.11 (4) 0.2, 11.11

16. The amount of sugar ($C_{12}H_{22}O_{11}$) required to prepare 2 L of its 0.1 M aqueous solution is : **[JEE(Main)-January 2019]**

(1) 136.8 g (2) 68.4 g (3) 17.1 g (4) 34.2 g

17. A solution of sodium sulfate contains 92 g of Na^+ ions per kilogram of water. The molality of Na^+ ions in that solution in mol kg^{-1} is: **[JEE(Main)-January 2019]**

(1) 16 (2) 8 (3) 4 (4) 12

EXERCISE # (JEE-ADVANCED)

1. At 100º C and 1 atmp , if the density of liquid water is 1.0 g cm^{-3} and that of water vapour is 0.0006 g cm^{-3} , then the volume occupied by water molecules in 1 L of steam at that temperature is :

(A) 6 cm^3 (B) 60 cm^3 **[JEE '2001]**

(C) 0.6 cm^3 (D) 0.06 cm^3

2. Calculate the molarity of pure water using its density to be 1000 kg m^{-3}. **[JEE'2003]**

3. One gm of charcoal absorbs 100 ml 0.5 M CH_3COOH to form a monolayer, and thereby the molarity of CH_3COOH reduces to 0.49. Calculate the surface area of the charcoal adsorbed by each molecule of acetic acid. Surface area of charcoal = 3.01×10^2 m^2/gm. **[JEE'2003]**

4. 20% surface sites have adsorbed N_2. On heating N_2 gas evolved from sites and were collected at 0.001 atm and 298 K in a container of volume is 2.46 cm^3. Density of surface sites is 6.023×10^{14}/ cm^2 and surface area is 1000 cm^2, find out the no. of surface sites occupied per molecule of N_2. **[JEE 2005]**

5. Given that the abundances of isotopes ^{54}Fe, ^{56}Fe and ^{57}Fe are 5%, 90% and 5%, respectively, the atomic mass of Fe is : **[JEE 2009]**

(A) 55.85 (B) 55.95 (C) 55.75 (D) 56.05

6. Silver (atomic weight = 108 g mol^{-1}) has a density of 10.5 g cm^{-3}. The number of silver atoms on a surface of area 10^{-12} m^2 can be expressed in scientific notation as y ´ 10^x. The value of x is - **[JEE 2010]**

7. Dissolving 120 g of urea (mol. wt. 60) in 1000 g of water gave a solution of density 1.15 g/mL. The molarity of the solution is **[JEE 2011]**

(A) 1.78 M (B) 2.00 M (C) 2.05 M (D) 2.22 M

8. A compound H_2X with molar weight of 80 g is dissolved in a solvent having density of 0.4 g /ml, Assuming no change in volume upon dissolution, the molality of a 3.2 molar solution is. **[JEE 2014]**

9. The mole fraction of a solute in a solution is 0.1. At 298 K, molarity of this solution is the same as its molality. Density of this solution at 298 K is 2.0 g cm^{-3}. The ratio of the molecular weights of the solute and solvent, is : **[JEE 2016]**

10. The mole fraction of urea in an aqueous urea solution containing 900 g of water is 0.05. If the density of the solution is 1.2 g cm^{-3}, the molarity of urea solution is ___

(Given data : Molar masses of urea and water are 60 g mol^{-1} and 18 g mol^{-1}, respectively) **[JEE 2019]**

ANSWER KEY

EXERCISE # (S-1)

1.	**(a)** 0.5 M, **(b)** 0.5 M, **(c)** 0.2 M	**2.**	0.01 M
3.	0.15 M	**4.**	0.06 M
5.	13 gm	**6.**	55.55 m.
7.	27	**8.**	0.05
9.	13×10^{-1}	**10.**	13.15
11.	16.66%	**12.**	1.2888.
13.	1.25 gm/mL	**14.**	45.45%
15.	0.6667, 0.6667	**16.**	2.5×10^{-3}M
17.	2.7×10^{-4}	**18.**	0.6 M
19.	1.736 litre	**20.**	174.5 mL
21.	0.05	**22.**	0.204 M
23.	2 M	**24.**	1.5 ml
25.	5.56 ml	**26.**	0.8
27.	0.4	**28.**	2.796
29.	12 V	**30.**	44.8 V

31. **(i)** 20 gm H_2SO_4 ; **(ii)** 35.4 gm H_2SO_4; **(iii)** H_2SO_4= 35.4 gm, H_2O = 34.6gm

32. **(a)** 0.169; **(b)** 118 %

33. 10 ml

34.	NO = 44 ml ; N_2O = 16 ml	**35.**	C_2H_2 = 6 ml, CO = 14 ml
36.	30 ml	**37.**	70 ml

38. CH_4 = 4.5 ml, CO_2 = 1.5 ml

39.	alkene	**40.**	10

EXERCISE # (S-II)

1.	250	**2.**	24.51 ml	**3.**	1.052 gm/mL	**4.**	0.5
5.	60	**6.**	3.33 m	**7.**	68.1 L	**8.**	2

9. **(a)** 24.4% **(b)** 5.5 m **(c)** 0.09 **(d)** 6.6 M **(e)** 39%

EXERCISE # (O-I)

1.	C	**2.**	D	**3.**	D	**4.**	B	**5.**	C
6.	A	**7.**	C	**8.**	B	**9.**	C	**10.**	D
11.	A	**12.**	C	**13.**	C	**14.**	B	**15.**	D
16.	B	**17.**	A	**18.**	B	**19.**	A	**20.**	B
21.	A	**22.**	C	**23.**	C	**24.**	C	**25.**	D
26.	A	**27.**	C	**28.**	A	**29.**	D	**30.**	B
31.	B	**32.**	B	**33.**	A	**34.**	A	**35.**	B
36.	B	**37.**	C	**38.**	B	**39.**	C	**40.**	A
41.	D	**42.**	B	**43.**	A	**44.**	A	**45.**	A

EXERCISE # (O-II)

1. (B) **2.** (D) **3.** (A),(C) **4.** (B), (D) **5.** (B),(D)

6. (A,C) **7.** (A) $\rightarrow$ Q; (B) $\rightarrow$ P; (C) $\rightarrow$ S; (D) $\rightarrow$ R

8. (A)$\rightarrow$P,Q,R,S ; (B)$\rightarrow$Q,R,T ; (C)$\rightarrow$Q,S ; (D)$\rightarrow$P

9. (A) $\rightarrow$Q; (B) $\rightarrow$ P,; (C) $\rightarrow$ S; (D) $\rightarrow$ R **10.** **(C)** **11.** **(C)**

12.	(C) ,	**13.**	(C)	**14.**	(B)	**15.**	(C)	**16.**	(34.0%)
17.	(C)	**18.**	(D)	**19.**	(A)	**20.**	(B)	**21.**	(B)
22.	(C)	**23.**	(B)	**24.**	**(D)**	**25.**	**(B)**	**26.**	**(C)**
27.	**(A)**								

EXERCISE # (JEE MAIN)

1.	(4)	**2.**	(1)	**3.**	(1)	**4.**	(1)	**5.**	(1)	**6.**	(4)	**7.**	(2)
8.	(4)	**9.**	(1)	**10.**	(4)	**11.**	(4)	**12.**	(4)	**13.**	(1)	**14.**	(2)
15.	(3)	**16.**	(2)	**17.**	(4)								

EXERCISE # (JEE ADVANCED)

1.	(C)	**2.**	55.5 mol L^{-1}	**3.**	5×10^{-19} m^2	**4.**	(2)	**5.**	(B)
6.	(7)	**7.**	(C)	**8.**	(8)	**9.**	(9)	**10.**	(2.98)

IIT CHEMISTRY

PHYSICAL CHEMISTRY

CONCENTRATION TERMS SOLTUIONS

HINT & SOLUTIONS : CONCENTRATION TERMS

EXERCISE # S-I

1. (a) $M = \dfrac{4\times1000}{40\times200} = 0.5$ M

(b) $M = \dfrac{5.3\times1000}{106\times100} = 0.5$ M

(c) $M = \dfrac{0.365\times1000}{36.5\times50} = 0.2$ M

2. $M = \dfrac{0.115\times1000}{23\times500} = 0.01$ M

3. Molarity of $Na^+ = \dfrac{3.5}{23}$

i.e. 0.15 M

4. Molarity of $BaCl_2\cdot SH_2O = \dfrac{10.56}{352\times1} = 0.03$ M

$\Rightarrow$ Concentration of chloride ion = 2 × 0.03 M = 0.06 M

5. $M_{HCl} = \dfrac{1.825\times1000}{36.5\times100} = 0.5$ M $\qquad \Rightarrow [Cl^-] = 0.5$ M

Now, $[BaCl_2] = \dfrac{[Cl^-]}{2}$

Let weight of $BaCl_2$ be x gm

$\Rightarrow \quad \dfrac{x\times1000}{208\times250}\times2 = 0.5 \qquad \Rightarrow \quad x = \dfrac{0.5\times208\times250}{2\times1000}$

$\Rightarrow$ x = 13 gm $\qquad \Rightarrow$ Weight of $BaCl_2$ required is 13 gm.

6. Let the moles of H_2O & NaCl be 1

Molality, $M = \dfrac{1\times1000}{18\times1}$

$\Rightarrow$ m = 55.55

7. Let mass of H_2O added be x gm

$$x_{CH_3OH} = \frac{n_{CH_3OH}}{n_{CH_3OH} + n_{H_2O}}$$

$$0.25 = \frac{\frac{16}{32}}{\frac{16}{32} + \frac{x}{18}}$$

$$\Rightarrow \quad 0.25\left(0.5 + \frac{x}{18}\right) = 0.5$$

$$\Rightarrow \quad 0.25 \times \frac{x}{18} = 0.5 - 0.125$$

$$\Rightarrow \quad x = \frac{0.375 \times 18}{0.25} \quad \Rightarrow \quad x = 27 \text{ gm}$$

8. $CH_3OH \rightleftharpoons CH_3O^- + H^+$

0.5	0	0
0.5–0.5α	0.5α	0.5α

Let α be the degree of dissociation

$\Rightarrow \quad [H^+] = 0.5\alpha = 2.5 \times 10^{-4}$

$\Rightarrow \quad \% \alpha = 0.05$

9. $M = \frac{13 \times 0.98 \times 1000}{98 \times 100} = 13 \times 10^{-1}$

10. $M = \frac{40 \times 1.2 \times 1000}{36.5 \times 100} = 13.15$

11. $\% \frac{W}{W}$ of $CH_3OH = \left(\frac{15}{100 \times 0.90} \times 100\right) = 16.66\ \%$

12. $6.90 = \frac{30 \times d \times 1000}{56 \times 100}$

$\Rightarrow \quad d = \frac{6.90 \times 56 \times 100}{30 \times 1000} \quad \Rightarrow d = 1.288$ g/ml

13. 8 % $\frac{W}{W}$ i.e. weight of solution i.e. NaOH = 8 gm

weight of solution = 100 gm

10 % $\frac{W}{V}$ i.e. weight of NaOH = 10 gm

Volume of solution = 100 ml

Now, $M = \frac{10 \times 1000}{40 \times 100}$ $\Rightarrow 2.5$

Now, $2.5 = \frac{8 \times d \times 1000}{40 \times 100}$ $\Rightarrow d = \frac{2.5 \times 40 \times 100}{8 \times 1000}$ $\Rightarrow$ d = 1.25 gm/ml

14. $0.2 = \frac{n_{solute}}{n_{solute} + 55.55}$

$0.2 \times n_{solute} + 0.2 \times 55.55 = n_{solute}$

$\Rightarrow$ $0.8 \times n_{solute} = 0.2 \times 55.55$ $\Rightarrow$ $n_{solute} = 13.88$

% $\frac{W}{W}$ of solute = $\frac{833.25}{1833.25} \times 100$ = 45.45 %

15. $NH_4Cl \longrightarrow NH_4^+ + Cl^-$

2	0	0
0	2	2

molality of NH_4^+ = $\frac{2 \times 1000}{(1000 \times 3.107 - 2 \times (18 + 35.5))}$ = $\frac{2 \times 1000}{3000}$ = 0.66

molality of Cl^- = $\frac{2 \times 1000}{(1000 \times 3.107 - 2 \times (18 + 35.5))}$ = $\frac{2000}{3000}$ = 0.66

16. Weight of solute = 405×10^{-4}

$M = \frac{405 \times 10^{-4} \times 1000}{162 \times 100}$ $\Rightarrow$ $M = 2.5 \times 10^{-3}$

17. Weight of solute = 1.9×10^{-4}

$\Rightarrow$ $M = \frac{1.9 \times 10^{-4} \times 1000}{7 \times 100}$

$\Rightarrow$ 2.7×10^{-4}

18. Molarity of Na^+ i.e. $[Na^+] = \dfrac{500\times0.2+500\times.5\times2}{1000}$

$= \dfrac{600}{1000} = 0.6$ M

19. $M_1V_1 = M_2V_2$

$\Rightarrow \quad \dfrac{98\times1.8\times1000}{98\times100}\times V_1 = 2.5 \times 12.5$

$\Rightarrow \quad V_1 = 1.736$ liter

20. $\dfrac{20\times1000}{63\times100}\times V_1 = \dfrac{69.8\times1000}{63\times100}\times50$

$\Rightarrow \quad V_1 = \dfrac{69.8\times500}{63}\times\dfrac{63}{200}$

$\Rightarrow \quad V_1 = 174.5$ ml

21. $\dfrac{n_{urea}}{n_{H_2O}} = \dfrac{1}{4}$

$\Rightarrow \quad \dfrac{W_{urea}}{W_{H_2O}} = \dfrac{60}{72}$

$\Rightarrow$ weight of solution= 132 gm

In 132 gm mole of urea = 1

$\Rightarrow$ In 500 gm mole of urea = $\dfrac{1}{132}\times500$

Also, In 132 gm, mole of H_2O = 4

In 500gm, mole of H_2O = $\dfrac{4}{132}\times500$

Now, on dilution

$$x_{solute} = \frac{\frac{500}{132}}{\frac{500}{132}+\left(\frac{4}{132}\times500+\frac{1000}{18}\right)} = 0.05$$

22. Molarity of diluted solution = $\dfrac{2.2V}{11V\times0.98}$

$= \dfrac{20}{98} = .204$ M

23. $[NaCl]_{mix.} = \dfrac{500 \times 2 + 200 \times 2}{700}$

$= \dfrac{1400}{700} = 2\text{ M}$

24. Let amount of H_2O added be V.

$\Rightarrow \quad \dfrac{40}{170(1+V)} = \dfrac{16}{170}$

$\Rightarrow \quad V = 1.5$ ml

25. Let volume of .8 M $AlCl_3$ be V ml

$0.6 = \dfrac{.8 \times V \times 3 + 50 \times .2 \times 2}{50 + V}$

$\Rightarrow \quad V = \dfrac{100}{18}$

i.e. $\quad V = 5.56\text{ml}$

26. $Ca(OH)_2 + 2HCl \longrightarrow 2aCl_2 + 2H_2O$

n $\quad$ 2n

$Al(OH)_3 + 3HCl \longrightarrow AlCl_3 + 3H_2O$

n $\quad$ 2n

$\Rightarrow$ Total moles of HCl = 5n

$\Rightarrow$ $5n = .5 \times 4$

$\Rightarrow$ n = 0.4 moles

$\Rightarrow$ Total moles of mixture = 0.8

27. Let volume of 2.50 M NaOH be V_1

& volume of 0.40 M NaOH be V_2

$\Rightarrow \quad 2.50\ V_1 + 0.40\ V_2 = 3$ .....(1)

& $V_1 + V_2 = 3$ .....(2)

Solving (1) & (2)

We get, $\left(\dfrac{V_1}{V_2} = 0.4\right)$

28. $3BaCl_2 + Al_2(SO_4)_3 \longrightarrow 3BaSO_4 + 2AlCl_3$

moles: $(0.6 \times 30 \times 10^{-3})$ $(20 \times .2 \times 10^{-3})$

$\Rightarrow \quad Al_2(SO_4)$ is L.R.

So, mass of $BaSO_4$ formed = $(3 \times 20 \times .2 \times 10^{-3}) \times 233 = 2.796$ gm

29. Volume strength of resulting solution = $\dfrac{\dfrac{20}{1000}\times 50+\dfrac{10}{1000}\times 200}{\dfrac{250}{1000}}$ = 12 V

30. $H_2O_2 \longrightarrow H_2O + \frac{1}{2}O_2$

mole: $\dfrac{500}{22.4}$ 2 1

Volume of O_2 produced from 1 lit H_2O_2 = 2 mole

= 2 × 22.4

= 44.8 liters

31. (i) Let mass of SO_3 be x gm & mass of H_2SO_4 be (100 – x) gm

$\Rightarrow$ $118 = 100 + \dfrac{18x}{80}$

$\Rightarrow$ x = 80 gm

$\Rightarrow$ mass of H_2SO_4 = 20 gm

(ii) $SO_3 + H_2O \longrightarrow H_2SO_4$

80 gm 18gm 98 gm

24 gm $\left(\dfrac{98\times 24}{80}\right)$

$\Rightarrow$ maximum mass of H_2SO_4 obtained

$= 6+\left(\dfrac{98\times 24}{80}\right)$ = 35.4 gm

(iii) If 40 gm water is added

Amount of H_2SO_4 = 35.4 gm

Amount of H_2O = 34.6 gm

32. (a) $x_{H_2SO_4} = \dfrac{\dfrac{10}{98}}{\dfrac{10}{98}+\dfrac{40}{80}}$ = 0.169

(b) % strength of oleum = $100+\dfrac{18\times 80}{80}$ = 118%

33. Vol. of O_3 = 20 mL

	$2\,O_3$ $\longrightarrow$	$3\,O_2$
v_i	20 mL	80 mL
v_f	0	80 + 30
		= 110 mL

Δv = 110 – 100 = 10 mL

34. $2\,NO + 2H_2 \longrightarrow N_2 + 2H_2O$

x mL $\qquad \frac{x}{2}$ mL

$N_2O + H_2 \longrightarrow N_2 + H_2O$

(60–x) mL $\qquad$ (60–x) mL

$$60 - x + \frac{x}{2} = 38$$

$$x = 44 \text{ mL}$$

Volume of NO = 44 mL $\qquad$ Volume of N_2O = 16 mL

35. $C_2H_2 + \frac{5}{2}O_2 \longrightarrow 2\,CO_2 + H_2O\,(\ell)$

x mL $\quad$ 2.5x mL $\quad$ 2x ml

$CO + \frac{1}{2}O_2 \longrightarrow CO_2$

y mL $\quad \frac{y}{2}$ mL $\quad$ y mL

$x + y = 20$ …...(i) $\qquad 2x + y = 26$ …….(ii)

$\frac{5x}{2} + \frac{y}{2} = 22 \quad \Rightarrow \quad 5x + y = 44$ …….(iii)

$x = 6 \quad y = 14$

Volume of C_2H_2 = 6 mL , Volume of CO = 14 mL

36.

	CO +	$\frac{1}{2}O_2 \longrightarrow$	CO_2
v_i	10 mL	5 mL	0
v_f	0	0	10 mL

Final vol. = 10 + 20 = 30 mL

37. $C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$

20 mL $\qquad$ 40 mL

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

30 mL $\qquad$ 30 mL

Vol. of CO_2 = 70 mL

38.

CH_4	+	$2O_2$	$\longrightarrow$	CO_2	+	$2H_2O$
x mL		2x mL		x mL		
$C_2\,H_4$	+	$3O_2$	$\longrightarrow$	$2\,CO_2$	+	$2H_2O$
y mL		3y mL		2y mL		
CO_2	+	O_2	$\longrightarrow$	X (no reaction)		
z mL						

$x + y + z = 10$ …….(i) $\quad y = 4$

$\Delta v = 10 + v - [10 + y + v - 2x - 3y] = 17$

$2x + 2y = 17 \quad \Rightarrow \quad x = 4.5$

Volume of CH_4 = 4.5 mL

Volume of $C_2\,H_2$ = 4 mL $\quad z = 1.5$

Volume of CO_2 = 1.5 mL

39. $C_x\,H_y + \left(x + \frac{y}{4}\right) O_2 \longrightarrow x\,CO_2 + \frac{y}{2}\,H_2O$

$$\frac{x + y/4}{x} = 1.5$$

$$\frac{x}{y} = \frac{1}{2}$$

40.

CO	+	$\frac{1}{2}\,O_2$	$\longrightarrow$	CO_2		
x		$\frac{x}{2}$		x		
CH_4	+	$2O_2$	$\longrightarrow$	CO_2	+	$2H_2O$
10–x		2(10–x)		10–x		

Moles of CO_2 = x + 10 – x = 10

EXERCISE # S-II

1. $H_3PO_4 + 3NaOH \longrightarrow Na_3PO_4 + 3H_2O$

m moles of NaOH $= 3 \times$ m moles if H_3PO_4

$= 3 \times 20 \times 2 = 120$

$M_{NaOH} \times 300 = 120$

$M_{NaOH} = 0.4$

$$0.4 = \frac{0.2 \times V + 500 \times 0.5}{V + 500}$$

V = 250 mL

2. $Al_2(SO_4)_3 + 3Ca(NO_3)_2 \longrightarrow 2Al(NO_3)_3 + 3CaSO_4$

$\frac{1}{3} \times \frac{1}{136}$ mol $\qquad$ $\frac{1}{136}$ mol

$$0.1 \times V(L) = \frac{1}{3 \times 136}$$

V(mL) = 24.51 mL

3. Mass of fat = 100 × 0.875 = 87.5 g

Mass of fat free milk = 1035 – 87.5 = 947.5 g

Vol. of fat free milk = 900 mL

Density of fat free milk $= \frac{947.5}{900} = 1.052$ g/mL

4. $$[B^-] = \frac{100 \times 0.1 + 100 \times 0.2 \times 2}{150 + 250} \times 4 = 0.5\ M$$

5. $$60 \times \frac{x}{100} \times 0.6 = \frac{12}{100} \times 0.9 \times 200$$

X = 60 mL

6. $$m = \frac{2+8}{3} = \frac{10}{3}$$

7. $2Al + 2\,NaOH + 2H_2O \longrightarrow 2NaAlO_2 + 3H_2$

2 moles 3 moles

Total mass of NaOH = 5 × 0.1 × 40 + 200 × 1.5 × 0.2 = 80 g

V_{H_2} = at STP = 3 × 22.7 = 68.1 L

8. $M = \dfrac{2\times0.5+\dfrac{72}{60}}{1.1} = 2$

9. 120 g, 40% (w/w) NaCl + 200g, 15% (w/w) NaCl

$W_{NaCl} = 120 \times \dfrac{40}{100} = 48g$ $W_{NaCl} = 200 \times \dfrac{15}{100} = 30g$

$W_{solvent} = 72$ g $W_{solvent} = 170g$

$W_{solution} = 320$ g

(a) mass % = $\dfrac{78}{320}\times100 = 24.375$

(b) m = $\dfrac{78/58.5}{242}\times1000 = 5.5$

(c) $X_{solute} = \dfrac{78/58.5}{78/58.8+\dfrac{242}{18}} = \dfrac{1.33}{1.33+13.44} = 0.09$

(d) M = $\dfrac{78/58.5}{320}\times1.6\times1000 = 6.6$

(e) % (w/w) = $\dfrac{78}{320}\times1.6\times100 = 39$ %

EXERCISE # O-I

1. $M = \frac{8}{40 \times 1} = 0.2$

The correct option is (C)

2. $M = \frac{5.85 \times 1000}{58.5 \times 500}$

$M = 0.2$

correct option is (D)

3. $0.1 = \frac{w}{98 \times 1}$

$\Rightarrow$ w = 9.8 gm.

correct option is (D)

4. $M = \frac{5 \times 1000}{34 \times 100}$

$M = 1.5$

correct option is (B)

5. $M = \frac{171}{342 \times 1}$

$= 0.5$

correct option is (C)

6. $2 = \frac{w \times 1000}{32 \times 150}$

$\Rightarrow \quad w = \frac{2 \times 32 \times 150}{1000}$

$\Rightarrow \quad w = 9.6$

the correct option is (A)

7. $\text{Molarity}_{(NaCl)} = \frac{w}{58.5 \times V}$ ...(1)

$\text{Molarity}_{(KCl)} = \frac{w}{74.5 \times V}$ ...(2)

$\Rightarrow$ Molarity of NaCl will be more than that of KCl

$\Rightarrow$ correct option is (C)

8. Molarity of pure water $= \frac{1000}{18 \times 1} \simeq 55.55$

correct option is (B)

9. $M = \frac{1170}{36.5 \times 1} = 32.05$

correct option is (C)

10. $m = \frac{18 \times 1000}{180 \times 1000}$

$\Rightarrow$ molality = .1

correct option is (D)

11. Correct option is (A).

12. (I) mass of pure NaOH = 20 gm

(II) mass of pure NaOH = 20 gm

(III) mass of pure NaOH = 24 gm

$\Rightarrow$ maximum mass of pure NaOH is in solution (III)

$\Rightarrow$ correct option is (C)

13. $X_{glycerine} = \frac{46/92}{46/92 + 36/18}$

$= \frac{0.5}{0.5 + 2}$

$= \frac{0.5}{2.5}$

$\simeq 0.20$

correct option is (C)

14. $X_{O_2} = \frac{8/32}{8/32 + 7/28} = \frac{0.25}{0.25 + 0.25} = 0.5$

correct option is (B)

15. $ppm = \frac{10}{1000} \times 10^6$

$= 10^4$ or 10,000 ppm

correct option is (D)

16. Molality is independent of temperature correct option is (B)

17. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

x $(1 - x)(0.2)$

Now, $.2(1 - x) = 2x$

$\Rightarrow x = \frac{1}{11}$

correct option is (A)

18. $m = \left(\frac{98 \times 1.8 \times 1000}{98 \times 100}\right) = 18$ m
correct option is (B)

19. $m = \left(\frac{0.2 \times 1000}{.8 \times 18}\right) = 13.9$
correct option is (A)

20. $m = \left(\frac{2.8 \times 1000}{56 \times 100}\right) = 0.5$
correct option is (B)

21. $SO_3 \;+\; H_2O \;\rightarrow\; H_2SO_4$
80g 18g 98g
4g $\left(\frac{18}{80} \times 4\right)$g $\left(\frac{98}{80} \times 4\right)$g $\simeq 4.9$ g
$\% \frac{w}{w} = \left(\frac{(100 \times 1.96 \times 0.8) + 4.9}{100 \times 1.96 + 4}\right)$
$\simeq 80.8\%$
correct option is (A)

22. $m_1v_1 = m_2v_2$
$3 \times v_1 = 1 \times 1$ $\Rightarrow v_1 = \frac{1}{3}$ lit.
or 333.3 ml
correct option is (C)

23. $m_1v_1 = m_2v_2$
i.e. $200 \times \frac{1}{2} = \frac{1}{10} \times v_{final=}$ $\Rightarrow$ $v_{final} = 1000$ ml $\Rightarrow$ water added = 1000 – 200
i.e. 800 cc correct option is (C)

24. $m_1v_1 = m_2v_2$
$18 \times 50 = m_2 \times 100$
$\Rightarrow m_2 = \frac{18 \times 50}{100}$ $\Rightarrow m_2 = 9$ $\Rightarrow$ correct option is (c)

25. $[H^+] = \frac{100x.3 + 200x.3 \times 2}{300}$
$= 0.5$
correct option is (D)

26. $\% \frac{w}{w} = \frac{24+15}{160} \times 100 \simeq 24.4\%$

correct option is (A)

27. NaOH + HCl $\rightarrow$ NaCl + H_2O

moles: $\left(\frac{8\times1\times1000}{40\times100}\right)$ $\left(\frac{10\times1000}{36.5\times125}\right)$

$\simeq 2$ $\qquad \simeq 2.2$

$\Rightarrow$ resultant solution will be acidic.

correct option is (C)

28. The resultant solution will be basic

$\Rightarrow$ correct option is (A)

29. Let volume of 0.2 M NaCl be V_1

& volume of 0.1 M $CaCl_2$ be V_2

$\Rightarrow$ $[Cl^-] = \frac{0.2v_1 + 0.1\times2\times v_2}{v_1+v_2}$ $\Rightarrow$ $[\text{cation}] = \frac{0.2v_1+0.1v_2}{v_1+v_2} = 0.6 \times \frac{0.2v_1+0.2v_2}{v_1+v_2}$

$\Rightarrow$ $\frac{v_1}{v_2} = 0.25$

$\Rightarrow$ the correct option is (D)

30.

	Ag_2SO_4	+ $2NaCl$	$\rightarrow$ $2AgCl(\downarrow)$	+ Na_2SO_4
moles	(2×2)	(4×1)	0	0
	2	0	4	2

$\Rightarrow$ molar concentration of all ions = $\frac{4+2+4+2}{6} \simeq 2M$

$\Rightarrow$ correct option is (B)

31. 11.35 V means 1 lit of H_2O_2 will produce 11.35 lits of O_{23} at S.T.P.

$\Rightarrow$ molarity = $\frac{v.s/11.35}{1} \simeq 1$

Now, $\% \frac{w}{v} = \frac{34}{1000} \times 100 \simeq 3.4\%$ $\Rightarrow$ correct option is (B)

32. Strength of final solution in g/lit = $\frac{(0.2+0.1)\times34}{200} \times 1000 \simeq 51 g/lit$

$\Rightarrow$ correct option is (B)

33. $[H^+] = \left(\frac{14\times2}{98\times100}\right) \simeq \frac{2}{700}$ $\Rightarrow$ correct option is (A)

34. $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$

284g $6 \times 18g$

xg $\left(\frac{18 \times 6}{284}\right) \times xg$

$\Rightarrow$ $127 = 100 + \left(\frac{18 \times 6}{284}\right) \times x$ $\Rightarrow$ x = 71 gm $\Rightarrow$ correct option is (A)

35. $\frac{\text{for 118\% oleum}}{118 = 100 + \frac{18x}{80}}$, Let mass of SO_3 = xg $\Rightarrow$ x = 80 gm

$\Rightarrow$ In 50 g oleum sample SO_3 is 40 gm & H_2SO_4 is 10 gm

SO_3	+	H_3O	$\rightarrow$	H_2SO_4
80g		18g		98 gm
40		9g		49 gm

$\Rightarrow$ Resulting solution contains 9 gm H_2O
59 gm H_2SO_4

$\Rightarrow$ correct option is (B)

36. $C_6H_5OH\,(g) + 7O_2\,(g) \longrightarrow 6\,CO_2\,(g) + 3H_2O\,(\ell)$

v_i	30 mL	v	0	0
v_f	0	v – 210	180	–

$\Delta v = (30 + v) - (v - 210 + 180)$
$= 30 + 30 = 60$ mL

37. $N_xO_y + y\,H_2 \longrightarrow \frac{x}{2}\,N_2 + y\,H_2O$

v_i	10 mL	$y \times 10$	
v_f	0	0	$10 \times \frac{x}{2}$

$10y = 30$
$y = 3$
& $\frac{10x}{2} = 10$
$x = 2$
$\rightarrow \therefore N_2O_3$

38. $2O_3 \longrightarrow 3O_2$

v_i	v	20 – v
v_f	0	20 – v + 1.5v

$20 - v + 1.5\,v = 29$
$0.5v = 9 \Rightarrow v = 18$ mL
Volume of O_3 = 18 mL Volume of O_2 = 2 mL
Vol. % of O_2 $= \frac{2}{20} \times 100 = 10\%$

39.

$$C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4\,CO_2 + 5\,H_2O$$
80 mL → 320 mL

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$
x mL → x mL

$$CO + \frac{1}{2}O_2 \longrightarrow CO_2$$
120 – x → 120 – x

Total Vol. of CO_2 = 320 + x + 120 – x
= 440 mL

40.

$$C_3H_8 + 5O_2 \longrightarrow 3\,CO_2 + 4\,H_2O$$
36.5 mL → 109.5 mL

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$
x mL → x mL

$$CO + \frac{1}{2}O_2 \longrightarrow CO_2$$
63.5 – x → 63.5 – x

Total Vol. of CO_2 = 173 mL

41.

$$C_3H_8 + \frac{7}{2}O_2 \longrightarrow 3\,CO + 4\,H_2O$$

	C_3H_8	O_2	CO	H_2O
n_i	$\frac{1}{11}$	$\frac{7}{16}$	0	0
n_f	0	$\frac{42}{22\times16}$	$\frac{3}{11}$	$\frac{4}{11}$

$$\frac{n_{CO}}{n_{O_2}} = \frac{16}{7}$$

$$W_{CO} = \frac{3}{11} \times 28 = 7.63$$

$$n_{O_2} = \frac{21}{16}$$

$$W_{O_2} = 42$$

$$n_{CO} \quad 3$$

$$W_{CO} = 84$$

$$\text{Mass \% of CO} = \frac{83}{126} \times 100$$

$$= \frac{200}{3}\,\%$$

42. $CO_2 (g) + C (s) \longrightarrow 2 CO (g)$

	$CO_2 (g)$	$2 CO (g)$
v_i	1	0
v_f	$1 - v$	$2v$
	0.6	0.8

$1 + 2v - v = 1.4 \Rightarrow v = 0.4$

Vol. of CO_2 : Vol. of CO

0.6 : 0.8

3 : 4

n_{CO_2} : n_{CO}

3 : 4

43. $SO_2 (g) + \frac{1}{2} O_2 (g) \longrightarrow SO_3 (g)$

	$SO_2 (g)$	$\frac{1}{2} O_2 (g)$	$SO_3 (g)$
(i) n_i	8 mole	17 mole	0 mole
n_f	0	13 mole	8 mole
(ii) n_i	21 mole	4 mole	0
n_f	13 mole	0	8 mole

44. Let the molecular formula of the compound be C_mH_n.

600 ml of reactants after reaction gives 700 ml of products.

$\underset{a}{X} + \underset{b}{O_2} \rightarrow \underset{c}{H_2O} + \underset{d}{CO_2}$

The number of moles is directly proportional to the volume of the gas.

Hence, $a + b = \frac{600}{22400}$ ……(1)

$c + d = \frac{700}{22400}$ ……(2)

a = md and b = nc

Hence, equation (1) becomes

Hence, $md + nc = \frac{600}{22400}$ ……(3)

When equation (2) and (3) are solved, m = 3 and n = 8

Hence, the molecular formula of the compound is C_3H_8.

45. $2A + 5B \rightarrow C + 2D$

Contraction in volume double the volume of A taken.

If B is taken in excess

EXERCISE # O-II

1. It depends on molar mass of solute.

2. (1) Mass of solution of 2M H_2SO_4

Mass of solution of 40% w/w MgO solution = 1000 gm

(2) Mass of H_2SO_4 in 2M H_2SO_4 = 196 gm

Mass of MgO in 40% MgO $= \frac{40}{100} \times 2 \times 1000$

$= 800$ gm

3. (A) Wt. of NaOH = $50 \times \frac{80}{100} = 40g$ (B) Wt. of NaOH = $\frac{50}{1.2} \times \frac{80}{100} = 33.33g$

(C) Wt. of NaOH = $\frac{50}{1000} \times 20 \times 40 = 40g$ (D) Wt. of NaOH = $\frac{50}{1000} \times 5 \times 40 = 10g$

4. 2 moles of solute in 1L of solution.

Mass of solution = 1090 g; mass of solvent = 900 g

Molality of Cl^- = $\frac{2 \times 2 \times 1000}{900} = 4.44$; Mole fraction $MgCl_2$ = $\frac{2}{52} = 0.038$

%w/V = $\frac{190 \times 100}{1000} = 19\%$ PPM of $MgCl_2$ = $\frac{190 \times 10^6}{1090} = 17.43 \times 10^4$

5. M = $\frac{56}{11.2}$ =5 %w/V = $\frac{170}{1000} \times 100$ = 17%

Mole fraction = $\frac{5}{5 + \left[\frac{530 - 170}{18}\right]} = 0.2$ m_{H2O2} = $\frac{5}{0.360} = \frac{1000}{72}$

6. $Ca(NO_3)_2 + Na_2C_2O_4 \rightarrow CaC_2O_4 + 2NaNO_3$

6 mmoles	3 mmoles	0	0
3 mmoles	0	3	6

$[Ca^{2+}]_f = \frac{3}{150} = 0.02\,M$ $[C_2O_4^{2-}]_f = \frac{3}{150} = 0.02\,M$

7. (A) 10 moles MgO $\longrightarrow$ 1 lit solution

400 gm MgO $\longrightarrow$ 1200 gm solution

400 gm MgO $\longrightarrow$ 800 gm solvent

OR 800 gm solvent $\longrightarrow$ 1200 gm solution

OR 100 gm solvent $\longrightarrow$ 150 gm solution

Option (Q) is correct

(B) 40 gm solute $\longrightarrow$ 100 ml solution

40 gm solute $\longrightarrow$ 160 gm solution

40 gm solute $\longrightarrow$ 120 gm solvent

Option (P) is matching

(C) 8 m $CaCO_3$

8 mole $CaCO_3$ $\longrightarrow$ 1000 gm solvent

800 gm $CaCO_3$ $\longrightarrow$ 1000 gm solvent

100 gm $CaCO_3$ $\longrightarrow$ 125 gm solvent

Option (S) is matching

(D) 0.6 moles of X $\longrightarrow$ 0.4 moles of Y

12 gm X $\longrightarrow$ 10 gm of Y

120 gm solute $\longrightarrow$ 100 gm of solvent

(R) is correct option

8. (A) $M = \frac{2}{1} = 2$

$\% \text{ w/w} = \frac{120}{1200} \times 100 = 10\ \%$

$\% \text{ w/v} = \frac{120}{1000} \times 100 = 12\%$

$m = \frac{2 \times 1000}{1200 - 120} = 1.85$

(B) $M = \frac{120}{180} = \frac{2}{3}$

$\% \text{ w/w} = \frac{120}{1200} \times 100 = 10\%$

$\% \text{ w/v} = \frac{120}{1000} \times 100 = 12\%$

$m = \frac{2/3}{1080} \times 1000 = 0.617$

(C) $\% \text{ w/w} = \frac{1 \times 60}{60 + 540} \times 100 = \frac{60}{600} \times 100 = 10\ \%$

$m = \frac{1}{540} \times 1000 = 1.85$

(D) $M = \frac{19.6}{98} \times 10 = 2$ $\quad \% \text{ w/w} = \frac{19.6}{120} \times 100 = 16.33\%$

$m = \frac{2}{1200 - 196} \times 1000 = 1.99$

9. (A) $M = \frac{20}{11.35} = 1.76$

(B) $M = \frac{24.5\times10}{98} = 2.5$

(C) $M = \frac{1000}{18} = 55.5$

(D) $M = \frac{5}{40}\times10\times1.2 = 1.5$

10. (1) $C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

$\frac{n_{O_2}}{n_{CO_2}} = \frac{5}{3}$ Option (R)

(2) $C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4\,CO_2 + 5H_2O$

$\frac{n_{O_2}}{n_{CO_2}} = \frac{13}{2\times4} = \frac{13}{8}$ Option (S)

(3) $C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O$

$\frac{n_{O_2}}{n_{CO_2}} = \frac{7}{2\times2} = \frac{7}{4}$ Option (P)

(4) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

$\frac{n_{O_2}}{n_{CO_2}} = \frac{1}{2}$ Option (Q)

11. (P) Turpentile oil $\longrightarrow$ O_3

(Q) $CuSO_4$ / $CaCO_2$ $\longrightarrow$ H_2O

(R) KOH $\longrightarrow$ CO_2, SO_2Cl_2

(S) Alkaline pyro gallol $\longrightarrow$ O_2

12. $M = \frac{9.8}{98} \times 10 \times 1.5 = 1.5$

Moles of $H_2SO_4 = 1.5 \times 2 = 3$

13. moles of $H^+ = 3 \times 2 = 6$

moles of $OH^- = 3 \times 1 = 3$

$\left[H^+\right]_f = \frac{6-3}{5} = \frac{3}{5}M$

14. $n_{SO_3} = \frac{20}{80} = \frac{1}{4}$

$n_{H_2SO_4} = \frac{30}{98}$

$X_{SO_3} = \frac{0.25}{0.25+\frac{30}{98}} = 0.45$

15. $SO_3 \quad + \quad H_2O \quad \longrightarrow \quad H_2SO_4$

$\frac{1}{4}$ mol $\quad \frac{1}{4}$ mol

Mass of H_2O vacts with 50g sample = 4.5g

% labeling of oleum = 100 + 2 × 4.5 = 109%

16. Moles of AgBr = moles of Br

Moles of Br = $\frac{0.12}{188}$

Mass of Br = $\frac{0.12}{188}\times 80$ = 0.051g

Mass % = $\frac{0.051}{0.15}$ × 100 = 34 %

17. Moles of S = moles of $BaSO_4$ = $\frac{0.35}{233}$

Mass of S = $\frac{0.35}{233}$ × 32 = 0.048g

Mass % of S = $\frac{0.048}{0.2595}\times 100$ = 18.25 %

18. 1 × moles of P = 2 × moles of $Mg_2P_2O_7$ = 2 × $\frac{0.22}{222}$

Mass of P = $\frac{0.44}{222}\times 31$ = 0.0614g

Mass % of P = $\frac{0.0614}{0.12}\times 100$ = 51.2 %

19. 1 × moles of P = 2 × moles of $Mg_2P_2O_7$

Moles of $Mg_2P_2O_7$ = $\frac{1}{2}\times\frac{10\times 6.2}{100}\times\frac{1}{31} = \frac{1}{100}$

Mass of $Mg_2P_2O_7$ = $\frac{1}{100}\times 222$ = 2.22g

20. $P_{N_2} = 715 – 15 = 700$ mm

$$n_{N_2} = \frac{\frac{700}{760}\times 50\times 10^{-3}}{0.0821\times 300} = 0.00187$$

Mass of N – atom = 0.00187 × 28 = 0.05236g

$$\text{Mass \% of N} = \frac{0.05236}{0.3}\times 100 = 17.46\ \%$$

21. $2NH_3 + H_2SO_4 \longrightarrow$ wt. of N $= \frac{14\times 20}{1000}$

20 m mol 10 mmol $= 0.28$g

$2NaOH + H_2SO_4 \longrightarrow$ % wt. of N $= \frac{0.28}{0.5}\times 100$

30 m mol 15 m mol $= 56$ %

22. $2\ NH_3 + H_3PO_3 \longrightarrow$ wt. of N $= \frac{14\times 20}{1000}$

20 m mol 10 m mol $= 0.28$ g

$Ca(OH)_2 + H_3PO_3$ % wt. of N $= \frac{0.28}{0.4}\times 100$

15 m mol 15 m mol $= 70$ %

23. $2NH_3 + H_2SO_4 \longrightarrow$ wt. of N $= 14 \times 0.4 \times 10^{-4}$

0.4×10^{-4} 0.2×10^{-4} $= 5.6\times 10^{-4}$

$$\text{\% wt. of N} = \frac{5.6\times 10^{-4}}{2\times 10^{-3}}\times 100 = 28\%$$

24-27 $C_n H_{2n+2} + \left(\frac{3n+1}{2}\right)O_2 \longrightarrow \underset{2mL}{nCO_2} + (n + 1)\ H_2O$

v $\left(\frac{3n+1}{2}\right)v$ nv

$\underset{4mL}{N_2} + 3H_2 \longrightarrow \underset{8mL}{2NH_3}$

$v + \left(\frac{3n+1}{2}\right)v = 6$

$2v + 3nv + v = 12$

$3v = 6 \Rightarrow v = 2$

$n = 1$

Alkane $\Rightarrow CH_4$

Vol. of CH_4 = 2 mL Vol. of N_2 = 4 mL

Vol. of O_2 = 4 mL

EXERCISE # JEE-MAINS

1. Molarity $= \dfrac{\text{mols of solute}}{\text{volume of sol. }(\ell)} = \dfrac{6.02 \times 10^{21} \times 1000}{6.02 \times 10^{23} \times 100} = 0.1$ M

2. $X_{\text{ethyl alcohol}} = \dfrac{5.2}{5.2 + \dfrac{1000}{18}} = 0.086$

3. Molarity $= \dfrac{\text{mols of solute} \times 1000}{\text{volume of sol. (mL)}} = \dfrac{95 \times 1.834 \times 1000}{98 \times 100} = 17.778$

4. Molarity $= \dfrac{\text{mols of solute}}{\text{volume of sol. }(\ell)} = \dfrac{120 \times 1.15}{60 \times 1120} = 2.05$ M

5. $M_1V_1 + M_2V_2 = M_3V_3$

$2 \times 10 + 0.5 \times 200 = M_3 \times 210$

$M_3 = 0.57$ M

6. 3M = 3 moles of solute present in 1L of solution

Wt. of solute = 3 ×58.5 = 175.5 g

Wt. of solution = 1000 mL ×1.252 = 1252 g

Wt. of solvent =1252 – 175.5 = 1076.5

$m = \dfrac{3 \times 1000}{1076.5} = 2.786$

7. $BaCl_2 \quad + \quad H_2SO_4 \quad \rightarrow BaSO_4 \quad + \quad 2\ HCl$

$\dfrac{20.8}{208} = 0.1 \qquad \dfrac{4.9}{98} = 0.05$

Mole of $BaSO_4$ formed = 0.05

Wt. of $BaSO_4$ formed = 0.1×233 = 11.65 gram

8. Mass of organic compound = 1.4 g

let it contain x mmole of N atom.

organic compound $\longrightarrow$ NH_3

x m mole

$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$. (1st)

6 mmole

initially taken.

$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$ (2nd)

2 mmole

reacted

Hence m moles of H_2SO_4 reacted in 2nd equation = 1

$\Rightarrow$ m moles of H_2SO_4 reacted from 1st equation = 6 – 1 = 5 m moles

$\Rightarrow$ m moles of NH_3 in 1st equation = 2 × 5 = 10 m moles

$\Rightarrow$ m moles of N atom in the organic compound = 10 m moles

$\Rightarrow$ mass of N = $10 \times 10^{-3} \times 14 = 0.14$ g

$\Rightarrow$ % of N = $\frac{0.14}{1.4} \times 100$ = 10 %

9. Initial mmoles of CH_3COOH = 0.06 × 50

Final mmoles of CH_3COOH = 0.042 × 50

Hence, mass of CH_3COOH adsorbed per gram of charcoal = $\frac{(0.06 - 0.042) \times 50 \times 10^{-3} \times 60 \times 10^{3}}{3}$

= 18 mg

10. Moles of $CoCl_3 \cdot 6H_2O = 10^{-2}$

Mmoles of AgCl precipitated = $\frac{1.2 \times 10^{22}}{6 \times 10^{23}} = 2 \times 10^{-2}$ i.e. each complex furnishes 2 Cl^-

11. $X_{solvent} = 0.8$

$X_{solute} = 0.2$

m = $\frac{X_{solute}}{X_{solvent}} \times \frac{1000}{18} \times \frac{0.2}{0.8} \times \frac{1000}{18} = \frac{250}{18}$ = 13.88 mol / kg

12. $\frac{w}{w}$ % = 20

100 gm solution has 20 gm KI

80 gm solvent has 20 gm KI

m = $\frac{\frac{20}{166}}{\frac{80}{1000}} = \frac{20 \times 1000}{166 \times 80}$ = 1.506 $\simeq$ 1.51 mol / kg.

13. We know,

Volume strength = 11.2 × molarity = 11.2

$\Rightarrow$ molarity = 1 M

$\Rightarrow$ strength = 34 g / L

$\Rightarrow$ % w /w = $\frac{34}{1000}$ × 100 = 3.4 %

14. The balanced reaction is as follows :

$2H_2O_2 \rightarrow 2H_2O + O_2$

–1 –2 0 (oxidation state of O)

So, 2 moles of H_2O_2 gives 1 moles of O_2.

Therefore, 1 mole of H_2O_2 will give 11.35 of O_2 gas.

So, volume strength of H_2O_2 = 11.35 × molarity.

Hence, for 1 M H_2O_2, volume strength is 11.35

15. 8 g NaOH, mol of NaOH = $\frac{8}{40}$ = 0.2 mol

18 g of H_2O, mol of H_2O = $\frac{18}{18}$ = 1 mol

$\therefore \quad X_{NaOH} = \frac{0.2}{1.2} = 0.167$

Molality = $\frac{0.2 \times 1000}{18}$ = 11.11 m.

16. Molarity = $\frac{(n)_{solute}}{V_{solute}(\text{in litre})}$

$0.1 = \frac{\text{Amount of solute}}{342 \times 2}$

Amount of sugar ($C_{12}H_{22}O_{11}$) = 68.4 gram

17. Here molecular weight of Na is 23 g/mol

$n_{Na^+} = \frac{92}{23} = 4$

Molality is a number of moles of solute present in per kg of solvent.

So, molality = 4 molal

EXERCISE # JEE-ADVANCED

1. Density of liquid water $= 1 \text{ gcm}^{-3}$

Density of water vapour $= 0.0006 \text{ gcm}^{-3}$

Mass of 1000 ml stream $= 1000 \times 0.0006 = 0.6$ g

$\because$ volume of liquid water $= \dfrac{\text{Mass of 1000 ml stream}}{\text{Density of liquid water}}$

$$V = \frac{0.6\,g}{1 g.cm^{-3}}$$

$V = 0.6 \text{ cm}^3$

2. Molarity = Number of moles of solute per litre of solution in molar concentration

M = no of moles / volume

Mole = mass / molar mass = 1000 / 18 = 55.56 mol

1l of water = 1000 ml = 1 kg

Density = 1000 kg/m^3

Therefore Molarity = 55.56 mol/1L = 55.56 mol/L

3. Moles of CH_3COOH absorbed = Initial moles – Final moles

$= 0.5 \times 100 \times 10^{-3} - 0.049 \times 100 \times 10^{-3}$

$= 0.05 - 0.049 = 0.001$

No. of molecules of CH_3COOH absorbed

$= 0.001 \times 6.02 \times 10^{23}$

$= 6.02 \times 10^{20}$

Surface area $= 3.01 \times 10^2 \text{ m}^2$ (given)

Surface area of charcoal absorbed by in each

Molecule of charcoal absorbed by in each

Molecule of CH_3COOH $= \dfrac{3.01 \times 10^2}{6.02 \times 10^{20}} = 5 \times 10^{-19} \text{ m}^2$

4. Given that for absorbed N_2 on surface sites,

$P_{N_2} = 0.001$ atm, $V = 2.46 \text{ cm}^3$

$= 2.46 \times 10^{-3}$ *l*, T = 298 K

$$\therefore\ n_{N_2} = \frac{PV}{RT} = \frac{0.001 \times 2.46 \times 10^{-6}}{0.0821 \times 298} = 1.0 \times 10^{-7}$$

Molecules of absorbed $N_2 = 1.0 \times 10^{-7} \times 6.023 \times 10^{23} = 6.023 \times 10^{16}$

Total surface sites available = Number of sites

per $cm^2 \times$ Area $= 60.23 \times 10^{14} \times 1000 = 6.023 \times 10^{17}$

Surface sites on which N_2 is absorbed = 20% × Available sites

$= \dfrac{20}{100} \times 6.023 \times 10^{17} = 12.046 \times 10^{16}$

$\therefore$ Number of sites absorbed per molecule of

$N_2 = \dfrac{12.046 \times 10^{16}}{6.023 \times 10^{16}} = 2$

5. Average atomic mass of Fe

$= \dfrac{5 \times 54 + 90 \times 56 + 5 \times 57}{100}$

$= 55.95$ u

6. Volume of one mole of silver atoms $= \dfrac{108}{10.5}$ cm^3/mole

volume of one silver atom $= \dfrac{108}{10.5\,N_A} \times$ cm^3

so, $\dfrac{4}{3}\pi R^3 = \dfrac{108}{10.5} \times \dfrac{1}{6.022 \times 10^{23}} = 1.708 \times 10^{-23}$ [neglecting the void space]

$R^3 = 0.407 \times 10^{-23}$ cm^3

$R^3 = 0.407 \times 10^{-29}$ m^3

Area of each silver atom

$\pi R^2 = \pi \times (0.407 \times 10^{-29}\ m^3)^{2/3}$

so, number of silver atoms in given area. $= \dfrac{10^{-12}}{(0.407 \times 10^{-29} m^3)^{2/3}} = \dfrac{10^8}{(\pi \times 2)} = 1.6 \times 10^7$

7. Mole $= \dfrac{120}{60} = 2$

mass of solution = 1120 g

$V = \dfrac{1120}{1.15 \times 1000} =$ L

$M = \dfrac{2 \times 115}{112} = 2.05$ mol/litre

8. Given 3.2 M solution

$\therefore$ moles of solute = 3.2 mol

Consider 1 L Solution.

$\therefore$ volume of solvent = 1 L

$P_{solvent} = 0.4$ g.mL^{-1} $\therefore$ $m_{solvent} = P \times V = 400$ g

$\therefore$ molality $= \dfrac{3.2\text{ mol}}{0.4\text{ kg}} = 8$ molal

9. $\frac{X_{solute}}{X_{solvent}} = \frac{0.1}{0.9} = \frac{1}{9}$

$\frac{W_{solute}}{W_{solvent}} \times \frac{M_{solvent}}{M_{solute}} = \frac{1}{9}$ ……….. (Eq. 1)

$W_{solute} + W_{solvent}$ = Density × Volume

$W_{solute} + W_{solvent} = 2 \times V$

Molarity = Molality………. (Given)

$\frac{n_{solute}}{V_{solution}} = \frac{n_{solute}}{W_{solvent}}$

$W_{solvent} = V_{solution} = \frac{W_{solute} + W_{solvent}}{2}$

$2W_{solvent} = W_{solute} + W_{solvent}$

$W_{solute} = W_{solvent}$ ………… (Eq. 2)

From (1) and (2),

$\frac{M_{solute}}{M_{solvent}} = 9$

10. Mole fraction of urea in aqueous solution = 0.05

$0.05 = \frac{\text{Moles of urea}}{\text{Moles of urea} + \frac{900}{18}}$

0.05(Moles of urea) + 2.5 = Moles of urea

Moles of urea = 2.63 moles

Mass of urea = 2.63 × 60 = 158 gm

Mass of solution = 158 + 900 = 1058 gm

Density = 1.2 cm^3

Volume of solution $= \frac{1058}{1.2}$

= 881.67 ml

Molarity = $\frac{n_{solute}}{V_{solution\,(innL)}} \times 1000$

$= \frac{2.63}{881.67} \times 1000$

$= 2.9 \simeq 3$ M