CONCENTRATION TERMS

1. SOLUTIONS

A solution is a homogenous mixture of two or more pure substances whose composition may be altered within certain limits. Though the solution is homogenous in nature, yet it retains the properties of its constituents.

Generally solution is composed of two components, **solute** and **solvent**. Such type of solution is known as binary solution.

Solvent is that component in solution whose physical state is the same as that of the resulting solution while other component is called as solute. If the physical state of both component is same, then the component in excess is known as solvent and other one is called as solute. Each component in a binary solution can be in any physical state such as liquid, solid and gaseous state.

Types of Solutions

Type of Solutions	Solute	Solvent	Common Example
Gaseous Solutions	Gas	Gas	Mixture of oxygen and nitrogen gases
	Liquid	Gas	Chloroform mixed with nitrogen gas
	Solid	Gas	Camphor in nitrogen gas
Liquid Solutions	Gas	Liquid	Oxygen dissolved in water
	Liquid	Liquid	Ethanol dissolved in water
	Solid	Liquid	Glucose dissolved in water
Solid Solutions	Gas	Solid	Solution of hydrogen in palladium
	Liquid	Solid	Amalgam of mercury with sodium
	Solid	Solid	Copper dissolved in gold

2. CONCENTRATION OR STRENGTH OF SOLUTION :

The concentration of a solution is the amount of solute dissolved in a known amount of the solvent or solution. Solution can be described as dilute or concentrated solution as per their concentration. A dilute solution has a very small quantity of solute while concentrated solution has a large quantity of solute in solution. Various concentration terms are as follows.

2.1 Mass percentage :

It may be defined as the number of parts of mass of solute per hundred parts by mass of solution.

$$\textbf{\% by mass} \left(\frac{w}{W}\right) : = \frac{\text{wt. of solute}}{\text{wt. of solution}} \times 100$$

[X % by mass means 100 gm solution contains X gm solute and hence = and hence (100 – X) gm solvent]

2.2 Mass-volume percentage (W/V %) :

It may be defined as the mass of solute (in gm) present in 100 cm^3 of solution. For example, If 100 cm^3 of solution contains 5 g of sodium hydroxide, then the mass-volume percentage will be 5% solution.

$$\% \left(\frac{w}{V}\right) = \frac{\text{wt. of solute}}{\text{volume of solution}} \times 100$$

[X % $\left(\frac{w}{V}\right)$ means 100 ml solution contains X gm solute]

2.3 Volume Percent :

It can be represented as % v/v or % volume and normally used for the solutions in which both components are in liquids state. It is the number of parts of by volume solute per hundred parts by volume of solution. Therefore,

$$\% \left(\frac{v}{V}\right) = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100$$

2.4 Mole % $= \frac{\text{Moles of solute}}{\text{Total moles}} \times 100$

- For gases, **% by volume** is same as **mole %**

2.5 Mole Fraction (X) :

Mole fraction may be defined as the ratio of number of moles of one component to the total number of moles of all the components (solute and solvent) present in solution. It is denoted by letter X and the sum of all mole fractions in a solution is always equals to one.

$$\text{Mole fraction (X)} = \frac{\text{Moles of solute}}{\text{Total moles}}$$

Mole fraction does not depend upon temperature and can be extended to solutions having more than two components.

2.6 Molarity (M) :

Molarity is most common unit for concentration of solution. It is defined as the number of moles of solute present in one litre or one dm^3 of the solution or millimol of solute present in one mL of solution.

$$\text{Molarity (M)} = \frac{\text{Mole of solute}}{\text{volume of solution in litre}}$$

2.7 **Molality (m) :** The number of mole of the solute present in 1000 g of the solvent is known as molality of solution. It represented by letter 'm'.

$$\text{Molality (m)} = \frac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}}$$

The unit of molality is mol/kg and it does not affect by temperature.

2.8 **Parts per million (ppm) :** The very low concentration of solute in solution can be expressed in ppm. It is the number of parts by mass of solute per million parts by mass of the solution.

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

- Get yourselves very much comfortable in their inter conversion. It is very handy.

Concentration Type	Mathematical Formula	Concept
Percentage by mass	$\%\left(\frac{w}{w}\right) = \frac{\text{Mass of solute} \times 100}{\text{Mass of solution}}$	Mass (in gm) of solute present in 100 gm of solution.
Volume percentage	$\%\left(\frac{v}{v}\right) = \frac{\text{Volume of solute} \times 100}{\text{Volume of solution}}$	Volume (cm^3) of solute present in 100 cm^3 of solution.
Mass-volume percentage	$\%\left(\frac{w}{v}\right) = \frac{\text{Mass of solute} \times 100}{\text{Volume of solution}}$	Mass (in gm) of solute present in 100 cm^3 of solution.
Parts per million	$\text{ppm} = \frac{\text{Mass of solute} \times 10^6}{\text{Mass of solution}}$	Parts by mass of solute per million parts by mass of the solution
Mole fraction	$X_A = \frac{\text{Mole of A}}{\text{Mole of A} + \text{Mole of B} + \text{Mole of C} + ...}$ $X_B = \frac{\text{Mole of B}}{\text{Mole of A} + \text{Mole of B} + \text{Mole of C} + ...}$	Ratio of number of moles of one component to the total number of moles.
Molarity	$M = \frac{\text{Mole of solute}}{\text{Volume of solution (in L)}}$	Moles of solute in one litre of solution.
Molality	$m = \frac{\text{Mass of solute} \times 1000}{\text{Molar mass of solute} \times \text{Mass of solvent(g)}}$	Moles of solute in one kg of solvent

Ex.1 ***Calculate the mole fractions of the components of the solution composed by 92 g glycerol and 90 g water ? (M (water) = 18 ; M (glycerol) = 92)***

Moles of water = 90 g / 18 g = 5 mol water

Moles of glycerol = 92 g / 92 g = 1 mol glycerol

Total moles in solution = 5 + 1 = 6 mol

Mole fraction of water = 5 mol / 6 mol = 0.833

Mole fraction of glycerol = 1 mol / 6 mol = 0.167

Ex.2 ***What will be the molarity of solution when water is added to 16.4g $Ca(NO_3)_2$ to make 100 mL of solution?***

Mol of $Ca(NO_3)_2$ = 16.4/ 164 = 0.1

Molarity = Mole of solute / Volume of solution (L) = 0.10 mol / 0.10 L

Therefore, Molarity of given solution = 1.0 M

Ex.3 ***Calculate the molality of a solution containing 20 g of sodium hydroxide (NaOH) in 250 g of water?***

Moles of sodium hydroxide = 20 / 40 = 0.5 mol NaOH

250 gm = 0.25 kg of water

Hence molality of solution = Mole of solute / Mass of solvent (kg)= 0.5 mol / 0.25 kg

or Molality(m) = 2.0 m

Ex.4 ***Calculate the gram of copper sulphate ($CuSO_4$) needed to prepare 250.0 mL of 1.00 M $CuSO_4$?***

Moles of $CuSO_4 = M \times V = 1 \times \frac{250}{1000}$

Molar mass of copper sulphate = 159.6 g/mol

Hence Mass of copper sulphate (gm) = Moles of $CuSO_4$ × Molar mass of copper sulphate.

$$= 1 \times \frac{250}{1000} \times 159.6 \text{ g/mol} = 39.9 \text{ gm of Copper sulphate}$$

Ex.5 ***How many gram of H_2SO_4 are present in 500 ml of 0.2M H_2SO_4 solution ?***

$$M = \frac{\text{moles}}{\text{vol.}} \Rightarrow \text{moles of } H_2SO_4 = M \times V = 0.2 \times \frac{500}{1000} \text{L} = 0.1$$

Mass of H_2SO_4 = 0.1 × 98 = 9.8 g

Ex.6 ***Calculate the ppm of mercury in water in a sample containing 30 mg of Hg in 500 ml of solution.***

$$\text{Parts per million} = \frac{\text{Mass of solute} \times 10^6}{\text{Mass of solution}}$$

Mass of Hg = 30 mg

Mass of water = 500/1 = 500g = 50×10^4 mg

(density = mass / volume ; density of water 1 g / ml) $w = \frac{v}{d}$

Therefore, ppm of mercury = $\frac{30 \times 10^6}{50 \times 10^4}$ = 60 ppm of mercury

Ex.7 ***A 100g NaOH solution has 20g NaOH. Find molality.***

$$m = \frac{20/40}{100-20} \times 1000 = \frac{500}{80} = 6.25 \text{ mol / kg}$$

Ex.8 ***Find molality of aqueous solution of CH_3COOH whose molarity is 2M and density d = 1.2 g/mL.***

Hint : $\mathbf{\frac{1000 \times M}{1000 \times d - MMs}}$

where d = density in gL^{-1} , M = Molarity, m = molality, M_S = molar mass of solute.

$$m = \frac{2}{1200 - 2 \times 60} \times 1000 = 1.85 \text{ m}$$

Ex.9 ***A solution has 80% $\frac{w}{w}$ NaOH with density $2gL^{-1}$. Find (a) Molarity (b) Molality of solution.***

Let V be vol. of solution, in L

$$\text{Mass of solute} = (d \times V) \times \frac{\left(\%\frac{w}{w}\right)}{100} = 2 \times V \times \frac{80}{100} = 1.6V$$

(a) $M = \frac{1.6V/40}{V} = 0.04$ m (b) $m = \frac{1.6V/40}{2V - 1.6V} \times 1000 = 100 \text{ mol kg}^{-1}$

Ex.10 ***4.450 g sulphuric acid was added to 82.20 g water and the density of the solution was found to be 1.029 g/cc at 25°C and 1 atm pressure. Calculate***

(a) the weight percent,

(b) the mole fraction ,

(c) the mole percent,

(d) the molality ,

(e) the molarity of sulphuric acid in the solution under these conditions.

Sulphuric acid = 4.450 g , Water = 82.20 g ⇒ Wt. of solution = 86.65 g

∴ Density of solution = 1.029 g/cc.

(a) Weight percent = $\frac{\text{wt. of solute}}{\text{wt. of solution}} \times 100 = \frac{4.450}{86.65} \times 100 = 5.14$

(b) Mole fraction :

$$\text{Mole of solute} = \frac{\text{wt. of solute}}{\text{mol wt. of solute}} = \frac{4.45}{98} = 0.0454$$

Mole of solvent $= \dfrac{82.20}{18} = 4.566$

Total moles in solution $= 0.0454 + 4.566 = 4.6114$

Mole fraction of solute $= \dfrac{0.0454}{4.6114} = 0.0098$

(c) Mole percent $=$ mole fraction of solute $\times 100 = 0.0098 \times 100 = 0.98$

(d) Molality $= \dfrac{\text{moles of solute}}{\text{mass of solvent (in gm)}} \times 1000$

$= \dfrac{0.0454 \times 1000}{82.2} = 0.552$

(e) Molarity $= \dfrac{\text{moles of solute}}{\text{litre of solution}}$

Volume of solution $= \dfrac{\text{Mass}}{\text{Density}} = \dfrac{86.65}{1.029}\text{ ml} = \dfrac{86.65}{1.029 \times 1000}\text{ litre}$

Molarity $= \dfrac{\dfrac{0.0454}{86.54}}{1.029 \times 1000} = \dfrac{0.0454 \times 1000 \times 1.029}{86.65} = 0.539$

Ex.11 ***Find number of Na^+ & PO_4^{-3} ions in 250 ml of 0.2M Na_3PO_4 solution.***

$Na_3PO_4 + aq. \longrightarrow 3Na^+(aq) + PO_4^{-3}(aq)$ [Ionic compound when added to water ionize completely].

50 millimoles (m.m.) 150 mm 50 mm

No. of Na^+ ions $= 150 \times 10^{-3} \times N_A$; No. of PO_4^{-3} ions $= 50 \times 10^{-3} \times N_A$

Ex.12 ***80g NaOH was added to 2L water. Find molality of solution if density of water = 1g/mL***

Ans. $m = \dfrac{\text{moles of NaOH}}{\text{mass of } H_2O} \times 1000 = \dfrac{80/40}{2 \times 1000} \times 1000 = 1\text{ molal}$

Ex.13 The average concentration of Na^+ ion in human body is 3.0 to 3.9 gm per litre. The molarity of Na^+ ion is about.

0.15 M

Sol. $M_{Na^+} = \dfrac{n_{solute}}{\text{volume of solution in Lt}} = \dfrac{\frac{3+3.9}{2}}{23} = \dfrac{6.9}{46} = 0.15M$

DO YOUR SELF-01

Q.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

Q.2 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

Q.3 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

Q.4 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

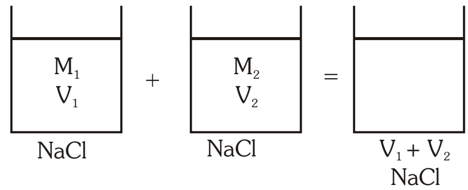
Q.5 What is the concentration of chloride ion, in molarity, in a solution containing 10.56 gm $BaCl_2.8H_2O$ per litre of solution ? (Ba = 137)

Answers :

Q.1 (C) Q.2 (D) Q.3 (B) Q.4 (D) Q.5 0.06 M

3. MIXING OF AND DILUTION SOLUTIONS :

It is based on law of conservation of moles of solute

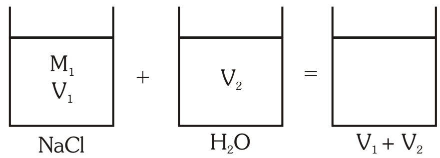


(i) Two solutions having same solute

$$\text{Final molarity} = \frac{\text{Total moles}}{\text{Total volume}} = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$$

(ii) Dilution Effect : When a solution is diluted, the moles of solute do not change but molarity changes while on taking out a small volume of solution from a larger volume, the molarity of solution do not change but moles change proportionately.

$$\text{Final molarity} = \frac{M_1V_1}{V_1 + V_2}$$



n-fold or n-times dilution

⇒ **Final volume = $V_1 + V_2 = n(V_1)$**

Ex.14 ***50 ml 0.2 M H_2SO_4 is mixed with 50 ml 0.3M H_2SO_4. Find molarity of final solution.***

$$M_f = \frac{\text{Total moles of } H_2SO_4}{\text{Total volume}} = \frac{50 \times 0.2 \times 10^{-3} + 50 \times 10^{-3} \times 0.3}{(50+50) \times 10^{-3}} = 0.25 \text{ M.}$$

Ex.15 ***Find final molarity in each case :***

(i) 500 ml 0.1 M HCl + 500 ml 0.2M HCl

(ii) 50 ml, 0.1M HCl + 150 ml, 0.3MHCl + 300 ml H_2O

(iii) 4.9g H_2SO_4 + 250 ml H_2O + 250 ml 0.1 M H_2SO_4

Answer :

(i) $M_f = \frac{500 \times 0.1 + 500 \times 0.2}{500 + 500} = 0.15$ M.

(ii) $M_f = \frac{50 \times 0.1 + 150 \times 0.3}{50 + 150 + 300} = \frac{50}{500} = 0.1$ M

(iii) $M_f = \frac{\frac{4.9}{98} + \frac{250}{1000} \times 0.1}{\left(\frac{250+250}{1000}\right)} = \frac{50+25}{500} = 0.15$ M

Ex.16 ***How much water should be added to 2M HCl solution to form 1 litre of 0.5 M HCl ?***

Let V be initial volume

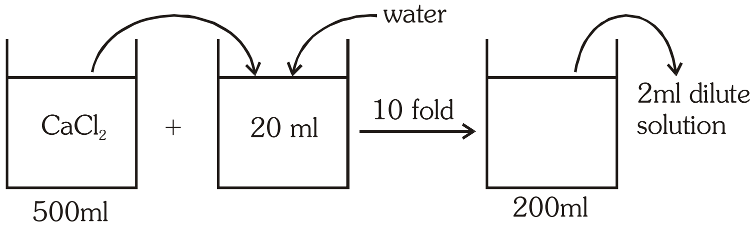
Then mol of HCl = constant

$2 \times V = 1 \times 0.5 \quad \Rightarrow V = 0.25$ L

Volume of water added = 1 – 0.25 = 0.75 L

Ex.17 ***1.11g $CaCl_2$ is added to water forming 500 ml of solution. 20 ml of this solution is taken and diluted 10 folds. Find moles of Cl^- ions in 2 ml of diluted solution.***

$\frac{1.11}{111} = 0.01$ mol $CaCl_2$



Moles of $CaCl_2$ in 20ml solution $= \frac{0.01}{500} \times 20 = \frac{0.01}{25}$

In 200 ml solution, moles of $CaCl_2 = \frac{0.01}{25}$ [Note : Dilution does not change moles of solute]

In 2 ml of dilute solution moles of $CaCl_2 = \frac{0.01/25}{200} \times 2 = \frac{0.01}{2500} = 4 \times 10^{-6}$

$\therefore$ moles of $Cl^- = 2 \times 4 \times 10^{-6} = 8 \times 10^{-6}$

Ex.18 ***What volumes of 1M & 2M H_2SO_4 solution are required to produce 2L of 1.75M H_2SO_4 solution?***

Let XL be vol. of 1M solution.

$\therefore$ (2 – X)L is vol. of 2M solution.

Moles of H_2SO_4 : $2 \times 1.75 = 1(X) + (2 - X)2 \Rightarrow X = 0.5$ L

i.e. 0.5L of 1M & 1.5 L of 2M solution are required.

Ex.19 ***A solution is made by mixing 300 ml 1.5M $Al_2(SO_4)_3$ + 300 ml 2M $CaSO_4$ + 400 ml 3.5M $CaCl_2$***

Find final molarity of (1) SO_4^{-2}, (2) Ca^{2+}, (3) Cl^-. [Assume complete dissociation of these compounds].

(1) $[SO_4^{-2}]_f = \frac{\text{Total moles}}{\text{Total volume}} = \frac{300 \times 1.5 \times 10^{-3} \times 3 + 300 \times 2 \times 10^{-3}}{(300 + 300 + 400) \times 10^{-3}} = 1.95\text{M}$

(2) $[Ca^{+2}]_f = \frac{300 \times 2 + 400 \times 3.5}{1000} = 2\text{M}$

(3) $[Cl^-]_f = \frac{400 \times 3.5 \times 2}{1000} = 2.8\text{M}$

Ex.20 ***A solution of KCl has a density of 1.69 g mL^{-1} and is 67% by weight. Find the density of the solution if it is diluted so that the percentage by weight of KCl in the diluted solution is 30%.***

Let the volume of the KCl solution be 100 mL,

Weight of KCl solution = 100 × 1.69 = 169 g

100 g of solution contains = 67 g of KCl

169 g of solution = $\frac{67}{100} \times 169 = 113.23\text{g}$

Lex x mL of H_2O be added.

New volume of solution = (100 + x) mL

New weight of solution = (169 + x) g

(Since x mL of H_2O = x g of H_2O, d_{H_2O} = 1)

New percentage of the solution = 30%

$$\% \text{ by weight} = \frac{\text{weight of solute} \times 100}{\text{weight of solution}}$$

$$30 = \frac{113.23}{(169 + x)} \times 100$$

x = 208.43 mL = 208.43 g

$$\text{New density} = \frac{\text{New weight of solution}}{\text{New volume of solution}} = \frac{(169 + x)}{(100 + x)}$$

∴ d = 1.224 gm/m*l*

Ex.21 Calculate the amount of the water "in mℓ"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 ? 1.5 ml

Sol. Before dilution = After dilution

$(n_{solute}) = (n_{solute})$

$M_i V_i = M_f V_f$

$$\frac{\frac{40}{170}}{1} \times 1 = \frac{\frac{16}{170}}{1}(1 + V)$$

⇒ V = 1.5 mL

Ex.22. 100 m*l*, 3%(w/v) NaOH solution is mixed with 100 m*l*, 9%(w/v) NaOH solution. The molarity of final solution is-

Ans. **(1.5)**

Total NaOH in 100 ml (1st solution) = 3 gm

Total NaOH in 100 ml (2nd solution) = 9 gm

$$\therefore \text{ Molarity} = \left(\frac{12/40}{200/1000}\right) = 1.5\text{M}$$

Ex.23. 1120 gm of 2 **'m'** urea solution is mixed with 2480 gm of 4 **'m'** urea solution. Calculate the molality of the resulting solution?

Ans. 3.33 m

Sol. Let 2 m, 1120 g solution have mass of solute = w gm

$\therefore$ solvent = (1120 – w) gm

& Let 4 m, 2480 g solution have mass of solute = w^1 gm

$\therefore$ solvent = (2480 – w) gm

$$\text{molality} = \frac{n_{solute}}{\text{wt. of solvent in kg}}$$

$$2 = \frac{w/60}{1120 - w} \times 1000$$

w = 120 gm

$$\& \quad 4 = \frac{w'/60}{2480 - w'} \times 1000$$

w' = 480 gm

$$\text{resulting molality m} = \frac{\frac{120+480}{60}}{1120-120+2480-480} \times 1000 = 3.33 \text{ m}$$

DO YOUR SELF-02

1. Find the resultant molarity obtained by mixing the 2 litre, 0.5M HCl + 3 litre, 0.2 M HCl.

2 Find the resultant molarity obtained by mixing the 500 ml, 1M NaCl + 200 ml, 2M NaCl

Answers:

1. **0.32 M** 2. $\frac{9}{7}$ **M**

4. SOME TYPICAL CONCENTRATION TERMS

4.1 *PERCENTAGE LABELLING OF OLEUM :*

Labelled as '% oleum' , it means maximum amount of H_2SO_4 that can be obtained from 100 gm of such oleum (mixture of H_2SO_4 and SO_3) by adding sufficient water. For ex. 109 % oleum sample means, with the addition of sufficient water to 100 gm oleum sample 109 gm H_2SO_4 is obtained.

% labelling of oleum sample = (100 + x)%

x = mass of H_2O required for the complete conversion of SO_3 in H_2SO_4

Ex.24 Find the mass of free SO_3 present in 100 gm , 109 % oleum sample.

Sol. 109 % means, 9 gm of H_2O is required for 100 gm oleum

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

SO_3	+	H_2O	$\longrightarrow$	H_2SO_4
		9gm		
1/2mole		1/2mole		
40gm				

$\therefore$ Mass of free SO_3 = 40 gm , Mass of H_2SO_4 = 60 gm

Ex.25 ***Find the % labelling of 100 gm oleum sample if it contains 20 gm SO_3.***

Sol. % labelling of oleum sample = (100 + x)%

SO_3	+	H_2O	$\longrightarrow$	H_2SO_4
20gm				
1/4mole		1/4mole		
		4.5gm		

$\therefore$ % labelling of oleum sample = (100 + 4.5) % = 104.5%

Ex.26 ***An oleum sample is labelled as 118 %, Calculate composition of mixture (mass of components) if 40 gm water is added to 30 gm given oleum sample.***

H_2SO_4= 35.4 gm, H_2O = 34.6gm

Sol. In 100 gm sample requires water = 18 gm

30 gm sample will require water $= \frac{18}{100} \times 30 = 5.4\text{gm}$

Mass of H_2O = 40 – 5.4 = 34.6 gm and mass of H_2SO_4 = 70 – 34.6 = 35.4 gm.

4.2 VOLUME STRENGTH OF H_2O_2 SOLUTION :

Labelled as 'volume H_2O_2 , it means volume of O_2 (in litre) at STP that can be obtained from 1 litre of H_2O_2 solution, when H_2O_2 when it decomposes according to

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

Volume Strength of H_2O_2 Solution = 11.35 × molarity

Ex.27 ***Find the % w/v of "10 V" H_2O_2 solution-***

Sol. Molarity (M) of solution $= \frac{\text{volume strength}}{11.35} = \frac{10}{11.35}$

$$\%\left(\frac{w}{v}\right) = \frac{M \times \text{mol. wt. of solute}}{10} = \frac{10}{11.35} \times \frac{34}{10} = 3\%$$

Ex.28 ***$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$***

Under conditions where 1 mole of gas occupies 24 dm^3, X L of $\frac{1}{24}$M solution of H_2O_2 produces 3 dm^3 of O_2. Thus X is :-

Ans. **(6)**

moles of $H_2O_2 = \frac{1}{24} \times X$

moles of $O_2 = \frac{3}{24} = \frac{1}{8}$.

moles of $H_2O_2 = \frac{1}{4} = \frac{X}{24}$

$X = 6$

DO YOUR SELF-03

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1. 34 g of hydrogen peroxide is present in 1135 mL of solution. Volume strength of solution is:
   (A) 10 V (B) 20 V (C) 30 V (D) 32 V
2. Label an oleum sample which has mass fraction of SO_3 equal to 0.6 :
   (A) 115 % (B) 109 % (C) 104.5 % (D) 113.5 %

Comprehension Q.3 and Q.4 (2 questions)

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

3. Find mole fraction of SO_3 .
   (A) 0.2 (B) 0.45 (C) 0.6 (D) 0.8
4. Determine % labelling of oleum solution.
   (A) 104.5 (B) 106 (C) 109 (D) 110

Answers :

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

PREVIOUS YEARS SOLVED EXAMPLES

Q.1 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]**

Ans. 5×10^{-19} m^2

Sol. Final molarity = 0.5 – 0.49 = 0.01 M

mole = M × v = $0.01 \times \frac{100}{1000} = 10^{-3}$

no of molecule = moles × N_A = $10^{-3} \times N_A = 6.02 \times 10^{20}$

1 gm contain charcoal = 3.01×10^2 m^2

6.02×10^{20} molecule of acetic acid absorbed charcoal = 3.01×10^2

1 molecule of acetic acid adsorbed charcoal = 3.01×10^2 m^2

6.02×10^{20} molecule of acetic acid absorbed charcoal = 3.01×10^2

1 molecule of acetic acid adsorbed charcoal = $\frac{3.01 \times 10^2}{6.02 \times 10^{20}} = 5 \times 10^{-19}$ m^2

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

Ans. 55.5 mol L^{-1}

Sol. $M = \frac{1000}{MW} = \frac{1000}{18} = 55.5$

Q.3 6.02×10^{21} molecules of urea are present in 100 ml of its solution. The concentration of urea solution is - **[AIEEE-2004]**

(A) 0.001 M (B) 0.01 M (C) 0.02 M (D) 0.1 M

Ans. (D)

Moles of urea $= \frac{6.02 \times 10^{21}}{6.02 \times 10^{23}} = \frac{1}{100}$

Molarity = $\frac{1000}{100 \times 100} = 0.1$ M

EXERCISE # S-I

CONCENTRATION TERMS

Q.1 Calculate the molarity of the following solutions :

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

CT0001

(b) 5.3 g of anhydrous sodium (Na_2CO_3) carbonate is dissolved in 100 mL of solution.

CT0001

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

CT0001

Q.2 Density of a solution containing 13% by mass of sulphuric acid is 0.98 g/mL. Then molarity of solution will be

CT0002

Q.3 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

CT0003

Q.4 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 2.1 ppm of lithium ions. If the molality of Li^+ is $x \times 10^{-4}$ m, then find x. (Li = 7)

CT0004

Q.5 A 7.0 M solution of KOH in water contains 28% by mass of KOH. What is density of solution in gm/ml ? (K = 39)

CT0005

Q.6 The concentration of a solution is 8% (w/w) and 10% (w/v). Calculate density (in gm/mℓ) of solution?

CT0006

Q.7 The mole fraction of solute in aqueous urea solution is 0.2. Calculate the mass percent of solute ?

CT0007

Q.8 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. If the molarity of solution is $x \times 10^{-3}$ M then find x ?

CT0008

Q.9 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)

CT0009

Q.10 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.

CT0010

PROBLEMS RELATED WITH MIXING & DILUTION

Q.11 Find out the volume (L) of 98% w/w H_2SO_4 (density = 1.8 gm/ ml), must be diluted to prepare 12.6 litres of 2.0 M sulphuric acid solution.

CT0011

Q.12 500 ml of 2 M NaCl solution was mixed with 200 ml of 1/4 M NaCl solution. Calculate the molarity of NaCl in final solution.

CT0012

Q.13 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 is :

CT0013

Q.14 500 gm of urea solution of mole fraction 0.2 is diluted to 1500 gm. Calculate the mole fraction of solute in the diluted solution ?

CT0014

Q.15 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 ?

CT0015

Q.16 What volume (in mℓ) 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 ?

CT0016

Q.17 A solution containing 200 ml 0.5 M KCl is mixed with 50 ml 19% w/v $MgCl_2$ and resulting solution is diluted 8 times. Molarity of chloride ion is final solution is :

CT0017

SOME TYPICAL CONCENTRATION TERMS

Q.18 An oleum sample is labelled as 118 %, Calculate

(i) Mass of H_2SO_4 (gm) in 100 gm oleum sample. **CT0018**

(ii) Maximum mass of H_2SO_4 (gm) that can be obtained if 30 gm sample is taken. **CT0018**

Q.19 A mixture is prepared by mixing 10 gm H_2SO_4 and 40 gm SO_3. Calculate

(a) mole fraction of H_2SO_4 **CT0019**

(b) % labelling of oleum **CT0019**

Q.20 500 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?

CT0020

Q.21 The volume strength of 100 ml H_2O_2 solution which produce 5.6 litre of oxygen gas at 1 bar & 0ºC.

CT0021

EXERCISE # S-II

Q.1 What volume of 0.2 M NaOH (in L) 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.

CT0022

Q.2 How much minimum volume (in L) of $\left(\frac{5}{51}\right)$ M aluminium sulphate solution should be added to excess calcium nitrate to obtain atleast 1 gm of each salt in the reaction.

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

CT0023

Q.3 One litre of milk weighs 1.035 kg. The butter fat is 4% (v/v) of milk and has density of 875 kg/m^3. If the density of fat free skimed milk is 'x' gm/L, the value of (x) is ?

CT0024

Q.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}.

CT0025

Q.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 mass of alcohol (in gm) in original sample.

CT0026

Q.6 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.

CT0027

Q.7 Determine the volume (in L) of diluted nitric acid (d = 1.11 g mL^{-1}, 20% w/v HNO_3) that can be prepared by diluting 50 mL of conc. HNO_3 with water (d =1.42 g mL^{-1}, 70% w /v).

CT0028

Q.8 50 ml of '20V' H_2O_2 is mixed with 200 ml, '10V' H_2O_2. The volume strength of resulting solution is

CT0029

Q.9 500 ml of 0.90M CH_3COOH solution is mixed with 600 ml 12% w/v CH_3COOH solution then calculate the final molarity of solution.

CT0030

Q.10 45.4 V H_2O_2 solution (500 ml) when exposed to atmosphere looses 11.2 litre of O_2 at 1 atm, & 273 K. New molarity of H_2O_2 solution (Assume no change in volume)

CT0031

EXERCISE # O-I

Q.1 125 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) Acidic (B) Basic (C) Neutral (D) Can not be predicted

CT0032

Q.2 The molarity of pure water is :

(A) 100 M (B) 55.6 M (C) 50 M (D) 18M

CT0033

Q.3 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

CT0034

Q.4 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

CT0035

Q.5 The molarity of a solution of sodium chloride in water containg 5.85 gm of sodium chloride in 500 ml of solution is :-

(A) 0.25 M (B) 2.0 M (C) 1.0 M (D) 0.2 M

CT0036

Q.6 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

CT0037

Q.7 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

CT0038

Q.8 Equal weight of NaCl and KCl are dissolved separately in equal volumes of solutions. Molarity of the solutions will be –

(A) Equal (B) Greater for NaCl (C) Greater for KCl (D) Uncomparable.

CT0039

Q.9 How much water should be added to 200 cc of semimolar solution of NaOH to make it exactly decimolar?

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

CT0040

Q.10 100 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 M (B) 0.6 M (C) 0.4 M (D) 0.5 M

CT0041

Q.11 Molality of 20% (w/w) aq.glucose solution is :

(A) $\frac{25}{18}$ m (B) $\frac{10}{9}$ m (C) $\frac{25}{9}$ m (D) $\frac{5}{18}$ m

CT0042

Q.12 Molarity of liquid HCl, if density is 1.17 g/cc. :

(A) 36.5 M (B) 18.25 M (C) 32.05 M (D) 42.10 M

CT0043

Q.13. 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

CT0044

Q.14 Equal volumes of 10% (w/v) of HCl is mixed with 10% (w/v) NaOH solution. The resultant solution be.

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

CT0045

Q.15 What volume of 0.2M NaOH solution is needed for complete neutralisation of 0.49 gm orthophosphoric acid -

(A) 75 ml (B) 300 ml (C) 0.075 ml (D) 50 ml

CT0046

Q.16 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

CT0047

Q.17 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) $\frac{2}{700}$ M (B) $\frac{2}{350}$ M (C) $\frac{3}{350}$ M (D) $\frac{3}{700}$ M

CT0048

Q.18 20 ml of '20 vol' H_2O_2 solution is diluted to 80 ml. The final volume strength of solution is -

(A) '80 vol' (B) '25 vol' (C) '5 vol' (D) '8 vol'

CT0049

Q.19 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

CT0050

Q.20 Molarity and Molality of a solute (M. wt = 50) in aqueous solution is 9 and 18 respectively. What is the density of solution.

(A) 1 g/cc (B) 0.95 g/cc (C) 1.05 g/cc (D) 2 g/cc

CT0051

Q.21 The relationship between mole fraction (X_A) of the solute & molality 'm' of its solution in ammonia would be

(A) $\frac{55.56(X_A)}{1-X_A}$ =m (B) $\frac{58.82(X_A)}{1-X_A}$ = m (C) $\frac{58.82(1-X_A)}{X_A}$ =m (D) $\frac{55.56(1-X_A)}{X_A}$ =m

CT0052

Q.22 3.0 molal NaOH solution has a density of 1.12 g/mL. The molarity of the solution is-

(A) 2.97 M (B) 3 M (C) 3.05 M (D) 3.5 M

CT0053

EXERCISE # O-II

Q.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.

CT0054

Q.2 **Statement-1 :** Molarity and molality have almost same value for a very dilute aqueous solution.

Statement-2 : In all very dilute solution, the mass of solvent (in gm_) is equal to the volume of solution (in 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 true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

CT0055

Q.3 **Statement-1 :** The mass fraction of solute in a solution is always greater than its mole fraction.

Statement-2 : Mole fraction of solvent in an aqueous solution of ethanol must be greater than that of solute.

(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 true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

CT0056

Q.4 The molar concentration of HCl (aq.) is 10^{-5} M. Which of the following statements are correct.

($d_{solution}$ = 1 gm /cc)

(A) The mole fraction of HCl $\cong 1.8 \times 10^{-7}$

(B) The concentration of HCl in ppm is 3.65 ppm

(C) The molality of HCl solution is approximately 10^{-5} m

(D) The (w/v)% of solution is 3.65×10^{-5} %

CT0057

Q.5 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

CT0058

Q.6 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 $\mathbf{19 \times 10^4}$ **ppm**

CT0059

Q.7 A sample of H_2O_2 solution labelled as 56.75 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) $m_{H_2O_2} = \frac{1000}{72}$

CT0060

Q.8 100 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

CT0061

Comprehension Q.9 and Q.10 (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.

Q.9 The number of moles H_2SO_4 added are

(A) 1 (B) 2 (C) 3 (D) 0.5

CT0062

Q.10 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) $\frac{2}{5}$

CT0063

Comprehension Q.11 and Q.14 (4 questions)

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

i. **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.

Q.11 0.30 gm of an organic compound gave 82.1 ml of nitrogen collected at 300K and 775 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) 31.11 (B) 15.56 (C) 28.0 (D) 31.72

CT0064

Q.12 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 (C) 66 (D) 40

CT0065

Q.13 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 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) 45

CT0066

Q.14 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

CT0067

TABLE TYPE QUESTION

	Column-I		Column-II		Column-III
(A)	2 M - aqueous NaOH solution (density = 1.25 gm/ml)	(P)	2 mole solute/litre solution	(I)	6 % (w/v) solution
(B)	1.5 m - aqueous NaOH solution (density = 1.06 gm/ml)	(Q)	1.5 mole solute/litre solution	(II)	8 % (w/v) solution
(C)	0.5 M aqueous Glucose solution (density = 1.09 gm/ml)	(R)	0.5 mole solute/litre solution	(III)	9 % (w/v) solution
(D)	1.5 M aqueous Urea solution (density = 1.15 gm/ml)	(S)	1.5 mole solute/kg solvent	(IV)	9 gm solute per 100 gm solvent

Q.15 Which of the following is correct match ?
(A) A – i – II (B) B – ii – I (C) C – iii – IV (D) D – iv – iii

CT0068

Q.16 Which of the following is correct match ?
(A) A – i – II (B) B – iv – I (C) C – iii – I (D) D – ii – I

CT0068

Q.17 Which of the following is correct match ?
(A) A – ii – III (B) B – ii – III (C) C – ii – III (D) D – ii – III

CT0068

MATCH THE COLUMN :

Q.18 Match the column-

Column-I (Concentration of aqueous solution)	Column-II (Density of given solutions is 1.2 g/ml)
(A) 2M NaOH solution	(P) 16gm solute in 240gm solution
(B) $8\%\left(\frac{w}{V}\right)$ KOH solution	(Q) 60gm solute in 240 gm solution
(C) $25\%\left(\frac{w}{W}\right)$ $CaCO_3$ solution	(R) 8gm solute in 100 ml solution
(D) $X_{C_3H_7OH} = \frac{1}{11}$	(S) 30 gm solute in 100 ml solution
	(T) 1 mole solute in 400 gm solution

CT0069

Q.19 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)	1.76 M
(C)	Pure water	(R)	1.5 M
(D)	5% w/w NaOH ($d_{solution}$= 1.2 gm/ml)	(S)	55.5 M

CT0070

Q.20.

	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 → ($d_{solution}$ = 1.2 g/mL)	(S)	m = 1.85
		(T)	m = 0.617

CT0071

EXERCISE # J-MAINS

1. 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) **[JEE-Main(Jan)-2020]**

CT0072

2. 10.30 mg of O_2 is dissolved into a liter of sea water of density 1.03 g/mL. The concentration of O_2 in ppm is **[JEE-Main(Jan)-2020]**

CT0073

3. The ammonia (NH_3) released on quantitative reaction of 0.6 g urea (NH_2CONH_2) with sodium hydroxide (NaOH) can be neutralized by : **[JEE-Main(Jan)-2020]**

(A) 100 ml of 0.1 M HCl (B) 200 ml of 0.4 M HCl
(C) 100 ml of 0.2 M HCl (D) 200 ml of 0.2 M HCl

CT0074

4. 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 _____. **[JEE-Main(Jan)-2020]**
Atomic weight : Fe = 55.85 ; S = 32.0 ; O = 16.00

CT0075

5. The amount of sugar ($C_{12}H_{22}O_{11}$) required to prepare 2 L of its 0.1 M aqueous solution is :
(A) 68.4 g (B) 17.1 g **[JEE-Main(Jan.)-2019]**
(C) 34.2 g (D)136.8 g

CT0076

6. 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(Jan.)-2019]**
(A) 16 (B) 8 (C) 4 (D) 12

CT0077

7. 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(Jan.)-2019]**
(A) 0.167, 11.11 (B) 0.2, 22.20 (C) 0.2, 11.11 (D) 0.167,22.20

CT0078

8. The volume strength of 1M H_2O_2 is: (Molar mass of H_2O_2 = 34 g mol^{-1})
(A) 16.8 (B) 11.35 **[JEE-Main(Jan.)-2019]**
(C) 22.4 (D) 5.6

CT0079

9. 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]**
(A) 13.6% (B) 3.4% (C) 34% (D) 1.7%

CT0080

10. What would be the molality of 20% (mass/mass) aqueous solution of KI?
(molar mass of KI = 166 g mol^{-1}) **[JEE-Main(april)-2019]**
(A) 1.08 (B) 1.48 (C) 1.51 (D) 1.35

CT0081

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]**

(A) 13.88×10^{-1} (B) 13.88×10^{-2} (C) 13.88 (D) 13.88×10^{-3}

CT0082

12. The amount of $BaS0_4$ 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 = 137, Cl = 35.5, S=32, H = 1 and O = 16)

(A)33.2 g (B) 11.65 g (C) 23.3 g (D) 30.6 g

CT0083

13. 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 $\frac{M}{10}$ sulphuric acid. The unreacted acid required 20 mL of $\frac{M}{10}$ sodium hydroxide for complete neutralizaton. The percentage of nitrogen in the compound is : **[JEE(Main-online)-2014]**

(A) 3% (B) 5% (C) 6% (D) 10%

CT0084

14. 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]**

(A) 0.57 M (B) 5.7 M (C) 11.4 M (D) 1.14 M

CT0085

15. 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]**

(A) 2.18 m (B) 3.00 m (C) 2.60 m (D) 2.79 m

CT0086

16. 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 :- **[JEE-(Main)-2012]**

(A) 17.8 M (B) 15.7 M (C) 10.5 M (D) 12.0 M

CT0087

17. 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 **[JEE-(Main)-2012]**

(A) 2.05 M (B) 0.50 M (C) 1.78 M (D) 1.02 M

CT0088

18. 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]**

(A) 0.086 (B) 0.050 (C) 0.100 (D) 0.190

CT0089

EXERCISE # JEE-ADVANCED

Q.1 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 **[JEE 2019]**

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

CT0090

Q.2 A compound $\mathbf{H_2X}$ 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]**

CT0091

Q.3 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

(A) 1.78 M (B) 2.00 M (C) 2.05 M (D) 2.22 M **[JEE 2011]**

CT0092

ANSWER-KEY

EXERCISE # S-I

Q.1	(a) 0.50 M, (b) 0.50 M, (c) 0.20 M	Q.2	1.30 M
Q.3	16.66 or 16.67	Q.4	3.00
Q.5	1.40	Q.6	1.25
Q.7	45.45	Q.8	2.50
Q.9	13.00 gm	Q.10	0.66 or 0.67
Q.11	1.40	Q.12	1.50 M
Q.13	Ans.(0.80)	Q.14	0.05
Q.15	0.20 M	Q.16	5.55 or 5.56
Q.17	Ans. (0.15 M)	Q.18	(i) 20.00; (ii) 35.40
Q.19	(a) 0.16 or 0.17; (b) 118.00	Q.20	45.40 V
Q.21	Ans. (56.00 V)		

EXERCISE # S-II

Q.1	0.25	Q.2	0.02
Q.3	1.04	Q.4	0.50 M
Q.5	21.60	Q.6	0.05
Q.7	0.17 or 0.18	Q.8	Ans.(12.00 V)
Q.9	Ans.(1.50 M)	Q.10	Ans. (2.00 M)

EXERCISE O-I

Q.1	Ans.(A)	Q.2	Ans(B)	Q.3	Ans.(C)
Q.4	Ans(A)	Q.5	Ans(D)	Q.6	Ans(B)
Q.7	Ans.(B)	Q.8	Ans.(B)	Q.9	Ans.(C)
Q.10	Ans.(D)	Q.11	Ans. (A)	Q.12	Ans.(C)
Q.13.	Ans(C)	Q.14	Ans.(C)	Q.15	Ans.(A)
Q.16	Ans.(B)	Q.17	Ans.(A)	Q.18	Ans.(C)
Q.19	Ans.(B)	Q.20	Ans.(B)	Q.21	Ans.(B)
Q.22	Ans.(B)				

EXERCISE # O-II

Q.1	Ans.(B)	Q.2	Ans.(C)	Q.3	Ans.(D)
Q.4	Ans.(A,C,D)	Q.5	Ans.(A, C)	Q.6	Ans.(B, D)
Q.7	(B, D)	Q.8.	Ans.(A, C)	Q.9	Ans.(C)
Q.10	Ans.(C)	Q.11	Ans.(A)	Q.12	Ans.(B)

Q.13	**Ans. (C)**	**Q.14**	**Ans.(B)**	**Q.15**	**Ans.(A)**
Q.16	**Ans. (B)**	**Q.17**	**Ans.(D)**		

Q.18 Ans. (A)-P, R ; (B)- P, R ; (C) - Q, S, T ; (D) – S, Q

Q.19 Ans. (A) → Q; (B) → P,; (C) → S; (D) → R

Q.20. Ans. (A) →(P,Q,R,S) ; (B) →(Q,R,T) ; (C) →(Q,S) ; (D) →(P)

EXERCISE # J-MAINS

1.	**Ans.(14.00)**	**2.**	**Ans.(10)**	**3.**	**Ans(C)**
4.	**Ans. (4.95 to 4.97)**	**5.**	**Ans.(A)**	**6.**	**Ans.(C)**
7.	**Ans.(A)**	**8.**	**Ans.(A)**	**9.**	**Ans.(B)**
10.	**Ans.(C)**	**11.**	**Ans.(C)**	**12.**	**Ans.(B)**
13.	**Ans.(D)**	**14.**	**Ans.(A)**	**15.**	**Ans.(D)**
16.	**Ans.(A)**	**17.**	**Ans.(A)**	**18.**	**Ans.(A)**

EXERCISE # J-ADVANCE

Q.1	**Ans.(2.98 or 2.99)**	**Q.2**	**Ans.(8.00)**	**Q.3**	**Ans.(C)**