

- Various methods to determine concentration of a solution are molality, molarity, molefraction, percentage by volume, percentage by mass.

Solution : When two or more substances mix and form a uniform or homogeneous mixture then such a mixture is called a solution.

Component or components whose proportion is relatively less in the solution are called solute.

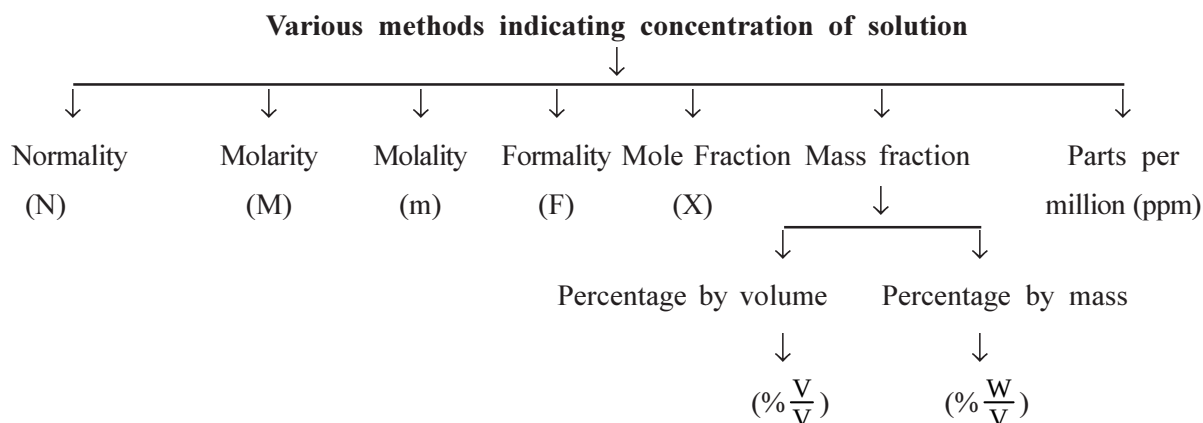
Component whose proportion is maximum in the solution is called a solvent.

A solution having one solute and one solvent are called binary solution.

Particle of solute present in a homogeneous mixture have 10^{-9} meter diameter of size.

- **Concentration**

Amount of solute dissolved in unit volume of solution or unit mass of solvent is called concentration.



- **Molality (m)**

When 1 gm mole of solute is dissolved in 1 kg of solvent the produced solution is called 1 molal solution or molality of solution is said to be 1.

$$\therefore \text{molality (m)} = \frac{\text{no. of moles of solute}}{\text{Mass of solvent (in kg)}}$$

$$\therefore \text{molality (m)} = \frac{\text{mass of solute (in gm)}}{\text{Molecular mass of solute} \times \text{weight of solvent (in kg)}}$$

for eg., 0.2 molal glucose solution - means 0.2 mole glucose is dissolved in 1000 gms of water. Molality of solution does not change with temperature because there is no effect of temperature on weight.

Concentration of a molal (m) solution is less than the concentration of a molar (M) solution.

Mathematically molaity is

$$m = \frac{\text{gm mole of solute}}{\text{wt of solvent in kg}}$$

$$m = \frac{\text{mass of solute}}{\text{molecular mass of solute}} \times \frac{1000}{\text{mass of solvent (in gram)}}$$

$$m = \frac{\text{millimoles of solute}}{\text{mass of solvent (in gm)}}$$

$$m = \frac{10 \times \text{solubility}}{\text{molecular mass of solute}}$$

$$m = \frac{100 \times \text{percentage by weight of solute (x)}}{(100 - x) \times \text{molecular mass of solute}}$$

- **Molarity (M)**

‘When 1 gm mole of solute is dissolved in 1 litre of solution it produces 1 molar solution or molarity of the solution is 1.’

In short, Molarity (M) = $\frac{\text{gm/litre}}{\text{Molecular mass}}$

Molarity (M) = $\frac{\text{number of moles of solute}}{\text{volume of solution in litre}}$ in short molarity = $\frac{\text{mole}}{\text{litre}}$

eg. 1 molar sugar solution means, 1 mole sugar (342 gm or 6.022×10^{23} molecules of sugar) dissolved in 1 litre solution.

Molarity of solution depends on temperature as there is effect of temperature on volume of the solution.

unit of molarity is mole/litre or mole/dm³.

Mathematically Molarity,

$$M = \frac{\text{number of moles (n) of solute dissolved in 1 litre of solution}}{\text{Molecular mass of solute}}$$

$$M = \frac{\text{Mass of solute (in gm)}}{\text{Molecular mass of solute}} \times \frac{1000}{\text{volume of solution (n ml)}}$$

$$M = \frac{\text{millimoles of solute}}{\text{Volume of solution (in ml)}}$$

$$M = \frac{\% \text{ of solute} \times 10}{\text{Molecular mass of solute}}$$

$$M = \frac{\text{strength of solute in gm/litre}}{\text{molecular mass of solute}}$$

- **Molarity and Normality of a mixture of solution produced by mixing two solutions having same solvent**

$$M \text{ (Molarity)} = \frac{M_1 V_1 + M_2 V_2}{V_1 + V_2} \quad \text{OR} \quad N \text{ (Normality)} = \frac{N_1 V_1 + N_2 V_2}{V_1 + V_2}$$

● **Relation between Molarity (M) and molality (m)**

$$\text{Molality (m)} = \frac{\text{Molarity}}{\text{density} - \frac{\text{molarity} \times \text{Molecular mass}}{1000}}$$

$$\text{Molarity (M)} = \frac{\text{Molality} \times \text{density}}{1 + \frac{\text{molality} \times \text{Molecular mass}}{1000}}$$

in short,

$$\text{Molality (m)} = \frac{M}{d - MM_2}$$

Where, M = Molarity, d = Density of solution in gm/ml, M_2 = molecular mass of solute

● **Mole Fraction (X)**

Ratio of number of moles of one component in the solution to the total number of moles of all components in the solution is called mole fraction.

If a binary solution has n_2 moles of solute and n_1 moles of solvent then

$$\text{Mole fraction of solute (X}_2\text{)} = \frac{n_2}{n_1 + n_2}, \text{ mole fraction of solvent (X}_1\text{)} = \frac{n_1}{n_1 + n_2}$$

i.e.,

$$\text{Mole fraction of a component (X)} = \frac{\text{number of moles of a component}}{\text{number of moles of all components in the solution}}$$

Sum of mole fraction of all components in a solution is 1. i.e. $X_1 + X_2 = 1$

multiplying mole fraction by 100 percentage mole can be calculated.

Relation between mole fraction of solute (X_2) and molarity (M)

$$X_2 = \frac{MM_1}{M(M_1 - M_2) + d}$$

where, M = Molarity

M_1 = Molecular mass of solvent in kg/mole, M_2 = Molecular mass of solute

d = density of solution in kg/litre

● **Mass Fraction**

(1) **Percentage by mass ($\% \frac{W}{W}$)** : amount of solute in gm dissolved in 100 gm solution is called

($\% \frac{W}{W}$) percentage by mass.

$$\% \frac{W}{W} = \frac{\text{wt of solute (in gm)}}{\text{wt of solution (in gm)}} \times 100$$

(2) Percentage by volume ($\% \frac{V}{V}$) : Volume in ml of solute dissolved in 100 ml solution is called ($\% \frac{V}{V}$) percentage by volume.

$$\% \frac{V}{V} = \frac{100 \times \text{volume of solute (in ml)}}{\text{volume of solution (in ml)}}$$

(3) Mass by volume percentage ($\% \frac{W}{V}$) : Amount of solute in gm dissolved in 100 ml solution is called ($\% \frac{W}{V}$) percentage mass by volume.

$$\% \frac{W}{V} = \frac{100 \times \text{amount of solute (in gm)}}{\text{volume of solution (in ml)}}$$

● **In short,**

mass fraction means fraction obtained by dividing mass of any one component in the solution by mass of all the components in the solution.

eg. In a given solution, component A has W_A gm and component B has W_B gms, then,

$$\text{Mass fraction of component A is } (X_A) = \frac{W_A}{W_A + W_B}$$

$$\text{Mass fraction of component B is } (X_B) = \frac{W_B}{W_A + W_B}$$

as result, $X_A + X_B = 1$

Multiplying mass fraction by 100 mass percentage can be obtained.

● **Normality (N)**

When 1 gm equivalent weight of solute is dissolved in 1 litre of solution it produces 1 normal solution and the normality of the solution is 1.

$$\text{Normality } N = \frac{\text{gm/litre}}{\text{equivalent weight}}$$

OR

$$N = \frac{\text{amount of solute (in gm)}}{\text{Equivalent wt. of solute} \times \text{volume of solution in litre}}$$

$$\text{equivalent weight of Acid} = \frac{\text{molecular mass of Acid (gm/mole)}}{\text{Basicity of Acid}}$$

$$\text{equivalent weight of Base} = \frac{\text{molecular mass of Base (gm/mole)}}{\text{Acidity of Base}}$$

- Mathematically

$$N = \frac{\text{weight of solute}}{\text{Equivalent weight of solute}} \times \frac{1000}{\text{volume of solution (in ml)}}$$

$$N = \frac{\text{percentage of solute} \times 10}{\text{Equivalent weight of solute}}$$

- **Normality of mixture of two or more solutions mixed together**

$$N = \frac{N_1 V_1 + N_2 V_2 + N_3 V_3 \dots}{V_1 + V_2 + V_3 \dots}$$

- **Relation between molarity and Normality**

- Normality (N) = Molarity (M) $\times \frac{\text{Molecular mass}}{\text{Equivalent mass}}$

- Normality $\times$ Equivalent mass = Molarity $\times$ molecular mass

- Normality of Acid = Molarity $\times$ basicity

- Normality of Base = Molarity $\times$ acidity

- **Formality (F)**

When 1 gm formula weight of solute is dissolved in one litre of aqueous solution is called one formal (1F) solution.

$$\text{Formality (F)} = \frac{1000 \times \text{wt. of solute (in gm)}}{\text{Formula wt. of solute} \times \text{volume of solution (in ml)}}$$

Unit formality is very famous in pharmacy and medical science field.

- **Parts per million (ppm)**

Sometimes amount of solute dissolved in the solution is very small in proportion and the concentration is expressed in parts per million (ppm)

eg., proportion of pollutant in air, amount of O₂ gas dissolved in ocean water, amount of pollutant in water etc.

$$\text{Parts per million for mass by volume} = \frac{\text{amount of solute (in mg)}}{\text{amount of solution (in ml)}} \quad \text{OR}$$

$$\text{Parts per million for mass by volume} = \frac{\text{amount of solute (in gm)}}{\text{amount of solution (in ml)}} \times 10^6$$

- **effect of temperature on units of concentration**

Value of Molality, mole fraction and percentage by mass do not change with change in temperature.

Value of Normality, molarity, percentage by volume, formality, parts per million for mass by volume changes with change in temperature.

- Calculate molarity of 98% percentage by mass H_2SO_4 at 308 K temperature having density 1.84 gm/ml ?
 (A) 18.4 M (B) 4.18 M (C) 8.14 M (D) 1.8 M
- Calculate mole fraction of amount of solute dissolved in 1.00 molal (m) of aqueous solution ?
 (A) 0.1770 (B) 0.0177 (C) 0.0344 (D) 1.7700
- Calculate concentration of urea having 6.022×10^{20} molecules in 100 ml urea (NH_2CONH_2) solution ?
 (A) 0.01 M (B) 0.001 M (C) 0.2 M (D) 0.1 M
- 0.5 M H_2SO_4 solution is more concentrated than 0.5 m H_2SO_4 solution then calculate its density ?
 (A) 1.07 gm ml^{-1} (B) 1.06 gm ml^{-1} (C) 1.05 gm ml^{-1} (D) 1.04 gm ml^{-1}
- Calculate molality of the mixture of solution produced by mixing 25 % $\frac{W}{W}$ of NaOH solution with 15 % $\frac{W}{W}$ solution ? (Molecular mass of NaOH = 40 gm/mole)
 (A) 12.74 m (B) 5.5 m (C) 9.0 m (D) 4.0 m
- Calculate concentration of the mixture of solution produced by mixing 300 gm 25% solution of NH_4NO_3 with 150 gm 40% NH_4NO_3 solution ?
 (A) 30 % (B) 35 % (C) 32.25 % (D) 37.25 %
- Calculate mole fraction of 18 % $\frac{W}{W}$ of glucose solution ?
 (A) 0.18 (B) 0.1 (C) 0.017 (D) 0.021
- Calculate concentration of NO_3^- ion in the mixture of solution produced by mixing 2 litre 3M AgNO_3 solution with 3 litre 1 M BaCl_2 solution ?
 (A) 1.2 M (B) 1.8 M (C) 0.5 M (D) 0.4 M
- How much water should be added to have 3M molarity of a mixture of solution produced by mixing 250 ml of 6M HCl solution with 650 ml. of 3M HCl solution ?
 (A) 250 ml (B) 1150 ml (C) 500 ml (D) 575 ml
- Calculate density (d) of H_2SO_4 solution having molality and molarity 94.5 and 11.5 respectively ?
 (A) 1.15 gm/litre (B) 1.25 gm/litre (C) 1.35 gm/litre (D) 1.45 gm/litre
- Calculate molarity of solution produced by dissolving 5.85 gm NaCl in 0.5 litre water ?
 (A) 0.2 M (B) 0.4 M (C) 1.0 M (D) 0.1 M
- To make a decimolar solution in 100 ml how many grams of a dibasic acid having molecular mass 200 gm/mole should be added ?
 (A) 20 gm (B) 1 gm (C) 2 gm (D) 10 gm

13. Calculate molar concentration of solution having 20 % FeCl_3 solution having density 1.1 gm/ml ?
 (A) 0.028 (B) 1.357 (C) 0.163 (D) 1.47
14. Calculate concentration of solution when 25 gm Na_2SO_4 is dissolved in 10^3 kg of solution ?
 (A) 2.5 ppm (B) 25 ppm (C) 250 ppm (D) 100 ppm
15. How many grams of sugar is required to prepare 5 % $\frac{W}{V}$ sugar ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$) in 2 litre aqueous solution ?
 (A) 200 gm (B) 500 gm (C) 100 gm (D) 10 gm
16. If 200 ml water is added to 0.2 M 500 ml solution calculate molarity (M) of diluted solution ?
 (A) 0.5010 M (B) 0.2847 M (C) 0.7093 M (D) 0.1428 M
17. Calculate molarity of the solution produced by dissolving 120 gm urea (molecular mass = 60u) in 1000 gm of water having density 1.15 gm ?
 (A) 0.50 M (B) 1.78 M (C) 1.02 M (D) 2.05 M
18. Which of the following has molar concentration same as 2N HCL ?
 (A) 4.0 N H_2SO_4 (B) 0.5 N H_2SO_4 (C) 1 N H_2SO_4 (D) 2 N H_2SO_4
19. Concentration of Ca^{2+} ion in a sample of water is 0.0002 M, then calculate concentration of Ca^{2+} in concentration mass by volume ppm ?
 (A) 4 (B) 8 (C) 10.08 (D) 0.4

Answers : 1. (A), 2. (B), 3. (A), 4. (D), 5. (B), 6. (A), 7. (D), 8. (A), 9. (A), 10. (B), 11. (A), 12. (C), 13. (B), 14. (B), 15. (C), 16. (D), 17. (D), 18. (A), 19. (B)

● **Vapour pressure of solution and Raoult's law**

Vapour pressure : At certain temperature the rate for the process of vapour to liquid phase and liquid to vapour phase becomes equal and hence equilibrium is established. Due to this at certain temperature pressure of vapour on surface on the solution becomes constant which is called vapour pressure of solution at that temperature.

Factors affecting vapour pressure : (1) Nature of liquid (2) temperature.

Raoult's law for a non volatile solute : If dilute and ideal solution is prepared by dissolving non-volatile solute in a volatile solvent the relative lowering of vapour pressure of the solution is equal to the mole fraction of the dissolved solute.

Mathematically Raoult's law :
$$\frac{P_1^0 - P_1}{P_1^0} = \frac{n_2}{n_1}$$

where, $n_2 = \frac{W_2}{M_2}$ and $n_1 = \frac{W_1}{M_1}$

$$\therefore \frac{P_1^0 - P_1}{P_1^0} = \frac{W_2 \times M_1}{M_2 \times W_1}$$

where, P_1^0 = vapour pressure of pure solvent, P_1 = vapour pressure of solution, W_1 = wt. of solvent, W_2 = wt. of solute, M_1 = molecular mass of solvent and M_2 = molecular mass of solute

Raoult's law for volatile solute and volatile solvent : "Vapour pressure of solution prepared from volatile substances is proportional to their mole fraction."

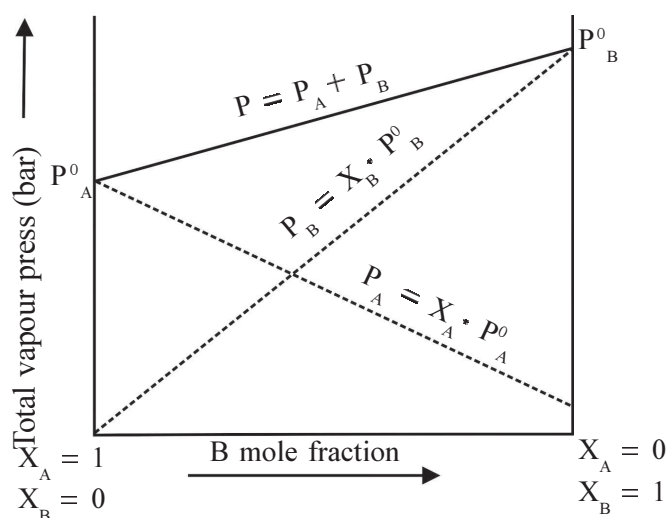
For a Binary solution having components A and B,

$$P_A = P_A^0 \cdot X_A \text{ and } P_B = P_B^0 \cdot X_B$$

From that,

$$\text{Total pressure } P = P_B^0 + (P_A^0 - P_B^0)X_A \text{ or } P = P_A^0 + (P_B^0 - P_A^0)X_B$$

On plotting a graph of P_A and P_B with mole fraction X_A and X_B is,



As shown in the figure, based on above equation. $P_B^0 > P_A^0$ which means component B is more volatile compared to component A. The lowest vapour pressure is P_A^0 and highest vapour pressure is P_B^0 .

When $X_A = 1$ Total vapour pressure of the solution is P_A^0 .

When $X_B = 1$ Total vapour pressure of the solution is P_B^0 .

molefraction of component A and B is Y_A and Y_B respectively to calculate partial pressure P_A and P_B at equilibrium following formula is used :

$$P_A = Y_A \cdot \text{Total pressure}$$

$$P_B = Y_B \cdot \text{Total pressure}$$

● Raoult's law for gaseous solute and liquid solvent

When a gaseous solute is dissolved in a liquid solvent when a gaseous solute is dissolved in a liquid solvent then the vapour pressure of the solution according to Raoult's law is,

$$P_A = P_A^0 \cdot X_A$$

Where, P_A = vapour pressure of component A

P_A^0 = Vapour pressure of pure solvent A

X_A = Mole fraction of A

When a gaseous solute is dissolved in a liquid solvent then according to Henry's law

$$P = K_H \cdot X_A$$

where, P = Total pressure

K_H = Henry's constant

X_A = mole fraction of component A

● **Limitations of Raoult's law**

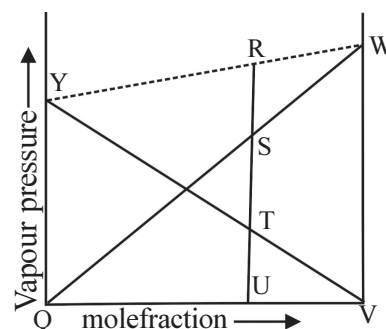
- (1) This law is applicable to very dilute solutions.
- (2) This law is applicable to ideal solutions.
- (3) This law is applicable to solutions, whose heat of dilutions does not change.
- (4) It is applicable to solutions whose total volume is equal to the sum of the volumes of solute and solvent, if they are in liquid state.
- (5) This law is applicable to the non-electrolyte aqueous solutions which do not undergo any dissociation or association when solute is dissolved in solvent.

20. Raoult's law for dilute solution

- (A) Relative decrease in vapour pressure of solution is proportional to amount of solute in solution.
- (B) Relative decrease in vapour pressure of solution is equal to mole fraction of solute.
- (C) relative decrease in vapour pressure of solution is equal to mole fraction of solvent.
- (D) vapour pressure of solution is equal to mole fraction of solvent.

21. For the given graph $RU - YQ \cdot UV =$

- (A) $VW \cdot QU$ (B) $RS \cdot TU$
- (C) $QY \cdot QU$ (D) $YW \cdot QV$



22. At a given temperature for a binary solution at equilibrium made up of liquid A and B has mole fraction of vapour state of liquid A 0.4 and partial pressure 400 mm then calculate partial pressure of liquid B ?

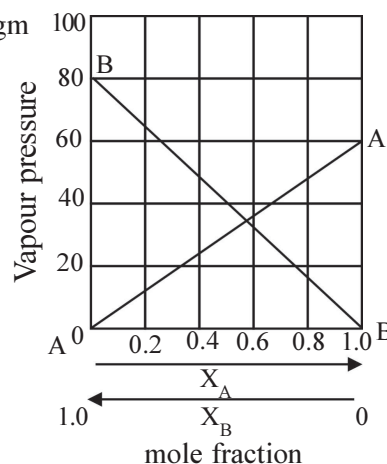
- (A) 600 mm (B) 300 mm (C) 500 mm (D) 200 mm

23. Vapour pressure of benzene and toluene is 0.9 bar and 0.85 bar respectively. Calculate the pressure of the solution prepared by mixing 7.8 gm benzene in 180 gm Toluene ?

- (A) 85.24 bar (B) 0.8524 bar
- (C) 0.08524 bar (D) 0.4860 bar

24. Based on the given figure. Calculate vapour pressure of solution prepared by mixing 1 mole of component A and 3 mole of component B.

- (A) 20 mm (B) 140 mm
- (C) 75 mm (D) 70 mm



25. Vapour pressure of CCl_4 at 25°C is 143 mm. If 0.5 gm non volatile solute is added in 100 cm^3 of CCl_4 calculate vapour pressure of the solution (density of $\text{CCl}_4 = 1.58\text{ gm/cm}^3$)
 (A) 141.93 mm (B) 94.39 mm (C) 199.34 mm (D) 143.99 mm
26. If ratio of partial pressure of substance A and B is $P_A^0 : P_B^0 = 1 : 2$ and ratio of molefraction is 1:2, then calculate molefraction of A in vapour state ?
 (A) 0.33 (B) 0.25 (C) 0.52 (D) 0.2
27. Vapour pressure of a mixture of ethanol and propanol at 300 K is 290 mm. If vapour pressure of propanol at 300 K is 200 mm and mole fraction of ethanol is 0.6 then at the same temperature calculate vapour pressure of ethanol ?
 (A) 300 mm (B) 700 mm (C) 350 mm (D) 360 mm
28. At a definite temperature vapour pressure of pure benzene is 0.85 bar. When 0.5 gm of solid nonvalatile electrolyte is dissolved in 39.0 gm benzene vapour pressure of solution becomes 0.845 bar calculate molecular mass of the solid substance ?
 (A) 58 gm mole^{-1} (B) 170 gm mole^{-1} (C) 180 gm mole^{-1} (D) 135 gm mole^{-1}
29. According to Raoult's law relative lowering in vapour pressure of non volatile solute is equally proportional to
 (A) mole fraction of solvent. (B) mole fraction of solute.
 (C) mass fraction of solute. (D) mass fraction of solvent.
30. On dissolving definite amount having molecular mass 60 gm/mole of substance in 180 gm of water, the vapour pressure of water decreases by 10% then calculate the amount dissolved ?
 (A) 30 gm (B) 120 gm (C) 12 gm (D) 60 gm
31. A binary ideal solution having two pure liquid substance A and B having vapour pressure P_A and P_B respectively. If liquid A has mole fraction X_A then what will be the total pressure of the solution ?
 (A) $P_A + X_A(P_B - P_A)$ (B) $P_A + X_A(P_A - P_B)$ (C) $P_B + X_A(P_B - P_A)$ (D) $P_B + X_A(P_A - P_B)$
32. Calculate vapour pressure of 4% $\frac{W}{W}$ of aqueous solution of urea ? (At 298 K temperature, vapour pressure 0.025 bar)
 (A) 0.000313 bar (B) 0.02469 bar (C) 0.04269 bar (D) 0.0246 bar
33. If relative decrease in vapour pressure of a non volatile solute containing solution is 0.0125, then calculate molality of the solution ?
 (A) 0.70 (B) 0.50 (C) 0.60 (D) 0.80
34. Vapour pressure of liquid P and Q are 80 and 60 torr respectively. If 3 mole of liquid P and 2 mole of liquid Q are mixed. Calculate vapour pressure of the mixture.
 (A) 140 torr (B) 68 torr (C) 72 torr (D) 20 torr

Answers : 20. (B), 21. (A), 22. (A), 23. (B), 24. (C), 25. (A), 26. (D), 27. (C), 28. (B), 29. (B), 30. (D), 31. (D), 32. (B), 33. (A), 34. (C)

● **Ideal and non Ideal solution**

Ideal solution : A solution which obeys Raoult's law at any concentration or temperature is called Ideal solution.

$$\text{For Ideal solution, } P_{\text{total}} = P_A + P_B = P_A^0 \cdot X_A + P_B^0 \cdot X_B$$

For such solution intermolecular force of attraction between A – A and B – B is same as intermolecular force of attraction of AB.

For such solution when solute is dissolved in a solvent, the solution produced have enthalpy changes zero ($\Delta H = 0$)

For such solution when solute and solvent in liquid form, when form a solution, the change in volume is zero ($\Delta V = 0$).

eg., (1) Bromo ethane and chloro ethane (2) Benzene Toluene (3) Hexane and Heptane (4) Chlorobenzene and Bromo benzene (5) Ethyl bromide and Ethyl iodide.

● **Non Ideal solution/True solution**

A solution which does not obey Raoult's law at any concentration or temperature is called non ideal solution (True solution)

For such solution, According to Raoult's law, vapour pressure of solution is more or less than the expected value.

For such solutions intermolecular force of attraction between A – A and B – B is not same as intermolecular force of attraction of A – B.

For such solution enthalpy change and volume change is not zero.

i.e., $\Delta H \neq 0$, $\Delta V \neq 0$

● **Non ideal solutions show +ve and –ve deviation from Raoult's law, the information regarding it is given in the table below :**

Positive deviation of non ideal solution from Raoult's law	negative deviation of non ideal solution from Raoult's law
(1) Does not obey Raoult's law. (2) $\Delta H_{\text{mix}} > 0$ endothermic reaction and absorbs energy (3) $\Delta V_{\text{mix}} > 0$ Volume increase on dissolution. (4) $P_A > P_A^0 \cdot X_A$; $P_B > P_B^0 \cdot X_B$ $\therefore P_A + P_B > P_A^0 \cdot X_A + P_B^0 \cdot X_B$ (5) Intermolecular force of attraction of A – B is weaker than intermolecular force of attraction of A – A and B – B (H – bond breaks due dissolution) (6) eg., $\rightarrow$ Acetone and ethanol $\rightarrow$ Acetone and CS_2 $\rightarrow$ water and methanol $\rightarrow$ CCl_4 and toluene $\rightarrow$ CCl_4 and CHCl_3 $\rightarrow$ Acetone and benzene	(1) does not obey Raoult's law.. (2) $\Delta H_{\text{mix}} < 0$ exothermic reaction and energy is released. (3) $\Delta V_{\text{mix}} < 0$ volume decreases on dissolution. (4) $P_A < P_A^0 \cdot X_A$; $P_B < P_B^0 \cdot X_B$ $\therefore P_A + P_B < P_A^0 \cdot X_A + P_B^0 \cdot X_B$ (5) Intermolecular force of attraction of A – B is stronger than intermolecular force of attraction of A – A and B – B (H-bond is formed due to dissolution) (6) eg, $\rightarrow$ Acetone and Aniline $\rightarrow$ Acetone and chloroform $\rightarrow$ CH_3OH and CH_3COOH $\rightarrow$ Water and HCl $\rightarrow$ Chloroform and benzene $\rightarrow$ water and HNO_3

35. Solution of Acetone in ethanol
- (A) shows positive deviation from Raoult's law. (B) acts as an Ideal solution.
(C) Obeys Raoult's law. (D) shows negative deviation from Raoult's law.
36. Which of the following pair will make an ideal solution ?
- (A) Chlorobenzene + Chloroethane (B) Benzene + Toluene
(C) Acetene + Chloroform (D) water + HCl
37. Which condition is favourable for non ideal solution ?
- (A) $\Delta H \neq 0, \Delta V = 0$ (B) $\Delta H = 0, \Delta V = 0$ (C) $\Delta H \neq 0, \Delta V \neq 0$ (D) $\Delta H = 0, \Delta V \neq 0$
38. If 30 ml chloroform and 50 ml Acetone are mixed to form a non ideal solution, then volume of the solution is
- (A) > 80 ml (B) < 80 ml (C) $= 80$ ml (D) ≥ 80 ml
39. Ideal solution
- (A) shows +ve deviation from Raoult's law. (B) shows -ve deviation from Raoult's law.
(C) has no relation with Raoult's law. (D) Obeys Raoult's law.
40. Ideal solution possesses which of the following characterisites ?
- (A) Obyes Raoult's law. (B) $\Delta H = 0$
(C) $\Delta V = 0$ (D) all three given.
41. To which of the following compound Raoult's law is not applicable ?
- (A) 1M NaCl (B) 1M urea (C) 1M glucose (D) 1M sucrose
42. A Binary solution is prepared by mixing n-Heptane and ehtanol, with respect to the nature of the solution, which of the following statement is correct ?
- (A) It makes an ideal solution.
(B) Non ideal solution shows positive deviation of Raoult's law.
(C) Non ideal solution shows negative deviation of Raoul'ts law.
(D) n-Heptane will show positive deviation and ethanol shows negative deviation of Raoult's law.
43. Which of the following mixture shows positive deviation of Raoult's law ?
- (A) $\text{CHCl}_3 + (\text{CH}_3)_2\text{CO}$ (B) $(\text{CH}_3)_2\text{CO} + \text{C}_6\text{H}_5\text{NH}_2$
(C) $\text{CHCl}_3 + \text{C}_6\text{H}_6$ (D) $(\text{CH}_3)_2\text{CO} + \text{CS}_2$
44. Select the correct statement from the given option ?
- (1) liquid mixture of CH_3COOH and CH_3OH shows negative deviation
- $$P_{\text{Total}} < P_A^0 \cdot X_A + P_B^0 \cdot X_B.$$
- (2) liquid mixture CH_3COCH_3 and CHCl_3 solution have heat of dilution $\Delta H < 0$ and $\Delta V < 0$ vapour pressure shows negative deviation.

- (3) For mixed solution of CH_3COCH_3 and C_6H_6 , $\Delta H > 0$ and $\Delta V > 0$ $P_{\text{Total}} > P_A^0 \cdot X_A + P_B^0 \cdot X_B$.
- (4) For these components in the solution $P_A > P_A^0 \cdot X_A$ and $P_B > P_B^0 \cdot X_B$ for such solution $\Delta H > 0$, $\Delta V < 0$ where vapour pressure shows positive deviation.
- (A) (1), (2), (3) (B) (1), (2), (4)
(C) (2), (3), (4) (D) (3), (4)
- 45. Statement I :** Mixture of Benzene and Toluene make ideal solution.
Statement II : Total volume of a mixture becomes 200 ml when 100 ml Benzene is mixed with 100 ml Toluene ie. $\Delta V = 0$ as well as there is no change in enthalpy.
- (A) Statement I is correct and statement II is incorrect.
(B) Statement I and II both are incorrect.
(C) Statement I and II are correct and statement II is the reason of statment I
(D) Statement I is incoruct and statement II is correct.
- 46.** Solutions produced by mixing of two components are given
- (1) Pure solvent $\rightarrow$ separated solvent molecules, ΔH_1
(2) Pure solute $\rightarrow$ separated solute molecules, ΔH_2
(3) separated solute and solvent molecule $\rightarrow$ solution, ΔH_3
- If prepared solution is ideal than
- (A) $\Delta H_{\text{solution}} = \Delta H_3 - \Delta H_1 - \Delta H_2$ (B) $\Delta H_{\text{solution}} = \Delta H_1 + \Delta H_2 + \Delta H_3$
(C) $\Delta H_{\text{solution}} = \Delta H_1 + \Delta H_2 - \Delta H_3$ (D) $\Delta H_{\text{solution}} = \Delta H_1 - \Delta H_2 - \Delta H_3$
- 47.** Which of the following does not show negative deviation from Raoult's law.
(A) Acetone-chloroform (B) Acetone-Benzene (C) Chloroform-ether (D) Chloroform-Benzene
- 48.** Ideal solution is prepared from liquid A and B if
(A) enthalpy of mixture is zero (B) entropy of mixture is zero.
(C) Free energy of mixture is zero. (D) Free energy and entropy of mixture is zero.
- 49.** Vapour pressure of non ideal solution is from vapour pressure obtained by Raoult's law.
(A) more (B) less (C) equal (D) Both (A) and (B).
- 50.** Which of the following pair will not make an ideal solution ?
(A) $\text{C}_6\text{H}_6 + \text{C}_6\text{H}_5\text{CH}_3$ (B) $\text{C}_4\text{H}_9\text{OH} + \text{H}_2\text{O}$ (C) $\text{CCl}_4 + \text{SiCl}_4$ (D) $\text{C}_2\text{H}_5\text{Br} + \text{C}_2\text{H}_5\text{I}$
- 51.** Ideal solution is prepared by mixing Benzene (A) and Toluene (B), then which option is not correct for the solution ?
(A) $P_A = X_A \cdot P_A^0$ (B) $P_{\text{Total}} > P_A + P_B$ (C) $P_{\text{Total}} = X_A \cdot P_A^0 + X_B \cdot P_B^0$ (D) $P_B = X_B \cdot P_B^0$

Answers : 35. (A), 36. (B), 37. (C), 38. (B), 39. (D), 40. (D), 41. (A), 42. (B), 43. (D), 44. (D), 45. (C), 46. (B), 47. (B), 48. (A), 49. (D), 50. (B), 51. (B)

● Vapour pressure composition - Henry's law

Henry's law : (Quantitative relation between solubility of the gaseous solute in a liquid solvent and pressure)

“The solubility of a gaseous solute in a liquid solvent at constant temperature is directly proportional to the pressure of gaseous solute”

Dalton independently concluded that the solubility of a gaseous solute in liquid solution is a function of the partial pressure of the gas. If the mole fraction is considered for the solubility of gaseous solute. The partial pressure of a gaseous solute over the solution is directly proportional to the mole fraction of the gaseous molecules.

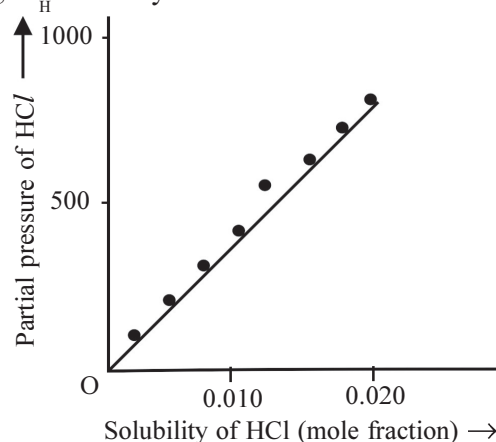
In the solution X is the mole fraction of gaseous solute dissolved in unit volume of solvent and its partial pressure is P , then according to Henry's law it is expressed as,

$$p \propto X. \therefore p = K_H \cdot X \quad \text{where, } K_H = \text{Henry's constant}$$

If in the solution mole fraction of gas is X and its partial pressure is P and graph is plotted between them the graph is a straight line as indicated in graph and the value of the slope is equal to value of K_H . The unit of K_H is bar.

As value of K_H increases, solubility of gaseous solute decreases.

With increase in temperature, value of K_H increases and solubility decreases.



● Limitations of Henry's law

- (1) This law is applicable to the gaseous solutes which show only ideal behaviour at high temperature and low pressure.
- (2) This law is applicable to solute which does not undergo association or dissociation when the solute is dissolved in solvent.
- (3) This law is applicable to gaseous solute which does not form any product by the chemical reaction, when gaseous solute is dissolved in liquid solvent.

● Application of Henry's law

- (1) To increase the solubility of CO_2 gas in cold drinks, soda water, beer, champagne, the gases are filled in bottle at high pressures and then sealed.
- (2) Due to higher partial pressure of oxygen gas entering into the lungs, it reacts with haemoglobin and forms oxyhaemoglobin. The partial pressure of oxygen gas is low in tissue. Hence, the oxygen is released from the oxyhaemoglobin itself and is useful in the utilisation of the function of cell.
- (3) The sea-divers use the cylinders filled with mixture of 2% O_2 and 98 % He gas during the diving in sea. Nowadays a cylinder filled with 11.7 % He, 56.2 % N_2 and 32.1 % O_2 gas mixture are used.

52. How many millimoles of H_2S is dissolved when it is passed through 1 litre of water at 300 K temperature ? (value of $K_H = 5.6 \times 10^{-4}$ bar and partial pressure is 3×10^{-8} bar)

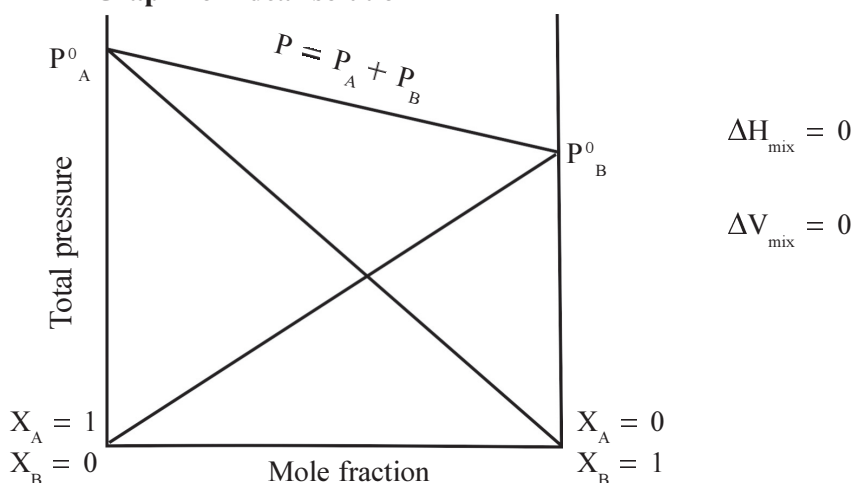
- (A) 2.9758 (B) 5.357 (C) 3.9758 (D) 29.758

53. In which condition Henry's law is obeyed ?
- (A) gaseous solute has ideal behaviour at high temperature and low pressure.
 (B) gaseous solute should not undergo association and dissociation in the solution.
 (C) gaseous solute react with the solvent.
 (D) All three conditions are applicable
54. Statement : "If at 1 atm 900 gm water can dissolve 0.003 mole of gas and under 2 atm pressure 0.006 mole gas is dissolved" This statement is obeying which of the law ?
- (A) Dalton's law of partial pressure (B) Graham's law of diffusion of gas
 (C) Raoult's law (D) Henry's law
55. Solubility of N_2 gas obeys Henry's law at 298 K temperature and 1.0×10^5 atm pressure. In the same way N_2 gas in air has mole fraction 0.8. How many moles N_2 gas will dissolve in 10 mole of water at 5 atm pressure and 298 K temperature ?
- (A) 4.0×10^{-4} (B) 4.0×10^{-5} (C) 5.0×10^{-4} (D) 4.0×10^{-6}
56. Which of the following gases will have lowest Henry's constant ?
- (A) N_2 (B) He (C) H_2 (D) CO_2
57. Ratio of O_2 and N_2 in air is 1 : 4, based on their mole fraction calculate the ratio of their solubility at room temperature and pressure ? (Henry's constant : $O_2 = 3.3 \times 10^7$, $N_2 = 6.6 \times 10^7$ torr)
- (A) 1:2 (B) 2:1 (C) 4:1 (D) 1:4
58. At a definite temperature Homogeneous mixture of gas A and gas B over water in a closed container at 2.0 bar pressure has mole fraction ratio 1 : 6. If their K_H are respectively 2.4×10^4 bar and 4.8×10^4 bar, then calculate the ratio of molefraction of these gases soluble form in water ?
- (A) 1 : 2 (B) 2 : 1 (C) 3 : 1 (D) 1 : 3

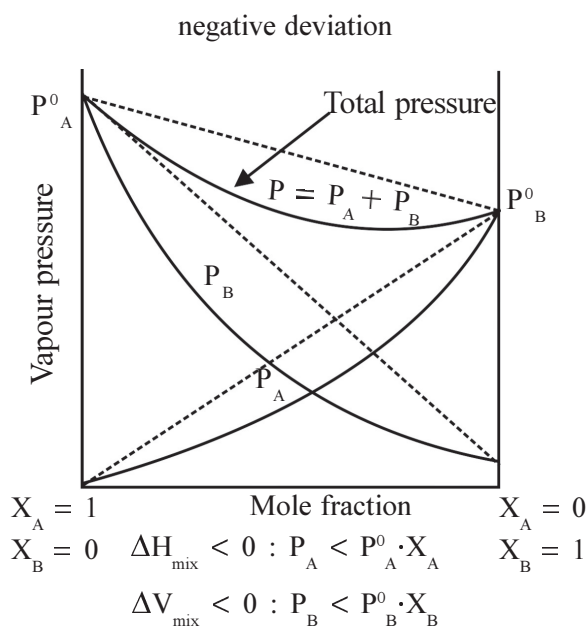
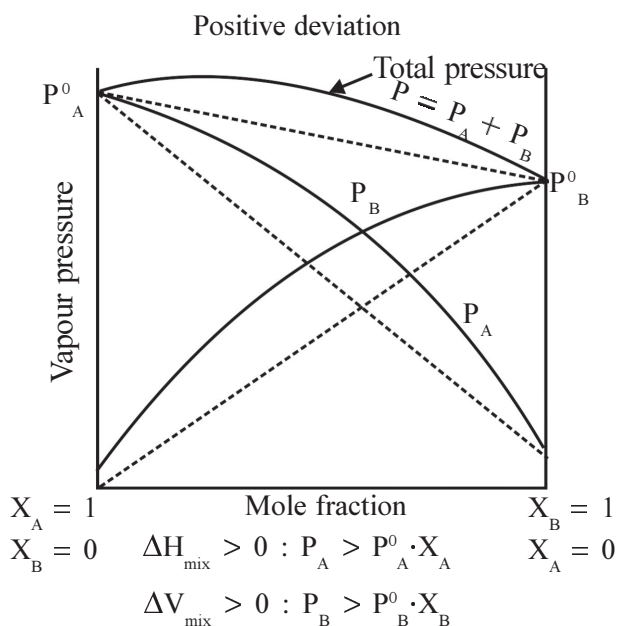
Answers : 52. (A) 53. (B) 54. (D) 55. (A) 56. (D) 57. (A) 58. (D)

● Graph for ideal and non ideal solution

● Graph for ideal solution



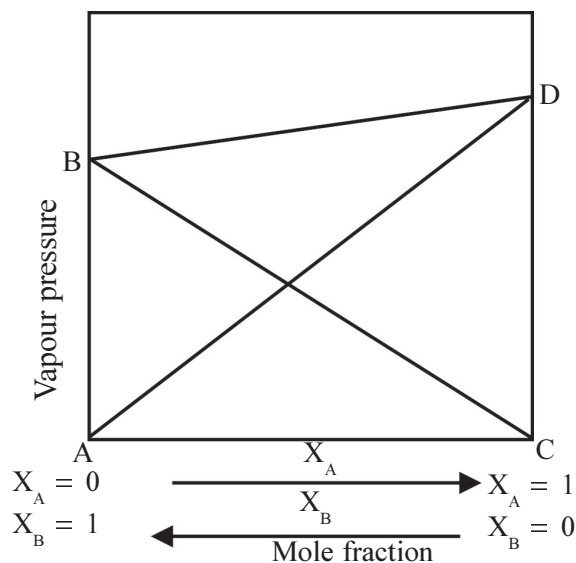
• Graph for non ideal solution



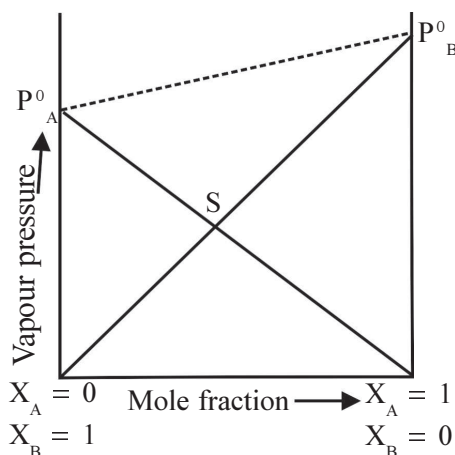
59. Based on the given figure. Select the correct statement for two volatile liquid in a solution.

- (1) AB and CD indicates vapour pressure of liquid B and A respectively.
- (2) Maximum pressure of the solution is indicated by AB and minimum pressure by CD
- (3) AD and BC indicates liquid B and A obey Raoult's law
- (4) BD indicates total pressure of the solution

- (A) Statement 1 and 3 are correct
- (B) Statement 2 and 4 are correct
- (C) Statement 1 and 4 are correct
- (D) Statement 2 and 3 are correct



60. What does point S indicate in the given figure ?

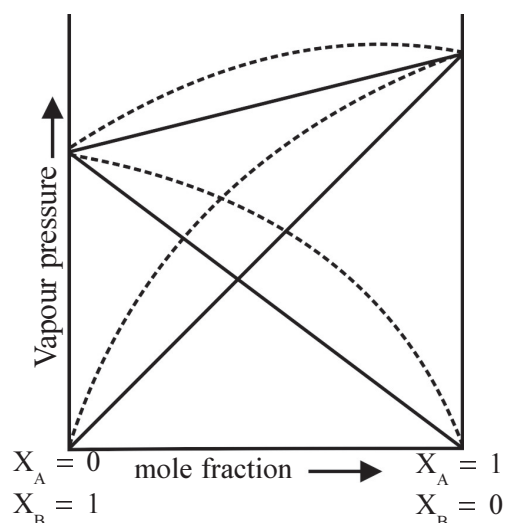


- (A) Both liquid have same partial pressure and mole fraction
- (B) Both liquid have same mole fraction but different partial pressure
- (C) Both liquid have different partial pressure and mole fraction
- (D) Both liquid have different mole fractions. But same partial pressure.

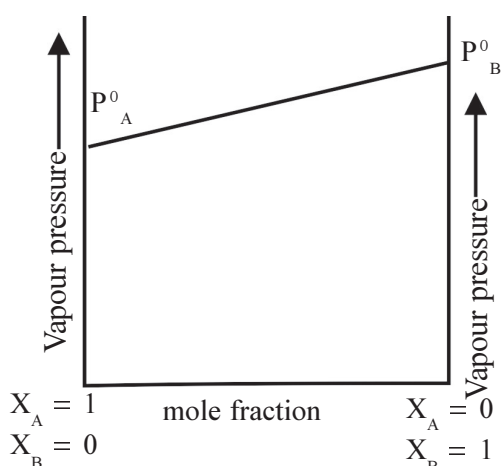
61. For the given graph of mole fraction versus vapour pressure select the correct option.

T = correct statement, F = incorrect statement

- Azotropic mixture of liquid A and liquid B will have maximum Boiling point.
 - When vapour pressure of both the liquid in the mixture is same $X_A < X_B$.
 - Given liquid mixture shows positive deviation for Raoult's law.
 - When $X_A = X_B$ then $P_A < P_B$.
- (A) TFTF (B) FFTF
(C) FTFT (D) FFTT



62. For two volatile liquids a graph of vapour pressure versus mole fraction is given below, then for the given graph which of the following is true.



- When $X_A = 1$ and $X_B = 0$, then $P = P_A^0$
- When $X_B = 0$ and $X_A = 0$, then $P = P_B^0$
- When $X_A = 1$ and $X_B = 0$, then $P < P_B^0$
- When $X_B = 1$ and $X_A = 0$, then $P > P_A^0$

Answers : 59. (C), 60. (D), 61. (C), 62. (A)

● Colligative Properties for dilute solutions

(1) Relative lowering in vapour pressure (2) depression in freezing point (3) elevation in boiling point (4) Osmotic pressure.

● Colligative Properties of a solution

‘Changes in certain properties of dilute solution depend on number of molecules of solutes but not on nature of solute such properties are called colligative properties.’

When a substance is dissolved in a pure solvent and a solution is prepared, then certain properties of solvent are changed.

- Vapour pressure of solution decreases compared to that of its pure solvent.
- Boiling point of solution increases compared to that of its pure solvent.
- Freezing point of solution decreases compared to that of its pure solvent.
- There are changes in osmotic pressure of the solution compared to that of its pure solvent.

Colligative properties of solution do not depend on concentration of solution but depend on total number of solute particle in the solution.

(1) Relative lowering in vapour pressure : vapour pressure of a solution prepared from a pure solvent is always less than the vapour pressure of pure solvent, hence, according to Raoult's law.

“When a very dilute or ideal solution is prepared by dissolving a non volatile solute, the relative lowering in vapour pressure is equal to molefraction of solute.”

If in a solution, vapour pressure of solution is P_1 and its mole fraction of solvent is X_1

$$P_1 \propto X_1 \quad \therefore P_1 = P_1^0 \cdot X_1$$

Where, P_1^0 = vapour pressure of pure solvent

Relative lowering in vapour pressure by dissolving non volatile solute in a volatile solvent is $\frac{P_1^0 - P_1}{P_1^0}$

and it is equal to mole fraction of dissolved solute X_2

$\therefore$ For very dilute solution,

$$\frac{P_1^0 - P_1}{P_1^0} = \frac{n_2}{n_1}$$

$$\text{but } n_2 = \frac{W_2}{M_2} \text{ and } n_1 = \frac{W_1}{M_1}$$

$$\therefore \frac{P_1^0 - P_1}{P_1^0} = \frac{W_2 \times M_1}{M_2 \times W_1}$$

where, W_1 = weight of solvent, W_2 = weight of solute,

M_1 = molecular mass of solvent, M_2 = molecular mass of solute

Vapour pressure of pure volatile solute is P_A^0 and vapour pressure of pure volatile solvent P_B^0 then,

$$P_A = P_A^0 \cdot X_A \text{ and } P_B = P_B^0 \cdot X_B \quad \therefore P_{\text{Total}} = P_A + P_B$$

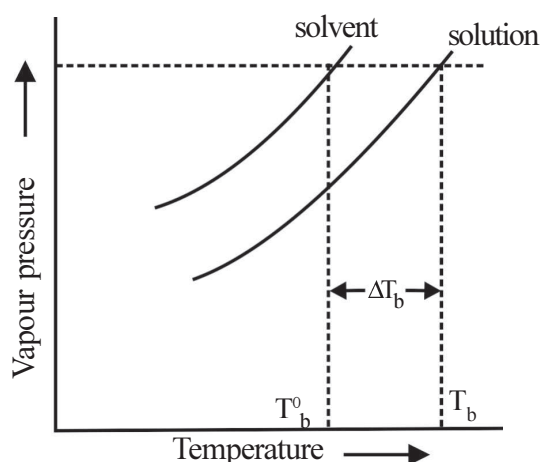
Mole fraction of gaseous components can be calculated as follows :

$$\text{Molefraction of component} = \frac{\text{Partial pressure of a component}}{\text{Total pressure}}$$

When gaseous solute is dissolved in a liquid solvent the solution then according to Raoult's law it vapour pressure $P_A = P_A^0 \cdot X_A$ and its solubility according to Henry's law $P = K_H \cdot X_A$.

(2) Elevation in Boiling point : The temperature at which vapour pressure of liquid is equal to vapour pressure (1 bar) of atmosphere is called **boiling point**.

Boiling point of the solution is more than the boiling point of its pure solvent (ΔT_b).



Graph of relation between vapour pressure of pure solvent and its solution at different temperature is given.

Suppose boiling point of pure solvent is T_b^0 and boiling point of solution is T_b , then the rise in the boiling point is, $\Delta T_b = T_b - T_b^0$ and is called elevation in boiling point.

Practical observation indicates that, elevation in boiling point (ΔT_b) is directly proportional to molal (m) concentration of solute in a dilute and ideal solution. It can be mathematically written as

$$\Delta T_b \propto m \quad \therefore \Delta T_b = K_b \cdot m$$

$$\text{but molality (m)} = \frac{1000 \times W_2}{M_2 \times W_1} \quad \therefore \Delta T_b = \frac{K_b \times 1000 \times W_2}{M_2 \times W_1} \quad \therefore K_b = \frac{\Delta T_b \times M_2 \times W_1}{1000 \times W_2}$$

Where, K_b = molal elevation constant

W_2 = weight of solute

ΔT_b = elevation in boiling point

M_2 = molecular mass of solute

W_1 = weight of solvent

Calculation of K_b based on molar vapourisation enthalpy

$$K_b = \frac{M \times R(T_b)^2}{\Delta_{\text{vap}} H \times 1000}$$

where, M = Molecular mass of solvent

T_b = boiling point of solvent

R = gas constant

$\Delta_{\text{vap}} H$ = Molar enthalpy of vapourisation

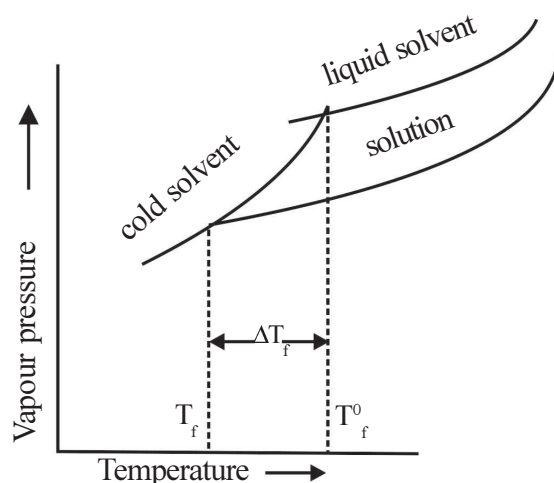
Unit of molal elevation constant (K_b) is K Kg mole^{-1} .

(3) Depression in Freezing point

The temperature at which solid and liquid state of a substance (solute or solvent) are in equilibrium then that temperature of the substance is called freezing point.

Freezing point of the solution is less than the freezing point of its pure solvent. This decrease in Freezing point is called depression in Freezing point (ΔT_f).

Graph of relation between vapour pressure of pure solvent and its solution at different temperature.



Suppose freezing point of pure solvent is T_f^0 and of solution T_f then, decrease in Freezing point is given by $\Delta T_f = T_f^0 - T_f$ and is known as depression in Freezing point.

Practical observation indicates that, depression in Freezing point (ΔT_f) is directly proportional to molal (m) concentration of solute in a dilute and ideal solution. Mathematically it can be written as,

$$\Delta T_f \propto m \quad \therefore \Delta T_f = K_f \cdot m$$

$$\text{but molality (m)} = \frac{1000 \times W_2}{M_2 \times W_1}$$

$$\Delta T_f = \frac{K_f \times 1000 \times W_2}{M_2 \times W_1}$$

$$K_f = \frac{\Delta T_f \times W_1 \times M_2}{1000 \times W_2}$$

where, K_f = molal depression constant

W_2 = wt. of solute

ΔT_f = depression in Freezing point

M_2 = molecular mass of solute

W_1 = wt. of solvent

Calculation of K_f based on Molar vapourisation enthalpy

$$K_f = \frac{M \times R(T_f)^2}{\Delta_{\text{fus}} H \times 1000}$$

Where, M = molecular mass of solute,

T_f = Freezing point of solute,

R = gas constant

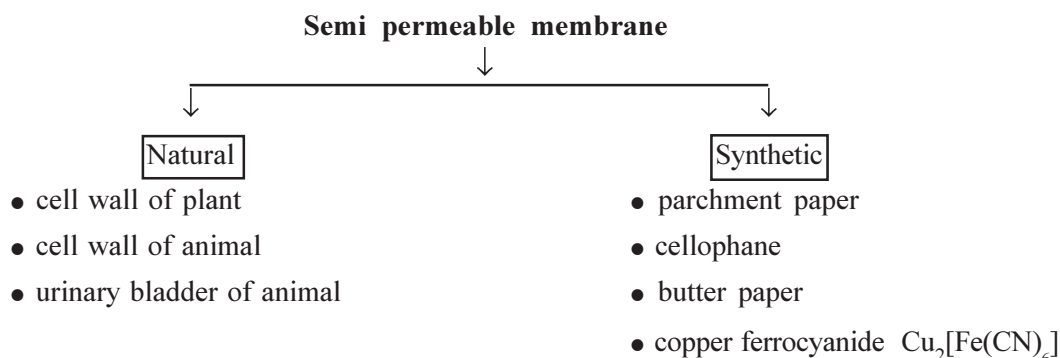
$\Delta_{\text{fus}} H$ = Molar fusion enthalpy

● Relation between elevation in boiling point and depression in Freezing point

$$\frac{\Delta T_b}{\Delta T_f} = \frac{\Delta K_b}{\Delta K_f} \quad \text{Where, } \Delta T_b = \text{elevation in boiling point, } \Delta T_f = \text{depression in Freezing point,}$$

K_b = molal elevation constant, K_f = molal depression constant

(4) Osmotic Pressure : Osmosis : When a semipermeable membrane is placed between two solutions of different concentration or between pure solvent and its solution, a spontaneous flow of solvent starts from a solution, having lower concentration to higher concentration or from a solvent to a solution respectively. This phenomena is called Osmosis.



of all the given semipermeable membranes copper ferrocyanide is considered to be the best semipermeable membrane.

● **Osmosis (Osmotic) pressure**

It is the minimum amount of pressure applied on the solution that just stops the flow of solvent towards solution across the semi permeable membrane.

● **Laws of osmotic pressure**

(1) Boyle-Van't Hoff law : “At constant temperature osmotic pressure (π) is directly proportional to the molar concentration of the solution”

$$\therefore \pi \propto C \text{ but, } C = \frac{n}{V} \quad \pi \propto \frac{n}{V} \quad n = \text{Soluble mole}$$

$$n = 1$$

$$\therefore \pi \propto \frac{1}{V} \quad \dots\dots\dots(1)$$

(2) Gay-Lussac Van't Hoff law : If the concentration of solute is constant then the osmotic pressure of solution is directly proportional to its absolute temperature.

$$\therefore \pi \propto T \quad \dots\dots\dots(2)$$

(3) Avagadro-Van't Hoff law : The number of molecules in the same volume of different solution having the same osmotic pressure at the same temperature.

$$\therefore \pi \propto n, \dots\dots(3)$$

● Now, from equation (1) (2) and (3) $\pi \propto \frac{nT}{V}$

$$\therefore \pi = \frac{nRT}{V} \quad \therefore \pi V = nRT$$

$$\text{now, } \frac{n}{V} = C \quad \pi = CRT$$

$$n = \frac{W}{M} \quad \pi V = \frac{WRT}{M} \quad \therefore \pi = \frac{WRT}{MV}$$

Where, π = Osmotic pressure W = weight of solute
 R = gas constant T = absolute temperature
 M = Molecular mass of gas V = volume of solute (litre)

● If two different solutions of the same component has osmotic pressure π_1 and π_2 ,

$$\pi_1 V_1 + \pi_2 V_2 = \pi_r (V_1 + V_2) \text{ where, } \pi_r = \text{Total osmotic pressure}$$

• Two different soluble components have n_1 and n_2 mole respectively with volume V_1 and V_2 their osmotic pressure,

$$\pi = \left(\frac{n_1 i_1 + n_2 i_2}{V_1 + V_2} \right) RT$$

• **Isoosmotic (Isotonic) solution**

‘Solution having same osmotic pressure at given temperature are called iso osmotic solution.’

The vapour pressure of iso osmotic solutions are equal. Hence such solutions are called Isotonic solutions.

Isoosmotic solutions have their concentrations equal.

Hypotonic solution : If osmotic pressure of two solutions are different then the solution having less osmotic pressure is called a hypotonic solution with respect to the other solution.

Hypertonic solution : A solution with higher osmotic pressure is called hypertonic solution with respect to the solution having less osmotic pressure.

In short, solution having lower osmotic pressure is called Hypotonic and having higher osmotic pressure is called Hypertonic solution.

• **Relation of osmotic pressure with various colligative properties**

$$(1) \pi = \left(\frac{P_1^0 + P_1}{P_1^0} \right) \times \frac{dRT}{1000 \times K_f}$$

$$(2) \pi = \Delta T_b \times \frac{dRT}{1000 \times K_b}$$

$$(3) \pi = \Delta T_f \times \frac{dRT}{1000 \times K_f} \quad \text{where, } \pi = \text{osmotic pressure, } d = \text{density}$$

R = universal gas constant, K_b = molal elevation constant

K_f = molal depression constant

63. Which of the following aqueous solution has highest boiling point ?

- (A) 0.1M KNO_3 (B) 0.1M Na_3PO_4 (C) 0.1M BaCl_2 (D) 0.1M K_2SO_4

64. Which of the following solution has highest freezing point ?

- (A) 1m $\text{K}_4[\text{Fe}(\text{CN})_6]$ solution (B) 1m $\text{C}_6\text{H}_{12}\text{O}_6$ solution
(C) 1m KCl solution (D) 1m salt solution

65. A solution has freezing point -0.186°C , then calculate its elevation in boiling point ?

- (A) 0.0512°C (B) 0.326°C (C) 0.0592°C (D) 0.0256°C

66. Osmotic pressure of solution of urea at 10°C is 500 mm. If the solution is diluted and temperature is raised to 25°C the osmotic pressure becomes 105.3 mm. Then how much is the solution diluted ?

- (A) 4 times (B) 3 times (C) 5 times (D) 2 times

67. If Boiling point of glucose solution is 100.128°C then calculate freezing point of solution ?

(For solution $K_f = 1.86^{\circ}\text{C}$ and $K_b = 0.512^{\circ}\text{C}$)

- (A) -0.346°C (B) -0.465°C (C) $+0.465^{\circ}\text{C}$ (D) -0.256°C

68. At 750 mm Height of mercury column boiling point of water is 99.63°C . Then how many grams of sucrose should be added in 500 gm water to make boiling point of solution 100°C ? ($K_b = 0.52\text{ K Kg mole}^{-1}$)

- (A) 121 gm (B) 150 gm (C) 180 gm (D) 300 gm

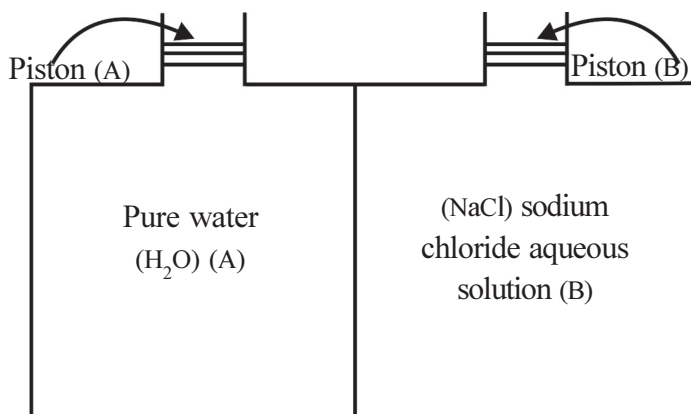
69. For the given figure select the correct option.

(A) Putting less pressure on piston B then the osmotic pressure water moves from (A) side to (B) side.

(B) Putting higher pressure on piston B then the osmotic pressure, water moves from (B) side to (A) side.

(C) Putting pressure on piston equal to that of osmotic pressure water moves from side B to side A

(D) On putting pressure on piston (A) water will move from A side to B side.



70. Which of the following solutions have same osmotic pressure ?

(i) 0.1 M NaCl solution

(ii) 0.1M glucose solution

(iii) 0.6 gm urea in 100 ml solution

(iv) 1.0 gram nonvolatile in 50 ml solution

(Molecular mass of X = 200 gm mole^{-1})

(A) (i), (ii), (iii)

(B) (ii), (iii), (iv)

(C) (i), (ii), (iv)

(D) (i), (iii), (iv)

71. 5 % (by mass) sugar cane water solution has freezing point 271 K and freezing point of pure water is 273.15 K. Calculate freezing point of 5% glucose solution.

(A) 250 K

(B) 269 K

(C) 310 K

(D) 275 K

72. Value of K_f for water is $1.86\text{ K kg mole}^{-1}$. If your vehicles radiator can accommodate 1.0 kg water, then how many grams of ethylene glycol ($\text{C}_2\text{H}_6\text{O}_2$) can be dissolved in it so that freezing point of solution becomes -2.8°C ?

(A) 72 gm

(B) 93 gm

(C) 39 gm

(D) 27 gm

73. How many grams of sucrose (Molecular mass 342 gm/mole) should be added in 100 gm water so that the difference between freezing point and boiling point of the solution is 105°C ?

($K_f = 1.860^{\circ}\text{C mole}^{-1}$, $K_b = 0.151^{\circ}\text{C mole}^{-1}$)

(A) 72 gram

(B) 34.2 gram

(C) 342 gram

(D) 460 gram

74. Calculate the boiling point of the solution produced by dissolving 13.44 gm CuCl_2 in 1 kg of water ? ($K_b = 0.52 \text{ K kg mole}^{-1}$; Molecular mass of $\text{CuCl}_2 = 134.4 \text{ gm/mole}$)
 (A) 0.05 (B) 0.1 (C) 10.16 (D) 0.92
75. At 273 K temperature in 250 ml water if 10 gm glucose (P_1) 10 gm urea (P_2) and 10 gm sucrose (P_3) are dissolved then which of the following relation of their osmotic pressure is true ?
 (A) $P_1 > P_2 > P_3$ (B) $P_3 > P_2 > P_1$ (C) $P_2 > P_1 > P_3$ (D) $P_2 > P_3 > P_1$
76. Which of the following is a Hypotonic solution ?
 (A) 0.01M FeCl_3 (B) 0.01M NaOH (C) 0.1M urea (D) 0.1M Na_2SO_4
77. For every 100 gm Acetone its molal elevation constant is 17.2°C , calculate boiling point of solution prepared by dissolving 0.456 gm camphor (molecular mass = 152 gm/mole) in 31.4 gm Acetone (Boiling point of Acetone = 56.30°C)
 (A) 0.16°C (B) 46.56°C (C) 56.46°C (D) 5.64°C
78. Osmotic pressure of a solution prepared by dissolving 36 gm glucose in one litre solution at 300 K is 4.98 bar. If the osmotic pressure of solution at same temperature is 1.76 bar then calculate concentration of the solution ?
 (A) 0.071 M (B) 0.0075 M (C) 0.71 M (D) 1.76 M
79. At 300 K temperature an aqueous solution of a non electrolyte has osmotic pressure 2 atm then calculate its freezing pt [$K_f = 1.86 \text{ K mole}^{-1}$, $R = 0.082 \text{ litre atm K}^{-1} \text{ mole}^{-1}$]
 (A) $+ 0.151^\circ$ (B) $- 0.151^\circ$ (C) -15.1° (D) $- 0.511^\circ$
80. Boiling point of solution of area in water is 100.18°C then calculate its freezing point ? [value of K_f and K_b for water is 1.86 and $0.512 \text{ K mole}^{-1}$ respectively]
 (A) $- 0.654^\circ \text{C}$ (B) $+ 0.654^\circ \text{C}$ (C) $- 65.4^\circ \text{C}$ (D) $- 0.456^\circ \text{C}$

Answers : 63. (B), 64. (B), 65. (A), 66. (C), 67. (B), 68. (A), 69. (B), 70. (B), 71. (B), 72. (B), 73. (A), 74. (C), 75. (B), 76. (D), 77. (C), 78. (A), 79. (B), 80. (A)

● **Methods to determine molecular mass using colligative properties**

(1) **Using Raoult's law :** Using Raoult's law for nonvolatile solute molecular mass (M_1) can be calculated as follows

$$\frac{P_1^0 - P_1}{P_1^0} = \frac{W_2 \times M_1}{M_2 \times W_1} \quad \text{OR} \quad M_2 = \frac{P_1^0}{P_1^0 - P_1} \times \frac{W_2 \times M_1}{W_1}$$

(2) **Molal elevation measurement method :** Using equation of molal elevation constant (K_b) molecular mass (M_2) of non volatile solute can be calculated as follows.

$$K_b = \frac{\Delta T_b \times W_1 \times M_2}{1000 \times W_2} \quad \text{OR} \quad M_2 = \frac{K_b \times 1000 \times W_2}{\Delta T_b \times W_1}$$

(3) **Molal depression measurement method :** Using equation of molal depression constant (K_f) molecular mass (M_2) of nonvolatile solute can be calculated as follows :

$$K_f = \frac{\Delta T_f \times W_1 \times M_2}{1000 \times W_2} \quad \text{OR} \quad M_2 = \frac{K_f \times 1000 \times W_2}{\Delta T_f \times W_1}$$

(4) Osmotic pressure measurement method : In fixed amount of solvent if fixed amount of solute is dissolved and solution is prepared at fixed temperature and the osmotic pressure is noted and then by using formula given below, molecular mass can be calculated.

$$\pi = \frac{WRT}{MV} \quad \text{OR} \quad M = \frac{WRT}{\pi V} \quad \text{OR} \quad \frac{W}{M} = C \therefore \pi = CRT$$

$$\therefore \text{Molar mass of solute substance} = \frac{\text{mass of solute} \times RT}{\text{Osmotic pressure of solution} \times \text{Volume of solution}}$$

-
- 81.** Substance is mixed 300 gm to prepare 25% by mass solution and is mixed 400 gm to prepare 40% by mass solution. Calculate percentage by mass of solute present in the mixture of the solution ?
 (A) 33.57 (B) 66.43 (C) 87.23 (D) 19.24
- 82.** 5.25% solution of a compound is isotonic with 1.5% solution of urea (molecular mass = 60 gm/mole). Both solutions are prepared from one solvent. If density of both the solution is 1.0 gm/cm³. Calculate molecular mass of a compound ?
 (A) 90.0 gm/mole (B) 115.0 gm/mole (C) 105.0 gm/mole (D) 210.0 gm/mole
- 83.** At 15°C temperature 20 gm solute is dissolved in 500 ml of water with osmotic pressure of 600 mm height of Hg column, calculate molar mass of solute ?
 (A) 1000 (B) 1200 (C) 1400 (D) 1800
- 84.** At fixed temperature 5 gram non electrolyte is dissolved in 100 gm water and vapour pressure of solution is 2985 newton meter⁻². If vapour pressure is 3000 newton m⁻² calculate molecular mass of solute ?
 (A) 60 gm (B) 120 gm (C) 180 gm (D) 380 gm
- 85.** In 35 gm chloroform 0.5143 gram Anthracene is dissolved 0.5143 gm and there is rise in boiling point of 0.323 K. Then calculate molecular mass of Anthracene ? (CHCl₃, K_b = 3.9 K kg mole⁻¹)
 (A) 79.42 gm/mole (B) 132.32 gm/mole (C) 177.42 gm/mole (D) 242.32 gm/mole
- 86.** At a fixed temperature vapour pressure of pure Benzene is 0.85 bar. If a 0.5 gm of nonvolatile and non electrolyte solid substance is dissolved in 39 gm Benzene the vapour pressure of the solution becomes 0.845 bar then calculate molecular mass of the solid substance ?
 (A) 58 (B) 170 (C) 180 (D) 145
- 87.** To make a solution of urea (Molecular mass = 60 gm/mole) having freezing point of -0.372°C How many grams of urea should be added in 8 Kg of water ? (K_f = 1.86° C kg mole⁻¹)
 (A) 96 gm (B) 106 gm (C) 90 gm (D) 120 gm
- 88.** At 17° C temperature 34.2 gm/litre of aqueous solution of sucrose [C₁₂H₂₂O₁₁] has osmotic pressure 2.38 atm then gm/ml of glucose solution will be iso osmotic to the above solution ?
 (A) 34.2 (B) 17.1 (C) 36.0 (D) 18.0
-

89. The difference between boiling point and freezing point of 100 gm sugar [$C_{12}H_{22}O_{11}$] aqueous solution at 1 atm is $105^{\circ}C$ then calculate solubility of sugar in the solution (molecular mass of sugar = 342 gm/mole, $K_b = 0.512$ and $K_f = 1.86^{\circ}C \text{ kg mole}^{-1}$)
 (A) 0.63 gm (B) 72.09 gm (C) 126.8 gm (D) 2.98 gm
90. At 298 K temperature when 10 gm nonvolatile solute is dissolved in 540 gm water, it reduces the vapour pressure of water from 0.0335 bar to 0.033 bar then calculate molecular mass of unknown solute ?
 (A) 22 gm/mole (B) 20 gm/mole (C) 42 gm/mole (D) 2.2 gm/mole
91. At 298 K temperature when 30 gm non volatile solute is dissolved in 90 gm water the vapour pressure of solution is 2.8 K pascal. At the same temperature if 18 gm water is added in the solution the new vapour pressure is 2.9 K pascal then calculate molecular mass of solute ?
 (A) 23 gm (B) 43 gm (C) 34 gm (D) 28 gm
92. When 3.24 gm of sulphur is dissolved in 40 gm of benzene. Compared to benzene the boiling point of its solution is 0.81 K more. If K_b of benzene is $2.53 \text{ K kg mole}^{-1}$. Calculate molecular formula of sulphur ?
 (A) S_4 (B) S_8 (C) S_6 (D) S_2
93. On dissolving 12.5 gm of non electrolyte substance in 175 gm water the rise in boiling point of the solution is 0.70 K. Calculate molecular mass of solute ? (K_b of water = $0.52 \text{ K kg mole}^{-1}$)
 (A) 53.06 gm (B) 16.4 gm (C) 35.60 gm (D) 5.306 gm
94. Two elements A and B have molecular formula of two compounds AB_2 and AB_4 when 1 gm of AB_2 is dissolved in 20 gm of benzene there is decrease in freezing point of 2.3 K and in the same way 1 gm of AB_4 is dissolved the freezing point decreases to 1.3 K. If molal depression constant of Benzene is $5.1 \text{ K kg mole}^{-1}$, then calculate molecular mass of A and B respectively ?
 (A) 196 and 110.87 gm (B) 25.59 and 42.64 gm
 (C) 20 and 24.64 gm (D) 26.95 and 24.46 gm
95. At $37^{\circ}C$ temperature osmotic pressure of blood is 8.21 atm, then intravenous injections which are isotonic to blood can dissolve, how many grams of glucose per litre in it ?
 (A) 58.06 gm (B) 180 gm (C) 18.06 gm (D) 82.1 gm
96. When 15 gm of unknown solute is dissolved in 450 gm of water the solution freezes at $-0.34^{\circ}C$ temperature then calculate molecular mass of compound ? ($K_f = 1.86 \text{ K kg/mole}$)
 (A) $180.53 \text{ gm mole}^{-1}$ (B) $186.35 \text{ gm mole}^{-1}$ (C) $158.0 \text{ gm mole}^{-1}$ (D) $182.35 \text{ gm mole}^{-1}$

Answers : 81. (A), 82. (D), 83. (B), 84. (C), 85. (C), 86. (B), 87. (A), 88. (D), 89. (B), 90. (A), 91. (C), 92. (B), 93. (A), 94. (B), 95. (A), 96. (D)

● Abnormal molecular mass and van't Hoff factor

● Abnormal molecular mass :

'When a solute is dissolved in a solvent and a solution is prepared there is dissociation or association taking place in it, so using colligative properties actual molecular mass of solute cannot be obtained. Hence molecular mass obtained experimentally is called Abnormal molecular mass.'

● **Dissociation** : When polar solute is dissolved in polar solvent, solute is ionized in solution and number of particles in solution increases. This is phenomena is called Dissociation.

eg., NaCl, K₂SO₄, FeCl₃ and Fe₂(SO₄)₃ are dissolved in water number of ions (particles) formed are 2, 3, 4 and 5 respectively.

● In dissociation, number of solute particle in the solution **increases**.

● **Association** : Some solute molecules when dissolved in solvent. Two or more than two molecule combine and forms associated molecules. This process is called association.

eg. Acetic acid, benzoic acid when dissolved in benzene two molecules of solute associates.

● Association **decreases** number of solute particles in solution.

The experimental molecular mass is more than the actual molecular mass. Hence such experimental molecular mass is called as Abnormal molecular mass.

Since colligative properties of a solution is applicable to dilute solution actual molecular mass of concentrated. Solution based colligative properties is not obtained and abnormal mass is obtained.

● **Van't-Hoff factor (i)**

Using colligative properties actual molecular mass cannot be calculated and abnormal molecular mass is obtained in such conditions scientist Van't Hoff introduced a new factor, which is known as Van't Hoff factor (i)

$$\text{Van't Hoff factor (i)} = \frac{\text{Normal mass of solute}}{\text{Abnormal mass of solute}}$$

$$\text{Van't Hoff factor (i)} = \frac{\text{Theoretical molar mass of solute}}{\text{Experimental molar mass of solute}}$$

$$\text{Van't Hoff factor (i)} = \frac{\text{Observed colligative property}}{\text{theoretical colligative property}}$$

● **Mathematical form of formula of colligative properties with vant hoff factor (i)**

$$(1) \text{ Raoult's law (i) : } \frac{P_1^0 - P_1}{P_1^0} = i \frac{n_2}{n_1}$$

$$(2) \text{ Molal elevation : } \Delta T_b = i \cdot K_b \cdot m$$

$$(3) \text{ Molal depression : } \Delta T_f = i \cdot K_f \cdot m$$

$$(4) \text{ Osmotic pressure : } \pi = i \frac{nRT}{V} \text{ but } \frac{n}{V} = C \quad \pi = iCRT$$

● **Solute in a solution**

On Association $i < 1$ means value of i is less than 1.

On Dissociation $i > 1$ means value of i is greater than 1.

No Association or Dissociation $i = 1$ means value of $i = 1$

● **Degree of Dissociation**

'The proportion of the mass of the given solute in the solution which gets dissociated is called degree of dissociation (∞).'

$\therefore$ Degree of dissociation (∞) = $\frac{i-1}{n-1}$, where, i = Van't Hoff factor, n = number of particles on dissociates

● **Degree of Association**

The proportion of the mass of the given solute in the solution which gets associated is called degree of Association (X).

$\therefore$ Degree of Association (X) = $(1 - i)\frac{n}{n-1}$, where i = Van't Hoff factor, n = number of particles combined due to association

97. 20 gm Napthoic acid ($C_{11}H_8O_2$) is dissolved in 50 gm Benzene and solution is prepared with decrease in freezing point of 2K, calculate value of Van't Hoff factor ?

(K_b of benzene $1.72 \text{ K Kg mole}^{-1}$)

- (A) 0.5 (B) 1 (C) 2 (D) 13

98. Which of the following is the correct relation between weak electrolyte A_xB_y , degree of dissociation (∞) and Van't Hoff factor ?

- (A) $\infty = \frac{i-1}{(x+y-1)}$ (B) $\infty = \frac{i-1}{x+y+1}$ (C) $\infty = \frac{x+y-1}{i-1}$ (D) $\infty = \frac{x+y+1}{i-1}$

99. To calculate molecular mass Van't Hoff factor (i) for Na_2SO_4 having ∞ degree of dissociation is ?

- (A) $1 + \infty$ (B) $1 - \infty$ (C) $1 + 2\infty$ (D) $1 - 2\infty$

100. For water molal depression constant is -1.8°C . If 5 gm Na_2SO_4 is dissolved in 45 gm water the freezing point changes to -3.82°C , calculate Van't Hoff factor i for Na_2SO_4 option ?

- (A) 0.381 (B) 2.05 (C) 2.63 (D) 3.11

101. Following formula are given for Van't Hoff factor (i) from which of these formula Van't Hoff factor cannot be calculated ?

- (A) $\pi V = \sqrt{i} n RT$ (B) $\Delta T_f = i \cdot K_f \cdot m$

- (C) $\Delta T_b = i \cdot K_b \cdot m$ (D) $\frac{P^0_{\text{solvent}} - P_{\text{solution}}}{P^0_{\text{solvent}}} = i \left[\frac{n}{N+n} \right]$

102. On dissolving 0.5 gm KCl in 100 gm water its freezing point becomes -0.24°C then calculate percentage dissociation of salt (K_f for water 1.86 K mole^{-1})

- (A) 90 % (B) 92 % (C) 94 % (D) 82 %

103. Suppose Van't Hoff factor for NaCl is 1.87. Now how many grams of NaCl molecular mass = 58.5 gm/mole should be dissolved in 65 gm of water to get decrease in freezing point of 7.5°C

(K_f for water = $1.86 \text{ K kgmol}^{-1}$)

- (A) 2.8 gm (B) 10.0 gm (C) 8.2 gm (D) 5.8 gm

104. When 19.5 gm CH_2FCOOH (Flouroacetic acid) is dissolved in 500 gm water. Which decreases the freezing point by 1 then calculate Van't Hoff factor and dissociation constant of Flouro acetic acid ?

(K_f for water = $1.86 \text{ K kgmol}^{-1}$)

- (A) 0.93 and 7.03×10^{-3} (B) 1.09 and 3.07×10^{-3}
(C) 1.0753 and 3.07×10^{-3} (D) 1.753 and 30.7×10^{-3}

105. Calculate the amount of CaCl_2 ($i = 2.47$) to be added to 2.5 litre of water at 27°C temperature to produce osmotic pressure of 0.75 atm ?
 (A) 0.03 mole (B) 3.0 mole (C) 0.03 mole (D) 30 mole
106. Calculate degree of dissociation of Na_2SO_4 if 0.004 M Na_2SO_4 solution is isotonic to 0.01 M glucose solution ?
 (A) 50 % (B) 75 % (C) 85 % (D) 25 %
107. The depression in freezing point of 0.01 m $\text{K}_3[\text{Fe}(\text{CN})_6]$ solution is 0.062 K, then calculate its degree of dissociation (∞) ? (molal depression constant of solvent ($K_f = 1.86 \text{ K kg mole}^{-1}$)
 (A) 0.734 (B) 0.778 (C) 0.877 (D) 0.0778
108. Depression in freezing point of solution produced by dissolving 1.5 gm phenol in 100 gm and toluene is 0.56 K. If its association produces dimer, calculate its degree of association. (molal depression constant of solvent $K_f = 4.0 \text{ K kg mole}^{-1}$.)
 (A) 0.879 (B) 24.2 (C) 0.242 (D) 0.0242
109. If a compound undergoes dissociation in one solvent and undergoes association in another solvent than the Van't Hoff factor (i) is respectively
 (A) less than 1 and more than 1 (B) less than 1 and less than 1
 (C) more than 1 and more than 1 (D) more than 1 and less than 1
110. At 300 K temperature 0.1 M potassium ferrocyanide $\text{K}_4[\text{Fe}(\text{CN})_6]$ aqueous solution undergoes 50% dissociation then calculate osmotic pressure of the solution ? ($R = 0.082 \text{ litre atm/mole K}$)
 (A) 7.38 atm (B) 3.78 atm (C) 3.83 atm (D) 8.38 atm
111. At 283 K temperature, osmotic pressure of aqueous solution of urea is 500 mm. If the temperature is made 298 K, then how many times should the solution be diluted to have osmotic pressure 105.3 mm ?
 (A) 10 times (B) 2.5 times (C) 5 times (D) 4 times
112. Concentration of four solutions of K_2SO_4 is 0.1 m, 0.01 m, 0.001 m and 0.0001 m. Which of this solution will have highest Van't Hoff factor (i) ?
 (A) 0.0001 m solution (B) 0.001 m solution (C) 0.01 m solution (D) 0.1 m solution

Answers : 97. (A), 98. (A), 99. (C), 100. (C), 101. (A), 102. (B), 103. (C), 104. (C), 105. (A), 106. (B), 107. (B), 108. (C), 109. (D), 110. (A), 111. (C), 112. (A)

- For each of the following questions there are two statements from which one is Assertion (A) and second is reason (R) study the statements carefully and select correct option as per the instruction.
 (A) Assertion (A) and reason (R) both are correct, where reason (R) is the explanation of Assertion (A).
 (B) Assertion (A) and reason (R) both are correct, where reason (R) is not the explanation of Assertion (A).
 (C) Assertion (A) is correct and Reason (R) is incorrect.
 (D) Assertion (A) is incorrect and Reason (R) is correct.

- 113. Assertion (A) :** In liquid state molarity changes with change in temperature.
Reason (R) : Volume changes with change in temperature.
- 114. Assertion (A) :** For ideal solution ΔH_{mix} and ΔV_{mix} is zero.
Reason (R) : In ideal solution intermolecular attraction A–B is equal to intermolecular attraction A–A and B–B.
- 115. Assertion (A) :** When NaCl is added to water, freezing point decreases.
Reason (R) : Due to lowering of vapour pressure of solution freezing point decreases.
- 116. Assertion (A) :** Compared to 1 molal aqueous solution, 1 molar aqueous solution is more concentrated.
Reason (R) : Molality of solution depends on its density while molarity does not depend on density.
- 117. Assertion (A) :** When a concentrated solution is diluted by adding more water. It does not change molarity of the solution.
Reason (R) : Ratio of moles of solute to volume is called molarity.
- 118. Assertion (A) :** Ideal solution is prepared by mixing benzene and Toluene.
Reason (R) : On mixing 50 ml benzene with 50 ml to Toluene, the volume of solution is 100 ml, so $\Delta V = 0$ and $\Delta H = 0$.
- 119. Assertion (A) :** Isotonic solutions do not show osmosis.
Reason (R) : Isotonic solutions have equal osmotic pressure.
- 120. Assertion (A) :** 1 molal aqueous solution of glucose contains 180 gm glucose in 1 kg water.
Reason (R) : 1 mole solute dissolved in 1000 gm solvent is called a 1 molal solution.
- 121. Assertion (A) :** When molecular mass of Acetic acid in Benzene and in water is calculated using depression in freezing point it gives different values.
Reason (R) : Water is polar and benzene is non polar.
- 122. Assertion (A) :** On increasing pressure on water freezing point decreases.
Reason (R) : Density of water is maximum at 273 K.
- 123. Assertion (A) :** Osmotic pressure of 0.1 M urea solution is less than that of 0.01 M NaCl solution.
Reason (R) : Osmotic pressure is not a colligative property.
- 124. Assertion (A) :** To remove snow from the road NaCl is used.
Reason (R) : Sodium chloride decreases freezing point of water.
- 125. Assertion (A) :** Iodine is more soluble in CCl_4 (carbon tetrachloride) than water.
Reason (R) : Non polar solutes are more soluble in polar solvents.
- 126. Assertion (A) :** Pressure cooker decreases time of cooking food.
Reason (R) : In the inner part of pressure cooker boiling point decreases.

Answers : 113. (A), 114. (A), 115. (A), 116. (B), 117. (D), 118. (A), 119. (B), 120. (A), 121. (A), 122. (C), 123. (C), 124. (A), 125. (A), 126. (B)

● **Passage type Questions :**

On the basis of the given paragraph answer the given multiple choice questions. Each question has one correct answer. Find the correct answer from them.

Passage : 1

At a definite temperature each liquid possesses definite vapour pressure, but when a solid or liquid solute substance is added to it then its vapour pressure changes. F.M. Raoult in 1986 studied colligative properties for vapour pressure of solution and the law given by him is called Raoult's law. When solute and solvent both are liquid their individual pressure is called partial pressure. It depends on the mole fraction of the components present in the solution. If a solution has two liquid components with different volatility then their mole fraction of soluble state and vapour state are different. If solute is a solid substance then vapour pressure of solution is less than that of its pure solvent. This decrease is known as relative lowering of vapour pressure. Relative lowering in vapour pressure of solution is equal to molefraction of solute. This law is useful to calculate molecular mass of solute.

- 127.** At a definite temperature pure components A and B have vapour pressure 108 and 36 torr respectively. If solution has equal moles of A and B components, calculate its vapour pressure ?
(A) 144 torr (B) 72 torr (C) 90 torr (D) 126 torr
- 128.** Calculate molefraction of vapour form of B component ?
(A) 0.50 (B) 0.75 (C) 0.25 (D) 0.33
- 129.** When a non volatile solute is dissolved in a solvent the vapour pressure of the solvent decreases 10 mm Height of Hg column. If mole fraction of solute is 0.2 calculate molefraction of solvent vapour pressure decreases 20 mm Height of Hg column ?
(A) 0.8 (B) 0.6 (C) 0.4 (D) 0.04
- 130.** Vapour pressure of pure component A is 10 torr. At identical temperature if one gram B component is added to 20 gm component A the vapour pressure decreases by 9 torr. If molecular mass of component A is 200 a.m.u. calculate molecular mass of component B ?
(A) 100 a.m.u. (B) 90 a.m.u. (C) 75 a.m.u. (D) 120 a.m.u.

Passage 2

Ideal solutions obey Raoult's law while non ideal solutions do not obey Raoult's law. In the same way when ideal solution is mixed, its volume and enthalpy do not change. Whereas for non ideal solution these properties changes based on their characteristics. Non ideal solutions can be classified into positive deviation form and negative deviation form. In a definite mixture both solutions produce Azeotropic mixture.

- 131.** Which of the following is not true for ideal-solution ?
(A) $\Delta S_{\text{mix}} = 0$ (B) $\Delta V_{\text{mix}} = 0$
(C) $\Delta H_{\text{mix}} = 0$ (D) It obeys Raoult's law
- 132.** In Azeotropic mixture of HCl and H₂O
(A) 48 % HCl (B) 22.2 % HCl (C) 36 % HCl (D) 20.2 % HCl

133. Which of the following does not show positive deviation of Raoult's law ?

- (A) Benzene chloroform (B) benzene Acetone
(C) Benzene ethanol (D) Benzene carbon tetrachloride

Passage : 3

Whenever colligative property of any electrolyte is calculated using any equation its experimental value will be more than the theoretical value because an electrolyte always undergoes dissociation in a solution. In the same way. Association of substance takes place (eg. Benzene, Acetic Acid) then the experimental value of colligative property is less than the theoretical value. This way experimentally calculated molecular mass is different from the theoretical value. It is known as abnormal molecular mass to rectify these errors Van't Hoff factor (i) is introduced. If value of Van't Hoff factor is known then degree of dissociation or association can be calculated.

134. Which of the following aqueous solution has maximum freezing point ?

- (A) 0.1 M urea (B) 0.1M sucrose (C) 0.1M AlCl_3 (D) 0.1M $\text{K}_4[\text{Fe}(\text{CN})_6]$

135. Calculate boiling point of 0.1 molal $\text{K}_4[\text{Fe}(\text{CN})_6]$ solution. (K_b for water = $0.52 \text{ K kg mole}^{-1}$)

- (A) 100.52°C (B) 100.104°C (C) 100.26°C (D) 102.6°C

136. If Van't Hoff factor of 0.1 M $\text{Ba}(\text{NO}_3)_2$ solution is 2.74 then calculate its percentage of dissociation ?

- (A) 91.3 % (B) 87 % (C) 100 % (D) 74 %

Passage : 4

When a solute is added to a pure solvent and a homogenous solution is prepared, then properties like boiling point, freezing point, vapour pressure etc. of pure solvent changes. All these properties are colligative properties. Colligative properties are very useful in daily life, like a mixture of ethylene glycol and water is used as anti-freezing reagent in the radiator of vehicles.

Given ethanol is mixed in water and solution M is prepared.

In this mixture mole fraction of ethanol is 0.9 molal depression constant of water is $K_{f_{\text{water}}} = 1.86 \text{ K kg mole}^{-1}$, molal depression constant of ethanol is $K_{f_{\text{ethanol}}} = 2.0 \text{ K kg mol}^{-1}$, molal elevation constant of water ($K_{b_{\text{water}}}$) = $0.52 \text{ K kg mole}^{-1}$, molal elevation constant of ethanol ($K_{b_{\text{ethanol}}}$) = $1.2 \text{ K kg mol}^{-1}$ standard freezing point of water = 273 K, standard freezing point of ethanol is = 155.7 K, standard boiling point of water is = 373 K, and standard boiling point of ethanol is = 351.5 K, vapour pressure of pure water = 32.8 mm, vapour pressure of pure ethanol is = 40 mm, Molecular mass of water = 18 gm/mole, molecular mass of ethanol is = 46 gm/mole.

If solvent is nonvolatile and non electrolyte and solution is dilute and ideal. Answer the following question.

137. What will be the freezing point of solution M ?

- (A) 268.7 K (B) 268.5 K (C) 234.2 K (D) 150.9 K

138. What will be the vapour pressure of solution M ?

- (A) 39.3 mm (B) 36.0 mm (C) 29.5 mm (D) 28.8 mm

139. On adding water to solution M, and mole fraction of water is 0.9. Calculate boiling point of water ?

- (A) 380.4 K (B) 376.2 K (C) 375.5 K (D) 354.7 K

Answers : 127. (B), 128. (C), 129. (B), 130. (B), 131. (A), 132. (D), 133. (A), 134. (B), 135. (C), 136. (B), 137. (D), 138. (A), 139. (B)

● **Match the column type questions :**

For the given question match the information of column I with column II. Select the correct option from the option (A), (B), (C) and (D) given below the question.

140.	Column-I	Column-II
	(A) 10.6 gm NaCl dissolved in 100 ml water (density = $1.06 \frac{\text{gm}}{\text{ml}}$)	(p) 0.1 M
	(A) 34.2 gm/litre sucrose solution (density = 1.0342 gm/ml)	(q) 1 M
	(C) 9.8 % H_2SO_4 solution (density = 1.25 gm/ml)	(r) 1.25 M
	(D) 20 % by volume ethanol 20 % solution (density = 0.938 gm/ml)	(s) 3.0 M

(A) (A)-(p), (B)-(q), (C)-(r), (D)-(s) (B) (A)-(q), (B)-(p), (C)-(s), (D)-(r)

(C) (A)-(q), (B)-(r), (C)-(p), (D)-(s) (D) (A)-(q), (B)-(p), (C)-(r), (D)-(s)

141.	Column-I	Column-II
	(A) 0.91 % NaCl solution in contact with blood cells	(p) Hypertonic solution
	(B) 1.25 % NaCl solution in contact with blood cells	(q) Hypotonic solution
	(C) 0.75 % NaCl solution in contact with blood cells	(r) Isotonic solution
	(D) 5.85 % NaCl solution in contact with glass wall	(s) Common solution

(A) (A)-(p), (B)-(q), (C)-(r), (D)-(s) (B) (A)-(r), (B)-(p), (C)-(q), (D)-(s)

(C) (A)-(s), (B)-(p), (C)-(q), (D)-(r) (D) (A)-(q), (B)-(p), (C)-(r), (D)-(s)

142.	Column-I (different solute equimolal solution)	Column-II (Elevationing Boiling point)
	(P) Sucrose, NaCl, BaCl ₂	(i) 1 : 1 : 1
	(Q) KCl, CaCl ₂ , K ₂ SO ₄	(ii) 3 : 2 : 5 : 2
	(R) Sucrose, glucose, urea	(iii) 2 : 3 : 3
	(S) Na ₃ PO ₄ , K ₄ [Fe(CN) ₆], C ₆ H ₅ NH ₂ Cl	(iv) 1 : 2 : 3
		(v) 1 : 1 : 2
		(vi) 2 : 2 : 5 : 1

(A) (P)-(iv), (Q)-(iii), (R)-(i), (S)-(vi)

(B) (P)-(iv), (Q)-(v), (R)-(i), (S)-(ii)

(C) (P)-(iv), (Q)-(iii), (R)-(v), (S)-(ii)

(D) (P)-(v), (Q)-(ii), (R)-(iv), (S)-(vi)

143.	Column-I	Column-II
	(P) P _{Total}	(i) $P_{\text{Total}} > P_A^0 \cdot X_A + P_B^0 \cdot X_B$
	(Q) attraction between molecule A and B	(ii) $P_{\text{Total}} < P_A^0 \cdot X_A + P_B^0 \cdot X_B$
	(R) Liquid heat of dilution	(iii) more attraction for A–A and B–B from.
	(S) Total volume of solution is volume of liquid	(iv) less attraction for A–A and B–B
	(T) indicates (–ve) deviation.	
	(T) Solution having negative deviation	(v) $\Delta H < 0$
		(vi) $\Delta H = 0$
		(vii) $\Delta V < 0$
		(viii) $\Delta H > 0$
		(ix) cyclohexane + Ethanol
		(x) Acetone + Aniline

(A) (P)-(ii), (Q)-(iii), (R)-(v), (S)-(vii), (T)-(x)

(B) (P)-(iii), (Q)-(iv), (R)-(vi), (S)-(viii), (T)-(ix)

(C) (P)-(vi), (Q)-(v), (R)-(vii), (S)-(ii), (T)-(iii)

(D) (P)-(vii), (Q)-(vi), (R)-(i), (S)-(iii), (T)-(ii)

144.	Column-I	Column-II
	(P) Positive deviation of non ideal solution	(i) n-Hexane-n-heptone
	(Q) Negative deviation of non ideal solution	(ii) CCl ₄ + Benzene
	(R) Abnormal molecular mass	(iii) chloroform + benzene
	(S) Ideal solution	(iv) acetic acid + Benzene

(A) (P)-(i), (Q)-(ii), (R)-(iii), (S)-(iv)

(B) (P)-(ii), (Q)-(iii), (R)-(iv), (S)-(i)

(C) (P)-(i), (Q)-(iii), (R)-(iv), (S)-(ii)

(D) (P)-(ii), (Q)-(iv), (R)-(iii), (S)-(i)

Answers : 140. (D), 141. (B), 142. (A), 143. (A), 144. (B)

● **True or false type of question :**

For every correct statement T and wrong statement (F) select the correct option from the given options :

145. (1) For a nonvolatile solute containing solution vapour pressure and mole fraction are equal.

(2) 0.1 M $\text{Ba}(\text{NO}_3)_2$ solution is diosmotic to 0.1 M Na_2SO_4 solution.

(3) Boiling point is a colligative property.

(4) When solute undergoes association and their Van't Hoff factor (i) is more than 1

(A) TTFF (B) FFTT (C) TTTT (D) FFFF

146. (1) For a solution prepared by mixing CH_3COCH_3 and C_6H_6 as $\Delta H > 0$ and $\Delta V > 0$ $P_{\text{Total}} > P_A^0 \cdot X_A + P_B^0 \cdot X_B$

(2) If density of 5 % $\frac{W}{W}$ is 1.043 gm/ml then its molality is 0.549 m.

(3) liquid having low vapour pressure has high boiling point.

(4) Two solutions A and B are separated by semipermeable membrane. If liquid flows from A to B side then concentration of A is more than that

(A) FTFT (B) TFTF (C) TTTT (D) FFFF

Answers : 145. (A), 146. (B)

● **Match the matrix type question (more than one correct Answer)**

Match column I with column II for given question, but information of column I is connected to more than one option. For e.g. 4×4 matrix is as follows.

	p	q	r	s
A	☒ p	☐ q	☐ r	☒ s
B	☐ p	☐ q	☒ r	☐ s
C	☒ p	☒ q	☐ r	☐ s
D	☐ p	☐ q	☐ r	☒ s

147.	Column-I	Column-II
	(A) 95.4 % aqueous ethanol solution	(p) maximum boiling azeotrope is obtained
	(B) 68 % aqueous HNO_3	(q) minimum freezing azeotrope is obtained.
	(C) 20.3 % aqueous HCl solution	(r) $\Delta V_{\text{mix}} = +\text{Ve}$
	(D) 6.8 % solution of chloroform in ethanol solution	(s) $\Delta H_{\text{mix}} = -\text{Ve}$
148.	Column-I	Column-II
	(A) Relative lowering in vapour pressure	(p) Increasing proportion of solute.
	(B) Osmotic pressure	(q) Salt is deposited at the bottom of the sea
	(C) Rise in Boiling point	(r) Construct base for Rast technique
	(D) depression in freezing point	(s) Familiar technique to calculate molecular mass of polymer substance

Answers : 147. (A)-(q), (r), (B)-(p), (s); (C)-(p), (s), (D)-(q), (r)
148. (A)-(p), (B)-(p), (q); (C)-(p), (D)-(p), (r)

● **Number (0 to 9) based Question**

Answer of the following question is in form of 0 to 9 decide the answer and follow the given method in column for eg. Question 1 to 4 have answers 4, 0, 9 and 2.

1	2	3	4
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

149. Suppose mole fraction of N_2 in air is 0.78. If at $25^\circ C$ room temperature and 1 atm pressure concentration of Nitrogen in one glass of water is $x \times 10^{-4}$ mole/litre, then calculate value of 'x' ? (Henry's constant $K_H = 8.42 \times 10^{-7}$)
150. Calculate osmotic pressure of the solution prepared by mixing 100 ml 1.4% urea solution (molecular mass = 60) and 100 ml 3.42% sugarcane (sucrose) solution (Molecular mass = 342) at $20^\circ C$ temperature ($R = 0.0821$ lit atm/mole K)
151. Calculate Van't Hoff factor for 75% dissociated potassium Ferocyanide $K_4[Fe(CN)_6]$ solution ?
152. How many pairs of solution show positive deviation from Raoult's law ?
- | | | |
|-----------------------|---------------------|---------------------------|
| $(CH_3)_2CO - CS_2$; | $CHCl_3 - C_6H_6$; | $C_2H_5OH - H_2O$; |
| $HNO_3 - H_2O$; | $CCl_4 - C_6H_6$; | $(CH_3)_2CO - C_2H_5OH$; |
| $CCl_4 - CHCl_3$; | $HCl - H_2O$; | $(CH_3)_2CO - CHCl_3$ |
153. How many ml of 0.1 M $AgNO_3$ solution will be needed to completely precipitate chloride ion into silver chloride from 30 ml 0.01 M $[Cr(H_2O)_5Cl]Cl_2$ solution.
154. How many solutions will boil above 372 K temp ?
- 0.1 M NaCl, 0.1 M glucose, 0.1 M $BaCl_2$, 0.1 M sucrose
- 0.1 M KNO_3 , 0.1 M Na_2SO_3 , 0.1 M $K_4[Fe(CN)_6]$
- 0.1 M K_2CO_3
155. From the following how many concentration units are temperature based ?

Molarity, mole fraction, Normality, formality, molality, percentage by volume and percentage by mass.

- 156.** If ratio of depression in freezing poing for the solution 1M urea, 0.5 M glucose, 1 M NaCl, and 1 M K_2SO_4 is $x : 1 : y : z$, then calculate value of $x + z$?
- 157.** Calculate moles of NaCl in 3 M NaCl 3 litre solution ?
- 158.** Calculate mass of ascorbic acid (vitamin $C-C_6H_8O_6$) dissolved in 75 gm Acetic acid $[CH_3COOH]$ having decrease in melting point of $1.5^\circ C$?
($K_f = 3.9 K \text{ kg mole}^{-1}$)
- 159.** Calculate degree of association (x) for benzoic acid having abnormal mass 244 gm/mole and actual molecular mass is 122gm/mole. Benzoic acid form dimer compound ?
- 160.** 2×10^{-6} kg of sulphur is soluble in 2 litre solution then from mass by volume of solution calculate its parts per million ?

Answers : 149. (5), 150. (4), 151. (4), 152. (6), 153. (6), 154. (8), 155. (3), 156. (8), 157. (9), 158. (5), 159. (1), 160. (1)

