CHAPTER

Liquid Solutions

INTRODUCTION

Definition of Solution :-

When two or more chemically non-reacting substances are mixed and form homogeneous mixture is called solution.

When the solution is composed of only two chemical substances, it is termed as binary solution, similarly, it is called ternary and quaternary if it is composed of three and four components respectively.

For binary solution : Solution = solute + solvent

- Generally the component present in lesser amount than other component in solution is called solute.
- Generally, the component present in greater amount than any or all other components is called the solvent.
- Physical state of solvent and solution is same.

- A solution may be regarded as a single phase containing more than one component.
- For the solubility of solids in liquids, where the liquid is present in large excess over the solid, there is no ambiguity in these terms, the solid being the solute and the liquid being the solvent.

Solution	Solute + Solvent		
Solution	(B)	(A)	
moles	n/n _B	N/N _A	
mass	W _(g)	W _(g)	
molar mass	m	М	
mole fraction	XB	XA	

- Ex.1 In a syrup (liquid solution) containing 60 g sugar (a solid) and 40g water (a liquid) same aggregation as solution water is termed as the solvent.
- **Ex.2** In a solution of alcohol and water ; having 10 ml alcohol and 20 ml water, water is solvent and alcohol will be solute.

S.No.	Solute	Solvent	Example	
1	Gas	Gas	Air	
2	Gas	Liquid	Aerated water $(CO_2 + H_2O)$	
3	Gas	Solid	Hydrogen in palladium	
4	Liquid	Liquid	Alcohol in water, benzene in toluene	
5	Liquid	Solid	Mercury in zinc amalgam	
6	Solid	Liquid	Sugar in water, common salt in water	
7	Solid	Solid	Various alloys	
8	Solid	Gas	Camphor in N ₂	
9	Liquid	Gas	$CHCl_3 + N_2$	

• On the basis of amount of solute, solutions can be classified in two ways.

(a) Dilute Solution

A solution in which relatively a small amount of solute is dissolved in large amount of solvent is called a dilute solution.

(b) Concentrated solution

A solution in which relatively a large amount of the solute is present is called a concentrated solution.

Properties of a solution :

- (i) A solution is uniform throughout, so it has uniform properties such as density, refractive index etc.
- (ii) Size of solute particles in a solution is the less than $10^{-7} 10^{-8}$ cm is known as true solutions.
- (iii) The components of a solution can not be easily separated by physical methods.
- (iv) The properties of a solution are the properties of its components. i.e. the components do not lose their properties when they form a solution.
- (v) The composition of a solution is not definite but can vary within certain limits.
- (vi) Certain properties of solution such as density, viscosity, surface tension, boiling point, freezing point etc. vary with the composition of the solution.

CONCENTRATION TERMS :

NORMALITY (N) :

The number of equivalents or gram equivalents of solute dissolved in one litre of the solution is known as normality (N) of the solution.

 $= \frac{\text{Number of gram equivalents of solute(g)}}{\text{volume of solution in litre (L)}}$

Mass of solute (g) Equivalent mass × Volume of solution (L)

MOLARITY (M) :

The number of moles of solute present in one litre solution is called its molarity (M).

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

FORMALITY (F) :

It is the number of formula mass in grams present per litre of solution. Formality is generally used for solutions of ionic compounds.

Formality =

Mass of solute (g)

Formula mass of solute (g) × Volume of solution (L)

MOLALITY (M) :

The number of moles or gram molecules of solute dissolve in 1000 gram of the solvent is called molality of the solution.

Molality of a solution

- _ Number of moles of solute Amount of solvent(kg)
- Number of moles of solute ×1000 Amount of solvent(g)

Strength of a Solution (S) :

The mass of solute in g dissolved in 1L solution is known as its strength in gL^{-1} .

 $S = \frac{Mass of solute(g)}{volume of solution(L)}$

 $S = Molarity of solution \times Molar mass of solute.$

 $S = Normality of solution \times Equivalent mass of$ solute.

Concentration in of terms percentage

PERCENTAGE BY MASS (w/W) :

Mass of solute in (g) present in given mass of solution (g); is called mass fraction of the solute.

Thus, mass fraction =
$$\frac{W}{W+W}$$

Where 'w' grams of solute is dissolved in W grams of solvent.

Mass% = $\frac{\text{Mass of solute}(g) \times 100}{\text{Mass of solution}(g)} = \frac{\text{w} \times 100}{\text{w} + \text{W}}$

Mass % is independent of temperature.

PERCENT BY VOLUME (v/V) :

This method is used for solutions of liquid in a liquid. The volume of liquid (solute) in ml dissolved in given volume of solution in ml is called volume fraction.

Volume fraction = $\frac{\text{Volume of liquid solute (mL)}}{\text{volume of solution (mL)}}$ Volume $\% = \frac{\text{Volume of solute} \times 100}{\text{Volume of solution}}$

PERCENT BY STRENGTH/ PERCENTAGE MASS BY VOLUME

(w/V):

 $\binom{w}{V} = \frac{\text{Mass of solute}(g) \times 100}{\text{Volume of solution}(ml)} = \frac{w \times 100}{V}$

PARTS PER MILLION (PPM) :

This method is used for expressing the concentration of very dilute solutions such as hardness of water, air pollution etc.

ppm of substance (by mass)

$$= \frac{\text{Mass of solute in gms} \times 10^6}{\text{Mass of solution(g)}}$$

ppm (by volume) = $\frac{\text{Volume of solute} \times 10^{6}}{\text{volume of solution}}$

ppm $\left(by \frac{w}{V}\right) = \frac{\text{mass of solute(g)}}{\text{volume of solution(mL)}} \times 10^{6}$

MOLE FRACTION :

The ratio of the number of moles of one component to the total number of moles of all the components present in the solution, is called the mole fraction of that component.

Mole fraction of solute

$$X_B = \frac{\text{moles of solute(n)}}{\text{mole of solute(n)+moles of solvent (N)}}$$

Mole fraction of solvent

$$X_{A} = \frac{\text{moles of solvent(N)}}{\text{mole of solute(n)+moles of solvent (N)}}$$

$$\frac{X_A + X_B = 1}{\frac{X_A}{X_B} = \frac{N_A}{n_B}}$$

RELATION BETWEEN MOLARITY AND Condition of dilution : NORMALITY :

 $S = Molarity \times Molar mass of solute and$ $S = Normality \times Equivalent mass of solute.$ So we can write $Molarity \times Molar mass of solute =$ $Normality \times Equivalent weight of solute.$ $Normality = \frac{Molarity \times Molar mass of solute}{Equivalent mass of solute}$ $= \frac{Molarity \times Molar mass of solute}{(Molar mass of solute / valency factor)}$

Normality = Molarity × Valency factor $N = M \times n$ factor ; $N \ge M$ because valency factor ≥ 1

RELATION BETWEEN MOLALITY (m) AND MOLE FRACTION :

$$\begin{aligned} \frac{x_{B}}{x_{A}} &= \frac{n_{B}}{N_{A}} = \frac{n_{B} \times M_{A} \times 1000}{w_{A} \times 1000} \\ \frac{x_{B}}{x_{A}} &= \frac{\text{molality} \times M_{A}}{1000} \\ \frac{x_{B}}{1 - x_{B}} &= \frac{\text{molality} \times M_{A}}{1000} : \text{ If } x_{B} <<<1 \text{ for very} \\ \text{dilute } x_{B} &= \frac{\text{molality} \times M_{A}}{1000} \end{aligned}$$

RELATION BETWEEN MOLALITY (m) AND MOLARITY (M) :

 $m = \frac{M \times 1000}{(d \times 1000) - (M \times m.w.)}$

d = density of solution m.w. = molecular weight of solute

CONCEPTS OF DILUTION :

The term dilution means addition of a solvent in a solution, where following remains unchanged after dilution and before dilution

- \bullet amount of solute (w_{B})
- \bullet moles of solute (M \times V)
- \bullet Number of gram equivalent of solute (N \times V)

$$\begin{split} & \mathsf{M}_1\mathsf{V}_1 = \mathsf{M}_2\mathsf{V}_2 \\ & \mathsf{N}_1\mathsf{V}_1 = \mathsf{N}_2\mathsf{V}_2 \end{split}$$

CONCEPTS OF MIXING OF SOLUTIONS

Case I : When acid-acid or base-base are mixed.

$$N_{R} = \frac{N_{1}V_{1} + N_{2}V_{2} + N_{3}V_{3} + \dots}{V_{1} + V_{2} + V_{3} + \dots}$$

Case II : Concept of neutralisation (when acidbase are mixed) then neutralisation will occur.

(i) Complete neutralisation

$$\frac{\mathsf{N}_{\mathsf{A}}\mathsf{V}_{\mathsf{A}} = \mathsf{N}_{\mathsf{B}}\mathsf{V}_{\mathsf{B}}}{\mathsf{B} \to \mathsf{Base}}; \left[\mathsf{N}_{\mathsf{R}} = \frac{\mathsf{N}_{\mathsf{A}}\mathsf{V}_{\mathsf{A}}}{\mathsf{V}_{\mathsf{A}} + \mathsf{V}_{\mathsf{B}}}\right]$$

where N_R is the normality of salt.

(ii) Incomplete neutralisation

 $\left[N_{R}=\frac{N_{A}V_{A}\sim N_{B}V_{B}}{V_{A}+V_{B}}\right]$ where N_R is the normality

of resultant acid or base.

Golden Key Points :

- If the density of solution is approximately 1g/cc then Molality > Molarity
- ppm unit is used to represent concentration of very dilute solutions like pollutants in environment and salts present in sea water.
- Those concentration terms which involves volume of solution are temperature dependent.
 - Molarity, normality, formality, % by volume, % w/V, are temperature dependent.
 - Molality, % w/W, mole fraction are temperature independent.

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Concept Application Exercise-1

 What will be the molarity of a solution containing 50g of Nacl in 500g of a solution and having a density of 0.936g/cm³ :

(1) 1.5 M	(2) 1.6 M
(3) 1.8 M	(4) 1.2 M

The density (in g mL⁻¹) of a 3.6M sulphuric acid solution, i.e., 29% H₂SO₄ (molar mlass = 98 g mol⁻¹) by mass will be :

(1) 1.45	(2) 1.64
(3) 1.88	(4) 1.22

3. 1 litre solution containing 49g of sulphuric acid is diluted to 10 litre with water. What is the normality of the resulting solution?

(1) 0.5 N	(2) 1.0 N
(3) 5.0 N	(4) 10.0 N

4. Mole fraction of the solute in a 1 molal aqueous solution is :

(1) 1.77	(2) 0.177
(3) 0.0177	(4) 0.0344

5. A solution of CaCl₂ is 0.5 mol/litre ; then the moles of chloride ion in 500 mL will be :

(1) 0.5	(2) 0.25M
(3) 1.0	(4) 0.75

6. 0.63 g of dibasic acid was dissolved in water. The volume of the solution was made 100 mL. 20mL of this acid solution required 10 mL N/5 NaOH solution. What is the molecular mass of the acid? (1) 63 (2) 126 (3) 252 (4) 128

An aqueous solution of 6.3g of oxalic acid dihydrate is made upto 250 mL. The volume of 0.1N NaOH required to completely neutralize 10mL of this solution is :

(1) 40 mL	(2) 20 mL
(3) 10 mL	(4) 4 mL

The volume of 0.1 N HCl required to neutralize completely 2g of equimolar mixture of Na₂CO₃ and NaHCO₃ is:

(1) 316 mL	(2) 158 mL
(3) 632 mL	(4) 237 mL

ANSWER KEY								
Que.	1	2	3	4	5	6	7	8
Ans.	2	4	1	3	1	2	1	1

SOLUBILITY

Maximum amount of solute which can be dissolved in a specified amount of solvent at constant temperature is solubility. Solubility is affected by nature of solute and solvent as well as by temperature and pressure.

(a) Solubility of Solid in Liquid :

Polar solutes are soluble in polar solvent and non polar solutes are soluble in non polar solvent due to similar intermolecular forces.

When solid solutes are dissolved in solvent then following equilibrium exists.

Solute + Solvent

Solubility of solids is affected by temperature and pressure according to Le-chatlier's principle. If dissolution is exothermic then solubility decreases with increase in temperature and if endothermic then solubility increases with increase in temperature.

Solubility of solids is not affected by pressure significantly since solids are highly incompressible.

(b) Solubility of Gases in Liquid :

Certain gases are highly soluble in water like NH₃, HCl etc. and certain gases are less soluble in water like O₂, N₂, He etc. Solubility of gases is affected by pressure and temperature. Increasing pressure increases solubility and increase in temperature decreases solubility. During dissolution of gas pressure of gas decrease and dissolution of gas is exothermic in nature.

HENRY'S LAW

It can be stated at constant temperature the solubility of a gas in a liquid is directly proportional to the partial pressure of the gas present above the surface of liquid or solution.

or

Mole fraction of gas in the solution is proportional to the partial pressure of the gas over the solution.

or

The partial pressure of the gas in vapour phase (P) is proportional to the mole fraction of the gas (X) in the solution. (This is most common definition)

 $P = K_H X$

K_H = Henry's Constant

Henry's Constant is not a universal constant. It depends on nature of gas and temperature. $K_{\rm H}$ increases with increase in temperature therefore solubility of gas decreases.

APPLICATION OF HENRY'S LAW

- 1. Soft drink bottles are sealed at high pressure, to increase the solubility of CO₂ in the soft drink.
- 2. At high altitude, partial pressure of oxygen is low, it leads to low concentration of oxygen in blood of people living there. Low concentration of oxygen develops anoxia, i.e. unable to think and act properly.

- 3. When scuba divers go deep in the sea, solubility of atmospheric gases increases in blood. when the dives come up, there is release of dissolved gases and it leads to the formation of bubles of nitrogen in our blood cpaillaries and hence therew is painful sensation called bends. To avvoid bends ; the tanks of scuba divers are filled with 11.7% He, 56.2% N₂ and 32.1% oxygen.
- (i) Gases are less soluble in aquesous solutions of electrolytes than in pures water. It is called salting out effect.
- (ii) Non-electrolytes such as sugar if present in a solution also reduce the solubility of gases in water.

VAPOUR PRESSURE :

At a constant temperature, the pressure exerted by the vapours of a liquid on its surface when they (liquid and its vapours) are in equilibrium, is known as vapour pressure.

Factor affecting vapour pressure :

- (a) Nature of liquid
- (b) Temperature

RAOULT'S LAW

(a) For liquid – liquid system : For a solution of volatile liquids the partial vapour pressure of any component at constant temperature is equal to vapour pressure of pure component multiplied by mole fraction of that component in the solution.

	Liquid (B)	Liquid (A)		
Vapour pressure in pure state	P_B^{0}	P_A^{0}		
Partial vapour pressure	P _B	P _A		
Mole fraction in solution	X _B	X _A		
Moles	n moles	N moles		
Mass	w gm	W gm		
Molar mass	m	М		
$P_A \propto X_A$ so $P_A = P_A^0 X_A$ (i)				
$P_B \propto X_B$ so $P_B = P_B^0 X_B$ (ii)				

At constant temperature partial vapour pressure of component is directly proportional to mole fraction of component in solution.

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According to Dalton's law given below :

 $P_{total} = P_A + P_B + \dots$ For 2 components

$$\begin{array}{|} \hline P_{s} = X_{A}P_{A}^{0} + X_{B}P_{B}^{0} \\ \hline P_{S} = (1 - X_{B}) P_{A}^{0} + X_{B} P_{B}^{0} \\ \hline P_{S} = P_{A}^{0} - X_{B}P_{A}^{0} + X_{B}P_{B}^{0} \\ \hline P_{S} = P_{A}^{0} + X_{B}(P_{B}^{0} - P_{A}^{0}) \end{array}$$



DALTAN'S LAW :

Partial pressure of gas = mole fraction × total pressure of gas

$$\begin{split} P_{A} &= Y_{A}P_{T} \\ P_{B} &= Y_{B}P_{T} \\ P_{A} + P_{B} &= P_{T} \\ \hline \\ \hline X_{A}P_{A}^{0} &= Y_{A} \end{split}$$

 $X_{\rm B} P_{\rm B}^0 = Y_{\rm B} P_{\rm T}$

 Y_A and Y_B are mole fraction in vapour phase (Where $P_T = P_S$)

X_A and Y_B gives mole fraction in liquid phase.

(b) For solid-liquid system : non-volatile solute (B) and volatile solvent (A) $P_B^0 = 0$ $P_S = X_A P_A^0 + X_B P_B^0$

$$P_{S} = X_{A}P_{A}^{0} P_{S} = \frac{N}{n+N}P_{A}^{0}$$

 $P_A{}^0$ = constant at constant temperature so $P_s \propto X_A$ For solution of non-volatile solute : At constant temperature vapour pressure of solution containing

non-volatile solute is proportional to mole fraction of solvent.

$$\begin{split} &\mathsf{P}_{S} \propto \frac{\mathsf{N}}{\mathsf{n} + \mathsf{N}} \\ &X_{A} + X_{B} = 1 \hspace{0.2cm} ; \hspace{0.2cm} \mathsf{P}_{S} = \left(1 - X_{B}\right)\mathsf{P}_{A}^{0} \hspace{0.2cm} ; \\ &\mathsf{P}_{S} = \mathsf{P}_{A}^{0} - X_{B}\mathsf{P}_{A}^{0} \\ &X_{B}\mathsf{P}_{A}^{0} = \mathsf{P}_{A}^{0} - \mathsf{P}_{S} \hspace{0.2cm} ; \hspace{0.2cm} \frac{\mathsf{P}_{A}^{0} - \mathsf{P}_{S}}{\mathsf{P}_{A}^{0}} = X_{B} = \hspace{0.2cm} \frac{\mathsf{n}}{\mathsf{n} + \mathsf{N}} \\ &\mathsf{P}_{A}^{0} - \mathsf{P}_{S} = \Delta\mathsf{P} \hspace{0.2cm} (\text{lowering of vapour pressure}) \\ & \frac{\mathsf{P}_{A}^{0} - \mathsf{P}_{S}}{\mathsf{P}_{A}^{0}} = \text{relative lowering of vapour pressure.} \end{split}$$

- When a non-volatile solute is added to a volatile liquid its vapour pressure decrease because less number of solvent particles present in solution at surface. (as compare to pure solvent)
- : less vapour is formed and vapour pressure of solution decreases

$$\frac{P_A^0}{P_A^0 - P_S} = \frac{n+N}{n}; \frac{P_A^0}{P_A^0 - P_S} = 1 + \frac{N}{n}; \frac{P_A^0 - P_A^0 + P_S}{P_A^0 - P_S} = \frac{N}{n}; \frac{P_S}{P_A^0 - P_S} = \frac{N}{n}$$
$$\frac{\frac{P_A^0 - P_S}{P_S} = \frac{N}{N}}{P_S}; \Delta P \propto \frac{N}{N}$$

IDEAL SOLUTION (mixture of	Non-ideal Solution		
two liquids A and B)	Positive deviation from Raoult's	Negative deviation from	
	law.	Raoult's Law	
1. A solution which obeys Raoult's law	Those solutions which do not	Those solutions which do not	
exactly at all concentrations and at all	obey Raoult's law are called non-	obey Raoult's law are called	
temperatures is called an ideal	ideal solutions.	non-ideal solutions.	
solution.			
2. A-A interaction = B - B interaction	In these solutions A-B interaction	In these solutions A-B	
= A - B interaction.	are less than A-A and B-B	interaction are stronger than	
There should be no chemical reaction	molecular interaction.	A-A and B-B molecular	
between liquid A and liquid B.	$P_{A} > P_{A}^{0}X_{A}; P_{B} > P_{B}^{0}X_{B}$	interactions.	
		$P_A < P_A^0 X_A ; P_B < P_B^0 X_B$	
3. Volume change on mixing should	$\Delta V_{mix} > 0$; volume increase after	$\Delta V_{mix} < 0$; volume decreases	
be zero. $\Delta V_{mix} = 0$	dissolution.	during dissolution.	
4. Heat change on mixing should be	$\Delta H_{mix} > 0 ;$	$\Delta H_{mix} < 0$;	
zero. $\Delta H_{mix} = 0$	endothermic dissolution;	exothermic dissolution;	
(Heat is neither absorbed nor evolved)	heat is absorbed.	heat is evolved.	
5.observed VP = calculated VP	The total vapour pressure of the	Total vapour pressure is less	
	solution will be greater than the	than sum of individual	
	corresponding vapour pressure	vapour pressure.	
	expected in case of an ideal	$P_{\text{total}} < (P_{\text{A}}^{0}X_{\text{A}} + P_{\text{B}}^{0}X_{\text{B}})$	
	solution of same composition, i.e.		
	$P_{\text{total}} > (P_{\text{A}}{}^{0}X_{\text{A}} + P_{\text{B}}{}^{0}X_{\text{B}})$		
6.observed BP = calculated BP	$(B.P.)_{th} > (B.P.)_{exp}$	$(B.P.)_{th} < (B.P.)_{exp}$	
7. $\Delta S_{mix} > 0$	$(\Delta S)_{mix} = +ve,$	$(\Delta S)_{mix} = +ve,$	
8. $\Delta G < 0$	$\Delta G = -ve$	$\Delta G = -ve$	
9. Examples :	Examples :	Examples:	
(i) Benzene and toluene	(i) Ethanol and cyclohexane	(i) CHCl ₃ and CH ₃ COOH ₃	
(ii) CCl ₄ and SiCl ₄	(ii) Ethanol and Water	(ii) CHCl ₃ and C ₆ H ₆	
(iii) n-hexane and n-heptane	(iii) Ethanol and Acetone	(iii) CHCl ₃ and $C_2H_5OC_2H_5$	
(iv) C ₂ H ₅ Br and C ₂ H ₅ Cl	(iv) Methanol and H ₂ O	(iv) CHCl ₃ and HNO ₃	
(v) PhCl and PhBr	(v) CCl ₄ and Benzene	(v) CHCl ₃ and CH ₃ COOH	
(vi) n-butylchloride and	(vi) CCl ₄ and Toluene	(vi) H_2O and HCl	
n-butylbromide	(vii) CCl ₄ and CHCl ₃	(vii) H ₂ O and HNO ₃	
	(viii) CCl ₄ and Methanol	(viii) CH ₃ COOH and CH ₃ OH	
	(ix) Benzene and Acetone	(ix) CH ₃ COOH and C ₅ H ₅ N	
	(x) CS_2 and Acetone	(x) CH ₃ COOH ₃ and Aniline	
	(xi) CS ₂ and Acetaldehyde		

IDEAL SOLUTION :



NON IDEAL HAVING SOLUTIONS **POSITIVE DEVIATION:**



IDEAL SOLUTIONS HAVING NON **NEGATIVE DEVIATION:**



AZEOTROPIC MIXTURE :

Some liquids on mixing, form azeotropes which are binary mixtures having the same composition in liquid and vapour phase and boil at a constant temperature.

Components form azeotrope can't be separated by fractional distillation but can be separated by azeotropic distillation.

Solutions showing Positive deviation form minimum boiling azeotrope and solutions showing negative deviation form maximum boiling azeotrope.

There are two types of azeotropes :

- (a) Minimum boiling azeotrope
- (b) Maximum boiling azeotrope
- The solutions which show a large positive (a) deviation from Raoul'ts law from minimum boiling azeotrope at a specific composition. For example, ethanol-water mixture (obtained by fermentation of sugars) on fractional distillation gives a solution containing approximately 95.57% w/W ethanol.
- (b) The solutions that show large negative deviation from Roult's law form maximum boiling azeotrope at a specific composition. Nitric acid and water is an example of this class of azeotrope. This azeotrope has the approximate composition, 68% nitric acid and 32% water by mass, with a boiling point of 393.5K.

Golden Key points :

- Those gases which can react with solvent do not follow Henry's Law. e.g. NH₃ in water.
 - Raoul'ts law is special case of Henry's Law.
- ΔS is positive and ΔG is negative for ideal as well as non ideal solutions.
- The vapour phase is richer in more volatile component than the less volatile component. This is called as Konowaloff's rule.

Concept Application Exercise-2

1. Henry's law constant for oxygen dissolved in water is 4.34×10^4 atm at 25°C. If the partial pressure of oxygen in air is 0.4 atm. Calculate the concentration (in moles per litre) of the dissolved oxygen in water in equilibrium with air at 25°C. (1) 5.11×10^{-4} (2) 5.11 \times 10⁻³

(3) 9.2×10^{-6} ((4) 0.92×10^{-6}

Vapour pressure of pure A $(p_A^o) = 100 \text{ mm Hg}$ Vapour pressure of pure B $(p_B^{o}) = 150 \text{ mm Hg}$ 2 mol of liquid A and 3 mol of liquid B are mixed to form an ideal solution. The vapour pressure of solution will be :

(1) 185 mm	(2)	130	mm
(3) 148 mm	(4)	145	mm

(4) 145 mm

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3. The vapour pressure of pure benzene at 88°C is 957 mm and that of toluene at the same temperature is 379.5 mm. The composition for benzene-toluene mixture boiling at 88°C will be

(1) $x_{benzene} = 0.66$; $x_{toluene} = 0.34$

(2) $x_{\text{benzene}} = 0.34$; $x_{\text{toluene}} = 0.66$

(3)
$$X_{\text{benzene}} = X_{\text{toluene}} = 0.5$$

- (4) $x_{benzene} = 0.75$; $x_{toluene} = 0.25$
- 4. An aqueous solution containing 28% by mass of liquid A (mol. mass = 140) has a vapour pressure of 160mm at 30°C. Find the vapour pressure of the pure liquid A. (The vapour pressure of water at 30°C is 150 mm)

5. Mole fraction of component A in vapour phase is x_1 and that of component A in liquid mixture is x_2 ; then ($p_A^o =$ vapour pressure of pure A; $p_B^o =$ vapour pressure of pure B), the total vapour pressure of liquid mixture is:

(1)
$$p_{A^{o}} \frac{x_{2}}{x_{1}}$$
 (2) $p_{A^{o}} \frac{x_{1}}{x_{2}}$
(3) $p_{B^{o}} \frac{x_{1}}{x_{2}}$ (4) $p_{B^{o}} \frac{x_{2}}{x_{1}}$

6. At 80°C, the vapour pressure of pure liquid A is 520mm Hg and that of pure liquid B is 1000mm Hg. If a mixture of solution A and B boils at 80°C and 1 atm pressure, the amount of A in the mixture is (1 atm = 760 mm Hg)

7. Mixture of volatile components A and B has total vapour pressure (in torr) : $P_{total} = 254 - 119x_A$. where x_A is the mole fraction of A in mixture. Hence p_A^o and p_B^o are (in torr) :

(1) 254, 119	(2) 119, 254
(3) 135, 254	(4) 154, 119

- Negative deviations from Raoult's law are exhibited by binary mixtures :
 - (1) in which the molecules tend to attract each other and hence their escape into the vapour phase is retarded.
 - (2) in which the molecules tend to repel each other and hence their escape into the vapour phase is retarded.
 - (3) in which the molecules tend to attract each other and hence their escape into the vapour phase is speeded.
 - (4) in which the molecules tend to repel each other and hence their escape into the vapour phase is speeded up.

The vapour pressure of pure benzene C_6H_6 at 50°C is 268 torr. How may moles of non-volatile solute per mole of benzene are required to prepare a solution of benzene having a vapour pressure of 167 torr at 50°C?

(1) 0.377	(2) 0.605
(3) 0.623	(4) 0.395

Two liquids A and B have vapour pressure in the ratio of p_A^o ; $p_B^o = 1 : 2$ at a certain temperature. Suppose we have an ideal solution of A and B in the mole fraction ratio A : B = 1 : 2. What would be the mole fraction of A in the vapour in equilibrium with the solution at a given temperature?

ANSWER KEY							
Que.	1	2	3	4	5	6	7
Ans.	1	2	1	2	1	1	3
Que.	8	9	10				
Ans.	1	2	2				

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COLLIGATIVE PROPERTIES OF (b) Elevation in Boiling Point : DILUTE SOLUTIONS (CP) : • The boiling point of a liquid is t

Those physical properties of a solution which depends upon the relative number of particles of solute and do not depend on nature of solute particles; are called colligative properties.

 $CP \propto$ Number of solute particles.

 ∞ Number of molecules (In the solution of non electrolyte)

 ∞ Number of ions (In the solution of electrolytes)

- ∞ Number of moles of solute
- ∞ Mole fraction of solute

The following four properties are (CP) :

(a) Relative lowering in vapour pressure of solvent

(b) Elevation in boiling point (ΔT_b) of solvent

(c) Depression in freezing point (ΔT_f) of solvent

(d) Osmotic pressure (π or P) of solution

(a) Relative Lowering in Vapour Pressure :

• When a nonvolatile solute is dissolved in a pure solvent, the vapour pressure of the solvent is lowered i.e. the vapour pressure of a solution is always lower than that of pure solvent, because the escaping tendency of solvent molecules decreases (due to lesser solvent molecules per unit surface area).

If at a certain temperature P° is the vapour pressure of pure solvent, and P_s is the vapour pressure of solution then

According the Raoult's law :

Relative lowering of vapour pressure =

$$\frac{\mathsf{P}_{\mathsf{A}}^{0}-\mathsf{P}_{\mathsf{S}}}{\mathsf{P}_{\mathsf{A}}^{0}}=\frac{\mathsf{n}_{\mathsf{B}}}{\mathsf{N}_{\mathsf{A}}+\mathsf{n}_{\mathsf{B}}}$$

For a dilute solution $n_B << N_A$

$$\frac{P_{A}^{0} - P_{S}}{P_{A}^{0}} \approx \frac{n_{B}}{N_{A}} \text{ So } \Delta P \propto \frac{n_{B}}{N_{A}}$$

• Relative lowering depends upon relative number of solute particles. Therefore it is called colligative properties.

- The boiling point of a liquid is that temperature at which its vapour pressure becomes equal to atmospheric pressure.
- When a non-volatile solute is dissolved in a pure solvent, its vapour pressure is decreased and boiling point increases. The difference of boiling points of the solution and pure solvent is called elevation in boiling point. (Δ T_b)
- If T⁰_b is the boiling point of pure solvent and (T_b) is the boiling point of the solution then, T_b > T_b⁰ and the elevation in boiling point Δ T_b = (T_b)-T_b⁰
- The elevation in boiling point (ΔT_b) is directly proportional to lowering of vapour pressure of the solution i.e.





$$\Delta T_b \propto (P^0 - P_s)$$
 from graph and

$$\Delta T_{b} \propto \Delta P \propto \frac{n_{B}}{N_{A}}$$

$$\therefore \quad \Delta T_{b} \propto \frac{n_{B}}{N_{A}} = \frac{w_{B}M_{A}}{m_{B}W_{A}}$$

for a solvent P^0 & M_A = constant

$$\therefore \quad \Delta T_{\rm b} \propto \frac{W_{\rm B}}{m_{\rm B}W_{\rm A}}$$

or
$$\Delta T_{b} = \frac{KW_{B}}{m_{B}W_{A}}$$

where K = elevation constant

if
$$\frac{W_B}{m_B} = 1$$
 mole and $W_A = 1$ g

then $\Delta T_b = K$ (Elevation constant or molecular elevation constant)

....

If
$$\frac{W_B}{M_B} = 1$$
 and $W_A = 1000$ gram ; Then ΔT_b

= K_b(molal elevation constant)

$$\therefore \frac{K}{1000} = K_{b} \text{ (molal elevation constant or}$$

Ebullioscopic constant)

$$\Delta T_{\rm b} = \frac{K_{\rm b} \times w_{\rm B} \times 1000}{m_{\rm B} \times W_{\rm A}}$$

 $\Delta T_b = Molality \times K_b$

$$\therefore \Delta T_b \propto molality$$

Hence elevation in boiling point (ΔT_b) is a colligative property.

• K_b only depends on nature of solvent which can be explained by thermodynamic relation.

$$\boxed{K_{b} = \frac{RT_{b}^{0^{2}}}{1000L_{V}} = \frac{MRT_{b}^{0^{2}}}{1000\Delta H_{vap}}}$$

Where $T_b^0 =$ Boiling point of solvent.

M = Molar mass of solvent.

 ΔH_{vap} = Enthalpy of vapourisation per mole of solvent

 L_{v} = latent heat of vapourisation per gram of solvent

• The molal elevation constant for some common solvents are given in the following table

Solvant	B.P. (°C)	Molal elevation constant (K _b)
Water	100.0	0.52
Acetone	56.0	1.70
Chloroform	61.2	3.63
Carbon tetra chloride	76.8	5.03
Benzene	80.0	2.53
Ethyl alcohol	78.4	1.20



- The freezing point of a liquid is that temperature at which the liquid is that temperature at which the liquid and its solid state exist in equilibrium with each other.
- It may be defined as the temperature at which the liquid and solid states of a substance have the same vapour pressure.
- When a non-volatile is dissolved in a pure solvent the vapour pressure of the solvent is lowered.
- If T^{o}_{f} is the freezing point of pure solvent and T_{f} is freezing point of solution then, $T_{f} < T^{o}_{f}$
- The difference in the freezing point of pure solvent and solution is called depression of freezing point $(\Delta T_f) \Delta T_f = T^0_f - T_f$ The depression in freezing point is directly proportional to lowering in vapour pressure (ΔP)

$$\Delta T_{\rm f} \propto \Delta P \propto \frac{n_{\rm B}}{N_{\rm A}} ; \Delta T_{\rm f}$$

so $\Delta T_{\rm f} = K_{\rm f} \times \text{molality}$

- K_f = molal depression constant or Cryoscopic constant.
- K_f only depends on nature of solvent which can be explained by thermodynamic relation

$$K_{f} = \frac{RT_{f}^{0^{2}}}{1000L_{f}} = \frac{RT_{f}^{0^{2}}M}{1000\Delta H_{f}}$$

Where T_{f}^{0} = Freezing point of solvent M = Molar mass of solvent.

 ΔH_f = Enthalpy of fusion per mole of solvent

 $L_{\rm f}$ = latent heat of fusion per gram of solvent

(c) Depression in freezing point

• The molal depression constant for some common solvents are given in the following table :

Solvant	F.P. (°C)	Molal depression constant (K _f)
Water	0.0	1.86
Ethyl alcohol	-114.6	1.99
Chloroform	-63.5	4.79
Carbon tetra chloride	-22.8	31.80
Benzene	5.5	5.12
Camphor	179.0	39.70

(d) Osmosis and osmotic pressure : OSMOSIS – Osmosis is defined as the spontaneous net flow of solvent molecules through semipermeable membrane from a solvent to a solution or from a dilute solution to a concentrated solution.



Level of solution rises in the thistle funnel due to osmosis of solvent

OSMOTIC PRESSURE (p or π) –

• The external pressure which must be applied on the solution in order to stop the flow of the solvent into the solution through semipermeable membrane is equal to osmotic pressure.

or

• Hydrostatic pressure developed in a vertical column when solution and solvent are separated by SPM.

Osmotic pressure = hydrostatic pressure ; $\pi = hdg$

where h = increase in level in the tube of unit cross section.

- d = density of solution,
- g = acceleration due to gravity

Van't Hoff law for Dilute Solution :

According to it Gas equation PV = nRT is also followed by dilute solution when pressure of gas is replaced by osmotic pressure of solution.

$$PV = n RT$$

$$\downarrow \downarrow \qquad \downarrow$$

$$\pi V = n RT$$

 π = Osmotic pressure of solution (atm)

V = Volume of solution (L)

n = moles of solute

R = (S) gas constant / solution constant =

 $(0.0821 \text{ L atm} \text{ mol}^{-1} \text{ K}^{-1})$; 0.083 L bar mol^{-1} \text{K}^{-1}

$$\pi = \left(\frac{n}{V}\right) RT$$

 $\pi = CRT$

At constant temperature $\pi \propto C$

- \therefore π is a colligative property.
- On the basis of osmotic pressure solution can be classified by following ways :

Isotonic solutions : Solutions having same

osmotic pressure are called isotonic solution. $\pi_1 = \pi_2$; primary condition

 $C_1RT = C_2RT$ (at same temperature)

 $\boxed{C_1 = C_2}$ (secondary condition); means $\frac{n_1}{V_1} = \frac{n_2}{V_2}$

(ii) π_1

 $\pi_1 > \pi_2$ or $C_1 > C_2$ hence solution 1 is called hypertonic and solution 2 is called hypotonic.

Reverse Osmosis :

If external pressure, greater than osmotic pressure is applied, then flow of solvent molecules can be made to proceed from solution towards pure solvent, i.e., in reverse direction of the ordinary osmosis. Reverse osmosis is used for the desalination of sea water for getting fresh drinking water.





(i)

Golden Key points :

- (i) $\frac{\Delta P}{P^0} \approx \frac{n}{N} \Longrightarrow \Delta P = \frac{wM}{mW} \times P^0$ (ii) $\Delta T_b = \left(\frac{w \times 1000}{m \times W}\right) K_b$ (iii) $\Delta T_f = \left(\frac{w \times 1000}{m \times W}\right) K_f$ (iv) $\pi = CRT$
- Best method to determine molecular weight of biomolecules like protein and polymers is osmotic pressure. Because in this colligative property there is no temperature change is involved so there is no chance of change in nature of biomolecule.

In other methods changes are very less and it is difficult to measure very small changes accurately. But osmotic pressure can be easily measured at room temperature at which biomolecules remain in original state.

• 0.91 % $\left(\frac{W}{V}\right)$ NaCl solution is isotonic with

blood.

- Intravenous injections need to be isotonic with blood to prevent damage to RBC.
- Magnitude of osmotic pressure is independent with the nature of solvent.
- Ostwalds process is used to determine elevation in boiling point.
- Camphor is the best solvent for determination of molar mass of solute by using depression in freezing point since its K_f is very high.

Concept Application Exercise-3

1. Lowering of vapour pressure due to a solute in 1 molal aqueous solution at 100°C is

(1) 13.44 mm Hg	(2) 14.12 mm Hg
(3) 13.2 mm Hg	(4) 35.2 mm Hg

2. The vapour pressure of a dilute aqueous solution of glucose is 700 mm Hg at 370 K. Calculate the mole fraction of solute.

(1) 4.76	(2) 47.6
(3) 0.921	(4) 0.0789

- The relative lowering of the vapour pressure of an aqueous solution containing a non-volatile solute is 0.0125. The molality of the solution is (1) 0.80 (2) 0.50 (3) 0.70 (4) 0.40
- 4.

3.

Equal amounts of a solute are dissolved in equal amounts of two solvents A and B. The lowering of vapour pressure for solution A has twice the lowerning of vapour pressure for solution B. If Mw_A and Mw_B are the molecular weights of solvents A and B, respectively, then

5.

6.

7.

The diagram given below is a vapour-pressurecomposition diagram for a binary solution of A and B. In the solution, A –B interactions are :



(1) Similar to A–A and B–B interactions
 (2) Greater than A–A and B–B interactions
 (3) Smaller than A–A and B–B interactions

(4) Unpredictable.

On dissolving 0.25g of a non-volatile substance in 30 mL benzene (density 0.8g mL⁻¹), its freezing point decreases by 0.25°C. Calculate the molecular mass of non-volatile substance ($K_f =$ 5.1 K kg mol⁻¹)

(1) 21.333	(2) 213.33
(3) 170.664	(4) 17.0664

10.0 g of glucose (π_1), 10.0 g of urea (π_2) and 10.0 g of sucrose (π_3) are dissolved in 250.0 mL of water at 273K (π = osmotic pressure of a solution). The relationship between the osmotic pressure of the solution is

(1)
$$\pi_1 > \pi_2 > \pi_3$$

(3) $\pi_2 > \pi_1 > \pi_3$
(2) $\pi_3 > \pi_1 > \pi_2$
(4) $\pi_2 > \pi_3 > \pi_1$

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8. Two solutions of glucose have osmotic pressures 1.5 and 2.5 atm 1 litre of first solution is mixed with 2 litre of second solution. The osmotic pressure of the resultant soluton will be

(1) 1.6 atm	(2) 6.12 atm
(3) 1.26 atm	(4) 2.16 atm

9. 18 g glucose and 6g urea are dissolved in 1 litre aqueous solution at 27°C. The osmotic pressure of the solution will be :

(1) 3.826 atm	(2) 4.926 atm
(3) 2.92 atm	(4) 9.42 atm

10. A solution containing 10 g per dm³ of urea (m.w. = 60) is isotonic with a 5% solution of a non-volatile solute. The molecular mass of this non-volatile solute is :
(1) 250 s moltaines (2) 200 s moltaines

(1) 250 g mol ^{-1}	(2) 300 g mol ⁻¹
(3) 350 g mol ^{-1}	(4) 200 g mol ⁻¹

11. The temperature at which 10% aqueous solution

 $\left(\frac{W}{V}\right)$ of glucose will exhibit the osmotic pressure

of 16.4 atm, is : $(R = 0.082 \text{ dm}^3 \text{ atm } \text{K}^{-1} \text{ mol}^{-1})$ (1) 360° C (2) 180 K (3) 300 K (4) 360 K

ANSWER KEY							
Que.	1	2	3	4	5	6	7
Ans.	1	4	3	4	3	2	3
Que.	8	9	10	11			
Ans.	Ans. 4 2 2 4						

ABNORMAL COLLIGATIVE PROPERTIES

- It has been observed that difference in the observed and calculated molecular masses of solute is due to association or dissociation of solute molecules in solution. It results in a change in the number of particles in solution.
- Van't hoff factor (i) : Tells about relationship between normal colligative properties and abnormal colligative properties.
- $i = \frac{\text{number of particles after dissolcation or association}}{\text{number of particles before dissolcation or association}}$

- = observed colligative properties calculated colligative properties
- _ calculated molecular mass
- observed molecular mass
- If i = 1 Neither dissociation nor association: Ex. Glucose, urea, sugar
- If i > 1 Dissociation will occur : Ex. NaCl, KCl, BaCl₂
- If i < Association will occur : Ex. CH₃COOH, PhCOOH in benzene

Case-I :

Dissociation of solute :

Molecules of electrolytes undergo ionization or dissociation in polar solvents to give two or more particles in solution. This dissociation results in an increase in the total number of particles, and therefore the value of colligative properties of such solutions will be higher. As the colligative properties are inversely related to molecular weight, so the molecular weight of ionizable solute will be less than the theoretical value.

Number of solute particles in solution increases.

- observed/experimental C.P. > calculated C.P. (normal)
- observed/experimental Molecular weight of of solute < calculated (normal) molecular weight of solute.

 $\therefore \quad \text{C.P.} \propto \frac{1}{\text{molecular weight of solute}}$

• Calculation of 'i' : Let solute be A_xB_y (electrolyte)

 $A_x B_y \rightarrow x A^{y+} + y B^{x-}; x + y$

= n (total number of io	ons)		
Initially	1 mol	0	0
After dissociation	$(1 - \alpha)$	xα	уα
Total number of solute	e particles		
$= 1 - \alpha + \mathbf{x}\alpha + \mathbf{v}\alpha$			

 $= 1 - \alpha + (x + y)\alpha$ $= 1 - \alpha + (x + y)\alpha$

Observed colligative property is proportional to observed number of solute particles $(1 - \alpha + n\alpha)$

 $i = \frac{number \text{ of particles after dissociation}}{number \text{ of particles before dissociation}}$

$$=\frac{1-\alpha+n\alpha}{1}$$

$$\frac{i = 1 - \alpha + n\alpha}{\alpha = \frac{(i - 1)}{\alpha}}$$

$$\alpha = \frac{1}{(n-1)}$$

where $\boldsymbol{\alpha}$ is the degree of dissociation

- For strong electrolytes if $\alpha = 1$ or 100% then i = n
- **Ex.** NaCl \Rightarrow i = 2; for α = 100% K₂SO₄ \Rightarrow i = 3 α = 100%
- Ex. $K_4[Fe(CN)_6] \Rightarrow i = 5 \text{ for } \alpha = 100\%$ For $\alpha \Rightarrow 50\%$ $i = 1 + (n-1)\alpha$

$$i = 3$$

• Observed C.P. = i (normal C.P.)

Case II:

Association of solute :

The formation of a bigger molecule by the union of two, three or more solute molecules is called association

As a result, the total number of particles in solution becomes less than the number of molecules initially dissolved in the solution and hence the colligative properties will have lower value. As the molar mass of solute is inversely proportional to the colligative properties, so the molar mass of solute will be greater than theoretical value.

Number of solute particles in solution decreases.

- observed/experimental C.P.< calculated C.P.
- observed/experimental molecular weight of solute > normal molecular weight of solute.

 \therefore C.P. $\propto \frac{1}{\text{molecular weight of solute}}$;

i < 1 for association.

Calculation of 'i' • $\begin{array}{ccc} \mathbf{nA} & \longrightarrow \\ 1 & \longrightarrow \end{array}$ [A] Initially 0 $(1-\alpha) \longrightarrow \frac{\alpha}{n}$ After association Total number of solute particles = $1 - \alpha + \frac{\alpha}{n}$ Observed C.P. \propto observed number of solute particles $\left(1-\alpha+\frac{\alpha}{n}\right)$ Van't hoff factor (i) $=\frac{\text{number of particles after association}}{\text{number of particles before association}}$ $i = \frac{1 - \alpha + \frac{\alpha}{n}}{1}$ $i = 1 - \alpha + \frac{\alpha}{n}$ α - degree of association n - number of solute particles which are associated. • if $\alpha = 100\%$ or 1 or α is not specified $|i = \frac{1}{n}|$

$$\alpha = \frac{1\!-\!i}{1\!-\!\frac{1}{n}}$$

Concept Application Exercise-4

1.	0.002 molar soluti	on of NaCl having degree of
	dissociation of 90%	% at 27°C has osmotic pressure
	equal to :	
	(1) 0.94 bar	(2) 9.4 bar
	(3) 0.094 bar	(4) 9.4×10^{-4} bar

- 2. A 0.2 molal solution of KCl freezes at -0.68° C. If K_f for H₂O is 1.86, the degree of dissociation of KCl is : (1) 75 % (2) 83% (3) 65% (4) 92 %
- 3. A certain substance 'A' tetramerises in water to the extent of 80%. A solution of 2.5g of A in 100 g of water lowers the freezing point 0.3°C. The molar mass of A is : ($K_f = 1.86$ K kg mol⁻¹ for water) (1) 1.22 (2) 21 (2) 244 (4) 62

 $(1) 1.22 \quad (2) 31 \quad (3) 244 \quad (4) 62$

(i)

4. Van't Hoff factor of Hg₂Cl₂ in its aqueous solution will be (Hg₂Cl₂) is 80% ionized in the solution):
(1) 1.6
(2) 2.6
(3) 3.6
(4) 4.6

5. 0.1 M aqueous solution of MgCl₂ at 300K is 4.92 atm. What will be the percentage ionization of the salt?
(1) 49% (2) 29% (3) 39% (4) 69%

- 6. Which of the following solutions will exhibit highest boiling point?
 (1) 0.01 M Na₂SO₄
 (2) 0.01 M KNO₃
 (3) 0.015 M urea
 (4) 0.015 M glucose
- 7. The freezing point depression of 0.001 m $K_x[Fe(CN)_6]$ is 7.10 × 10⁻³K. Determine the value of x. Given, $K_f = 1.86$ K kg mol⁻¹ for water. (1) 3 (2) 4 (3) 2 (4) 1
- 8. Van't Hoff factors of aqueous solutions of X, Y, and Z are 2.8, 1.8 and 3.5, respectively. Which of the following statement(s) is (are) correct?
 (1) BP : X < Y < Z
 (2) FP : Z < X < Y
 (3) Osmotic pressure : X = Y = Z
 - (4) VP : Y < X < Z
- 9. CNS^- ions give red colour with Fe^{3+} ions in aquous solution as :

 $\operatorname{Fe}^{3+}(\operatorname{aq}) + 3\operatorname{CNS}^{-}(\operatorname{aq}) \to \operatorname{Fe}(\operatorname{CNS})_{3}(\operatorname{aq})$

If 0.1 M KCNS solution is seperated from 0.1 M FeCl₃ solution by means of a semi permeable membrane, red colour will appear on :

- (1) FeCl₃ solution
- (2) KCNS solution side
- (3) Both sides
- (4) Neither side

ANSWER KEY							
Que.	1	2	3	4	5	6	7
Ans.	3	2	4	2	1	1	1
Que.	8	9					
Ans. 2 4							

Golden Key points :

Variation of vapour pressure with temperature (Clausius -Clapeyron equation)

$$\log_{10}\left(\frac{P_2}{P_1}\right) = \frac{\Delta H}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

 P_1 = vapour pressure at T_1

 P_2 = vapour pressure at T_2

 ΔH = latent heat of vaporation per mole

(ii) Anti-freeze solutions : Water is used in radiators of cars and other automobiles. In cold countries where the atmospheric temperature becomes less than zero degree, the water in the radiators would freeze. Anti-freeze solutions are useful under these conditions when the vechiles are used in the regions of sub-zero temperature so that the water does not freeze in radiators. Such solutions are made by dissolving ethylene glycol in water. Freezing point can be lowered to the desired extent by varying the concentration of ethylene glycol. Glycerol can also be used as anti-freeze.

(iii) **Freezing mixture :**

It is a mixture of ice and common salt (NaCl). It is used in the making of ice-cream and in that laboratories to create low temperatures. With the help of this mixture, a temperature as low as -33° C (240 K) can be achieved.

Note : Ebullioscopic and cryoscopic methods are effective when :

- (i) Solutions are dilute. Solutions obey Raoult's law.
- (ii) The solute is non-volatile.
- (iii) There is not association of dissolation of solute molecules in the solution.
- (iv) Solute does not form a solid solution with solvent in frozen state, i.e., only solvent separates in solid state on freezing the solution.
- (v) Equimolal quantities of different substances dissolved in the same quantity of solvent bring out the same depression in freezing point of the solvent under identical conditions.

SOLVED EXAMPLE

Example 1

Henry's law constant for O_2 dissolved in water is 4.34×10^4 atm at 25°C. If the partial pressure of oxygen in air is 0.4 atm. Calculate the concentration (M) of dissolved oxygen in water in equilibrium with air at 25°C :

Sol. Given $K_{\rm H} = 4.34 \times 10^4$ atm $p_{O_2} = 0.4$ atm acc. to Henry's Law $p = K_{\rm H}X$ $X_{O_2} = \frac{0.4}{4.34 \times 10^4} = 9.2 \times 10^{-6}$ Moles of water $(n_{\rm H_2O}) = \frac{1000}{18} = 55.8$ mol $X_{O_2} = \frac{n_{O_2}}{n_{O_2} + n_{\rm H_2O}}$

Since n_{O_2} is very small in comparison to n_{H_2O}

$$X_{O_2} = \frac{n_{O_2}}{n_{H_2O}}$$

Or $X_{O_2} \times n_{H_2O} = n_{O_2}$ So $n_{O_2} = 9.2 \times 10^{-6} \times 55.55 = 5.11 \times 10^{-4}$ mol So $M = 5.11 \times 10^{-4}$

Example 2

Sol.

The molarity of 20% (W/W) solution of sulphuric acid is 2.55 M. The density of the solution is : (A) 1.25 g cm⁻³ (B) 0.125 g L⁻¹ (C) 2.55 g cm⁻³ (D) unpredictable [A] Volume of 100 g of solution = $\frac{100}{d}$ ml \therefore M = $\frac{20 \times d \times 1000}{100 \times 98}$ or d = $\frac{2.55 \times 100 \times 98}{20 \times 1000}$ = 1.249 \approx 1.25

Example 3

Calculate molality of 1 litre solution of 93% H_2SO_4 by volume. The density of solution is 1.84 gm ml⁻¹

Sol. [B]

Given H₂SO₄ is 93% by volume wt. of H₂SO₄ = 93g Volume of solution = 100ml \therefore weight of solution = 100 × 1.84 gm e 184 gm wt. of water = 184 - 93 = 91 gm Molality = $\frac{\text{moles}}{\text{wt. of water in kg}}$ = $\frac{93 \times 1000}{98 \times 91}$ = 10.42

Example 4

Calculate the molarity and normality of a solution containing 0.5 gm of NaOH dissolved in 500 ml. solution-(A) 0.0025 M, 0.025 N (B) 0.025 M, 0.025 N (C) 0.25 M, 0.25 N (D) 0.025 M, 0.0025 N

Sol. [B]

Wt. of NaOH dissolved = 0.5 gm Vol. of NaOH solution = 500 ml

Calculation of molarity

0.5 g of NaOH = $\frac{0.5}{40}$ moles of NaOH [:: Mol. wt of NaOH = 40] = 0.0125 moles Thus 500 ml of the solution contain

NaOH = 0.0125 moles

$$= \frac{0.0125}{500} \times 1000$$

= 0.025 M

Hence molarity of the solution = 0.025 M

....

Calculation of normality

Since NaOH is monoacidic ;

Eq. wt. of NaOH = Mol. wt. of NaOH = 40

0.5 gm of NaOH =
$$\frac{0.5}{40}$$
 gm equivalents

= 0.0125 gm equivalents

Thus 500 ml of the solution contain NaOH

- = 0.0125 gm equ.
- \therefore 1000 ml of the solution contain

$$= \frac{0.0125}{500} \times 1000 = 0.025$$

Hence normality of the solution = 0.025 N

Example 5

...

Calculate the molality and mole fraction of the solute in aqueous solution containing 3.0 gm of urea per 250 gm of water (Mol. wt. of urea = 60). (A) 0.2 m, 0.00357 (B) 0.4 m, 0.00357 (C) 0.5 m, 0.00357

(D) 0.7m, 0.00357

Sol. [A]

Wt. of solute (urea) dissolved = 3.0 gmWt. of the solvent (water) = 250 gmMol. wt. of the solute = 60

3.0 gm of the solute $=\frac{3.0}{60}$ moles = 0.05 moles

Thus 250 gm of the solvent contain = 0.05 moles of solute

 \therefore 1000 gm of the solvent contain

$$= \frac{0.05 \times 1000}{250} = 0.2 \text{ moles}$$

Hence molality of the solution = 0.2 m

In short,

Molality = No. of moles of solute/1000 g of solvent

:. Molality = $\frac{3/60}{250} \times 1000 = 0.2 \text{ m}$

Calculation of mole fraction

3.0 gm of solute = 3/60 moles = 0.05 moles 250 gm of water = $\frac{250}{18}$ moles = 13.94 moles \therefore Mole fraction of the solute = $\frac{0.05}{18} - \frac{0.05}{18}$

$$= \frac{1}{0.05 + 13.94} = \frac{1}{13.99}$$
$$= 0.00357$$

Example 6

Sol

	15 gram of methyl alcohol is dissolved in 35		
	gram of water. What is the mass percentage of		
	methyl alcohol in solution?		
	(A) 30% (B) 50%		
	(C) 70% (D) 75%		
•	[A]		
	Total mass of solution = $(15 + 35)$ gram		
	= 50 gram		
	mass percentage of methyl alcohol		
	$= \frac{\text{Mass of methyl alcohol}}{\text{Mass of solution}} \times 100$		
	$= \frac{15}{50} \times 100 = 30\%$		

Example 7

Calculate the vapour pressure of a solution at 100°C containing 3g of cane sugar in 33g of water. (At wt. C = 12, H = 1, O = 16) (A) 760 mm (B) 756.90 mm (C) 758.30 mm (D) None Sol. **[B]** Vapour pressure of pure water (solvent) at 100° C, p⁰ = 760 mm. Vapour pressure of solution, p = ?Wt. of solvent, W = 33gWt. of solute, w = 3gMol. wt. of water (H₂O), M = 18Mol. wt. of sugar $(C_{12}H_{22}O_{11})$, m = 12 x 12 + 22 x 1 + 11 x 16 = 342

$$\frac{p^{\circ} - p}{p^{\circ}} = \frac{wM}{Wm}$$

$$\therefore p = p^{0} - \frac{w \times M}{m \times W} \times p^{0} = p =$$

$$760 - \frac{3 \times 18}{342 \times 33} \times 760$$

(
$$\therefore p^{0} \text{ for } H_{2}O = 760 \text{ mm})$$

$$= 760 - 3.19 = 756.90 \text{ mm}$$

Example 8

0.15g of a substance dissolved in 15g of solvent boiled at a temperature higher by 0.216° C than that of the pure solvent. Calculate the molecular weight of the substance. Molal elevation constant for the solvent is 2.16° C.

(A) 216	(B) 100
(C) 178	(D) None of these

Sol. [B]

Here it is given that

w = 0.15 g,
$$\Delta T_b = = 0.216^{\circ}C$$

W = 15g $K_b = 2.16^{\circ}C$
m = ?

Substituting values in the expression,

$$m = \frac{1000 \times K_b \times w}{\Delta T_b \times W}$$
$$m = \frac{1000 \times 2.16 \times 0.15}{0.216 \times 15} = 100$$

Example 9

Calculate the boiling point of a solution containing 0.45g of camphor (mol. wt. 152) dissolved in 35.4g of acetone (b.p. 56.3° C); K_b per 100 gm of acetone is 17.2°C. (A) 56.446° C (B) 52.401° C (C) 56.146° C (D) 50.464° C

Sol. [A]

Here it is given that w = 0.45 g, W = 35.4, m = 152, Kb = 17.2 per 100gmNow we know that $\Delta T_b = \frac{100 \times K_b \times w}{m \times W}$ (Note that this is expression when K_b is given per 100g of the solvent) Substituting the values in the above expression. $\Delta T_b = \frac{100 \times 17.2 \times 0.45}{152 \times 35.4} = 0.146^{\circ} \text{C}$ Now we know that B.P. of solution (T) - B.P. of solvent (T_0) $= \Delta T$ \therefore B.P. of solution (T) = B.P. of solvent(T_0) + ΔT Hence B.P. of solution = $56.3 + 0.146 = 56.446^{\circ} \text{C}$

Example 10

The freezing point of 0.2 molal K₂SO₄ is -1.1°C. Calculate Van't Haff factor and percentage degree of dissociation of K₂SO₄. K_f for water is 1.86° (A) 97.5 (B) 90.75 (C) 105.5 (D) 85.75 Sol. [A] ΔT_{f} = freezing point of water – freezing point of solution = $0^{\circ} C - (-1.1^{\circ} C) = 1.1^{\circ}$ We know that, $\Delta T_{f} = i \times K_{f} \times m$ $1.1 = i \times 1.86 \times 0.2$ $\therefore i = \frac{1.1}{1.86 \times 0.2} = 2.95$ But we know $i = 1 + (n - 1)\alpha$ $2.95 = 1 + (3 - 1) \alpha = 1 + 2\alpha$ $\alpha = 0.975$ Van't Haff factor (i) = 2.95Degree of dissociation = 0.975Percentage degree of dissociation = 97.5

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Example 11

Lowering of vapour pressure due to a solute in 1 molal aqueous solution at 100°C is -

- (A) 13.44 mm Hg (B) 14.12 mm Hg
- (C) 31.2 mm Hg (D) 35.2 mm Hg

Sol. [A]

$$m = \frac{x_{B} \times 1000}{(1 - x_{B})M_{A}} \quad x_{B} = \text{mole fraction of solute}$$

$$1 = \frac{x_{B} \times 1000}{(1 - x_{B}) \times 18} \quad m_{A} = \text{molar mass of solvent}$$

$$x_{B} = 0.0176$$

$$x_{A} = 1 - 0.0176 = 0.9824$$

$$p = p_{0}x_{A} = 760 \times 0.9824 = 746.62$$

$$\Delta p = p_{0} - p = 760 - 746.62 = 13.4$$

Example 12

The mass of a non-volatile solute (molecular mass = 40) which should be dissolved in 114 g octane to reduce its vapour pressure to 80% will be -

(A) 20 g	(B) 30 g
(C) 10 g	(D) 40 g

Sol. [C]

If $p_0 = 100$, then p = 80 $p = p_0 x_A$ $80 = 100 \times x_A$ $x_A = 0.80$ $x_A = \frac{n_A}{n_A + n_B} = \frac{114/114}{114/114 + w_B / 40}$ $0.8 \frac{1}{1 + w_B / 40} = 1 + \frac{w_B}{40} = \frac{1}{0.8} = w_B = 10 \text{ g}$

Example 13

How much C₂H₅OH should be added to 1 litre H₂O so that it will not freeze at -20° C? K_f = 1.86°C/m

Sol. Mass of 1 litre water = 1000 g

$$\therefore \Delta T = K_f \times \frac{W_B \times 1000}{m_B \times W_A} \quad 20 =$$

$$1.86 \times \frac{W_B \times 1000}{46 \times 1000} W_B = 494.6 g$$

Example 14

Three solutions of HCl having normality 12 N, 6 N and 2 N are mixed to obtain a solutions of 4 N normality. Which among the following volume ratio is correct for the above three components ?

(A) 1 : 1 : 5	(B) 1 : 2 : 6
(C) 2 : 1 : 9	(D) 1 : 2 : 4

Sol. [B]

Use Hit & Trial Method.
$$\begin{split} N_1 V_1 &+ N_2 V_2 + N_3 V_3 = N_R (V_1 + V_2 + V_3) \\ 12 \times 1 + 6 \times 2 + 2 \times 6 = N_R (9) \\ N_R &= 4 \end{split}$$

Exercise - 1

Concentration Terms

 10 gram of glucose are dissolved in 150 gram of water. The mass % of glucose is-

(1) 5% (2) 6.25% (3) 93.75% (4) 15% [C. 62.12%, I.C. 25.42%, U.A. 12.46%]

 25 mL of 3.0 M HNO₃ are mixed with 75 mL of 4.0M HNO₃. If the volumes are additive, the molarity of the final mixture would be-

(1) 3.25 M (2) 4.0 M (3) 3.75 M (4) 3.50 M [C. 62.10%, I.C. 26.87%, U.A. 11.03%]

3. Which of the following is correct-



(1) mole = molarity × V in L = $\frac{\text{wt.}}{\text{mol.wt.}}$ (2) milli mole = molarity × V in mL = -

(2) milli mole = molarity × v in mL = $\frac{1}{\text{mol.wt.}}$ ×1000

(3) Moles and millimoles of reactants react according to stoichiometric ratio of balanced chemical equation

(4) All

[C. 60.53%, I.C. 28.39%, U.A. 11.08%]

4. The molarity of a glucose solution containing 36 g of glucose per 400 mL of the solution is-

(1) 1.0 (2) 0.5 (3) 2.0 (4) 0.05 [C. 59.77%, I.C. 30.71%, U.A. 9.51%]

5. 10 mL of concentrated H₂SO₄ (18M) is diluted to one litre. The approximate strength of the dilute acid is-

1) 18 M	(2) 180 M
3) 0.18 M	(4) 1.8 M
	[C. 59.45%, I.C. 29.75%, U.A. 10.80%]

6. All of the water in a 0.20 M solution of NaCl was evaporated and 0.150 mol of NaCl was obtained. What was the original volume of the sample ?



(1) 30 mL	(2) 333 mL
(3) 750 mL	(4) 1000 mL
	[C. 58.04%, I.C. 28.23%, U.A. 13.73%]

Objective Problems | NEET

7. Equal weight of NaCl and KCl are dissolved separately in equal volumes of solutions molarity of the two solutions will be -



(1) Equal

(2) That of NaCl will be less than that of KCl

(3) That of NaCl will be more than that of KCl solution

(4) That of NaCl will be half of that of KCl solution

[C. 57.30%, I.C. 32.62%, U.A. 10.07%]

8. If 100 ml of 1.0 M NaOH solution is diluted to 1.0 L, the resulting solution contains-



(1) 1 mole of NaOH
(2) 0.1 mole of NaOH
(3) 10.0 mole of NaOH (4) 0.05 mole of NaOH
(C. 56.56%, I.C. 30.69%, U.A. 12.75%)

9. Density of water is 1g/mL. The concentration of water in mol/litre is-



- (1) 1000 (2) 18 (3) 0.018 (4) 55.5 [C. 56.05%, I.C. 35.11%, U.A. 8.84%]
- **10.** A molar solution is one that contains one mole of solute in



- (1) 1000 g of the solvent
- (2) one litre of the solution
- (3) 1000 g of the solution
- (4) 22.4 litres of the solution

[C. 54.73%, I.C. 32.10%, U.A. 13.17%]

11. 2.3 g of C_2H_5OH (mol. wt. 46) are dissolved in water to form 500 mL solution. The molarity of the solution is

(1) 0.01(2) 0.1**(3)** 0.05 (4) 2.0[C. 54.16%, I.C. 32.39%, U.A. 13.45%]

12. The amount of H_2SO_4 present in 400 mL of 0.1 M solution of the acid is -



(1) 2.45 g (2) 3.92 g (3) 9.80 g (4) 4.9 g [C. 53.09%, I.C. 26.25%, U.A. 20.66%]

13. How many grams of glucose should be dissolved to make one litre solution of 10% (w/v) glucose?



(2) 180 g (3) 100 g (4) 1.8 g (1) 10 g [C. 52.77%, I.C. 40.93%, U.A. 6.30%]

14. In the aqueous solution of sulphuric acid the mole fraction of water is 0.85. The molality of the solution is-

(1) 8.9 m (2) 0.19 m (3) 9.8 m (4) 15 m [C. 51.46%, I.C. 37.40%, U.A. 11.14%]

15. How many grams of NaOH will be needed to prepare 250 mL of 0.1 M solution



(1) 1 g (2) 10 g (3) 4 g (4) 6 g [C. 50.30%, I.C. 31.14%, U.A. 18.56%]

16. 100 ml of 0.3 N HCl solution is mixed with 200 ml of 0.6 N H₂SO₄ solution what is the normality of H_2SO_4 in the final solution

(1) 0.9 (2) 0.6 (3) 0.5 (4) 0.4[C. 49.80%, I.C. 43.13%, U.A. 7.07%]

17. 3.0 molal NaOH solution has a density of 1.110 g/mL. The molarity of the solution is:

(1) 2.9732 **(2)** 3.05 **(3)** 3. 64 (4) 3.0504 [C. 48.90%, I.C. 44.71%, U.A. 6.39%] **18.** What is the normality of 2M H₃PO₂ solution ?

(1) 0.5 N (2) 1.0 N (3) 2.0 N (4) 3.0 N [C. 48.44%, I.C. 42.65%, U.A. 8.91%]

19 A solution contains one mole of alcohol and four moles of water. What are the mole fractions of water and alcohol respectively-



(1) 1/4, 4/1	(2) 4/1, 1/4
(3) 4/5, 1/5	(4) 1/5, 4/5

[C. 48.20%, I.C. 33.34%, U.A. 18.46%]

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



- (1) 0.46(2) 0.36(3) 0.20(4) 0.40[C. 48.19%, I.C. 34.46%, U.A. 17.35%]
- **21.** 1000 g aqueous solution of CaCO₃ contains 10 g of calcium carbonate concentration of the solution is :



- (1) 10 ppm
- (3) 1000 ppm

(4) 10,000 ppm

(2) 100 ppm

[C. 46.91%, I.C. 43.76%, U.A. 9.33%]

22. The mole fraction of NaCl in a solution containing 1 mole of NaCl in 1000 g of water is :



(1) 0.0177 **(2)** 0.001 **(3)** 0.5 (4) 0.244 [C. 46.65%, I.C. 33.26%, U.A. 20.09%]

23. Normality of 0.3 M phosphorous acid (H₃PO₃) is:



(1) 0.15 (2) 0.6 **(3)** 0.9

[C. 45.49%, I.C. 44.51%, U.A. 10.00%]

(4) 0.1

24 100 ml of 0.5 N NaOH solution is added to 10 ml of 3 N H₂SO₄ solution and 20 ml of 1 N HCl solution. The mixture is -



- (1) Acidic (2) Alkaline
- (3) Neutral (4) None of these

[C. 45.49%, I.C. 44.51%, U.A. 10.00%]

25. 5.85 g of NaCl are dissolved in 90 g of water. The mole fraction of NaCl is :

(1) 0.1 (2) 0.01 (3) 0.2 (4) 0.0196 [C. 44.95%, I.C. 35.07%, U.A. 19.98%]

26. A 500 g tooth paste sample has 0.02 gm fluoride concentration. What is the concentration of fluorine in terms of ppm level ?

(1) 250 (2) 40 (3) 400 (4) 1000 [C. 43.73%, I.C. 45.11%, U.A. 11.16%]

27. Mole fraction of ethanol in ethanol water mixture is 0.25. Hence percentage concentration of ethanol by weight of mixture is -

(1) 25% (2) 75% (3) 46% (4) 54% [C. 42.90%, I.C. 49.85%, U.A. 7.25%]

28. 20.6 g NaBr is dissolved in 500ml solution what is the molarity of resulting solution?

(1) 0.6 (2) 0.4 (3) 1 (4) None [C. 42.75%, I.C. 38.80%, U.A. 18.44%]

29. 25 mL $\frac{N}{10}$ NaOH solution will exactly neutralize which of the following solution -

(1) 25 mL $\frac{N}{10}$ KOH solution

(2) 25 mL N H_2SO_4 solution

(3) 25 mL
$$\frac{N}{10}$$
 HCl solution
(4) 2.5 mL $\frac{N}{10}$ HNO₃ solution

(1) 2.14 N

[C. 42.53%, I.C. 46.27%, U.A. 11.20%]

30. Calculate normality of 2.1% (w/V) H₂SO₄ solution?

(2) 4.28 N	

(3) 0.428 N (4) 0.214 N [C. 41.11%, I.C. 43.22%, U.A. 15.68%] 31. Which of the following statement is true:(a) Molarity is the no. of moles of



solute dissolved per litre of solvent (b) The molarity and normality of a solution of sodium carbonate are same (c) Molality (m) of a solution is defined as the number of moles of solute dissolved in 1000 gm of solution

(d) The ratio of mole fraction of solute and solvent is in the ratio of there respective moles

(1) a & c (2) a & d (3) b & c (4) Only d [C. 38.37%, I.C. 36.45%, U.A. 25.17%]

32. If 8.3 mL of a sample of H_2SO_4 (36N) is diluted by 991.7 mL of water, the approximate normality of the resulting solution is:



(1) 0.4 **(2)** 0.2

[C. 36.51%, I.C. 54.10%, U.A. 9.39%]

(4) 0.3

33. The molality of 15% (wt./vol.) solution of H_2SO_4 of density 1.1 g/cm³ is approximately



(1) 1.2 (2) 1.4 (3) 1.8 (4) 1.6 [C. 36.05%, I.C. 35.38%, U.A. 28.58%]

(3) 0.1

34. 10 ml of an HCl solution gave 0.1435 gm of AgCl when treated with excess of AgNO₃. The normality of the HCl solution is -



(1) 0.1 (2) 3 (3) 0.3 (4) 0.2 [C. 31.80%, I.C. 60.83%, U.A. 7.36%]

35. A sugar syrup of mass 214.2 gm contains 34.2 gm of sugar. Calculate mole fraction of sugar in syrup



(1) 0.556	(2) 0.01
(3) 9.90 × 10 ⁻³	(4) 0.156
	[C. 30.31%, I.C. 59.95%, U.A. 9.74%]

			Liquid So	olutions	
36	How much w	water should be added to		Vapour Pressure And Raoult's Liquid Mixture)	s Law (
	200 cc of NaOH to mai (1) 1000 cc (3) 800 cc	(2) 400 cc (4) 600 cc (<i>I</i> , <i>I.C. 64.81%</i>)	U.A. 7.98% J	41. 1 mole of heptane (V.P. = 92 Hg) was mixed with 4 m octane (V.P. = 31 mm of H vapour pressure of resultin solution is -	mm of oles of g). The g ideal
Не	nry's Law			(1) 46.2 mm of Hg (2) 40.	0 mm of
37	Which of the	e following gas will have		(3) 43.2 mm of Hg (4) 38. [C. 50.64%]	4 mm of , <i>I.C. 39.74%</i> ,
	(1) NH ₃ (3) O ₂	(2) H ₂ (4) He		42. The boiling point of C_6H_6 , $C_6H_5NH_2$ and $C_6H_5NO_2$ are 65°C, 184°C and 212°C resp.	CH ₃ OH, e 80°C, ectively.
20	Which of t	<i>[C. 50.00%, I.C. 31.92%,</i>	U.A. 18.08%	Which will show highest pressure at room temperature?	vapour
30	Henry's law	?		(1) C_6H_6 (2) CH	I ₃ OH
				$(J) \cup_{6} \Pi_{5} \Pi_{1} \Pi_{2}$ (4) $\cup_{6} I$	151NU2

(2) CH₃OH $(4) C_6H_5NO_2$

(2) 40.0 mm of Hg

(4) 38.4 mm of Hg [C. 50.64%, I.C. 39.74%, U.A. 9.62%]

re And Raoult's Law (Liquid

[C. 48.17%, I.C. 41.72%, U.A. 10.11%]

43. At a given temperature, total vapour pressure in Torr of a mixture of volatile components A and B is given by $P_{Total} = 120 + 75 X_B$ hence, vapour pressure of pure A and **B** respectively

> (1) 120, 75 (2) 120, 195 (3) 120, 45 (4) 75, 45

[C. 47.02%, I.C. 45.96%, U.A. 7.02%]

44. What is correct relation between mole fraction in vapour phase (Y_A) of A in terms of X_A . If mole fraction in solution of A is (X_A) : (If P_B^0 is vapour pressure of A in pure state)

(1)
$$(1 - X_A)P_A^0$$
 (2) $\frac{X_A}{1 - X_A}P_A^0$
(3) $\frac{1 - X_A}{X_A}P_A^0$ (4) $\frac{P_A^0 X_A}{P_S}$

(1)
$$(1 - M_A)^T A_A$$
 (2) $\frac{1}{14}$
(3) $\frac{1 - X_A}{X_A} P_A^0$ (4) $\frac{P}{14}$





- (1) HCl (2) He
- $(3) O_2$ (4) H₂

[C. 40.19%, I.C. 33.48%, U.A. 26.33%]

- **39.** Henry's law constant for dissolution of CH₄ in benzene at 298 K is 2×10^5 mm of Hg. Then solubility of CH₄ in benzene at 298 K under 760 mm of
 - (1) 1.2 \times 10⁻⁵ (2) 3.8 \times 10⁻³ (3) 4×10^{-7}
 - (4) 1×10^{-2}

[C. 36.79%, I.C. 25.31%, U.A. 37.89%]

40. In solubility of gas 'X' is 0.5 gL^{-1} at 1 bar then its solubility at 3 bar pressure will be



(1) 0.5 gL^{-1} (2) 1.5 gL^{-1} (3) 3.0 gL^{-1} (4) 2 gL^{-1} [C. 34.68%, I.C. 29.72%, U.A. 35.60%]

Hg is

45. Mole fraction of A vapours above the solution in mixture of A and $B(X_A = 0.4)$ will be [Given : $P_A^\circ = 100$ mm Hg and $P_B^\circ =$

200 mm Hg]

- (1) 0.4 (2) 0.8
- (3) 0.25 (4) None of these

[C. 44.66%, I.C. 48.72%, U.A. 6.61%]

46. The relative lowering in vapour pressure is-



- (1) $\propto X_{solute}$ (3) = X_{solute}
- (4) \propto m [C. 41.42%, I.C. 51.37%, U.A. 7.21%]

(2) $\propto \frac{1}{X_{\text{solute}}}$

47. If P_A^0 and P_B^0 are 108 and 36 torr respectively. What will be the mole fraction of A in vapour phase if B has mole fraction in solution 0.5?

(1) 0.25 (2) 0.75 (3) 0.60 (4) 0.35 [C. 40.40%, I.C. 29.17%, U.A. 30.43%]

48. At 88 °C benzene has a vapour pressure of 900 Torr and toluene has a vapour pressure of 360 Torr. What is the mole fraction of benzene in the mixture with toluene that will boil at 88 °C at 1 atm. pressure, benzene - toluene form an ideal solution -

(1) 0.416 (2) 0.588 (3) 0.688 (4) 0.740 [C. 37.88%, I.C. 56.49%, U.A. 5.62%]

Ideal And Non-Ideal Solution

49. An ideal solution is that which



(1) Shows positive deviation from Raoult's law

(2) Shows negative deviation from Raoult's law

- (3) Has no connection with Raoult's law
- (4) Obeys Raoult's law

[C. 65.26%, I.C. 17.49%, U.A. 17.25%]

50. When a substance is dissolved in a solvent, the vapour pressure of solvent decreases. This brings



- (1) An increase in boiling point of the solution
- (2) A decrease in boiling point of a solution
- (3) An increase in freezing point of the solvent
- (4) None of the above

[C. 64.52%, I.C. 29.29%, U.A. 6.20%]

51. Among the following, that does not form an ideal solution is-



- (1) C_6H_6 and $C_6H_5CH_3$
- (2) C_2H_5Cl and C_6H_5OH
- (3) C_6H_5Cl and C_6H_5Br
- (4) C₂H₅Br and C₂H₅I

[C. 54.95%, I.C. 22.82%, U.A. 22.23%]

52. Which of the following is not correct for ideal solution ?



(1) Raoult's law is obeyed for entire concentration range and temperatures

- $(2) \Delta S_{mix} = 0$
- $(3) \Delta V_{mix} = 0$

(4)
$$\Delta H_{mix} = 0$$

[C. 51.43%, I.C. 32.21%, U.A. 16.36%]

53. Binary liquid mixtures which exhibit positive deviations from Raoult's law boil at temperature than the expected boiling point -



- (1) Lower
- (2) Higher
- (3) Same
- (4) Can't be said

[C. 50.96%, I.C. 38.56%, U.A. 10.48%]

54. Which of the following conditions is not correct for ideal solution?



- (1) no change in volume on mixing
- (2) no change in enthalpy on mixing
- (3) it obey's Raoult's law
- (4) Ionisation of solute should occurs to a small extent

[C. 50.20%, I.C. 30.30%, U.A. 19.49%]

- **55.** For a solution of two liquids A and B, it was proved that $P = X_A (P_A^0 - P_B^0)$
 - $+ P_{\rm B}^{0}$. The solution is -
 - (1) Ideal
 - (3) Semi ideal

(2) Non ideal (4) None of the above [C. 49.86%, I.C. 40.06%, U.A. 10.09%]

56. An aqueous solution of methanol in water has vapour pressure -



- (1) Equal to that of water
- (2) Equal to that of methanol
- (3) More than that of water
- (4) Less than that of water

[C. 49.58%, I.C. 33.95%, U.A. 16.48%]

- 57. Which pair shows a contraction in volume on mixing along with evolution of heat?

(1) $CHCI_3 + C_6H_6$ (3) $H_2O + HNO_3$

[C. 42.05%, I.C. 25.00%, U.A. 32.95%]

(2) $H_2O + HCI$

(4) All

58. Among the following that forms an ideal solution



- (1) water and methanol
- (2) acetone and ethanol
- (3) benzene and toluene
- (4) water and HCl

[C. 40.58%, I.C. 40.26%, U.A. 19.17%]

Azeotropic Mixture

59. Azeotropic mixture are -



- (1) Mixture of two solids
- (2) Those which boil at different temperatures
- (3) Those which can be fractionally distilled
- (4) Constant boiling mixtures

[C. 55.56%, I.C. 33.02%, U.A. 11.43%]

60. Azeotropic mixture of water and HCl boils at 381.5 K. By distilling the mixture it is possible to obtain-



- (1) Pure HCl only
- (2) Pure water only
- (3) Neither HCl nor water
- (4) Both water and HCl in pure state

```
[ C. 48.19%, I.C. 31.43%, U.A. 20.38%]
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61. An azeotropic mixture of two liquids boil at a lower temperature than either of them when



- (1) It is saturated
- (2) It does not deviate from Raoult's law
- (3) It shows negative deviation from Raoult's law

(4) It show positive deviation from Raoult's law

[C. 44.01%, I.C. 35.33%, U.A. 20.66%]

62. An azeotropic mixture of two liquids has b.p. lower than either of them when it



- (1) shows a (+ve) deviation from Raoult's law
- (2) shows no deviation from Raoult's law
- (3) shows (+ve) deviation from Henry's law
- (4) shows (-ve) deviation from Henry's law

[C. 39.64%, I.C. 25.37%, U.A. 34.99%]

Colligative Properties

63. The passing of solvent particles through semipermeable membrane is called-



- (1) Osmosis (2) Electrodialysis
- (3) Electrophoresis
- (4) Electroplating [C. 68.96%, I.C. 25.88%, U.A. 5.16%]
- 64. An example of colligative property is-



- (1) Freezing point (2) Boiling point
- (3) Vapour pressure (4) Osmotic pressure

[C. 63.04%, I.C. 22.29%, U.A. 14.67%]

65. Two solutions have different osmotic pressures. The solution of higher osmotic pressure is called-

(1) Isotonic solution	(2) Hypotonic solution
(3) Isotopic solution	(4) Hypertonic solution
	[C. 62.70%, I.C. 31.82%, U.A. 5.48%]

- **66.** Elevation in boiling point was 0.52°C when 6g of compound x was dissolved in 100g of water. The molecular weight of x is $(\mathrm{K}=5.2~\mathrm{K}~\mathrm{mol}^{-1}~100~\mathrm{g}~\mathrm{H_2O})$ (1) 120 (2) 60 (3) 100 (4) 342 [C. 61.48%, I.C. 32.17%, U.A. 6.35%]
- **67.** Which of the following is not a colligative property -

(1) ΔT_{f}	(2) π
(3) ΔT _b	(4) K _b
	[C. 60.75%, I.C. 31.97%, U.A. 7.28%]

68. The osmotic pressure of solution increases if -



- (1) Temperature is decreased (2) Concentration is decreased
- (3) Number of solute particle is increased
- (4) Volume is increased

[C. 60.60%, I.C. 22.44%, U.A. 16.96%]

69. At constant temperature the osmotic pressure of a solution is -



- (1) Directly proportional to the concentration
- (2) Inversely proportional to the concentration

(3) Directly proportional to the square of concentration

(4) Directly proportional to the square root of concentration

[C. 60.08%, I.C. 29.25%, U.A. 10.67%]

70. In cold countries, ethylene glycol is added to water in the radiators of cars during winters. It results in-



- (1) Lowering in boiling point
- (2) Reducing viscosity
- (3) Reducing specific heat
- (4) Lowering in freezing point

[C. 59.50%, I.C. 34.04%, U.A. 6.45%]

71. What would be the freezing point of aqueous solution containing 17g of C_2H_5OH in 1000g of water $K_f =$ 1.86K molality⁻¹. -

(1) − 0.69°C	(2) – 0.34°C
(3) 0.0°C	(4) 0.34°C
	[C. 59.45%, I.C. 31.99%, U.A. 8.56%]

72. In osmosis phenomenon net flow of



(1) Solvent molecules move from higher concentration to lower concentration (2) Solvent molecules move from lower concentration to higher concentration (3) Solvent molecules move from higher concentratioin to lower concentration (4) Solute molecules move from lower concentration to higher concentration

[C. 57.04%, I.C. 33.80%, U.A. 9.15%]

73. The freezing point of a 0.05 molal solution of a non electrolyte in water is -



 $(K_f = 1.86 \text{ K molarity}^{-1})$

(1) – 1.86 °C	(2) – 0.93°C
$(3) - 0.093^{\circ}C$	(4) 0.093°C

[C. 57.00%, I.C. 35.87%, U.A. 7.13%]

74. If density of 2 molal sucrose solution is 1.4 gm/ml at 25°C, find osmotic pressure?



- (1) 4.06 atm
- (2) 2 atm

(3) 40.6 atm

(4) 3.4 atm [C. 56.91%, I.C. 36.77%, U.A. 6.32%]

elevation/depression **75.** The molal constant depends upon:



(1) nature of solvent (2) Nature of solute

(3) Temperature (4) ΔH solution

[C. 56.41%, I.C. 37.32%, U.A. 6.28%]

76. The elevation of boiling point method is used for the determination of moleuclar weight of :



- (1) Non-volatile and soluble solute
- (2) Non-volatile and insoluble solute
- (3) Volatile and soluble solute
- (4) Volatile and insoluble solute

[C. 56.02%, I.C. 37.29%, U.A. 6.68%]

77 Molal depression constant of water is $1.86 \text{ K Kg mol}^{-1}$. 0.02 mol of urea dissolved in 100 g of water will produce a depression in freezing point of



- (1) 0.186 °C (2) 0.372 °C (3) 1.86 °C (4) 3.72 °C [C. 55.80%, I.C. 36.39%, U.A. 7.82%]
- **78.** Solute when dissolved in water -



- (1) Increases the vapour pressure of water
- (2) Decreases the boiling point of water
- (3) Decreases the freezing point of water
- (4) All of the above

[C. 54.61%, I.C. 38.73%, U.A. 6.66%]

79. If 0.1 M solution of glucose and 0.1 M urea solution are placed on two sides of a semipermeable membrane to equal heights. Then it will be correct to say that -

(1) There will be not net movement across the membrane

- (2) Glucose will flow towards urea solution
- (3) Urea will flow towards glucose solution

(4) Water will flow from urea solution towards glucose solution

[C. 54.48%, I.C. 35.86%, U.A. 9.66%]

80. Which inorganic precipitate acts as semipermeable membrane?

- (1) Calcium sulphate
- (2) Barium oxalate
- (3) Nickel phosphate
- (4) Copper ferrocyanide

[C. 53.92%, I.C. 34.64%, U.A. 11.44%]

81. A solution containing 4g of a non-



volatile organic solute per 100 ml was found to have an osmotic pressure

equal to 500 cm of mercury at 27°C.

The molecular weight of solute is -

(1) 14.97 **(2)** 149.7 **(3)** 1697 (4) 1.497 [C. 52.59%, I.C. 41.81%, U.A. 5.60%]

82. The molal elevation constant is the ratio of the elevation in B.P. to;



- (1) Molarity
- (2) Molality
- (3) Mole fraction of solute
- (4) Mole fraction of solvent

[C. 52.32%, I.C. 37.09%, U.A. 10.60%]

83. 0.5 M solution of urea is isotonic with-



- (1) 0.5 M NaCl solution
- (2) 0.5 M sugar solution
- (3) 0.5 M BaCl₂ solution
- (4) 0.5 M solution benzoic acid in benzene

[C. 51.84%, I.C. 24.46%, U.A. 23.69%]

84. The osmotic pressure of blood is 7.65 atm at 310K. An aqueous solution of Glucose that will be isotonic with blood haswt/vol. -



(1) 5.41%	(2) 54.1%
-----------	------------------

(3) 3.5%

[C. 50.46%, I.C. 44.06%, U.A. 5.48%]

(4) 4.53%

85. If P₀ and P_S are the vapour pressure of solvent and its solution respectively.
N₁ and N₂ are the mole fraction of solvent and solute respectively then -

(1)
$$P_{S} = \frac{P_{0}}{N_{2}}$$

(2) $P_{0} - P_{S} = P_{0}N_{2}$
(3) $P_{S} = P_{0}N_{2}$
(4) $\frac{(P_{0} - P_{s})}{P_{S}} = \frac{N_{1}}{(N_{1} + N_{2})}$

- **86.** Vapour pressure of a solvent containing nonvolatile solute is -
 - (1) More than the vapour pressure of a solvent
 - (2) Less than the vapour pressure of solvent
 - (3) Equal to the vapour pressure of solvent
 - (4) None of these

[C. 49.66%, I.C. 28.87%, U.A. 21.47%]

87. The vapour pressure of water at room temperature is 23.8 mm of Hg. The vapour pressure of an aqueous solution of sucrose with mole fraction of solute 0.1 is equal to -

(1) 23.9 mm Hg	(2) 24.2 mm Hg
(3) 21.42 mm Hg	(4) 31.44 mm Hg
	[C. 48.07%, I.C. 46.14%, U.A. 5.79%

88. Colligative properties depend on the -



(1) Relative no. of solute molecules in soln. and the nature of the solvent

(2) Relative no. of solute molecules in solvent and the nature of solute

(3) Relative no. of solute molecules and the nature of solute and solvent

(4) Relative no. of solute molecules,

irrespective of the nature of solvent and solute [C. 47.73%, I.C. 41.88%, U.A. 10.39%] **89.** The vapour pressure of a dilute aqueous solution of glucose is 750 mm of mercury at 373 K. The mole fraction of solute is -



(1) $\frac{1}{10}$ (2) $\frac{1}{7.6}$ (3) $\frac{1}{35}$ (4) $\frac{1}{76}$

90. An aqueous solution containing 1g of urea boils at 100.25 °C. The aqueous solution containing 3g of glucose in the same volume will boil at -



(1) 100.75 °C	(2) 100.5 °C
(3) 100 °C	(4) 100.25 °C
	[C. 47.06%, I.C. 45.48%, U.A. 7.47%]

91. An unripe mango placed in a concentrated solution to prepare pickle. Shrivels because-----.



- (1) It gains water due to osmosis.
- (2) It loses water due to reverse osmosis.
- (3) It gains water due to reverse osmosis.
- (4) It loses water due to osmosis.

[C. 46.78%, I.C. 42.41%, U.A. 10.81%]

92. When one mole of non-volatile solute is dissolved in three moles of solvent, the vapour pressure of the solution relative to the vapour pressure of the pure solvent is -



(1) $\frac{1}{3}$ (2) $\frac{1}{4}$ (3) $\frac{3}{4}$ (4) 1 [C. 46.30%, I.C. 46.43%, U.A. 7.27%]

93. Camphor is used as solvent to determine the molecular weight of nonvolatile solute by Rast method because for camphor



- (1) Molal depresion constant is high
- (2) Melting point is high
- (3) Being cheap
- (4) All

[C. 45.08%, I.C. 45.42%, U.A. 9.49%]

94. The vapour pressure of a solution having solid as solute and liquid as solvent is -

(1) Directly proportional to mole fraction of the solvent

(2) Inversely proportional to mole fraction of the solvent

(3) Directly proportional to mole fraction of the solute

(4) Inversely proportional to mole fraction of the solute

[C. 43.65%, I.C. 47.23%, U.A. 9.12%]

95. If a thin slice of sugar beet is placed in concentrated solution of NaCl then

(1) Sugar beet will lose water from its cells

- (2) Sugar beet will absorb water from solution
- (3) Sugar beet will neither absorb nor lose water

(4) Sugar beet will dissolve in solution

[C. 43.17%, I.C. 46.13%, U.A. 10.70%]

96. A solution containing 500 g of a protein per litre is isotonic with a solution containing 3.42 g of sucrose per litre. The molecular mass of protein is -

 (1) 5
 (2) 146

 (3) 34200
 (4) 50000

[C. 43.00%, I.C. 48.12%, U.A. 8.87%]

97. The lowering of vapour pressure of a solvent by addition of a non-volatile solute to it is directly proportional to



- (2) The nature of the solute in the solution
- (3) The atmospheric pressure

(4) All

[C. 42.58%, I.C. 49.86%, U.A. 7.56%]

98. If mole fraction of the solvent in a solution decreases then



- (1) Vapour pressure of solution increases
- (2) b.pt decreases
- (3) Osmotic pressure increases
- (4) All are correct

[C. 42.08%, I.C. 50.82%, U.A. 7.10%]

99. The best colligative property used for the determination of molecular masses of polymers is -



- (1) Relative lowering in vapour pressure
- (2) Osmotic pressure
- (3) Elevation in boiling point
- (4) Depression in freezing point

[C. 40.19%, I.C. 31.30%, U.A. 28.52%]

100 An aqueous solution freezes at -0.186 °C (K_f =1.86°; K_b = 0.512°). What is the elevation in boiling point ?



(1) 0.186	(2) 0.512
(3) $\frac{0.512}{1.86}$	(4) 0.0512
2100	[C. 38.03%, I.C. 53.24%, U.A. 8.73%]

101Osmotic pressure of a sugar solution at 24°C is 2.5 atmospheres. The concentration of the solution in mole per litre.



(1) 10.25 (2) 1.025 (3) 1025 (4) 0.1025 [C. 35.91%, I.C. 56.35%, U.A. 7.73%]

102In the case of osmosis, solvent molecules move from:



(1) Higher vapor pressure to lower vapor pressure

(2) Higher concentration to lower

concentration

(3) Lower vapor pressure to higher vapor pressure

(4) Higher osmotic pressure to lower osmotic pressure

[C. 31.34%, I.C. 60.30%, U.A. 8.36%]



103The van't Hoff factor for a dilute aqueous solution of glucose is:

(1) zero (2) 1.0 (3) 1.5 (4) 2.0[C. 67.97%, I.C. 24.84%, U.A. 7.19%]

- **104**Which salt may show the same value of Vant Hoff factor (i) as that of K₄[Fe(CN)₆] in very dilute solution state -
 - (1) $Al_2 (SO_4)_3$ (2) NaCl (3) $Al(NO_3)_3$ (4) Na₂SO₄ [C. 63.33%, I.C. 29.28%, U.A. 7.39%]
- **105**Which solution will show maximum elevation in boiling point -



- (1) 0.1 M KCl (2) 0.1 M BaCl₂ $(3) 0.1 \text{ M FeCl}_3$ (4) 0.1 M $Fe_2(SO_4)_3$ [C. 63.26%, I.C. 31.54%, U.A. 5.20%]
- **106** Which of the following solutions will have highest boiling point?



- (1) 1% Glucose in water
- (2) 1% Sucrose in water
- (3) 1% NaCl in water
- (4) 1% Urea in water

[C. 63.03%, I.C. 32.23%, U.A. 4.74%]

107 In which of the following , the Vant Hoff factor (i) is equal to one-



(1) NaCl (2) KNO_3 (3) Urea (4) All [C. 62.00%, I.C. 30.08%, U.A. 7.92%]

108Which of the following 0.1 M aqueous solutions will have the lowest freezing point-



- (1) Potassium sulphate (2) Sodium chloride
- (3) Urea (4) Glucose [C. 58.66%, I.C. 35.71%, U.A. 5.63%]

109 The correct relationship between the boiling points of very dilute solution of Na_2SO_4 (T₁K) and $NaCl(T_2K)$ having the same molar concentration is:



- (2) $T_1 > T_2$ (4) $T_2 \le T_1$ [C. 56.70%, I.C. 26.58%, U.A. 16.72%]
- **110**The osmotic pressure of equimolar solutions of BaCl₂, NaCl and glucose will be in the order -



- (1) Glucose > NaCl > BaCl₂
- (2) $BaCl_2 > NaCl > Glucose$
- (3) $NaCl > BaCl_2 > Glucose$
- (4) $NaCl > Glucose > BaCl_2$

[C. 56.29%, I.C. 26.95%, U.A. 16.77%]

111 Which aqueous solution has minimum freezing point -



(1) 0.01 M NaCl

(1) 1

(1) $T_1 = T_2$

(3) $T_2 > T_1$

(3) 0.005 M MgI₂

(4) $0.005 \text{ M} \text{MgSO}_{4}$ [C. 55.30%, I.C. 40.05%, U.A. 4.65%]

(2) 0.005 M C₂H₅OH

112The substance A when dissolved in solvent B shows the molecular mass corresponding to A₃. The Vant Hoff's factor will be -

(2) 2

(4) $\frac{1}{3}$ **(3)** 3 [C. 53.35%, I.C. 39.63%, U.A. 7.01%]

113A 5.8% (wt./vol.) NaCl solution will exert an osmotic pressure closest to which one of the following?



- (1) 5.8% (wt./vol) sucrose solution
- (2) 5.8% (wt./vol) glucose solution
- (3) 2 M sucrose solution
- (4) 1 M glucose solution

[C. 51.48%, I.C. 44.07%, U.A. 4.44%]

- **114**.Which of the following aqueous solution will show maximum vapour pressure at 300 K?
 - (1) 1 M NaCl (2) 1 M CaCl₂ (3) 1 M AlCl₃ (4) 1 M C₁₂H₂₂O₁₁ [C, 5].45%, LC, 4].84%, U.A. 6.71%]

115 Van't Hoff factor (i)



(1) Is less than one in case of dissociation

(2) Is more than one in case of association

- (3) $i = \frac{\text{normal molecular mass}}{\text{observed molecular mass}}$ (4) $i = \frac{\text{observed molecular mass}}{\text{normal molecular mass}}$ (C, 51.29%, LC, 40.09%, U.A, 8.62%)
- **116**.Which one of the following pairs of solutions will be expected to be isotonic under the same temperature-



- (1) 0.1M urea and 0.1M NaCl
- (2) 0.1M urea and 0.2M $MgCl_2$
- (3) 0.1M NaCl and 0.1M Na₂SO₄
- (4) $0.1M \text{ Ca}(\text{NO}_3)_2$ and $0.1M \text{ Na}_2\text{SO}_4$

[C. 50.48%, I.C. 43.81%, U.A. 5.71%]

117 The experimental molecular weight of an electrolyte will always be less than its calculated value because the value of Van't Hoff factor, (i) is -



(3) One

(2) Greater than 1

(4) Zero

[C. 50.39%, I.C. 40.55%, U.A. 9.06%]

118 When mercuric iodide is added to the aqueous solution of potassium iodide, the -



- (1) The boiling point does not change
- (2) freezing point is raised
- (3) The freezing point is lowered
- (4) freezing point does not change

[C. 49.71%, I.C. 46.20%, U.A. 4.09%]

119Which is the correct relation between osmotic pressure of 0.1M NaCl solution and 0.1M Na₂SO₄ solution ?



(1) The osmotic pressure of Na_2SO_4 is less than NaCl solution

- (2) The osmotic pressure Na_2SO_4 is more than NaCl solution
- (3) Both have same osmotic pressure
- (4) None of the above

[C. 49.24%, I.C. 45.18%, U.A. 5.58%]

120Which solution will have least vapour pressure-



- (1) 0.1 M BaCl₂
- (2) 0.1 M Urea
- (3) 0.1 M Na₂SO₄
- (4) 0.1 M Na₃PO₄

[C. 48.78%, I.C. 48.78%, U.A. 2.44%]

121 The molar mass of NaCl determined by the osmotic pressure method will be-



- (1) Higher than the theoretical value
- (2) Lower than the theoretical value
- (3) The same as the theoretical value
- (4) None of these

[C. 47.50%, I.C. 49.00%, U.A. 3.50%]

122Which of the following aqueous solutions should have the highest boiling point?



- (1) 1.0 M NaOH
 - (2) 1.0 M Na₂ SO₄

(3) 1.0 M NH₄NO₃ **(4)** 1.0 M KNO₃

[C. 47.27%, I.C. 45.98%, U.A. 6.75%]

123The substance when dissolved in water would decrease the vapour pressure of water to the greatest extent is -



(1) 0.1 M KCl (3) 0.1 M BaCl₂

(2) 0.1 M urea
(4) 0.1 M NaCl
(C. 46.39%, I.C. 51.03%, U.A. 2.58%)

124 The freezing point of equimolal aqueous solution will be highest for-



(1) C₆H₅NH₃Cl

- (2) $Ca(NO_3)_2$
- (3) $La(NO_3)_3$
- (4) $C_6H_{12}O_6$ (Glucose)

[C. 44.38%, I.C. 33.13%, U.A. 22.50%]

125 Which one has same Van't Hoff factor i as that of Hg₂Cl₂

- (1) NaCl
- (2) Na₂SO₄
- (3) $Al(NO_3)_3$
- (4) $Al_2(SO_4)_3$

[C. 44.19%, I.C. 46.82%, U.A. 8.99%]

126Which of the following solutions at the same temperature will be isotonic 9



(1) 3.42 g of cane sugar in one litre water and

0.18 g of glucose in one litre water

(2) 3.42 g of cane sugar in one litre water and

0.18 g of glucose in 0.1 litre water

(3) 3.42 g of cane sugar in one litre water and

0.585g of NaCl in one litre water

(4) 3.42 g of cane sugar in one litre water and

1.17 g of NaCl in one litre water

[C. 42.42%, I.C. 50.38%, U.A. 7.20%]

127The freezing point order of the solution of glucose is



(1) 10% > 3% > 2% > 1%

- (2) 1% > 2% > 3% > 10%
- (3) 1% > 3% > 10% > 2%
- (4) 10% > 1% > 3% > 2%

[C. 40.64%, I.C. 54.77%, U.A. 4.59%]

128A 0.004M solution of Na₂SO₄ is isotonic with a 0.010M solution of glucose at the 25°C temperature. The apparent degree of dissociation of Na₂SO₄ is

(1) 25% (2) 50% (3) 75% (4) 85% [C. 40.00%, I.C. 54.04%, U.A. 5.96%]

129A 1.17% solution of NaCl is isotonic with 7.2% solution of glucose calculate the value of i of NaCl



(1) 1 (2) 2 **(3)** 3 **(4)** 4 [C. 39.61%, I.C. 54.59%, U.A. 5.80%]

130 The following aqueous solution in the correct order of decreasing freezing point is -



(1) 0.2M BaCl₂, 0.2M KCl, 0.1M Na₂SO₄

(2) 0.2M KCl, 0.1M Na₂SO₄, 0.2M BaCl₂

(3) 0.1M Na₂SO₄, 0.2M KCl, 0.2M BaCl₂

(4) 0.1M Na₂SO₄, 0.2M BaCl₂, 0.2M KCl

[C. 35.71%, I.C. 35.71%, U.A. 28.57%]

131 The values of observed and calculated molecular weight of silver nitrate are 92.64 and 170 respectively.



The degree of dissociation of silver nitrate is:

(1) 60% **(2)** 83.5% **(3)** 46.7% **(4)** 60.23% [C. 31.43%, I.C. 62.86%, U.A. 5.71%]

132The lowring of vapour pressure of 0.1M aqueous solutions of NaCl, $CuSO_4$ and K_2SO_4 are :



- (1) All equal
- (2) In the ratio of 1 : 1 : 1.5
- (3) In the ratio of 3:2:1
- (4) In the ratio of 1.5 : 1 : 2.5

[C. 15.63%, I.C. 79.69%, U.A. 4.69%]

Exercise - 2

- **1.** Assuming each salt to be completely dissociated which of the following will have highest osmotic pressure-
 - (1) Decimolar $Al_2(SO_4)_3$
 - (2) Decimolar BaCl₂
 - (3) Decimolar Na₂SO₄

(4) A solution obtained by mixing equal volumes of (B) and (C) and filtering

Decimolar solution of potassium ferricyanide, K₃[Fe(CN)₆] has osmotic pressure of 3.94 atm at 27°C. Hence percent ionisation of the solute is -

(1) 10% **(2)** 20% **(3)** 30% **(4)** 40%

3. The solubility of $N_2(g)$ in water exposed to the atmosphere, when its partial pressure is 593 mm is 5.3 × 10^{-4} M. Its solubility at 760 mm and at the same temperature is :

(1) 4.1×10^{-4} M (2) 6.8×10^{-4} M

- (3) 1500 M
- (4) 2400 M
- 4. Arrange the following aqueous solutions in the order of their increasing boiling points :
 (i) 10⁻⁴ M NaCl
 (ii) 10⁻⁴ M Urea
 (iii) 10⁻³ M MgCl₂
 (iv) 10⁻² M NaCl

 (1) (i) < (ii) < (iv) < (iii)
 (2) (ii) < (i) < (iv) < (iv)
 (3) (ii) < (i) < (iii) < (iv)
 - (4) (iv) < (iii) < (i) = (ii)



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(1) 39.2 gram	(2) 1.1 molal
(3) 0.5 molal	(4) 0.1 molal

6. Increasing the temperature of an aqueous solution will cause -



- (1) Decrease in Molality
- (2) Decrease in molarity
- (3) Decrease in mole fraction
- (4) Decrease in % w/w
- 7. Which of the following is correct for an ideal solution? (i) $\Delta G_{mix} = 0$ and $\Delta H_{mix} > 0$ (ii) $\Delta H_{mix} = 0$ and $\Delta V_{mix} = 0$ (iii) $\Delta V_{mix} = 0$ and $\Delta S_{mix} > 0$ (iv) $\Delta H_{mix} > 0$ and $\Delta S_{mix} > 0$ Correct option is

(1) i, ii, iii	(2) ii, iii
(3) i, ii, iv	(4) i, ii, iii, iv

8. Osmotic pressure of a solution containing 1 g protein in 100 mL solution at 300 K is 1.66 bar. What is the molecular weight of protein $(R = 0.083 \text{ L bar mol}^{-1} \text{ K}^{-1})$



- (1) 150
 (2) 120

 (3) 130
 (4) 300
- **9.** How many grams of a non volatile solute having a molecular weight of 90 are to be dissolved in 97.5 g water in order to decrease the vapour pressure of water by 2.5 percent ?



(1) 25 **(2)** 18 **(3)** 12.5 **(4)** 9

10. The solubility of gases in liquids:



(1) Increases with increase in pressure and temperature

(2) Decreases with increase in pressure and temperature

(3) Increases with increase in pressure and decrease in temperature

(4) Decreases with increase in pressure and increase in temperature

11. A mixture of liquid showing positive deviation in Raoult's law is -



(CH₃)₂CO + C₂H₅OH
 (CH₃)₂CO + CHCl₃
 (C₂H₅)₂O + CHCl₃
 (CH₃)₂CO + C₆H₅NH₂

12. 25 mL of 3 M HCl were added to 75 mL of 0.05 M HCl. The molarity of HCl in the resulting solution is approximately-



(1) 0.055 M	(2)	0.35 M
(3) 0.787 M	(4)	3.05 M

13. The relationship between osmotic pressure at 273 K when 10 g glucose (P₁) ,10 g urea (P₂) and 10 g sucrose (P₃) are dissolved in 250 mL of water is :

(1)
$$P_1 > P_2 > P_3$$

(2) $P_3 > P_1 > P_2$
(3) $P_2 > P_1 > P_3$
(4) $P_2 > P_3 > P_1$

14. 1.0 molal aqueous solution of an electrolyte A_2B_3 is 60% ionised. The boiling point of the solution at 1 atm is ($K_{b(H_2O)} = 0.52 \text{ Kkgmol}^{-1}$)



(1) 274.76 K	(2) 377 K
(3) 376.4 K	(4) 374.76 K

15. Osmotic pressure of 30% solution of glucose is 1.20 atm and that of 3.42% solution of cane sugar is 2.5 atm. The osmotic pressure of the mixture containing equal volumes of the two solutions will be -

(1) 2.5 atm	(2) 3.7 atm
-------------	-------------

- (**3**) 1.85 atm (**4**) 1.3 atm.
- 16. A complex containing K^{+,} Pt (IV) and Cl⁻ is 100% ionised giving i = 3. Thus, complex is



- (1) K_2 [PtCl₄] (2) K_2 [PtCl₆] (3) K_3 [PtCl₅] (4) K[PtCl₃]
- **17.** The osmotic pressure of a solution of benzoic acid dissolved in benzene is less than expected because;



- (1) Benzoic acid is an organic solute
- (2) Benzene is a non-polar solvent
- (3) Benzoic acid dissociates in benzene
- (4) Benzoic acid gets associated in benzene
- **18.** Select incorrect statement :



(1) Higher the value of k_H (Henry's law constant) at a given pressure, the lower is the solubility of the gas in the liquid
 (2) Solubility of a gas in a liquid decreases

with increases in temperature and pressure

(3) to minimize the painful effects accompanying the decompression of deep sea divers, O_2 diluted with less soluble He gas is used as breathing gas

(4) The solubility of a gas in a liquid is governed by Henry's law



		Liquiu
19.	Consider the following statements (i) Osmotic pressure method is the	
	most useful method to determining	THE REACTOR
	the molecular weight of	
	macromolecules	
	(ii) The molecular weight of the	
	macromolecules does not change in	
	presence of an electrolyte in the	
	solution	
	(iii) Colligative properties are helpful	
	to determine moleculer weight of	
	macromolecules	
	(iv) Chloroform - Acetone is a	
	negative deviation azeotropic	
	mixtures	
	Which of the above statement is/are	
	$(1) 1 (2) 1, 11, 111 (2) \cdots (4) \cdots (4)$	
	(3) 11, 111 (4) 11, 1V	
20.	0.2 mole of HCl and 0.1 mole of	

20. 0.2 mole of HCl and 0.1 mole of □
CaCl₂ were dissolved in water to have 500 ml of solution, the molarity of Cl⁻ ions is-

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(1) 0.04 M	(2) 0.8 M
(3) 0.4 M	(4) 0.08 M

21. Which of the following statement is / are correct?
(i) For ideal solution (Van't Hoff factor), i = 1

(ii) For non electrolyte, i = 1

(iii) For electrolyte undergoing dissociation, i > 1

(iv) For electrolyte undergoing association, i < 1 Correct option is

(1) ii	(2) iii, iv
(3) i, ii, iii	(4) All of the above

22. Hydrochloric acid solution A and B have concentration of 0.5 N and 0.1 N respectively. The volume of solutions A and B required to make 2 liters of 0.2 N HCl are -



- (1) 0.5 lit. of A + 1.5 lit. of B
- (2) 1.5 lit. of A + 0.5 lit. of B
- (3) 1.0 lit. of A + 1.0 lit. of B
- (4) 0.75 lit. of A + 1.25 lit. of B
- **23.** Ethylene glycol is used as an antifreeze in a cold climate. Mass of ethylene glycol which should be added to 4 Kg of water to prevent it from freezing at -6° C will be : (k_f for water = 1.86 K kg mol⁻¹, and molar mass of ethylene glycol = 62 g mol⁻¹)
 - (1) 400.00 g (2) 304.60 g
 - (**3**) 800.00 g (**4**) 204.30 g
- **24.** Which of the following solutions has the highest normality -



- (1) 8 grams of KOH per litre
- (2) N phosphoric acid
- (3) 6 gms of NaOH per 100 ml
- (4) 0.5 M H₂SO₄
- **25.** A 0.2 molal aqueous solution of a weak acid (HX) is 20% ionised. The freezing point of this solution is (Given : $K_f = 1.86$ °C/m for water)



- (1) $-0.31^{\circ}C$ (2) $-0.45^{\circ}C$ (3) $-0.53^{\circ}C$ (4) $-0.90^{\circ}C$
- **26.** The vapour pressure of pure benzene and toluene are 160 and 60 torr respectively. The mole fraction of toluene is vapour phase in contact with equimolar solution of benzene and toluene is -

(1) 0.50 **(2)** 0.6 **(3)** 0.27 **(4)** 0.73



27. The degree of dissociation (α) of a weak electrolyte, $A_x B_y$ is related to van't Hoff factor (i) by the expression

(1)
$$\alpha = \frac{x+y-1}{i-1}$$
 (2) $\alpha = \frac{x+y+1}{i-1}$
(3) $\alpha = \frac{i-1}{(x+y-1)}$ (4) $\alpha = \frac{i-1}{(x+y+1)}$

28. Glucose is added to 1 litre water to such an extent that $\frac{\Delta T_f}{K_f}$ becomes equal to $\frac{1}{1000}$, the wt. of glucose added is -

(1) 180 g (2) 18 g (**3**) 1.8 g (4) 0.18 g

29. The Van't Hoff factor for 0.1 M $Ba(NO_3)_2$ solution is 2.74. The degree of dissociation is

(1) 91.3% (2) 87% (3) 100% (4) 74%

30. Among 0.1 M solutions of urea, Na₃ PO_4 and $Al_2(SO_4)_3$



(a) The vapour pressure and freezing point are the lowest for urea

(b) The vapour pressure and freezing

point are the highest for urea

(c) The elevation in boiling point is

the highest for $Al_2(SO_4)_3$

(d) The depression in freezing point is the highest for $Al_2(SO_4)_3$

(1) Only a	(2) b & c both
(3) b, c and d	(4) a, b, c and c

31. For an ideal solution of A and B which statement is incorrect : -

(1) The enthalpy change of mixing of A and B is zero

(2) The volume change of solution A and B is zero

(3) The intermolecular forces of A and B is same as that of A-A and B-B

(4) The entropy change of mixture of A and B is zero

- **32.** The relationship between the values of osmotic pressure of solutions obtained by dissolving 6.00 g L^{-1} of CH₃COOH (π_1) and 7.45 g L⁻¹ of KCl (π_2) is :-
 - (1) $\pi_1 > \pi_2$ (2) $\pi_1 < \pi_2$ (3) $\pi_1 = \pi_2$ (4) None of these
- **33.** Which of the following plots does not represent the behaviour of an ideal binary liquid solution :-



(1) Plot of P_A versus X_A (mole fraction of A in liquid phase) is linear

- (2) Plot of $P_{\rm B}$ versus $X_{\rm B}$ is linear
- (3) Plot of p_{total} versus X_A (or X_B) is linear
- (4) Plot of p_{total} versus X_A is non linear
- **34.** An X molal solution of a compound in benzene has mole fraction of solute equal to 0.2. The value of X is-

*	
(1) 14	(2) 3.2
(3) 1.4	(4) 2

35. Select correct statement -



(1) Boiling point of 1 molal NaCl solution is twice that of 1 molal sucrose solution (2) Boiling point elevation of 1 molal glucose solution is half of the 1 molal KCl solution (3) Boiling point is a colligative property (4) All of the above

36. The average osmotic pressure of human blood is 7.8 bar at 37°C. What is the concentration of an aqueous NaCl solution that could be used in the blood stream -



(1) 0.16 mol/L	(2) 0.32 mol/L
(3) 0.60 mol/L	(4) 0.45 mol/L



37. Boiling point of benzene is 353.23 K. When 1.8 g of non-volalite solute is dissolved in 90 g of benzene. then boiling point raised to 354.11 K. Given K_b (benzene) = 2.53 K kg mol⁻ ¹. Then molecular mass of non volatile substance is : -

(1) 58 g mol ⁻¹	(2) 120 g mol ⁻¹
(3) 116 g mol ⁻¹	(4) 60 g mol ⁻¹

38. The vapour pressure of two pure liquids (1) and (2) are 100 and 80 torr respectively. The total pressure of the solution obtained by mixing 2 mol of (1) and 3 mol of (2) would be



- (3) 88 torr (4) 180 torr
- **39.** Elevation of boiling point of 1 molar aqueous glucose solution (density = 1.2 g/ml) is



- (1) $K_{\rm h}$ (2) 1.20 K_h (3) 1.02 K_h (4) 0.98 K_h
- **40.** An aqueous solution contains 5% and 10% of urea and glucose respectively (by wt.). If K_f for water is 1.86, the freezing point of solution is



- **41.** On adding a non volatile solute to a solvent, the vapour pressure of solvent decreases and becomes $z \times [vapour]$ pressure of solvent] where z is
 - (1) mole fraction of solvent
 - (2) mole fraction of solute
 - (3) molality
 - (4) molarity



42. A 5% solution (by mass) of cane sugar in water has freezing point of 271 K and freezing point of pure water is 273.15K. The freezing point of a 5% solution (by mass) of glucose in water is -

(1) 271 K	(2) 273·15 K
(3) 269∙07 K	(4) 277·23 K

43. Which of the following solution will have highest freezing point?



(1) 2 M NaCI (2) 1.5 M AlCl₃ (3) $1M AI_2(SO_4)_3$

(4) 3M urea

44. A solution of urea (mol. mass 56g mol^{-1}) boils at 100.18°C at the atmospheric pressure. If K_f and K_b for water are 1.86 and 0.512K kg mol⁻¹ respectively the above solution will freeze at



(1) −6.54°C	(2) –0.654°C
(3) 6.54°C	(4) 0.654°C

45. A solution containing 28 phosphorus in 315 gm CS_2 (b.p. = 46.3°C) boils at 47.9°C (K_h for CS_2 is 2.34). What will be the molecular formula of phosphorus (Assume complete association)?



- (1) P₄ (2) P₂ (3) P₆ (4) None of these
- **46.** A solution has a 1 : 4 mole ratio of pentane to hexane. The vapour pressure of the pure hydrocarbons at 20°C are 440 mmHg for pentane and 120 mmHg for hexane. The mole fraction of pentane in the vapour phase would be

(1) 0.200	(2) 0.478
(3) 0.549	(4) 0.786



- **47.** The freezing point of a solution containing 0.2 g of acetic acid in 20 g benzene is lowered by 0.45° C, calculate the degree of dimerisation of acetic acid is benzene. K_f for benzene is 5.12 Kmol⁻¹ Kg
 - **(1)** 0.527 **(2)** 0.80

(3) 0.945	(4) None of these
N 2	

48. The vapour pressure of a solvent decreases by 10 mm of Hg when a non-volatile solute was added to the solvent. The mole fraction of the solute in the solution is 0.2. What should be the mole fraction of the solvent if the decrease in vapour pressure is to be 20 mm of Hg -

(1) 0.2	(2) 0.4
(3) 0.6	(4) 0.8

49. FeCl₃ on reaction with $K_4[Fe(CN)_6]$ in aqueous solution gives blue colour. These are separated by a semipermeable membrane AB as shown. Due to osmosis there is :



- (1) blue colour formation in side X
- (2) blue colour formation in side Y

(3) blue colour formation in both of the sides X and Y

(4) no blue colour formation

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(1) A-(i), B-(ii), C-(iii), D-(iv), E-(v)

- (2) A-(i), B-(iii), C-(ii), D-(iv), E-(v)
- (3) A-(v), B-(iv), C-(iii), D-(ii), E-(i)
- (4) A-(v), B-(iv), C-(i), D-(iii), E-(ii)

51. Only One Match is possible :

	List-A		List-B
	Vapour		Mole
(A)	pressure of	(i)	fraction of
	solution		solute
	Lowering in		Mole
(\mathbf{R})	vapour	(ii)	fraction of
	pressure of	(11)	solvent
	solution		Sorvent
	Acetone-		$\Delta H_{mixing} =$ +ve
(C)	CHCl ₃	(iii)	
	solution		
	Hexane-		ли
(D)	ethanol	(iv)	$\Delta \Pi_{mixing} - ve$
	solution		
	van't Hoff		Graatar
(E)	factor for	(v)	than unity
	glucose0H ₂ O		
	van't Hoff	(vi)	Equal to
(F)	factor for		unity
	NaCl-H ₂ O		

- (1) A-(ii), B-(i), C-(iv), D-(iii), E-(vi), F-(v)
- (2) A-(ii), B-(iii), C-(iv), D-(i), E-(vi), F-(v)
- (3) A-(i), B-(ii), C-(v), D-(iv), E-(vi), F-(iii)
- (4) A-(ii), B-(i), C-(v), D-(iii), E-(vi), F-(iv)



52. Match the items given in column I with the type of solutions given in column II.

	Column-I		Column-II
		(A)	A solution of
(i)	Soda water		the gas in
			solid
(;;)	(ii) Sugar (D)	A solution of	
(11)	solution	(Б)	the gas in gas
(iii)	Air	(C)	A solution of
			solid in liquid
	Hydrogen		A solution of
(iv)	gas in	(D)	the gas in
	palladium		liquid

- (1) (i)-A, (ii)-D, (iii)-C, (iv)-B (2) (i)-C, (ii)-B, (iii)-D, (iv)-A
- (3) (i)-D, (ii)-C, (iii)-B, (iv)-A
- (4) (i)-D, (ii)-A, (iii)-B, (iv)-C
- **53.** Match the laws given in column I with expressions given in column II.



	Column-I		Column-II
(i)	Raoult's law	(A)	$\Delta T_f = K_f m$
(ii)	Henry's law	(B)	$\pi = CRT$
(iii)	Elevation of boiling point	(C)	${ m P}={ m x_1P_1^0}+{ m X_2P_2^0}$
(iv)	Depression in freezing point	(D)	$\Delta T_b = K_b m$
(v)	Osmotic pressure	(E)	$P = K_{H}.X$

- (2) (i)-D, (ii)-E, (iii)-B, (iv)-C, (v)-A
- (3) (i)-E, (ii)-C, (iii)-D, (iv)-B, (v)-A
- (4) (i)-C, (ii)-E, (iii)-D, (iv)-A, (v)-B

54. Assertion : Cooking time is reduced in pressure cookers.



Reason : Boiling point inside the pressure cooker is raised.

 If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion
 If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

- (3) If Assertion is True but the Reason is False
- (4) If both Assertion & Reason are false.
- **55. Assertion :** When Benzoic acid is dissolved in benzene its Vant Hoff factor is less than one



Reason : In benzene, benzoic acid has tendency to form dimer.

 If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion
 If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

- (3) If Assertion is True but the Reason is False
- (4) If both Assertion & Reason are false.
- **56.** Statement I : Non-ideal solutions form azeotropic mixture.



Statement II : Boiling point of azeotropic mixture is only higher than boiling points of both the components.

- (1) Both Statement I and Statement II are false
- (2) Statement I is true but Statement II is false
- (3) Statement I is false but Statement II is true
- (4) Both Statement I and Statement II are true

57. Statement I : Elevation in boiling point of 0.1 M KCl and 0.1 M CaCl₂ is same.

Statement II : Because colligative properties depends on molarity only.

- (1) Both Statement I and Statement II are false
- (2) Statement I is true but Statement II is false
- (3) Statement I is false but Statement II is true
- (4) Both Statement I and Statement II are true
- **58. Assertion :** The molality of the solution doesn't change with change in temperature.



Reason : The molality is expressed in units of moles per 100 ml. solution.

 (1) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion
 (2) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(3) If Assertion is True but the Reason is False

(4) If both Assertion & Reason are false.

59. Assertion : Osmosis involves movement of solvent molecules from its lower concentration to its higher concentration.



Reason : Solutions having the same osmotic pressure are called isotonic solutions.

 (1) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion
 (2) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(3) If Assertion is True but the Reason is False

(4) If both Assertion & Reason are false.

60. Assertion : Azeotropic mixture can't be separated by fractional distillation.
 Reason : Azeotropic mixtures are constant boiling mixtures.



 (1) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion
 (2) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(3) If Assertion is True but the Reason is False

- (4) If both Assertion & Reason are false.
- **61.** Assertion : ΔV_{mix} and ΔS_{mix} for an ideal solution is zero.



Reason : A...B interaction in an ideal solution are not same as between A... A and B...B.

 If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion
 If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(3) If Assertion is True but the Reason is False(4) If both Assertion & Reason are false.

62. Assertion : Addition of ethylene glycol to water lowers the freezing point of water, therefore, used as antifreeze substance.



Reason : Ethylene glycol is soluble in water.

 (1) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion
 (2) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(3) If Assertion is True but the Reason is False

(4) If both Assertion & Reason are false.

63. Assertion : Reverse osmosis is used to purify sea water.Reason : Solvent molecules pass



Reason : Solvent molecules pass from concentrate solution to pure solvent through semipermeable membrane if high pressure (> π) is applied on solution side

 If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion
 If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(3) If Assertion is True but the Reason is False

(4) If both Assertion & Reason are false.

64. Assertion : Camphor is used as a solvent in the determination of the molecular mass of naphthalene and anthracene



Reason : Camphor has high molal elevation constant

 If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion
 If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(3) If Assertion is True but the Reason is False

(4) If both Assertion & Reason are false.

Exercise - 3

1. Which one of the following is incorrect for ideal solution ?



- (1) $\Delta G_{mix} = 0$
- (2) $\Delta H_{mix} = 0$
- (3) $\Delta U_{mix} = 0$
- (4) $\Delta P = P_{obs} P_{calculated by Rault's law} = 0$ [C. 66.29%, I.C. 27.15%, U.A. 6.56%] [NEET-2016]
- 2. Which of the following is dependent on temperature ?
 - (1) Molality (2) Molarity

(4) Weight percentage (3) Mole fraction [C. 59.71%, I.C. 29.90%, U.A. 10.40%] [NEET-2019]

3. Which one of the following electrolytes has the same value of van't Hoff's factor (i) as that the $Al_2(SO_4)_3$ (if all are 100% ionised)?

(1) $K_3[Fe(CN)_6]$ (2) $Al(NO_3)_3$ (3) $K_4[Fe(CN)_6]$ (4) K_2SO_4 [C. 59.67%, I.C. 31.60%, U.A. 8.73%] [NEET-2015]

- **4.** If molality of the dilute is doubled, the value of molal depression constant (K_f) will be
 - (1) doubled (2) halved
 - (3) tripled

(4) unchanged [C. 57.21%, I.C. 33.19%, U.A. 9.61%] [NEET-2019]

5. The mixture that forms maximum, boiling azeotrope is :



- (1) Acetone + Carbon disulphide
- (2) Heptane + Octane
- (3) Water + Nitric acid
- (4) Ethanol + Water

[C. 50.87%, I.C. 37.02%, U.A. 12.11%] [NEET-2019]

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6. For an ideal solution the correct option is :



- (1) Δ_{mix} H =0 at constant T and P (2) Δ_{mix} G =0 at constant T and P
- (3) Δ_{mix} S =0 at constant T and P
- (4) $\Delta_{mix} V \neq 0$ at constant T and P

[C. 50.48%, I.C. 39.66%, U.A. 9.86%] [NEET-2019]

7. 1 gm of polymer having molar mass 1,60,000 gm dissolve in 800 ml water, so calculate osmotic pressure in pascal at 27°C (R = 8.314 J/K mole)



- (1) 19.4 (4) 1.20 (2) 0.90 (3) 0.50 [C. 49.11%, I.C. 38.22%, U.A. 12.67%] [NEET-2019]
- 8. The Van't Hoff factor i for a which undergoes compound dissociation in one solvent and association in other solvent is respectively :



- (1) less than one and greater than one
- (2) less than one and less than one
- (3) greater than one and less than one
- (4) greater than one and greater than one [C. 44.34%, I.C. 42.39%, U.A. 13.27%] [AIPMT PRE-2011]
- **9.** Ethylene glycol is used as antifreeze to reduce freezing point of water to -2.4 °C What mass of antifreeze is required for 2L water ?

$$\left(\mathrm{K_{f}~water}~=~1.\,86rac{\mathrm{K~kg}}{\mathrm{mole}}
ight)$$

(1) 16 kg (2) 160 g (3) 1.60 kg (4) 16 g

[C. 43.87%, I.C. 28.68%, U.A. 27.45%] [NEET-2019]

10. Which one is not equal to zero for an ideal solution : -



- (1) ΔS_{mix}
- (2) ΔV_{mix}
- (3) $\Delta P = P_{observed} P_{Raoult}$
- (4) ΔH_{mix}

(

[C. 42.82%, I.C. 29.03%, U.A. 28.16%] [NEET-2015]

11. What is the mole fraction of the solute in a 1.00 m aqueous solution ?



(1) 0.03564(2) 0.0177

(4) 1.770 (3) 0.177

[C. 42.74%, I.C. 48.92%, U.A. 8.33%] [NEET-2015]

- **12.** When 45 gm solute is dissolved in 600 gm water freezing point lower by 2.2 K. calculate molar mass of solute $(K_f = 1.86 \text{ K kg mol}^{-1})$
 - (1) 63.4 (2) 80 gm
 - (3) 90 gm (4) 21 gm

[C. 42.36%, I.C. 50.64%, U.A. 7.01%] [NEET-2019]

13. Mole fraction of the solute in a 1.00 molal aqueous solution is :



1) 0.1770	(2) 0.0177
3) 0.0344	(4) 1.7700

[C. 42.15%, I.C. 49.89%, U.A. 7.96%] [AIPMT PRE-2011]

14. The following solutions were prepared by dissolving 10 g of glucose ($C_6H_{12}O_6$) in 250 ml of water (P_1) , 10 g of urea (CH₄N₂O) in 250 ml of water (P_2) and 10 g of sucrose $(C_{12}H_{22}O_{11})$ in 250 ml of water (P₃). The right option for the decreasing order of osmotic pressure of these solution is-

(1)
$$P_3 > P_1 > P_2$$
 (2) $P_2 > P_1 > P_3$
(3) $P_1 > P_2 > P_3$ (4) $P_2 > P_3 > P_1$
[C. 42.06%, I.C. 40.28%, U.A. 17.66%] [NEET-2021]

15. The correct option for the value of vapour pressure of a solution at 45°C with benzene to octane in molar ratio 3 : 2 is :



- (2) 160 mm of Hg (1) 350 mm of Hg
- (4) 336 mm of Hg (3) 168 mm of Hg

[C. 41.87%, I.C. 48.02%, U.A. 10.12%] [NEET-2021]

16. Of the following 0.10 m aqueous solutions, which one will exhibit the largest freezing point depression ?



- (1) KCl (2) $C_6H_{12}O_6$ (3) $Al_2(SO_4)_3$ (4) K₂SO₄ [C. 41.71%, I.C. 29.72%, U.A. 28.57%] [NEET-2014]
- **17.** The van't Hoff factor (i) for a dilute aqueous solution of the strong electrolyte barium hydroxide is



- (1) 3 (2) 0**(3)** 1 (4) 2 [C. 41.70%, I.C. 35.87%, U.A. 22.42%] [NEET-2016]
- **18.** 6.02×10^{20} molecules of urea are present in 100 ml of its solution. The concentration of urea solution is -(Avogadro constant, $N_A = 6.02 \times 10^{23}$



 mol^{-1}) (1) 0.001 M (2) 0.02 M (3) 0.01 M (4) 0.1 M

[C. 41.03%, I.C. 31.94%, U.A. 27.03%] [NEET UG-2013]

19. 200 mL of an aqueous solution of a protein contains its 1.26 g. The Osmotic pressure of this solution at 300 K is found to be 2.57×10^{-3} bar. The molar mass of protein will be (R $= 0.083 \text{ L bar mol}^{-1} \text{ K}^{-1}$):

(1) 61038 g mol^{-1} (2) 51022 g mol⁻¹

(3) 122044 g mol⁻¹ (4) 31011 g mol⁻¹

[C. 40.79%, I.C. 50.00%, U.A. 9.21%] [AIPMT MAINS-2011]

20. The freezing point depression □ constant for water is -1.86°Cm⁻¹. If 5.00 g Na₂SO₄ is dissolved in 45.0g H₂O, the freezing point is changed by -3.82°C. Calculate the Van't Hoff factor for Na₂SO₄

(1) 2.05 **(2)** 2.63

(3) 3.11 **(4)** 0.381

[C. 40.48%, I.C. 49.21%, U.A. 10.32%] [AIPMT PRE-2011]

- **21.** Freezing point of 0.4 m solution of a weak monoprote acid is -0.1° C. What is its Van't Hoff factor i ? (K_f = 1.86 K kg mol⁻¹)
 - (1) 1.5 (2) 1.6 (3) 1.34 (4) 1.1 [C. 40.36%, I.C. 54.29%, U.A. 5.36%] [NEET-2019]
- **22.** The freezing point depression constant (K_f) of benzene is 5.12 K kg mol⁻¹. The freezing point depression for the solution of molality 0.078 m containing a non-electrolyte solute in benzene is (rounded off upto two decimal places) :

(1) 0.80 K	(2) 0.40 K
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(**3**) 0.60 K (**4**) 0.20 K

[C. 40.33%, I.C. 28.31%, U.A. 31.35%] [NEET-2020]

- **23.** Vapour pressure of chloroform (CHCl₃) and dichloromethane (CH₂Cl₂) at 25°C are 200 mm Hg and 415 mmHg respectively. Vapour pressure of the solution obtained by mixing 25.5 g of CHCl₃ and 40 g of CH₂Cl₂ at the same temperature will be : (Molecular mass of CHCl₃ = 119.5 u and molecular mass of CH₂Cl₂ = 85u)
 - (1) 347.9 mmHg (2) 280.5 mmHg
 - (3) 173.9 mmHg (4) 615 mmHg [C. 39.56%, I.C. 38.40%, U.A. 22.04%] [AIPMT MAINS-2012]

24. An aqueous solution is 1.00 molar in KI. Which change will cause the vapour pressure of the solution of increase ?



- (1) Addition of water
- (2) Addition of NaCl
- (3) Addition of Na₂SO₄
- (4) Addition of 100 molal KI

[C. 39.07%, I.C. 53.08%, U.A. 7.86%] [AIPMT-2010]

25. The boiling point of 0.2 mol kg⁻¹ solution of X in water is greater than equimolal solution of Y in water. Which one of the following statements is true in this case ?



(1) Molecular mass of X is greater than the molecular mass of Y.

(2) Molecular mass of X is less than the molecular mass of Y.

(3) Y is undergoing dissociation in water while X undergoes no change.

(4) X is undergoing dissociation in water while Y undergoes no change

[C. 38.79%, I.C. 34.48%, U.A. 26.72%] [NEET-2015]

26. Which of the following statements about the composition of the vapour over an ideal 1 : 1 mol mixture of benzene and toluene is correct ? Assume that the temperature is constant at 25°C. (Given vapour pressure data at 25°C, benzene = 12.8 kJ toluene = 3.85 kPa)



(1) The vapour will contain a higher percentage of benzene.

(2) The vapour will contain a higher percentage of toluene.

(3) The vapour will contain equal amounts benzene and toluene.

(4) Not enough information is given to make prediction.

[C. 38.25%, I.C. 42.70%, U.A. 19.05%] [NEET-2016]



27. A solution of sucrose (molar mass = 342 g mol^{-1}) has been prepared by dissolving 68.5 g of sucrose in 1000 g of water. The freezing point of the solution obtained will be : (K_f for water = $1.86 \text{ K kg mol}^{-1}$)

(1)
$$-0.570^{\circ}$$
C (2) -0.372° C

 $(3) - 0.520^{\circ}C$ $(4) + 0.372^{\circ}C$

[C. 35.36%, I.C. 54.50%, U.A. 10.14%] [AIPMT-2010]

28. p_A and p_B are the vapour pressure of pure liquid components, A and B, respectively of an ideal binary solution. If x_A represents the mole fraction of component A, the total pressure of the solution will be

$$(1) p_{\rm B} + x_{\rm A} (p_{\rm B} - p_{\rm A})$$

(2)
$$p_A + x_A (p_A - p_B)$$

$$(3) p_{\mathrm{A}} + x_{\mathrm{A}} (p_{\mathrm{B}} - p_{\mathrm{A}})$$

- (4) $p_B + x_A(p_A p_B)$
 - [C. 34.41%, I.C. 58.89%, U.A. 6.70%] [AIPMT PRE-2012]
- **29.** Which of the following compounds can be used as antifreeze in automobile radiators ?
 - (1) Nitrophenol (2) Ethyl alcohol
 - (3) Methyl alcohol (4) Glycol [C. 33.71%, I.C. 43.25%, U.A. 23.05%] [AIPMT MAINS-2012]
- **30.** Consider the following liquid vapour equilibrium.

Liquid \rightleftharpoons Vapour Which of the following relations is correct?

(1)
$$\frac{\mathrm{dlnG}}{\mathrm{dT}^2} = \frac{\Delta \mathrm{H}_v}{\mathrm{RT}^2}$$

(2)
$$\frac{\mathrm{dlnP}}{\mathrm{dT}} = \frac{-\Delta \mathrm{H}_v}{\mathrm{RT}}$$

(3)
$$\frac{-\Delta \mathrm{H}_v}{\mathrm{RT}} = \frac{-\Delta \mathrm{H}_v}{\mathrm{T}^2}$$

(4)
$$\frac{\mathrm{dlnP}}{\mathrm{dT}} = \frac{\Delta \mathrm{H}_v}{\mathrm{RT}^2}$$

[C. 32.61%, I.C. 36.67%, U.A. 30.72%] [NEET-2016]

31. At 100°C the vapour pressure of a solution of 6.5 g of a solute in 100 g water is 732 mm of Hg. If $K_b = 0.52$, the boiling point of this solution will be :

(1) 101°C	(2) 100°C
(3) 102°C	(4) 103°C

C (4) 103°C [C. 30.61%, I.C. 29.22%, U.A. 40.16%] [NEET-2016]

- **32.** 25.3 g of sodium carbonate, Na₂CO₃ is dissolved in enough water to make 250 mL of solution. If sodium carbonate dissociates completely, molar concentration of sodium ion, Na⁺ and carbonate ions, CO_3^{2-} are respectively (Molar mass of Na₂CO₃ = 106 g mol⁻¹)
 - (1) 0.477 M and 0.477 M
 - (2) 0.955 M and 1.910 M
 - (3) 1.910 M and 0.955 M
 - (4) 1.90 M and 1.910 M

[C. 28.63%, I.C. 34.53%, U.A. 36.84%] [AIPMT-2010]

33. Given below are two statements : one is labelled as Assertion A and the other labelled as Reason R : Assertion A : Helium is used to dilute



oxygen in diving apparatus. **Reasons** \mathbf{R} : Helium has high solubility in O₂

In the light of the above statements. choose the **correct** answer from the options given below :

(1) Both A and R are true and R is NOT the correct explanation of A.

(2) A is true but R is false.

(3) A is false but **R** is true.

(4) Both A and R are true and R is the correct explanation of A.

[C. 12.44%, I.C. 49.31%, U.A. 38.25%] [NEET-2023]



Liquid Solutions								
				Answer Key	Y			
Exercise - 1 Objective Problems NEET								
1. 2	2. 3	3. 4	4. 2	5. 3	6. 3	7. 3	8. 2	
9. 4	10. 2	11. 2	12. 2	13. 3	14. 3	15. 1	16. 4	
17. 1	18. 3	19. 3	20. 3	21. 4	22. 1	23. 2	24. 3	
25. 4	26. 2	27. 3	28. 2	29. 3	30. 3	31. 4	32. 4	
33. 4	34. 1	35. 3	36. 3	37. 1	38. 1	39. 2	40. 2	
41. 3	42. 2	43. 2	44. 4	45. 3	46. 3	47. 2	48. 4	
49. 4	50. 1	51. 2	52. 2	53. 1	54. 4	55. 1	56. 3	
57. 4	58. 3	59. 4	60. 3	61. 4	62. 1	63. 1	64. 4	
65. 4	66. 2	67. 4	68. 3	69. 1	70. 4	71. 1	72. 2	
73. 3	74. 3	75. 1	76. 1	77. 2	78. 3	79. 1	80. 4	
81. 2	82. 2	83. 2	84. 1	85. 2	86. 2	87. 3	88. 1	
89. 4	90. 4	91. 4	92. 3	93. 1	94. 1	95. 1	96. 4	
97. 1	98. 3	99. 2	100.4	101.4	102. 1	103.2	104. 1	
105.4	106.3	107.3	108. 1	109.2	110.2	111. 1	112.4	
113. 3	114. 4	115.3	116. 4	117.2	118.2	119.2	120.4	
121. 2	122. 2	123. 3	124. 4	125. 2	126. 2	127. 2	128. 3	
129. 2	130.3	131.2	132.2					
E	2							
Exercise -	- 2					Objective Pr	oblems NEE I	
1. 1	2. 2	3. 2	4. 3	5. 4	6. 2	7. 2	8. 1	
9. 3	10. 3	11. 1	12. 3	13. 3	14. 4	15. 3	16. 2	
17. 4	18. 2	19. 2	20. 2	21. 4	22. 1	23. 3	24. 3	
25. 2	26. 3	27. 3	28. 4	29. 2	30. 3	31. 4	32. 2	
33. 4	34. 2	35. 2	36. 1	37. 1	38. 3	39. 4	40. 3	
41. 1	42. 3	43. 4	44. 2	45. 1	46. 2	47. 3	48. 3	
49. 4	50. 3	51. 1	52. 3	53. 4	54. 1	55. 1	56. 2	
57. 1	58. 3	59. 2	60. 1	61. 4	62. 3	63. 1	64. 1	

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Liquid Solutions								
Exercise -	- 3				Pre	vious Year Pr	oblems NEET	
1. 1	2. 2	3. 3	4. 4	5. 3	6. 1	7. 1	8. 3	
9. 2	10. 1	11. 2	12. 1	13. 2	14. 2	15. 4	16. 3	
17. 1	18. 3	19. 1	20. 2	21. 3	22. 2	23. 1	24. 1	
25. 4	26. 1	27. 2	28. 2	29. 4	30. 4	31. 1	32. 3	
33. 2								