Chapter

16

Solutions

COMPONENTS OF SOLUTION

A solution is a homogenous mixture of two or more components called solute and solvent.

(i) **Solute :** The component present in lesser amount than other component in solution is called solute.

(ii) **Solvent :** The component present in greater amount than any or all other components is called the solvent.

A solution consisting of two components, i.e., one solute and one solvent is called a **binary solution.**

TYPES OF SOLUTIONS

On the basis of physical state of solute and solvent : There may be the following nine types of binary solutions :

S.No.	Solute	Solvent	Example
1.	Gas	Gas	Air
2.	Gas	Liquid	CO_2 in soda water
3.	Gas	Solid	Hydrogen in Pd/Pt.
4.	Liquid	Gas	Fog
5.	Liquid	Liquid	Alcohol in water, benzene in toluene
6.	Liquid	Solid	Mercury in zinc amalgam
7.	Solid	Gas	Smog
8.	Solid	Liquid	Sugar in water
9.	Solid	Solid	Alloys

CONCENTRATION OF SOLUTIONS

Composition of a solution can be described by expressing its concentration. There are several ways of expressing the concentration of the solution quantitatively.

(i) Mass Percentage (w/W)

It is given by

$$\text{mass\% of a component} = \frac{\text{Mass of the component in the solution}}{\text{Total mass of the solution}} \times 100$$

(ii) Volume Percentage (v/V)

It is given by

$$\text{volume\% of a component} = \frac{\text{Volume of the component}}{\text{Total volume of solution}} \times 100$$

(iii) Weight – Volume Percentage (w/V)

$$\text{Weight – volume percentage} = \frac{\text{Weight of solute (gm)}}{\text{Volume of solution (ml)}} \times 100$$

(iv) Parts per Million

It is defined as:

$$\text{Parts per million} = \frac{\text{Number of parts of component}}{\text{Total number of parts of all components of the solution}} \times 10^6$$

(v) Normality

$$\text{Normality} = \frac{\text{Number of gram equivalents of solute}}{\text{Volume of solution (lit)}}$$

$$\text{As Gram equivalents of solute} = \frac{\text{Weight of solute (gm)}}{\text{Equivalent weight of solute}}$$

(vi) Mole fraction

It is defined as:

$$\text{Mole fraction of a component} = \frac{\text{Number of moles of the component}}{\text{Total number of moles of all the components}}$$

(vii) Molarity (M)

It is defined as:

$$\text{Molarity} = \frac{\text{Number of moles of solute}}{\text{Volume of solution}(\text{in L})}$$

(viii) Molality (m)

It is defined as:

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

(ix) Formality

$$\text{Formality} = \frac{\text{weight of solute (gm)}}{\text{Formula weight of solute}} \times \frac{1}{\text{Volume of solution (lit.)}}$$

Note:

(i) Mass %, ppm, mole fraction and molality are independent of temperature, whereas molarity is a function of temperature. It is because volume depends on temperature and mass does not.

(ii) The molarity equation is $M_1V_1 = M_2V_2$ (for dilution from volume V_1 to V_2)

For a reaction between two reactants,

$$\frac{M_1V_1}{n_1} = \frac{M_2V_2}{n_2}$$

where n_1 and n_2 are their stoichiometric coefficients in the balanced equation.

SOLUBILITY

Solubility of a substance, is its maximum amount that can be dissolved in a specified amount of solvent. It depends on nature of solute and solvent, temperature and pressure.

Solubility of a Solid in a Liquid

When a solid solute is added to the solvent, some solute dissolves (dissolution) while some solute particles get separated (crystallization). A stage is reached when the two processes occur at the same rate and a state of dynamic equilibrium is reached. The solution which is in dynamic equilibrium with undissolved solute is the saturated solution and contains the maximum amount of solute dissolved in a given amount of solvent. The concentration of solute in such a solution is its solubility.

Thus, the solubility of a solid in a liquid at any temperature is defined as the maximum amount of the solid in grams which can be dissolved in 100g of the liquid to form the saturated solution.

Effect of temperature: If dissolution process is endothermic ($\Delta H > 0$), solubility increases with increase in temperature and if it is exothermic ($\Delta H < 0$), solubility decreases.

Nature of the solute and solvent: Ionic compound dissolves in polar solvents due to strong electrostatic forces of attraction between ions and polar solvent molecules. Non-polar compound dissolve in non polar solvents due to similar solute-solute, solute-solvent and solvent-solvent interactions.

Effect of pressure: Solids and liquids are incompressible and practically remain unaffected by changes in pressure.

Solubility of a Gas in a Liquid

It is generally expressed in terms of absorption coefficient which is defined as the volume of gas (reduced to NTP) dissolved by unit volume of solvent at particular temperature and 1 atm. pressure of gas.

Nature of the gas: Easily liquifiable gases are more soluble. Example: CO_2 is more soluble than O_2 and H_2.

Nature of the solvent: Gases capable of forming ions in aqueous solution are more soluble in water than in other solvent.

Example : HCl, NH_3 etc.

Effect of temperature: Solubility of a gas in a liquid decreases with increase in temperature. It is an exothermic process i.e., Gas + Solvent $\rightleftharpoons$ Solution + Heat

Applying Le Chatelier, principle, increase in temperature would shift the equilibrium in backward direction, i.e, solubility will decrease.

Effect of pressure: The solubility of a gas increases with increase in pressure. Henry's law states that at a constant temperature, solubility of a gas in a liquid is directly proportional to the pressure of the gas, i.e. Expressing solubility in terms of mole fraction of gas in the solution Henry's law can be written as,

$$p = K_H x$$

$p \rightarrow$ partial pressure of the gas in vapour phase

$x \rightarrow$ mole fraction of the gas in solution

$K_H \rightarrow$ Henry's law constant

- Henry's constant, K_H is a junction of the nature of the gas.
- Greater the value of K_H, lower is the solubility of the gas at the same partial pressure.
- The value of K_H increases with increase in temperature.

$$K_H \propto \frac{1}{x} \text{ and } K_H \propto T \quad \therefore x \propto \frac{1}{T}$$

It is due to this reason that aquatic species are more comfortable in cold water than in hot water.

Applications of Henry's Law

(i) To increase the solubility of CO_2 in soft drinks and soda water, the bottle is sealed under high pressure.

(ii) To avoid bends as well as toxic effects of high concentrations of nitrogen in the blood, the tanks used by scuba divers are filled with air diluted with helium, nitrogen and oxygen.

(iii) At high altitudes, the partial pressure of oxygen is less which leads to low concentration of oxygen in blood, causing climbers to become weak and unable to think clearly, symptoms of a condition known as anoxia.

VAPOUR PRESSURE OF LIQUID SOLUTIONS AND RAOULT'S LAW

Vapour Pressure of Liquid-liquid Solutions

When two volatile liquids are taken in a closed vessel, a stage is reached when an equilibrium is established between vapour phase and liquid phase. The relationship between them is given by Raoult's law i.e.,

It states that at a given temperature, the partial vapour pressure of any component of the solution is equal to the product of the vapour pressure of the pure component and its mole fraction in the solution.

$$p_1 \propto x_1 \text{ and } p_1 = p_1{}^\circ x_1$$

$$p_2 \propto x_2 \text{ and } p_2 = p_2{}^\circ x_2$$

where p_1 and p_2 are partial pressures of components 1 and 2

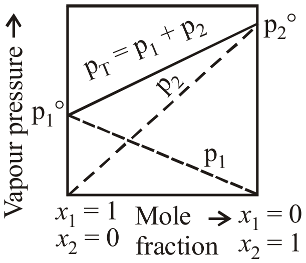
$p_1{}^\circ$ and $p_2{}^\circ$ are their partial pressures in pure state

x_1 and x_2 are mole fractions of component 1 and 2.

According to Dalton's law of partial pressure,

$$\begin{aligned} p_{Total} &= p_1 + p_2 = x_1p_1{}^\circ + x_2p_2{}^\circ \\ &= (1 - x_2)p_1{}^\circ + x_2p_2{}^\circ \\ &= p_1{}^\circ + (p_2{}^\circ - p_1{}^\circ)\, x_2 \end{aligned}$$

Diagrammatically, it is represented as:



The composition of the vapour phase is given by:

$p_1 = y_1 p_{Total}$

$p_2 = y_2 p_{Total}$

where y_1 and y_2 are the mole fractions of components 1 and 2 in the vapour phase.

Vapour Pressure of Solutions of Solids in Liquids

If a non-volatile solute is added to a solvent to give a solution, the vapour pressure of the solution will be from solvent alone and it is lower than the vapour pressure of the pure solvent at the same temperature.

Then, the total vapour pressure will be given by

$p_T = p_1 + p_2$

as $p_2 = 0$ (non-volatile solute)

$\therefore \quad p_T = p_1 = p_1^\circ x_1$

i.e., vapour pressure of solution $\propto$ mole fraction of the solvent in solution.

Mole fraction of the solvent in solution,

$$x_1 = \frac{n_1}{n_1 + n_2}$$

where n_1 = moles of solvent and n_2 = moles of solute

$p_T = p_1^\circ x_1$

$$\text{i.e., } \frac{p^o_T}{p^o_1} = \frac{n_1}{n_1 + n_2}$$

$$\frac{p^o_1 - p_T}{p^o_1} = \frac{n_2}{n_1 + n_2}$$

where $\frac{p^o_1 - p_T}{p^o_1}$ is called relative lowering of vapour pressure and

$\frac{n_2}{n_1 + n_2}$ = mole fraction of the solute in the solution.

Limitations of Raoult's Law

(i) Raoult's law is applicable only to very dilute solutions.

(ii) Raoult's law is applicable to solutions containing non-volatile solute only.

(iii) Raoult's law is not applicable to solutes which dissociates or associate in solution.

IDEAL AND NON-IDEAL SOLUTIONS

An Ideal solution possesses the following characteristics.

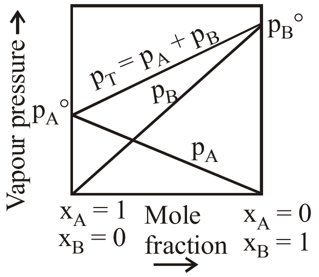
(i) The interactions between components are similar to those in pure components.

(ii) There is no volume change and enthalpy change on mixing the components. ($\Delta V = 0, \Delta H = 0$)

(iii) Each component obeys Raoult's law at all temperatures and concentrations i.e, $P_A = x_A P_A^\circ$ and $P_B = x_B P_B^\circ$

(iv) They do not form azeotropes

Their graphical behaviour is shown as:



Examples:

(i) Benzene and toluene

(ii) n-Hexane and n-Heptane

(iii) Ethyl iodide and ethyl bromide

(iv) Chlorobenzene and bromobenzene

Non Ideal: Solution possesses the following characteristics:

(i) The interactions between components are different from those in pure components.

(ii) $\Delta V \neq 0, \Delta H \neq 0$ on mixing the components.

(iii) They do not obey Raoult's law. They show positive or negative deviations from Raoult's law, i.e., $P_A \neq x_A P_A^\circ$ and $P_B \neq x_B P_B^\circ$

(iv) They form azeotropes

Azeotropic Mixtures

They are binary mixtures of two liquids having same composition in liquid and vapour phase and boil at a constant temperature and can be distilled without any change in their composition. They are formed by non–ideal solutions. They are of two type.

Minimum boiling azeotropes : it is formed by liquids showing positive deviation. Such azeotropes have boilig point lower than either any of the pure component.

Maximum boiling azeotropes : It is formed by liquids showing negative deviation such azeotropes have boiling point higher than either of the pure component.

Non-Ideal Solutions are divided **into two types:**

Non-ideal solutions showing positive deviations

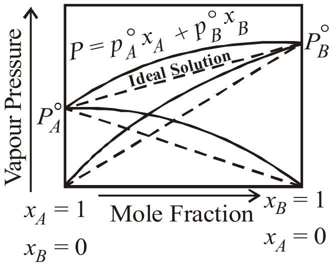
1. The interactions between components are less than in pure components, i.e., A – B < A – A/B – B
2. $\Delta V_{mixing} = +ve$
3. $\Delta H_{mixing} = -\ ve$
4. $P_A > x_A P_A^\circ; P_B > x_B P_B^\circ$

Examples:

(i) Acetone + ethyl alcohol

(ii) Water + Ethylalcohol

(iii) Acetone + Benzene



Non-ideal solutions showing negative deviations

1. The interactions between components are more than in pure components, i.e., A – B > A – A/B – B
2. $\Delta V_{mixing} = -\ ve$
3. $\Delta H_{mixing} = -\ ve$
4. $P_A < x_A P_A^\circ, P_B < x_B P_B^\circ$

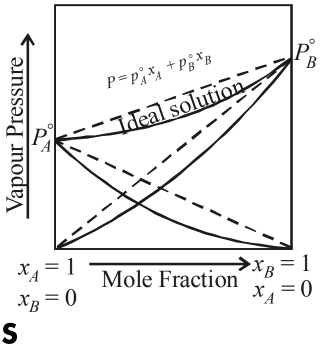
Examples:

(i) $H_2O + HCl$

(ii) $CH_3OH + CH_3COOH$

(iii) $H_2O + HNO_3$

(iv) Chloroform + Benzene



COLLIGATIVE PROPERTIES

Those properties of ideal solutions which depend only on the number of particles of solute dissolved in a definite amount of the solvent and do not depend on the nature of the solute are called colligative properties.

The important colligative properties are :

(i) Relative Lowering of Vapour Pressure

It is given by:

$$\frac{p^\circ - p_s}{p^\circ} = \frac{n_2}{n_1 + n_2} = \frac{w_2/M_2}{w_1/M_1 + w_2/M_2}$$

for very dilute solution, $\frac{p^\circ - p_s}{p^\circ} \simeq \frac{n_2}{n_1} = \frac{w_2/M_2}{w_1/M_1}$

for all solutions, $\frac{p^\circ - p_s}{p_s} = \frac{n_2}{n_1} = \frac{w_2/M_2}{w_1/M_1}$

(dilute or concentrated)

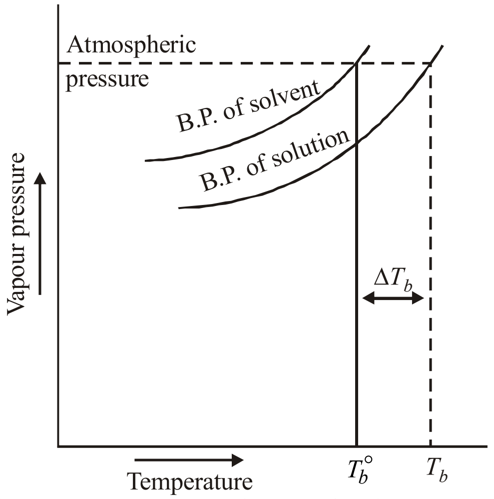
Where $n_1, w_1, M_1 \rightarrow$ number of moles, mass in g, mol. mass of solvent.

$n_2, w_2, M_2 \rightarrow$ number of moles, mass in g, mol. mass of solute.

(ii) Elevation of Boiling Point

The boiling point of the solution is always higher than that of the pure solvent. This is because vapour pressure of solution is lower than that of pure solvent and hence, the solution has to be heated more to make the vapour pressure equal to the atmospheric pressure.

Graphically, it is represented as



If T_b° is vapour pressure of solvent and T_b is vapour pressure of the solution than

$$T_b > T_b^\circ$$

The difference ΔT_b is called elevation in boiling point

$$\Delta T_b = T_b - T_b^\circ$$

Quantitatively, it is given by

$\Delta T_b = K_b \times m$, where $m =$ molality

$$T_b - T_b^\circ = K_b \times m = K_b \times \frac{w_2}{M_2} \times \frac{1000}{w_1}$$

$\boxed{M_2 = \frac{1000 \times K_b \times w_2}{\Delta T_b \times w_1}}$ (K_b = molal elevation constant or ebullioscopic constant)

Molal elevation constant is also given as

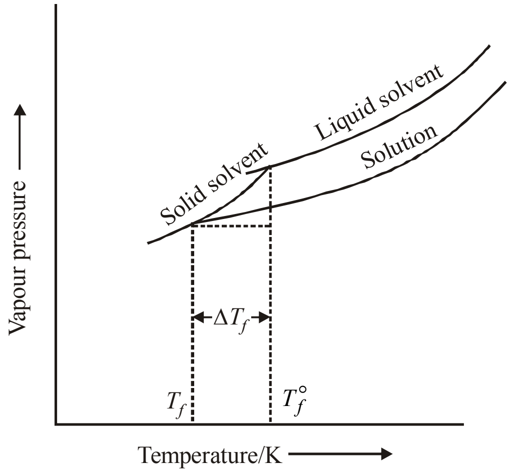
$$K_b = \frac{RM_1T_b^2}{1000\Delta H_v}$$

where, T_b = b. pt. of pure solvent
ΔH_v = Enthalpy of fusion of solvent
M_1 = Molar mass of solvent

(iii) Depression in Freezing Point

Vapour pressure of the solution is less than that of pure solvent. As freezing point is the temperature at which the vapour pressure of the liquid and solid phase are equal, therefore, for the solution, this will occur at a lower temperature ($\because$ lower the temperature lower is the vapour pressure)

Graphically, it is represented as:



If T_f° is freezing point of pure solvent and T_f freezing point of the solution, then $T_f < T_f^\circ$. The depression in freezing point ΔT_f is given by

$$\Delta T_f = T_f^\circ - T_f$$

Quantitatively, it is given by

$\Delta T_f = K_f \times m$

$T_f^\circ - T_f = K_f \times m$ ($m \rightarrow$ molality)

$$= K_f \times \frac{w_2}{M_2} \times \frac{1000}{w_1}$$

$\boxed{M_2 = \frac{1000 \times K_f \times w_2}{\Delta T_f \times w_1}}$ (K_f = molal depression constant or cryoscopic constant)

Relation for molal depression constant :

$$K_f = \frac{M_1RT_f^2}{1000\Delta H_f}$$

where, T_f = Freezing point of pure solvent
ΔH_f = Enthalpy of fusion of solvent

Note:

Depression in freezing point is used in:

(a) making antifreeze solutions
(b) melting of ice on the roads

(iv) Osmotic Pressure

The net spontaneous flow of the solvent molecules from the solvent to the solution or from a less concentrated solution to a more concentrated solution through a semipermeable membrane is called osmosis.

The minimum excess pressure that has to be applied on the solution to prevent the entry of the solvent into the solution through the semi-permeable membrane is called osmotic pressure.

Quantitatively, it is given by

$\pi \propto C$ where $\pi \rightarrow$ osmotic pressure
$\pi \propto T$ $C \rightarrow$ conc. of solution
$\therefore \pi \propto CT$ $T \rightarrow$ temperature

$\boxed{\pi = CRT}$ R → gas constant

$$C = \frac{n}{V}$$

where, n = number of moles of the solute
V = volume of solution

$$\pi = \frac{n}{V}RT$$

$$\boxed{\pi V = nRT}$$

Note:

(i) When the semi-permeable membrane permits solvent molecules to come out through the membrane, it is called exo-osmosis and when the membrane permits solvent molecules to enter inside, it is called endo-osmosis.

(ii) If pressure higher than osmotic pressure is applied on the solution, the solvent will flow from the solution into the pure solvent through the semi-permeable membrane. This process is called reverse osmosis and it is used in the **desalination of water** i.e., removal of salts from sea water.

(iii) Such solutions which have the same osmotic pressure at the same temperature are called isotonic solutions. If one solution is of lower osmotic pressure, it is called hypotonic with respect to more concentrated solution. The more concentrated solution is said to be hypertonic with respect to dilute solution.

(iv) When an animal cell is placed in a hypotonic solution, the cell swells and bursts (hemolysis).When a cell is placed in hypertonic solution, the cell contracts in size (plasmolysis). When excess of fertilizers (like urea) are applied, plasmolysis takes place and plants dry up (wilt).

ABNORMAL MOLECULAR MASSES

In case of aqueous solutions of electrolytes, inorganic bases and salts, which dissociate completely or partially in the solution, or if association takes place in the solution as in the case of acetic acid and benzoic acid, the number of particles in the solution changes (increases in case of dissociation and decreases for association). As a result, value of colligative property also changes and as

$$\text{molecular mass} \propto \frac{1}{\text{colligative properties}}$$

∴ observed molecular mass comes out to be different from theoretical value. This observed molecular mass is called **abnormal molecular mass.**

Van't Hoff Factor

The extent of association or dissociation can be determined with the help of van't Hoff factor (*i*) It is defined as the ratio of normal mass to the observed molecular mass of solute i.e.,

$$i = \frac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$$

$$\text{or } i = \frac{\text{Observed colligative property}}{\text{Calculated colligative property}}$$

$$\text{or } i = \frac{\text{Total number of moles of particles after association / dissociation}}{\text{Number of moles of particles before association / dissociation}}$$

Thus, the modified colligative properties are:

(a) Relative lowering of vapour pressure

$$\frac{p^\circ - p_s}{p^\circ} = ix_2$$

(b) Elevation in boiling point

$$\Delta T_b = T_b - T_b{}^\circ = ik_b m$$

(c) Depression in freezing point

$$\Delta T_f = T_f{}^\circ - T_f = ik_f m$$

(d) Osmotic pressure

$$\pi = iCRT = i\frac{n}{v}RT$$

Note:

(i) i > 1 if there is dissociation of the solute in solution and i < 1 if there is association of the solute in solution.

(ii) For 100% dissociation of the solute, i = number of ions produced from one molecule of the solute.

(iii) Degree of dissociation is defined as the fraction of the total substance that undergoes dissociation i.e.,

$$\text{Degree of dissociation } (\alpha) = \frac{\text{Number of moles dissociated}}{\text{Total number of moles taken}}$$

	$(A)_n \rightleftharpoons$	nA
Initial mole	1	0
Dissociation mole	α	$n\alpha$
Equilibrium mole	$(1-\alpha)$	$n\alpha$

∴ Total number of moles = $[(1-\alpha) + n\alpha]$ mole
= $1 + \alpha(n-1)$ mole

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

$$\alpha = \frac{i-1}{n-1} \quad (n \rightarrow \text{number of ions produced on dissociation})$$

$$\text{or, } \alpha = \frac{M_c - M_o}{M_o(n-1)} \quad \begin{bmatrix} M_c \rightarrow \text{normal molecular mass} \\ M_o \rightarrow \text{observed molecular mass} \end{bmatrix}$$

(iv) Degree of association is defined as the fraction of the total substance which exists in the form of associated molecules i.e.,

	nA $\rightleftharpoons$	$(A)_n$
Equilibrium moles	$(1-\alpha)$ mole	$\frac{\alpha}{n}$ mole

$$\therefore\ \text{Total no. of moles} = 1 - \alpha + \frac{\alpha}{n}$$

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

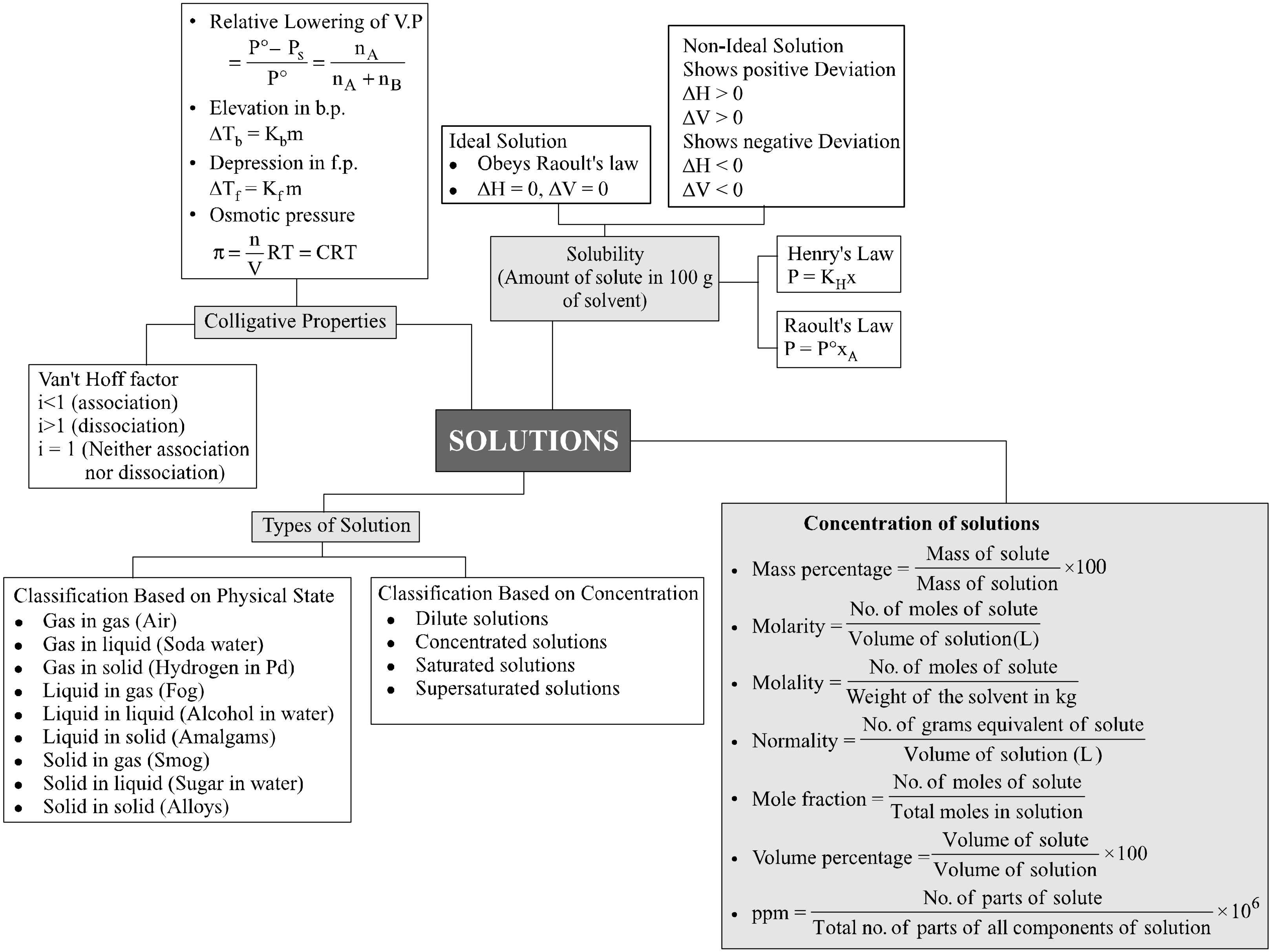
$$\text{Degree of association } (\alpha) = \frac{\text{Number of moles associated}}{\text{Total number of moles taken}}$$

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

n = number of molecules of the solute associated

$$\text{or, } \alpha = \frac{M_o - M_c}{M_o}\frac{n}{(n-1)}$$

CONCEPT MAP



SOLUTIONS

Colligative Properties

- Relative Lowering of V.P $= \frac{P^\circ - P_s}{P^\circ} = \frac{n_A}{n_A + n_B}$
- Elevation in b.p. $\Delta T_b = K_b m$
- Depression in f.p. $\Delta T_f = K_f m$
- Osmotic pressure $\pi = \frac{n}{V} RT = CRT$

Van't Hoff factor
i<1 (association)
i>1 (dissociation)
i = 1 (Neither association nor dissociation)

Solubility
(Amount of solute in 100 g of solvent)

Ideal Solution
- Obeys Raoult's law
- $\Delta H = 0, \Delta V = 0$

Non-Ideal Solution
Shows positive Deviation
$\Delta H > 0$
$\Delta V > 0$
Shows negative Deviation
$\Delta H < 0$
$\Delta V < 0$

Henry's Law
$P = K_H x$

Raoult's Law
$P = P^\circ x_A$

Types of Solution

Classification Based on Physical State
- Gas in gas (Air)
- Gas in liquid (Soda water)
- Gas in solid (Hydrogen in Pd)
- Liquid in gas (Fog)
- Liquid in liquid (Alcohol in water)
- Liquid in solid (Amalgams)
- Solid in gas (Smog)
- Solid in liquid (Sugar in water)
- Solid in solid (Alloys)

Classification Based on Concentration
- Dilute solutions
- Concentrated solutions
- Saturated solutions
- Supersaturated solutions

Concentration of solutions
- Mass percentage $= \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$
- Molarity $= \frac{\text{No. of moles of solute}}{\text{Volume of solution(L)}}$
- Molality $= \frac{\text{No. of moles of solute}}{\text{Weight of the solvent in kg}}$
- Normality $= \frac{\text{No. of grams equivalent of solute}}{\text{Volume of solution (L)}}$
- Mole fraction $= \frac{\text{No. of moles of solute}}{\text{Total moles in solution}}$
- Volume percentage $= \frac{\text{Volume of solute}}{\text{Volume of solution}} \times 100$
- ppm $= \frac{\text{No. of parts of solute}}{\text{Total no. of parts of all components of solution}} \times 10^6$

EXERCISE - 1

Conceptual Questions

1. Lowering in vapur pressrue is the highest for :
(a) 0.1 M glucose (b) 0.1 M $BaCl_2$
(c) 0.2 M urea (d) 0.1 M $MgSO_4$

2. Formation of a solution from two components can be considered as
(i) Pure solvent → separated solvent molecules, ΔH_1
(ii) Pure solute → separated solute molecules, ΔH_2
(iii) Separated solvent & solute molecules → Solution, ΔH_3
Solution so formed will be ideal if
(a) $\Delta H_{soln} = \Delta H_3 - \Delta H_1 - \Delta H_2$
(b) $\Delta H_{soln} = \Delta H_1 + \Delta H_2 + \Delta H_3$
(c) $\Delta H_{soln} = \Delta H_1 + \Delta H_2 - \Delta H_3$
(d) $\Delta H_{soln} = \Delta H_1 - \Delta H_2 - \Delta H_3$

3. An aqueous solution containing 1 gm of urea boils at 100.25ºC. The aqueous solution containing 3 g of glucose in the same volume will boil at (mol. wt. of urea = 60 and of glucose = 180) :
(a) 100.25ºC (b) 100ºC
(c) 100.15ºC (d) 100.50ºC

4. The statement "If 0.003 moles of a gas are dissolved in 900 g of water under a pressure of 1 atmosphere, 0.006 moles will be dissolved under a pressure of 2 atmospheres", illustrates
(a) Dalton's law of partial pressure
(b) Graham's law
(c) Raoult's law
(d) Henry's law

5. Which of the following modes of expressing concentration is independent of temperature ?
(a) Molarity (b) Molality
(c) Formality (d) Normality

6. Molarity of liquid HCl will be, if density of solution is 1.17 gm/cc
(a) 36.5 (b) 32.05 (c) 18.25 (d) 42.10

7. The molarity of a solution containing 5 gm of NaOH in 250 ml solution :
(a) 0.5 (b) 1.0 (c) 1.5 (d) 2.0

8. Concentrated hydrochloric acid contains 37% HCl (by mass). The density of this solution is 1.18 gm/ml. The molarity of the solution is :
(a) 10 M (b) 12 M (c) 13 M (d) 14 M

9. An X molal solution of a compound in benzene has mole fraction of solute equal to 0.2. The value of X is
(a) 14 (b) 3.2 (c) 1.4 (d) 2

10. The molarity of the solution containing 7.1 g of Na_2SO_4 in 100 ml of aqueous solution is
(a) 2 M (b) 0.5 M (c) 1 M (d) 0.05 M

11. The vapour pressure of pure benzene at 25°C is 640 mm Hg and that of solution of solute A is 630 mm Hg. The molality of solution is –
(a) 0.2 m (b) 0.4 m (c) 0.5 m (d) 0.1 m

12. The molarity of pure water is :
(a) 50 M (b) 18 M (c) 55.6 M (d) 100 M

13. The osmotic pressure at 17ºC of an aq. solution containing 1.75 gm of sucrose per 150 ml solution is :
(a) 0.08 atm (b) 8.1 atm (c) 0.8 atm (d) 9.1 atm

14. An aqueous solution of glucose is 10% in strength. The volume in which 1 g mole of it is dissolved, will be :
(a) 9 litre (b) 1.8 litre (c) 8 litre (d) 0.9 litre

15. 10 g of NaCl is dissolved in 10^6 g of the solution. Its concentration is :
(a) 100 ppm (b) 0.1 ppm (c) 1 ppm (d) 10 ppm

16. On adding a solute to a solvent having vapour pressure 0.80 atm, vapour pressure reduces to 0.60 atm. Mole fraction of solute is :
(a) 0.25 (b) 0.75 (c) 0.50 (d) 0.33

17. If 0.44 gm of substance dissolved in 22.2 gm of benzene lowers the freezing point of benzene by 0.567ºC, then the molecular mass of substance is, the molal depression constant= 5.12ºC mol^{-1}.
(a) 128.4 (b) 156.6 (c) 178.9 (d) 232.4

18. 2.5 litres of NaCl solution contain 5 moles of the solute. What is the molarity?
(a) 5 molar (b) 2 molar (c) 2.5 molar (d) 12.5 molar

19. Which of the following statements, regarding the mole fraction (x) of a component in solution, is incorrect?
(a) $0 \le x \le 1$ (b) $x \le 1$
(c) x is always non-negative (d) None of these

20. When 10 g of a non-volatile solute is dissolved in 100 g of benzene, it raises boiling point by 1ºC then molecular mass of the solute is (K_b for benzene = 2.53 km^{-1})
(a) 223 g (b) 243 g (c) 233 g (d) 253 g

21. The mole fraction of the solute in one molal aqueous solution is:
(a) 0.009 (b) 0.018 (c) 0.027 (d) 0.036

22. When a solute is present in trace quantities the following expression is used
(a) Gram per million (b) Milligram percent
(c) Microgram percent (d) Parts per million

23. 5 ml of N HCl, 20 ml of N/2 H_2SO_4 and 30 ml of N/3 HNO_3 are mixed together and volume made to one litre. The normality of the resulting solution is
(a) $\frac{N}{5}$ (b) $\frac{N}{10}$ (c) $\frac{N}{20}$ (d) $\frac{N}{40}$

24. The molal freezing point constant for water is 1.86ºC. Therefore, the change in freezing point of 0.1 molal of NaCl solution in water is expected to be
(a) 0.372ºC (b) –1.86ºC (c) –0.186ºC (d) –0.372ºC

25. Vapour pressure of benzene at 30°C is 121.8 mm Hg. When 15 g of a non volatile solute is dissolved in 250 g of benzene its vapour pressure decreased to 120.2 mm Hg. The molecular weight of the solute (Mo. wt. of solvent = 78)
(a) 356.2 (b) 456.8 (c) 530.1 (d) 656.7

26. If 20 g of a solute was dissolved in 500 ml. of water and osmotic pressure of the solution was found to be 600 mm of Hg at 15ºC, then molecular weight of the solute is :
(a) 1000 (b) 1200 (c) 1400 (d) 1800

27. A solution containing components A and B follows Raoult's law when
(a) A – B attraction force is greater than A – A and B – B
(b) A – B attraction force is less than A – A and B – B
(c) A – B attraction force remains same as A–A and B –B
(d) volume of solution is different from sum of volume of solute and solvent

28. The vapour pressure of two liquids 'P' and 'Q' are 80 and 60 torr, respectively. The total vapour pressure of solution obtained by mixing 3 mole of P and 2 mole of Q would be
(a) 72 torr (b) 140 torr
(c) 68 torr (d) 20 torr

29. A mixture of components *A* and *B* will show –ve deviation when
(a) $\Delta V_{\text{mix}} > 0$ (b) $\Delta H_{\text{mix}} < 0$
(c) *A*–*B* interaction is weaker than *A*–*A* and *B*–*B* interactions
(d) *A*–*B* interaction is stronger than *A*–*A* and *B*–*B* interactions.

30. A non-ideal solution was prepared by mixing 30 mL chloroform and 50 mL acetone. The volume of mixture will be
(a) > 80 mL (b) < 80 mL (c) = 80 mL (d) ≥ 80 mL

31. The volume of gas decreases from 500 cc to 300 cc when a sample of gas is compressed by an average pressure of 0.6 atm. During this process 10 J of heat is liberated . The change in internal energy is.
(a) –2.16 J (b) 12.15 J (c) 2.16 J (d) 101.3 J

32. Which of the following liquid pairs shows a positive deviation from Raoult's law ?
(a) Water - Nitric acid
(b) Benzene - Methanol
(c) Water - Hydrochloric acid
(d) Acetone - Chloroform

33. 18 g of glucose ($C_6H_{12}O_6$) is added to 178.2 g of water. The vapour pressure of water for this aqueous solution is
(a) 76.00 torr (b) 752.40 torr
(c) 759.00 torr (d) 7.60 torr

34. If all the four following compounds were sold at the same price, which would be cheapest for preparing an antifreeze solution for a car radiator?
(a) $C_3H_5(OH)_3$ (b) $C_2H_4(OH)_2$
(c) C_2H_5OH (d) CH_3OH

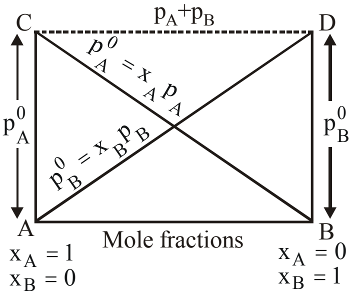
35. The value of P° for benzene is 640 mm of Hg. The vapour pressure of solution containing 2.5gm substance in 39gm. benzene is 600mm of Hg the molecular mass of *X* is –
(a) 65.25 (b) 130 (c) 40 (d) 75

36. An ideal solution is formed when its components
(a) have no volume change on mixing
(b) have no enthalpy change on mixing
(c) Both (a) and (b) are correct
(d) Neither (a) nor (b) is correct

37. All form ideal solution except
(a) C_6H_6 and $C_6H_5CH_3$ (b) C_2H_6 and C_2H_5I
(c) C_6H_5Cl and C_6H_5Br (d) C_2H_5I and C_2H_5OH.

38. For which of the following parameters the structural isomers C_2H_5OH and CH_3OCH_3 would be expected to have the same values?(Assume ideal behaviour)
(a) Boiling points
(b) Vapour pressure at the same temperature
(c) Heat of vaporization
(d) Gaseous densities at the same temperature and pressure

39. In the accompanied diagram, the ideal behaviour of a solution is shown by the line/s



(a) AD (b) CB
(c) CD (d) AD, CB and CD

40. Which one of the following is non-ideal solution
(a) Benzene + toluene
(b) *n*-hexane + *n*-heptane
(c) Ethyl bromide + ethyl iodide
(d) $CCl_4 + CHCl_3$

41. The molal elevation constant is the ratio of elevation in boiling point to:
(a) molality (b) mole fraction
(c) molarity (d) none

42. The azeotropic mixture of water (b.p.100°C) and HCl (b.p.85°C) boils at 108.5°C. When this mixture is distilled it is possible to obtain
(a) pure HCl
(b) pure water
(c) pure water as well as pure HCl
(d) neither HCl nor H_2O in their pure states

43. The molar freezing point constant for water is 1.86 °C/mol. If 342 g of cane sugar ($C_{12}H_{22}O_{11}$) is dissolved in 1000 g of water, the solution will freeze at :
(a) – 1.86°C (b) 1.86°C
(c) – 3.92°C (d) 2.42°C

44. Which will form maximum boiling point azeotrope
(a) $HNO_3 + H_2O$ solution
(b) $C_2H_5OH + H_2O$ solution
(c) $C_6H_6 + C_6H_5CH_3$ solution
(d) None of these

45. The vapour pressure at a given temperature of an ideal solution containing 0.2 mol of a non-volatile solute and 0.8 mol of solvent is 60 mm of Hg. The vapour pressure of the pure solvent at the same temperature is
(a) 150 mm of Hg (b) 60 mm of Hg
(c) 75 mm of Hg (d) 120 mm of Hg

46. When a hard boiled egg after shelling is immersed in saturated brine:
(a) it shrinks
(b) it grows is size
(c) its size remains unchanged
(d) it initially grows in size and then shrinks

47. 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 the vapour pressure is to be 20 mm of Hg ?
(a) 0.8 (b) 0.6 (c) 0.4 (d) 0.2

48. A solution of acetone in ethanol
(a) shows a positive deviation from Raoult's law
(b) behaves like a non ideal solution
(c) obeys Raoult's law
(d) shows a negative deviation from Raoult's law

49. Azeotropic mixture of water and HCl has the percentage of HCl.
(a) 20.2% (b) 26.4% (c) 48% (d) 68%

50. Which of the following aqueous solution has minimum freezing point ?
(a) 0.01 m NaCl (b) 0.005 m C_2H_5OH
(c) 0.005 m MgI_2 (d) 0.005 m $MgSO_4$.

51. On adding 0.750 gm of compound in 25 gm of solvent, the freezing point is depressed by 0.502°C. The molecular wt. of the substance is [The molecular depression constant = 50.2°C per 100 gm of solvent]
(a) 100 (b) 200 (c) 300 (d) 400

52. 5 gm of CH_3COOH is dissolved in one litre of ethanol. Suppose there is no reaction between them. If the density of ethanol is 0.789 gm/ml then the molality of resulting solution is
(a) 0.0256 (b) 0.1056 (c) 0.1288 (d) 0.1476

53. Which one of the following is a colligative property ?
(a) Boiling point (b) Vapour pressure
(c) Osmotic pressure (d) Freezing point

54. If 0.1 M solution of glucose and 0.1 M solution of urea are placed on two sides of the semipermeable membrane to equal heights, then it will be correct to say that
(a) there will be no net movement across the membrane
(b) glucose will flow towards urea solution
(c) urea will flow towards glucose solution
(d) water will flow from urea solution to glucose

55. When 800 gm of a 40% solution by weight was cooled, 100 gm of solute precipitated. The percentage composition of remaining solution is
(a) 31.43% (b) 5.56% (c) 6.78% (d) 6.96%

56. At 25°C, the highest osmotic pressure is exhibited by 0.1 M solution of
(a) $CaCl_2$ (b) KCl (c) glucose (d) urea

57. Which one of the following salts will have the same value of van't Hoff factor (*i*) as that of $K_4[Fe(CN)_6]$.
(a) $Al_2(SO_4)_3$ (b) NaCl (c) $Al(NO_3)_3$ (d) Na_2SO_4.

58. Which of the following 0.10 m aqueous solutions will have the lowest freezing point ?
(a) $Al_2(SO_4)_3$ (b) $C_6H_{12}O_6$
(c) KCl (d) $C_{12}H_{22}O_{11}$

59. Which of the following colligative property can provide molar mass of proteins (or polymers or colloids) with greatest precision ?
(a) Osmotic pressure
(b) Elevation of boiling point
(c) Depression of freezing point
(d) Relative lowering of vapour pressure

60. Camphor is often used in molecular mass determination because
(a) it is readily available
(b) it has a very high cryoscopic constant
(c) it is volatile
(d) it is solvent for organic substances

61. The freezing point of a 3% aq. solution of A is equal to the freezing point of 9% aq. solution of B. If the molecular weight of 'A' is 60, then the molecular wt. of B is
(a) 45 (b) 90 (c) 180 (d) 360

62. 1.00 g of a non-electrolyte solute (molar mass 250 g mol^{-1}) was dissolved in 51.2 g of benzene. If the freezing point depression constant, K_f of benzene is 5.12 K kg mol^{-1}, the freezing point of benzene will be lowered by
(a) 0.3 K (b) 0.5 K (c) 0.4 K (d) 0.2

63. The normality of mixture obtained by mixing 100 ml of 0.4 M H_2SO_4 and 200 ml of 0.2 M HCl is
(a) 0.0267 (b) 0.2670 (c) 1.0267 (d) 1.1670

64. Brownian movement is found in
(a) unsaturated solution (b) saturated solution
(c) colloidal solution (d) suspension solution

65. A solution is formed by diluting 250 ml. of 0.400 N H_2SO_4 with one litre of water. The normality of above formed solution is :
(a) 0.400 N (b) 0.899 N (c) 0.040 N (d) 0.080 N

66. In a 0.2 molal aqueous solution of a weak acid HX the degree of ionization is 0.3. Taking k_f for water as 1.85, the freezing point of the solution will be nearest to
(a) −0.360ºC (b) −0.260ºC
(c) +0.481ºC (d) −0.481ºC

67. Which one of the following aqueous solutions will exihibit highest boiling point ?
(a) 0.015 M urea (b) 0.01 M KNO_3
(c) 0.01 M Na_2SO_4 (d) 0.015 M glucose

68. The amount of dibasic acid present in 100 ml of the aq. solution to give solution of [mol. wt. = 200] normality of 0.1 N is
(a) 0.5 gm (b) 1 gm (c) 1.5 gm (d) 2 gm

69. The elevation in boiling point of a solution of 13.44 g of $CuCl_2$ in 1 kg of water using the following information will be (Molecular weight of $CuCl_2$= 134.4 g and K_b= 0.52 K kg mol^{-1})
(a) 0.16 (b) 0.05 (c) 0.1 (d) 0.2

70. The molecular weight of benzoic acid in benzene as determined by depression in freezing point method corresponds to :
(a) ionization of benzoic acid.
(b) dimerization of benzoic acid.
(c) trimerization of benzoic acid.
(d) solvation of benzoic acid.

71. A 0.5 molal solution of ethylene glycol in water is used as coolant in a car. If the freezing point constant of water be 1.86°C per mole, the mixture shall freeze at
(a) 0.93°C (b) –0.93°C (c) 1.86°C (d) –1.86°C

72. The rise in the boiling point of a solution containing 1.8 g of glucose in 100 g of solvent is 0.1°C. The molal elevation constant of the liquid is
(a) 0.01 K/m (b) 0.1 K/m (c) 1 K/m (d) 10 K/m

73. The solutions which have same osmotic concentrations are known as
(a) Normal (b) Isotonic
(c) Hypotonic (d) Hypertonic

74. The normal boiling point of the solution is the temperature at which the vapour pressure of the solution is –
(a) equal to 1 torr (b) equal to 76 mm Hg
(c) equal to 2.0 atm (d) equal to 1 atm

75. The temperature at which 10% aqueous solution (*w*/*v*) of glucose will exhibit the osmotic pressure of 14 bar is –
(a) 307.3°C (b) 307.3 K (c) 34 K (d) −34°C

76. 4 gm castic soda is dissolved in 100 cc of solution. The normality of solution is
(a) 0 (b) 0.5 (c) 1 (d) 1.5

77. If A contains 2% NaCl and is separated by a semipermeable membrane from B which contains 10% NaCl, then which event will occur ?
(a) NaCl will flow from A to B
(b) NaCl will flow from B to A
(c) Water will flow from A to B
(d) Water will flow from B to A

78. KBr is 80% ionized in solution. The freezing point of 0.4 molal solution of KBr is :

$$K_f(H_2O) = 1.86\frac{\text{K kg}}{\text{mole}}$$

(a) 274.339 K (b) −1.339 K
(c) 257.3 K (d) −1.339°C

79. Which of the following pairs of solution are isotonic at the same temperature ?
(a) 0.1 M $Ca(NO_3)_2$ and 0.1 M Na_2SO_4
(b) 0.1 M NaCl and 0.1 M Na_2SO_4
(c) 0.1 M urea and 0.1 M $MgCl_2$
(d) 0.2 M urea and 0.1 M NaCl

80. The relationship between the values of osmotic pressure of 0.1 M solutions of $KNO_3(P_1)$ and $CH_3COOH(P_2)$ is :
(a) $\frac{P_1}{P_1+P_2} = \frac{P_2}{P_1+P_2}$ (b) $P_1 > P_2$
(d) $P_2 > P_1$ (d) $P_1 = P_2$

81. Which of the following solutions will exhibit highest boiling point?
(a) 0.01 M Na_2SO_4 (aq) (b) 0.01 M KNO_3 (aq)
(c) 0.015 M urea (aq) (d) 0.015 M glucose (aq)

82. What is the freezing point of a solution containing 8.1 g HBr in 100 g water assuming the acid to be 90% ionised ?
(K_f for water = 1.86 K kg mol^{-1}) :
(a) 0.85K (b) −3.53K (c) 0K (d) −0.35K

83. Osmotic pressure of 0.4% urea solution is 1.64 atm and that of 3.42% cane sugar is 2.46 atm. When the above two solutions are mixed, the osmotic pressure of the resulting solution is :
(a) 0.82 atm (b) 2.46 atm
(c) 1.64 atm (d) 4.10 atm

84. The freezing point of 1% solution of lead nitrate in water will be :
(a) 2°C (b) 1°C (c) 0°C (d) below 0°C

85. A solution of urea (mol. mass 56 g mol^{-1}) boils at 100.18°C at the atmospheric pressure. If K_f and K_b for water are 1.86 and 0.512 K kg mol^{-1} respectively, the above solution will freeze at
(a) 0.654°C (b) −0.654°C
(c) 6.54°C (d) −6.54°C

86. If $\frac{N}{10}$ 50 ml H_2SO_4, $\frac{N}{3}$ 30 ml HNO_3, $\frac{N}{2}$ 10 ml HCl is mixed and solution is made to 1L. Then normality of resultant solution is
(a) $\frac{N}{20}$ (b) $\frac{N}{40}$ (c) $\frac{N}{50}$ (d) N

87. The molal elevation constant for water is 0.52. What will be the boiling point of 2 molar sucrose solution at 1 atm. pressure? (Assume B.P. of pure water as 100°C)
(a) 101.04°C (b) 100.26°C
(c) 100.52°C (d) 99.74°C

88. A 0.0020 m aqueous solution of an ionic compound $Co(NH_3)_5(NO_2)Cl$ freezes at – 0.00732 °C. Number of moles of ions which 1 mol of ionic compound produces on being dissolved in water will be (K_f = – 1.86°C/m)
(a) 3 (b) 4 (c) 1 (d) 2

89. An aqueous solution is 1.00 molal in KI. Which change will cause the vapour pressure of the solution to increase?
(a) Addition of NaCl
(b) Addition of Na_2SO_4
(c) Addition of 1.00 molal KI
(d) Addition of water

90. 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 K kg mol^{-1}).
(a) – 0.372°C (b) – 0.520°C
(d) + 0.372°C (d) – 0.570°C

91. 25.3 g of sodium carbonate, Na_2CO_3 is dissolved in enough water to make 250 mL of solution. If sodium carbonate dissociates completely, molar concentration of sodium ions, Na^+ and carbonate ions, CO_3^{2-} are respectively (Molar mass of Na_2CO_3 = 106 g mol^{-1})
(a) 0.955 M and 1.910 M (b) 1.910 M and 0.955 M
(c) 1.90 M and 1.910 M (d) 0.477 M and 0.477 M

92. The freezing point depression constant for water is – 1.86°C m^{-1}. If 5.00 g Na_2SO_4 is dissolved in 45.0 g H_2O, the freezing point is changed by – 3.82°C. Calculate the van't Hoff factor for Na_2SO_4
(a) 2.05 (b) 2.62 (c) 3.11 (d) 0.381

93. The van't Hoff factor *i* for a compound which undergoes dissociation in one solvent and association in other solvent is respectively :
(a) less than one and greater than one.
(b) less than one and less than one.
(c) greater than one and less than one.
(d) greater than one and greater than one.

94. Mole fraction of the solute in a 1.00 molal aqueous solution is
(a) 0.1770 (b) 0.0177 (c) 0.0344 (d) 1.7700

95. A 0.1 molal aqueous solution of a weak acid is 30% ionized. If K_f for water is 1.86°C/m, the freezing point of the solution will be :
(a) −0.18°C (b) −0.54°C (c) −0.36°C (d) −0.24°C

96. 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 L bar mol^{-1} K^{-1})
(a) 51022 g mol^{-1} (b) 122044 g mol^{-1}
(c) 31011 g mol^{-1} (d) 61038 g mol^{-1}

97. 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.
(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) $P_B + X_A(P_A - P_B)$

98. A mixture of ethyl alcohol and propyl alcohol has a vapour pressure of 290 mm Hg at 300 K. The vapour pressure of propyl alcohol is 200 mm Hg. If the mole fraction of ethyl alcohol is 0.6, its vapour pressure (in mm Hg) at the same temperature will be

(a) 360 (b) 350 (c) 300 (d) 700

99. A binary liquid solution is prepared by mixing *n*-heptane and ethanol. Which one of the following statements is correct regarding the behaviour of the solution?

(a) The solution is non-ideal, showing – ve deviation from Raoult's Law.
(b) The solution is non-ideal, showing + ve deviation from Raoult's Law.
(c) *n*-heptane shows + ve deviation while ethanol shows – ve deviation from Raoult's Law.
(d) The solution formed is an ideal solution.

100. The molarity of a solution obtained by mixing 750 mL of 0.5(M) HCl with 250 mL of 2(M) HCl will be :

(a) 0.875 M (b) 1.00 M (c) 1.75 M (d) 0.975 M

EXERCISE - 2

Applied Questions

1. π_1, π_2, π_3 and π_4 atm are the osmotic pressures of 5% (mass/volume) solutions of urea, fructose, sucrose and KCl respectively at certain temperature. The correct order of their magnitudes is :

(a) $\pi_1 > \pi_4 > \pi_2 > \pi_3$ (b) $\pi_1 < \pi_4 < \pi_2 < \pi_3$
(c) $\pi_4 > \pi_1 > \pi_2 > \pi_3$ (d) $\pi_4 > \pi_1 > \pi_3 > \pi_2$

2. The osmotic pressure (at 27° C) of an aqueous solution (200mL) containing 6 g of a protein is 2×10^{-3} atm. If $R = 0.080$ L atm mol^{-1}K^{-1}, the molecular weight of protein is

(a) 7.2×10^5 (b) 3.6×10^5
(c) 1.8×10^5 (d) 1.0×10^5

3. The freezing point of equimolal aqueous solutions will be highest for :

(a) $C_6H_5NH_3Cl$ (aniline hydrochloride)
(b) $Ca(NO_3)_2$
(c) $La(NO_3)_3$
(d) $C_6H_{12}O_6$ (glucose)

4. Which of the following has been arranged in the increasing order of freezing point?

(a) $0.025M\ KNO_3 < 0.1M\ NH_2CSNH_2 < 0.05M\ BaCl_2 < 0.1M\ NaCl$
(b) $0.1M\ NaCl < 0.05M\ BaCl_2 < 0.1M\ NH_2CSNH_2 < 0.025M\ KNO_3$
(c) $0.1M\ NH_2CSNH_2 < 0.1M\ NaCl < 0.05M\ BaCl_2 < 0.025M\ KNO_3$
(d) $0.025M\ KNO_3 < 0.05M\ BaCl_2 < 0.1M\ NaCl < 0.1M\ NH_2CSNH_2$

5. The volume of 4 N HCl and 10 N HCl required to make 1 litre of 6 N HCl are

(a) 0.75 litre of 10 N HCl and 0.25 litre of 4 N HCl
(b) 0.50 litre of 4 N HCl and 0.50 litre of 10 N HCl
(c) 0.67 litre of 4 N HCl and 0.33 litre of 10 N HCl
(d) 0.80 litre of 4 N HCl and 0.20 litre of 10 N HCl

6. A solution of $Al_2(SO_4)_3$ {d=1.253 gm / ml} contain 22% salt by weight. The molarity, normality and molality of the solution is

(a) 0.805 M, 4.83 N, 0.825 m
(b) 0.825 M, 48.3 N, 0.805 m
(c) 4.83 M, 4.83 N, 4.83 m
(d) None of these

7. The mole fraction of water in 20% aqueous solution (By weight) of H_2O_2 is

(a) $\frac{77}{68}$ (b) $\frac{68}{77}$ (c) $\frac{20}{80}$ (d) $\frac{80}{20}$

8. Molarity of H_2SO_4 is 18 M. Its density is 1.8 g/ml. Hence molality is

(a) 36 (b) 200 (c) 500 (d) 18

9. The solution containing 4.0 gm of a polyvinyl chloride polymer in 1 litre of dioxane was found to have an osmotic pressure 6.0×10^{-4} atmosphere at 300K, the value of R used is 0.082 litre atmosphere mole^{-1}K^{-1}. The molecular mass of the polymer was found to be

(a) 3.0×10^2 (b) 1.6×10^5 (c) 5.6×10^4 (d) 6.4×10^2

10. At temperature 327°C and concentration C osmotic pressure of a solution is P, the same solution at concentration C/2 and at temperature 427°C shows osmotic pressure of 2 atm, value of P will be

(a) $\frac{12}{7}$ (b) $\frac{24}{7}$ (c) $\frac{6}{5}$ (d) $\frac{5}{6}$

11. In countries nearer to polar region, the roads are sprinkled with $CaCl_2$. This is

(a) to minimise the snow fall
(b) to minimise pollution
(c) to minimise the accumulation of dust on the road
(d) to minimise the wear and tear of the roads

12. If α is the degree of dissociation of Na_2SO_4, the Vant Hoff's factor (i) used for calculating the molecular mass is

(a) $1+\alpha$ (b) $1-\alpha$ (c) $1+2\alpha$ (d) $1-2\alpha$

13. The correct relationship between the boiling points of very dilute solutions of $AlCl_3$ (t_1) and $CaCl_2$ (t_2), having the same molar concentration is

(a) $t_1 = t_2$ (b) $t_1 > t_2$ (c) $t_2 > t_1$ (d) $t_2 \geq t_1$

14. If the various terms in the given below expressions have usual meanings, the van't Hoff factor (i) cannot be calculated by which one of the following expressions

(a) $\pi V = \sqrt{inRT}$
(b) $\Delta T_f = iK_f.m$
(c) $\Delta T_b = iK_b.m$
(d) $\dfrac{P^\circ_{\text{solvent}} - P_{\text{solution}}}{P^\circ_{\text{solvent}}} = i\left(\dfrac{n}{N+n}\right)$

15. A 0.001 molal solution of $[Pt(NH_3)_4Cl_4]$ in water had a freezing point depression of 0.0054°C. If K_f for water is 1.80, the correct formulation for the above molecule is
(a) $[Pt(NH_3)_4Cl_3]Cl$ (b) $[Pt(NH_3)_4Cl_2]Cl_2$
(c) $[Pt(NH_3)_4Cl]Cl_3$ (d) $[Pt(NH_3)_4Cl_4]$

16. The amount of urea to be dissolved in 500 c.c. of water ($K = 1.86°C\ mol^{-1}$) to produce a depression of 0.186°C in the freezing point is :
(a) 9 g (b) 6 g (c) 3 g (d) 0.3 g

17. Which has the minimum freezing point ?
(a) One molal NaCl aq. solution
(b) One molal $CaCl_2$ aq. solution
(c) One molal KCl aq. solution
(d) One molal urea aq. solution

18. On mixing 3 g of non - volatile solute in 200 mL of water, its boiling point (100°) becomes 100.52°C. If K_b for water is 0.6 K/m then molecular wt. of solute is :
(a) $10.5\ g\ mol^{-1}$ (b) $12.6\ g\ mol^{-1}$
(c) $15.7\ g\ mol^{-1}$ (d) $17.3\ g\ mol^{-1}$

19. 1 mol each of the following compounds is dissolved in 1L of solution. Which will have the largest ΔT_b value?
(a) HF (b) HCl (c) HBr (d) HI.

20. Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is
(a) 1/2 (b) 2/3 (c) $\frac{1}{3} \times \frac{273}{298}$ (d) 1/3.

21. A 5.25% solution of a substance is isotonic with a 1.5% solution of urea (molar mass = $60\ g\ mol^{-1}$) in the same solvent. If the densities of both the solutions are assumed to be equal to $1.0\ g\ cm^{-3}$, molar mass of the substance will be
(a) $210.0\ g\ mol^{-1}$ (b) $90.0\ g\ mol^{-1}$
(c) $115.0\ g\ mol^{-1}$ (d) $105.0\ g\ mol^{-1}$.

22. At 80° C, the vapour pressure of pure liquid 'A' is 520 mm Hg and that of pure liquid 'B' is 1000 mm Hg. If a mixture solution of 'A' and 'B' boils at 80° C and 1 atm pressure, the amount of 'A' in the mixture is (1 atm = 760 mm Hg)
(a) 52 mol percent (b) 34 mol percent
(c) 48 mol percent (d) 50 mol percent

23. The vapour pressure of water at 20°C is 17.5 mm Hg. If 18 g of glucose ($C_6H_{12}O_6$) is added to 178.2 g of water at 20°C, the vapour pressure of the resulting solution will be
(a) 17.325 mm Hg (b) 15.750 mm Hg
(c) 16.500 mm Hg (d) 17.500 mm Hg

24. Two liquids *X* and *Y* form an ideal solution. At 300 K, vapour pressure of the solution containing 1 mol of *X* and 3 mol of *Y* is 550 mm Hg. At the same temperature, if 1 mol of *Y* is further added to this solution, vapour pressure of the solution increases by 10 mm Hg. Vapour pressure (in mm Hg) of *X* and *Y* in their pure states will be, respectively:
(a) 300 and 400 (b) 400 and 600
(c) 500 and 600 (d) 200 and 300

25. On mixing, heptane and octane form an ideal solution. At 373 K, the vapour pressures of the two liquid components (heptane and octane) are 105 kPa and 45 kPa respectively. Vapour pressure of the solution obtained by mixing 25.0 g of heptane and 35 g of octane will be (molar mass of heptane = $100\ g\ mol^{-1}$ and of octane = $114\ g\ mol^{-1}$)
(a) 72.0 kPa (b) 36.1 kPa (c) 96.2 kPa (d) 144.5 kPa

26. A 5% solution of cane sugar (molar mass 342) is isotonic with 1% of a solution of an unknown solute. The molar mass of unknown solute in g/mol is :
(a) 171.2 (b) 68.4 (c) 34.2 (d) 136.2

27. K_f for water is $1.86\ K\ kg\ mol^{-1}$. If your automobile radiator holds 1.0 kg of water, how many grams of ethylene glycol ($C_2H_6O_2$) must you add to get the freezing point of the solution lowered to –2.8ºC ?
(a) 72 g (b) 93 g (c) 39 g (d) 27 g

28. When 20 g of naphthoic acid ($C_{11}H_8O_2$) is dissolved in 50 g of benzene ($K_f = 1.72\ K\ kg\ mol^{-1}$), a freezing point depression of 2 K is observed. The Van't Hoff factor (*i*) is
(a) 0.5 (b) 1 (c) 2 (d) 3

29. The Henry's law constant for the solubility of N_2 gas in water at 298 K is 1.0×10^5 atm. The mole fraction of N_2 in air is 0.8. The number of moles of N_2 from air dissolved in 10 moles of water at 298 K and 5 atm pressure is
(a) 4.0×10^{-4} (b) 4.0×10^{-5}
(c) 5.0×10^{-4} (d) 4.0×10^{-6}

30. Dissolving 120 g of urea (mol. wt. 60) in 1000 g of water gave a solution of density 1.15 g/mL. The molarity of the solution is
(a) 1.78 M (b) 2.00 M (c) 2.05 M (d) 2.22 M

31. The freezing point (in °C) of a solution containing 0.1 g of $K_3[Fe(CN)_6]$ (Mol. wt. 329) in 100 g of water ($K_f = 1.86\ K\ kg\ mol^{-1}$) is
(a) -2.3×10^{-2} (b) -5.7×10^{-2}
(c) -5.7×10^{-3} (d) -1.2×10^{-2}

32. For a dilute solution containing 2.5 g of a non-volatile non-electrolyte solute in 100 g of water, the elevation in boiling point at 1 atm pressure is 2°C. Assuming concentration of solute is much lower than the concentration of solvent, the vapour pressure (mm of Hg) of the solution is (take $K_b = 0.76\ K\ kg\ mol^{-1}$)
(a) 724 (b) 740 (c) 736 (d) 718

33. If sodium sulphate is considered to be completely dissociated into cations and anions in aqueous solution, the change in freezing point of water (ΔT_f), when 0.01 mol of sodium sulphate is dissolved in 1 kg of water, is ($K_f = 1.86\ K\ kg\ mol^{-1}$)
(a) 0.372 K (b) 0.0558 K
(c) 0.0744 K (d) 0.0186 K

34. Which observation(s) reflect(s) colligative properties?
(i) a 0.5 m NaBr solution has a higher vapour pressure than a 0.5 m $BaCl_2$ solution at the same temperature
(ii) pure water freezes at the higher temperature than pure methanol
(iii) a 0.1 m NaOH solution freezes at a lower temperature than pure water

Choose the correct answer from the codes given below
(a) (i), (ii) and (iii) (b) (i) and (ii)
(c) (ii) and (iii) (d) (i) and (iii)

35. When a gas is bubbled through water at 298 K, a very dilute solution of the gas is obtained. Henry's law constant for the gas at 298 K is 100 kbar. If the gas exerts a partial pressure of 1 bar, the number of millimoles of the gas dissolved in one litre of water is

(a) 0.555 (b) 5.55
(c) 0.0555 (d) 55.5

36. 1.5 g of a non-volatile, non-electrolyte is dissolved in 50 g benzene (K_b = 2.5 K kg mol^{-1}). The elevation of the boiling point of the solution is 0.75 K. The molecular weight of the solute in g mol^{-1} is

(a) 200 (b) 50
(c) 75 (d) 100

37. Which one of the following statements is false?

(a) Raoult's law states that the vapour pressure of a component over a binary solution of volatile liquids is directly proportional to its mole fraction
(b) Two sucrose solutions of the same molality prepared in different solvents will have the same depression of freezing point
(c) The correct order of osmotic pressures of 0.01 M solution of each compound is $BaCl_2 > KCl > CH_3COOH$ > glucose
(d) In the equation osmotic pressure π = MRT, M is the molarity of the solution

38. At 300 K the vapour pressure of an ideal solution containing 1 mole of liquid A and 2 moles of liquid B is 500 mm of Hg. The vapour pressure of the solution increases by 25 mm of Hg, if one more mole of B is added to the above ideal solution at 300 K. Then the vapour pressure of A in its pure state is

(a) 300 mm of Hg (b) 400 mm of Hg
(c) 500 mm of Hg (d) 600 mm of Hg

39. Henry's law constant of oxygen is 1.4×10^{-3} mol. lit^{-1}. atm^{-1} at 298 K. How much of oxygen is dissolved in 100 ml at 298 K when the partial pressure of oxygen is 0.5 atm?

(a) 1.4 g (b) 3.2 g
(c) 22.4 mg (d) 2.24 mg

40. 1 g of a non-volatile, non-electrolyte solute of molar mass 250 g/mol was dissolved in 51.2 g of benzene. If the freezing point depression constant K_f of benzene is 5.12 kg K mol^{-1}. The freezing point of benzene is lowered by

(a) 0.3 K (b) 0.5 K
(c) 0.2 K (d) 0.4 K

41. Negative deviation from Raoult's law is observed in which one of the following binary liquid mixtures?

(a) Ethanol and acetone
(b) Benzene and toluene
(c) Acetone and chloroform
(d) Chloroethane and bromoethane

42. The system that forms maximum boiling azeotrope is

(a) carbondisulphide – acetone
(b) benzene – toluene
(c) acetone – chloroform
(d) *n*-hexane – *n*-heptane

43. Which one of the following gases has the lowest value of Henry's law constant?

(a) N_2 (b) He
(c) H_2 (d) CO_2

44. A solution is prepared by dissolving 10 g NaOH in 1250 mL of a solvent of density 0.8 mL/g. The molality of the solution in mol kg^{-1} is

(a) 0.25 (b) 0.2
(c) 0.008 (d) 0.0064

45. The freezing point of equimolal aqueous solution will be highest for

(a) $C_6H_5NH_3^+Cl^-$ (b) $Ca(NO_3)_2$
(c) $La(NO_3)_2$ (d) $C_6H_{12}O_6$

DIRECTIONS for Qs. 46 to 50 : These are Assertion-Reason type questions. Each of these question contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Answer these questions from the following four options.

(a) Statement-1 is true, Statement-2 is true, Statement-2 is a correct explanation for Statement-1
(b) Statement-1 is True, Statement-2 is True ; Statement-2 is NOT a correct explanation for Statement-1
(c) Statement-1 is True, Statement-2 is False
(d) Statement-1 is False, Statement-2 is True

46. **Statement-1 :** If one component of a solution obeys Raoult's law over a certain range of composition, the other component will not obey Henry's law in that range.
Statement-2 : Raoult's law is a special case of Henry's law.

47. **Statement-1 :** Lowering of vapour pressure is directly proportional to osmotic pressure of the solution.
Statement-2 : Osmotic pressure is a colligative property.

48. **Statement-1 :** If a liquid solute more volatile than the solvent is added to the solvent, the vapour pressure of the solution may increase i.e., $p_s > p^o$.
Statement-2 : In the presence of a more volatile liquid solute, only the solute will form the vapours and solvent will not.

49. **Statement-1 :** Azeotropic mixtures are formed only by non-ideal solutions and they may have boiling points either greater than both the components or less than both the components.
Statement-2 : The composition of the vapour phase is same as that of the liquid phase of an azeotropic mixture.

50. **Statement-1 :** Camphor is used as solvent in the determination of molecular masses of naphthalene, anthracene etc.
Statement-2 : Camphor has high molal elevation constant.

EXERCISE - 3

Exemplar & Past Years NEET/AIPMT Questions

Exemplar Questions

1. Which of the following units is useful in relating concentration of solution with its vapour pressure?

(a) Mole fraction (b) Parts per milion
(c) Mass percentage (d) Molality

2. On dissolving sugar in water at room temperature solution feels cool to touch. Under which of the following cases dissolution of sugar will be most rapid?

(a) Sugar crystals in cold water
(b) Sugar crystals in hot water
(c) Powdered sugar in cold water
(d) Powdered sugar in hot water

3. At equilibrium the rate of dissolution of a solid solute in a volatile liquid solvent is ....

(a) less than the rate of crystallisation
(b) greater than the rate of crystallisation
(c) equal to the rate of crystallisation
(d) zero

4. A beaker contains a solution of substance 'A'. Precipitation of substance 'A' takes place when small amount of 'A' is added to the solution. The solution is ....

(a) saturated (b) supersaturated
(c) unsaturated (d) concentrated

5. Maximum amount of a solid solute that can be dissolved in a specified amount of a given liquid solvent does not depends upon ....

(a) temperature (b) nature of solute
(c) pressure (d) nature of solvent

6. Low concentration of oxygen in the blood and tissues of people living at high altitude is due to ....

(a) low temperature
(b) low atmospheric pressure
(c) high atmospheric pressure
(d) both low temperature and high atmospheric pressure

7. Considering the formation, breaking and strength of hydrogen bond, predict which of the following mixtures will show a positive deviation from Raoult's law?

(a) Methanol and acetone
(b) Chloroform and acetone
(c) Nitric acid and water
(d) Phenol and aniline

8. Colligative properties depend on ....

(a) the nature of the solute particles dissolved in solution
(b) the number of solute particles in solution
(c) the physical properties of the solution particles dissolved in solution
(d) the nature of solvent particles

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

(a) 1.0 M NaOH (b) 1.0 M Na_2SO_4
(c) 1.0 M NH_4NO_3 (d) 1.0 M KNO_3

10. The unit of ebullioscopic constant is

(a) K kg mol^{-1} or K $(molality)^{-1}$
(b) mol kg K^{-1} or K^{-1} (molality)
(c) kg mol^{-1} K^{-1}or K^{-1} $(molality)^{-1}$
(d) K mol kg^{-1}or K (molality)

11. In comparison to a 0.01 M solution of glucose, the depression in freezing point of a 0.01 M $MgCl_2$ solution is ....

(a) the same (b) about twice
(c) about three time (d) about six times

12. An unripe mango placed in a concentrated salt solution to prepare pickle shrivels because ....

(a) it gains water due to osmosis
(b) it loses water due to reverse osmosis
(c) it gains water due to reverse osmosis
(d) it loses water due to osmosis

13. At a given temperature, osmotic presure of a concentrated solution of a substance ....

(a) is higher than that of a dilute solution
(b) is lower than that of a dilute solution
(c) it gains water due to reverse osmosis
(d) it loses water due to osmosis

14. Which of the following statements is false?

(a) Two different solutions of sucrose of same molality prepared in diffferent solvents will have the same depression in freezing point.
(b) The osmotic pressure of a solution is given by the equation $\pi = CRT$ (where, C is the molarity of the solution)
(c) Decreasing order of osmotic pressure for 0.01 M aqueous solutions of barium chloride, potassium chloride, acetic acid and sucrose is

$$BaCl_2 > KCl > CH_3COOH > \text{sucrose}$$

(d) According to Raoult's law, the vapour pressure exerted by a volatile component of a solution is directly proportional to its mole fraction in the solution

15. The value of van't Hoff factors for KCl, NaCl and K_2SO_4 respectively are ....

(a) 2, 2 and 2 (b) 2, 2 and 3
(c) 1, 1 and 2 (d) 1, 1 and 1

16. Which of the following statement is false?

(a) Units of atmospheric pressure and osmotic pressure are same
(b) In reverse osmosis, solvent molecules move through a semipermeable membrane from a region of lower concentration of solute to a region of higher concentration
(c) The value of molal depression constant depends on nature of solvent
(d) Relative lowering of vapour pressure, is a dimensionless quantity

17. Value of Henry's constant K_H ....

(a) increases with increase in temperature

(b) decreases with increase in temperature

(c) remains constant

(d) first increases then decreases

18. The value of Henry's constant, K_H is ....

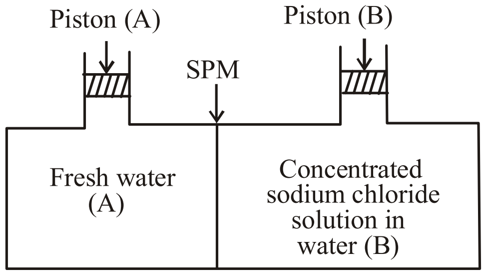
(a) greater for gases with higher solubility

(b) greater for gases with lower solubility

(c) constant for all gases

(d) not related to the solubility of gases

19. Consider the figure and mark the correct option.



(a) Water will move form side (A) to side (B) if a pressure lower than osmotic pressure is applied on piston (B)

(b) Water will move from side (B) to side (A) if a pressure greater than osmotic pressure is applied on piston (B)

(c) Water will move from side (B) to side (A) if a pressure equal to osmotic pressure is applied on piston (B)

(d) Water will move from side (A) to side (B) if pressure equal to osmotic pressure is applied on piston (A)

20. We have three, aqueous solutions of NaCl labelled as 'A', 'B' and 'C' with concentrations 0.1 M,0.01M and 0.001 M, respectively. The value of van't Hoff factor for these solutions will be in the order ....

(a) $i_A < i_B < i_C$ (b) $i_A > i_B > i_C$

(c) $i_A = i_B = i_C$ (d) $i_A < i_B > i_C$

21. On the basis of information given below mark the correct option.

Information

(i) In bromoethane and chloroethane mixture intermolecular interactions of A — A and B — B type are nearly same as A — B type interactions.

(ii) In ethanol and acetone mixture A — A or B — B type intermolecular interactions are stronger than A — B type interactions.

(iii) In chloroform and acetone mixture A — A or B — B type intermolecular interactions are weaker than A — B type interactions.

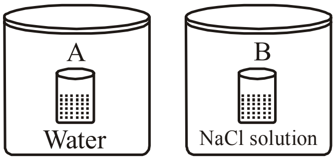
(a) Solution (ii) and (iii) will follow Raoult's law

(b) Solution (i) will follow Raoult's law

(c) Solution (ii) will show negative deviation from Raoult's law

(d) Solution (iii) will show positive deviation from Raoult's law

22. Two beakers of capacity 500 mL were taken. One of these beakers labelled as "A" was filled with 400 mL water whereas the beaker labelled "B" was filled with 400 mL of 2M solution of NaCl. At the same temperature both the beakers were placed in closed containers of same material and same capacity as shown in figure.



At a given temperature, which of the following statement is correct about the vapour pressure of pure water and that of NaCl solution?

(a) Vapour pressure in container (A) is more than that in container (B)

(b) Vapour pressure in container (A) is less than that in container (B)

(c) Vapour pressure is equal in both the containers

(d) Vapour pressure in container (B) is twice the vapour pressure in container (A)

23. If two liquids A and B form minimum boiling azeotrope at some specific composition then

(a) A — B interactions are stronger than those between A — A or B — B

(b) vapour pressure of solution increases because more number of molecules of liquids A and B can escape from the solution

(c) vapour pressure of solution decreases because less number of molecules of only one of the liquids escape from the solution

(d) A — B interactions are weaker than those between A — A or B — B

24. 4 L of 0.02 M aqueous solution of NaCl was diluted by adding 1 L of water. The molality of the resultant solution is ....

(a) 0.004 (b) 0.008

(c) 0.012 (d) 0.016

25. On the basis of information given below mark the correct option.

Information On adding acetone to methanol some of the hydrogen bonds between methanol molecules break.

(a) At specific composition methanol-acetone mixture will form minimum boiling azeotrope and will show positive deviation from Raoult's law

(b) At specific composition methanol-acetone mixture will form maximum boiling azeotrope and will show positive deviation from Raoult's law

(c) At specific composition methanol-acetone mixture will form maximum boiling azeotrope and will show negative deviation from Raoult's law

(d) At specific composition methanol-acetone mixture will form minimum boiling azeotrope and will show negative deviation from Raoult's law

26. K_H value for Ar (g), CO_2 (g), HCHO (g) and CH_4 (g) are 40.39, 1.67, 1.83×10^{-5} and 0.413 respectively.
Arrange these gases in the order of their increasing solubility.
(a) $HCHO < CH_4 < CO_2 < Ar$
(b) $HCHO < CO_2 < CH_4 < Ar$
(c) $Ar < CO_2 < CH_4 < HCHO$
(d) $Ar < CH_4 < CO_2 < HCHO$

NEET/AIPMT (2013-2017) Questions

27. How many grams of concentrated nitric acid solution should be used to prepare 250 mL of 2.0M HNO_3 ? The concentrated acid is 70% HNO_3 ***[2013]***
(a) 90.0 g conc. HNO_3
(b) 70.0 g conc. HNO_3
(c) 54.0 g conc. HNO_3
(d) 45.0 g conc. HNO_3

28. Which condition is not satisfied by an ideal solution?
(a) $\Delta_{mix} H = 0$ ***[NEET Kar. 2013]***
(b) $\Delta_{mix} V = 0$
(c) $\Delta_{mix} S = 0$
(d) Obeyance to Raoult's Law

29. Of the following 0.10 m aqueous solutions, which one will exhibit the largest freezing point depression? ***[2014]***
(a) KCl (b) $C_6H_{12}O_6$
(c) $Al_2(SO_4)_3$ (d) K_2SO_4

30. Which one of the following electrolytes has the same value of van't Hoff's factor (i) as that of the $Al_2(SO_4)_3$ (if all are 100% ionised) ? ***[2015]***
(a) $K_3[Fe(CN)_6]$ (b) $Al(NO_3)_3$
(c) $K_4[Fe(CN)_6]$ (d) K_2SO_4

31. 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 ? ***[2015]***
(a) Molecular mass of X is greater than the molecular mass of Y.
(b) Molecular mass of X is less than the molecular mass of Y.
(c) Y is undergoing dissociation in water while X undergoes no change.
(d) X is undergoing dissociation in water.

32. Which one is not equal to zero for an ideal solution: ***[2015]***
(a) ΔS_{mix} (b) ΔV_{mix}
(c) $\Delta P = P_{observed} - P_{Raoult}$ (d) ΔH_{mix}

33. What is the mole fraction of the solute in a 1.00 m aqueous solution ? ***[2015 RS]***
(a) 0.177 (b) 1.770
(c) 0.0354 (d) 0.0177

34. At 100°C the vapour pressure of a solution of 6.5g of a solute in 100 g water is 732 mm. If $K_b = 0.52$, the boiling point of this solution will be ***[2016]***
(a) 101°C (b) 100°C
(c) 102°C (d) 103°C

35. If molality of the dilute solutions is doubled, the value of molal depression constant (K_f) will be:- ***[2017]***
(a) halved (b) tripled
(c) unchanged (d) doubled

36. Which of the following is dependent on temperature? ***[2017]***
(a) Molarity (b) Mole fraction
(c) Weight percentage (d) Molality

37. Which of the following statement about the composition of the vapour over an ideal 1 : 1 molar 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 kPa, toluene = 3.85 kPa) ***[2016]***
(a) The vapour will contain a higher percentage of benzene
(b) The vapour will contain a higher percentage of toluene
(c) The vapour will contain equal amounts of benezene and toluene
(d) Not enough information is given to make a predication

Hints & Solutions

EXERCISE - 1

1. (b) Lowering in vapour pressure is the highest for that molecules for which Vont-Hoff factor is maximum because. Now, Von't Hoff factor is maximum for $BaCl_2$ [As number of ions formed here after dissociation in water is zero], this will have the highest lowering of vapour pressure.

2. (b) For an ideal solution, $\Delta H_{mixing} = 0$

$\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$ (According to Hess's law)

i.e., for ideal solutions there is no change in magnitude of the attractive forces in the two components present.

3. (a) $$\Delta T = K_b . \frac{m}{M} \times \frac{1000}{W}$$

$$0.25 = K_b . \frac{1}{M} \times \frac{1000}{W} = K_b \times \frac{1}{60} \times \frac{1000}{W}$$

$$\Delta T = K_b \times \frac{0.3}{180} \times \frac{1000}{W}$$

$$\frac{\Delta T}{0.25} = \frac{3}{180} \times 60 = 1 \Rightarrow \Delta T = 0.25\,^{\circ}C$$

New boiling point of glucose solution = 100.25 °C.

4. (d)

5. (b) The molality involves weights of the solute and the solvent. Since weight does not change with the temperature, therefore molality does not depend upon the temperature.

6. (b) Density = 1.17 gm/cc (Given)

As $d = \frac{\text{Mass}}{\text{Volume}}$

volume = 1cc $\therefore$ mass = d = 1.17g

$$\text{Molarity} = \frac{\text{No. of moles}}{\text{Volume in litre}} = \frac{1.17 \times 1000}{36.5 \times 1}$$

$$= \frac{1170}{36.5} = 32.05\text{M}$$

7. (a) $$\text{Molarity} = \frac{\text{mole}}{\text{litre}} = \frac{5/40}{250/1000}$$

$$= \frac{5}{40} \times \frac{1000}{250} = 0.5\text{M}$$

8. (b) $$\text{Molarity} = \frac{\text{mole}}{\text{litre}} = \frac{37/36.5}{100/1.18 \times 1000}$$

[37 gm HCl in 100 gm of solution

$$= \frac{100}{1.18}\ \text{C.C} = \frac{100}{1.18 \times 1000}\ 1 \Bigg]$$

$$= \frac{37}{36.5} \times \frac{1.18 \times 1000}{100} = 11.96 \approx 12.$$

9. (b) Relation between molality and mole fraction is

$$m = \frac{1000 \times x_2}{x_1 M_1} = \frac{1000 \times .2}{.8 \times 78} = 3.2$$

Thus, $X(m) = 3.2$

10. (b) $$\text{M} = \frac{\text{Wt} \times 1000}{\text{M.Wt.} \times \text{V}};\quad \text{M} = \frac{7.1 \times 1000}{142 \times 100} = 0.5\text{M}$$

11. (a) $$\frac{\Delta p}{p^{\circ}} = \frac{n_2}{n_1 + n_2} \quad \text{or} \quad \frac{n_2}{n_1 + n_2} = \frac{640 - 630}{640} = \frac{0.0156}{1}$$

or 1 mole i.e., 78g benzene contains solute = 0.0156 mol

$$\therefore \text{ Molality of solution } = \frac{0.0156 \times 10^3}{78} = 0.2\,m$$

12. (c) $$\text{Molarity} = \frac{\text{Number of moles}}{\text{Volume of solution (L)}}$$

$$\text{Moles of water } = \frac{\text{Mass}}{\text{Molar mass}} = \frac{1000}{18} = 55.6$$

$$\text{Molarity} = \frac{55.6}{1} = 55$$

13. (c) $\pi V = nRT$

$$\pi = \frac{nRT}{V} = \frac{1.75 \times 0.0821 \times (273 + 17)}{342 \times 150/1000}$$

[M.W. of sucrose = 342]

$$= \pi = \frac{1.75}{342} \times \frac{1000}{150} \times 0.0821 \times 290 = 0.8\text{ atm.}$$

14. (b) $\because$ 10 g glucose is dissolved in = 100 ml solution.

$\therefore$ 180 g (g mole) is dissolved in

$$= \frac{100}{10} \times 180 = 1800\text{ ml} = 1.8\text{ L}$$

15. (d) $$\text{ppm} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$$

$$\therefore \text{ ppm } = \frac{10}{10^6} \times 10^6 = 10\text{ ppm}$$

16. (a) $$\frac{p^{\circ} - p}{p^{\circ}} = x_{solute}$$

Given, $p^{\circ} = 0.8$ atm, $p = 0.6$ atm, $x_{solute = ?}$

$$\frac{0.8 - 0.6}{0.8} = x_{solute} \quad \text{or} \quad \frac{0.2}{0.8} = x_{solute},$$

or $x_{solute} = 0.25$

17. (c) $$\Delta T = K_b \frac{m \times 1000}{M\,W}$$

$$\Rightarrow 0.567 = 5.12 \times \frac{0.44 \times 1000}{M \times 22.2}$$

$$\Rightarrow M = \frac{512 \times 0.44 \times 1000}{0.567 \times 22.2} = 178.9$$

18. (b) Molarity $= \dfrac{\text{No. of moles of solute}}{\text{Volume in litres}} = \dfrac{5}{2.5} = 2\,M$

19. (a) Mole fraction of any component A in solution

$$x = \frac{\text{No. of moles of A}}{\text{Total No. of moles of solution}}$$

As total no. of moles of solution > No. of moles of A
Thus x can never be equal to one or zero.

20. (d) $\Delta T = k_b \dfrac{m}{M} \times \dfrac{1000}{W}$

$$\Rightarrow 1 = 2.53 \times \frac{10}{M} \times \frac{1000}{100}$$

$$\Rightarrow M = \frac{2.53 \times 100}{1} = 253\text{ g}$$

21. (b) One molal solution means one mole of solute is present in 1 kg (1000 g) solvent
i.e., mole of solute = 1

$$\text{Mole of solvent } (H_2O) = \frac{1000\text{g}}{18\text{g}} = \frac{1000}{18}$$

$$\text{Mole fraction of solute} = \frac{1}{\left(1 + \frac{1000}{18}\right)} = \frac{18}{1008} = 0.018.$$

22. (d)

23. (d) $NV = N_1V_1 + N_2V_2 + N_3V_3$

or, $1000N = 1 \times 5 + \dfrac{1}{2} \times 20 + \dfrac{1}{3} \times 30$ or $N = \dfrac{1}{40}$.

24. (d) $\Delta T = k_f \times \dfrac{m}{M} \times \dfrac{1000}{W}$

$$= 1.86 \times \frac{0.1 \times 1000}{1000} = 0.186$$

Since NaCl is 100% ionised so Vant Hoff factor = 2

So, $\Delta T' = i \times \Delta T = 2 \times 0.186 = -0.372°C$

25. (a) Given vapour pressure of pure solvent ($P°$) = 121.8 mm Hg; Weight of solute (w) = 15 g
Weight of solvent (W) = 250 g; Vapour pressure of solution (P) = 120.2 mm Hg and Molecular weight of solvent (M) = 78
From Raoult's law

$$= \frac{P^o - P}{P^o} = \frac{w}{m} \times \frac{M}{W}$$

$$\frac{121.8 - 120.2}{121.8} = \frac{15}{m} \times \frac{78}{250}$$

$$\text{or} \quad m = \frac{15 \times 78}{250} \times \frac{121.8}{1.6} = 356.2$$

26. (b) $\pi = CRT$

$$\frac{600}{760} = \frac{20 \times 1000 \times 0.083 \times (273 + 15)}{M \times 500}$$

$$\left[600\text{mm} = \frac{600}{760} \text{ atmosphere}\right]$$

$$\Rightarrow M = \frac{38 \times 20 \times 1000 \times 0.083 \times 288}{30 \times 500}$$

$$= 1211 \approx 1200$$

27. (c) These two components A and B follows the condition of Raoult's law if the force of attraction between A and B is equal to the force of attraction between A and A or B and B.

28. (a) Given $V.P_P = 80$ torr
$V.P_Q = 60$ torr

$$P_{total} = V \cdot P_P \times x_p + V \cdot P_q \times x_q$$

$$= \left[80 \times \frac{3}{5} + 60 \times \frac{2}{5}\right] = 16 \times 3 + 12 \times 2$$

$P_{total} = 48 + 24 = 72$ torr

29. (d) A solution containing A and B components shows negative deviation when A–A and B–B interactions are weaker than that of A–B interactions. For such solutions.
$\Delta H = -$ve and $\Delta V = -$ve

30. (b) Chloroform and acetone form a non-ideal solution in which A......B type of interactions are readily seen due to intensive H-bonding instead of A......A and B......B type. Therefore, the solution shows negative deviation from Raoult's law i.e.

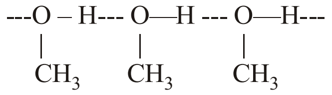
$$\Delta V_{mix} = -\text{ve}\,; \quad \Delta H_{mix} = -\text{ve}$$

$\therefore$ Total volume of solution is less than 80 ml.

31. (c) Here, $\Delta V = 500 - 300 = 200\text{ cc} = 0.2\text{ L}$
$p = 0.6$ atm
$q = 10$ J

$W = p\Delta v = (0.2 \times 0.6) = 0.12$ Latm
Also, 1 L atm = 101.3 J
$\therefore\ W = 0.12 \times 101.3 = 12.156$ J
But q = –ve, when heat is liberated
$\therefore\ \Delta E = q + W = -10 + 12.16 = 2.16$ J

32. (b) Positive deviations are shown by such solutions in which solvent-solvent and solute-solute interactions are stronger than the solute-solvent interactions. In such solution, the interactions among molecules becomes weaker. Therefore their escaping tendency increases which results in the increase in their partial vapour pressures.
In pure methanol there exists intermolecular H–bonding.



$$\text{---}\underset{\substack{|\\ CH_3}}{O} - H\text{---}\underset{\substack{|\\ CH_3}}{O}\text{—}H\text{---}\underset{\substack{|\\ CH_3}}{O}\text{—}H\text{---}$$

On adding benzene, its molecules come between ethanol molecules there by breaking H-bonds which weaken intermolecular forces. This results in increase in vapour pressure.

33. (b) Moles of glucose $= \frac{18}{180} = 0.1$

Moles of water $= \frac{178.2}{18} = 9.9$

Total moles = 0.1 + 9.9 = 10

$$p_{H_2O} = \text{Mole fraction} \times \text{Total pressure} = \frac{9.9}{10} \times 760$$

= 752.4 Torr

34. (d) Antifreeze is a water based liquid coolant used in gasoline and diesel engines. Compounds like methanol, ethanol, glycol, glycerol are added to the water to reduce the freezing point of the mixture below the lowest temperature that the engine is likely to be exposed and to inhibit corrosion in cooling systems which often contain a range of electrochemically incompatible metals. If all the mentioned compounds are available at same price then the compound having lowest molecular weight will be the choice because

$$\Delta T_f = iK_f \frac{w}{M.W.} \times \frac{1000}{w_{solvent}}$$

So, less quantity of the compound will result in large depression in freezing point of antifreeze solution.

35. (d) $$\frac{P^\circ - P}{P^\circ} = \frac{n_2}{n_1 + n_2}$$

$$\frac{640 - 600}{640} = \frac{2.5/x}{39/78}$$

$$x = \frac{640 \times 78 \times 2.5}{39 \times 40} = 80$$

36. (c) For ideal solution,

$\Delta V_{mixing} = 0$ and $\Delta H_{mixing} = 0$.

37. (d) C_2H_5I and C_2H_5OH form non-ideal solution.

38. (d) Gaseous densities of ethanol and dimethyl ether would be same at same temperature and pressure. The heat of vaporisation, V.P. and b.pts will differ due to H-bonding in ethanol.

39. (c) The given vapour pressure graph shows that on mixing two components having vapour pressures p_A and p_B in any ratio, the total vapour pressure of the solution, shown by the line CD, does not show any deviation from ideal behaviour. Lines AD and CB are also do not show any deviation from their expected behaviour but these lines show the individual beheviour of components A and B.

40. (d)

41. (a) Molal elevation constant is given by the formula,

$K_b = \frac{\Delta T_b}{m}$, where m is molality and ΔT_b is elevation in boiling point.

42. (d) Azeotropic mixture is constant boiling mixture, it is not possible to separate the components of azeotropic mixture by boiling.

43. (a) Freezing point of water is, T = 0°C

When 342 g of cane sugar ($C_{12}H_{22}O_{11}$) is dissolved in 1000 g of water, the freezing point of water is depressed by ΔT_f which is given by,

$$\Delta T_f = K_f m = K_f \frac{w_{sol}}{M.W} \times \frac{1000}{w_{solvent}}$$

$$= (1.86\ ^\circ C/mol) \times \frac{342\ g}{(342 g/mol)} \times \frac{1000}{1000}$$

$= 1.86°C$.

So, freezing point of solution

$= T - \Delta T_f$

$= (0 - 1.86)\ ^\circ C$

$= -1.86\ ^\circ C$

44. (a) The solutions (liquid mixture) which boils at constant temperature and can distil as such without any change in composition are called azeotropes.

Solution of HNO_3 and H_2O will form maximum boiling point azeotrope. Maximum boiling azeotropes show negative deviation from Raoult's law.

	Composition (%)	Boiling Point
HNO_3	68.0	359 K
H_2O	32.0	373 K

Boiling point of the azeotrope of these two solutions is 393.5 K.

45. (c) According to Raoult's law

$$\frac{p^\circ - p}{p^\circ} = x_B$$

$$\left[\begin{array}{l} x_B = \text{Mole fraction of solute} = \frac{.2}{.2 + .8} = \frac{1}{5} \\ p = 60 \text{ mm of Hg} \end{array}\right]$$

$$\frac{p^\circ - p}{p^\circ} = \frac{1}{5} \text{ or } 4p^\circ = (p) \times 5$$

$$\Rightarrow p^\circ = \frac{60 \times 5}{4} = 75 \text{mm of Hg}$$

46. (a) When hard boiled egg after shelling is immersed in saturated brine, its size remains same because of the cagulation of inner liquid there is no flow of solvent molecules across the membrane.

47. (b) According to Raoult's law

$$\frac{\Delta p}{p^\circ} = \frac{n}{n + N} \text{ (mole fraction of solute)}$$

$$\frac{10}{p^\circ} = 0.2 \therefore p^\circ = 50 \text{ mm of Hg}$$

For other solution of same solvent

$$\frac{20}{p^\circ} = \frac{n}{n + N} \text{ (Mole fraction of solute)}$$

$$\Rightarrow \frac{20}{50} = \text{Mole fraction of solute}$$

$\Rightarrow$ Mole fraction of solute = 0.4

As mole fraction of solute + mole fraction of solvent = 1

Hence, mole fraction of solvent = 1 – 0.4 = 0.6

48. (a) A solution of acetone in ethanol shows positive deviation from Raoult's law. It is because ethanol molecules are strongly hydrogen bonded. When acetone is added, these molecules break the hydrogen bonds and ethanol becomes more volatile. Therefore its vapour pressure is increased.

49. (a) Liquid mixture having a definite composition and boil like a pure liquid is called an azeotrope.
$\Rightarrow$ Mixture showing +ive deviation from Raoult's Law forms minimum boiling azeotrope while mixture showing –ive deviation from Raoult's law forms maximum boiling azeotrope.

50. (a) $\Delta T_f = i \times K_f \times m$
Van't Hoff factor, $i = 2$ for NaCl, $m = 0.01$
hence $\Delta T_f = 0.02\, K_f$ which is maximum in the present case.
Hence ΔT_f is maximum or freezing point is minimum.

51. (c) We know that

$$\Delta T_f = \frac{100 \times K_f \times w}{m \times W} \quad \therefore m = \frac{100 \times K_f \times w}{\Delta T_f \times W}$$

Now, K_f = molecular depression constant
$= 50.2°C$ per 100 gm
$\Delta T_f = 0.502°C$
$W = 25$ gm

$$m = \frac{100 \times 50.2 \times 0.750}{0.502 \times 25} = 300$$

52. (b) density of ethanol = 0.789 gm/ml.
wt. of 1000 ml = volume × density = 789g

$$\therefore \text{Molality} = \frac{\text{Mass of } CH_3COOH}{\text{Mol. mass of } CH_3COOH} \times \frac{1000}{\text{wt. of ethanol}}$$

$$= \frac{5}{60} \times \frac{1000}{789} = 0.1056 \text{ mol/g}$$

53. (c) Osmotic pressure is a colligative property.

54. (a) As both the solutions are isotonic hence there is no net movement of the solvent occurs through the semipermeable membrane between two solutions.

55. (a) Total wt. of solution = 800 gm.

$$\text{Wt. of solute} = \frac{40}{100} \times 800 = 320 \text{ g.}$$

So, 100 gm solute precipitated
Remining total wt. of solute = 320 – 100 g
= 220 g
Remining total wt. of solution = 800 – 100
= 700 g

$$\therefore \% \text{ composition} = \frac{220}{700} \times 100 = 31.43\%$$

56. (a) Concentration of particles in $CaCl_2$ solution will be maximum as $i = 3$ for $CaCl_2$ and $i = 2$ for KCl.
Glucose and Urea do not dissociate into ions, as they are nonelectrolytes.

57. (a) $K_4[Fe(CN)_6]$ and $Al_2(SO_4)_3$ both dissociates to give 5 ions or $i = 5$
$K_4[Fe(CN)_6] \rightleftharpoons 4K^+ + [Fe(CN)_6]^{4-}$
and $Al_2(SO_4)_3 \rightleftharpoons 2Al^{3+} + 3SO_4^{--}$

58. (a) Depression in freezing point ∝ No. of particles.
(when concentration of different solutions is equal)
$Al_2(SO_4)_3$ provides five ions on ionisation
$Al_2(SO_4)_3 \longrightarrow 2Al^{3+} + 3SO_4^{2-}$
while KCl provides two ions
$KCl \longrightarrow K^+ + Cl^-$
$C_6H_{12}O_6$ and $C_{12}H_{22}O_{11}$ are not ionised so they have single particle in solution.
Hence, $Al_2(SO_4)_3$ have maximum value of depression in freezing point or lowest freezing point.

59. (a) Molecular masses of polymers are best determined by osmotic pressure method. Firstly because other colligative properties give so low values that they cannot be measured accurately and secondly, osmotic pressure measurements can be made at room temperature and do not require heating which may change the nature of the polymer.

60. (b) Solvent having high cryoscopic constant (camphor) can be used in determination of molecular masses of organic compounds like naphthalene, anthracene etc., by cryoscopic method.

61. (c) $\Delta T_A = K_f m_A$, $\Delta T_B = K_f M_B$
$\Delta T_A = \Delta T_B$, $m_A = m_B$

$$\frac{\text{Mass of solute A}}{\text{Molecular mass of A}} = \frac{\text{Mass of B}}{\text{Molecular mass of B}}$$

$$\frac{3}{60} = \frac{9}{\text{Molecular mass of B}}$$

Molecular mass of B = 180.

62. (c) $\Delta T = K_f m = \dfrac{K_f \times W_2 \times 1000}{M_2 W_1} = 5.12 \times \dfrac{1}{250} \times \dfrac{1000}{51.2} = 0.4K$

63. (b) Total no. of milli equivalents of acids
$= (100 \times 0.4 + 200 \times 0.2)$ meq.
$= 40 + 40 = 80$ meq.
Total volume of mixture = 300
$\therefore \quad N \times 300 = 80$

$$N = \frac{80}{300} = 0.2670\,N.$$

64. (c) Colloidal particles exhibit ceaseless chaotic and random motions, such motions of the particles are called Brownian motion.

65. (d) $V_1 = 250$ml; $N_1 = 0.4N$
$V_2 = 1250$ ml; $N_2 = ?$
Applying the law of equivalence :–
No. of equivalents before dilution = No. of equivalents after dilution
$\therefore \quad N_1V_1 = N_2V_2$
$(0.25) \times (0.4) = (1.25) \times N_2$
$N_2 = 0.080$ N .

66. (d) $(\underset{1-0.3}{HX} \rightleftharpoons \underset{0.3}{\overset{+}{H}} + \underset{0.3}{X^-}, i = 1.3); \Delta T_f = K_f \times m \times i$

$\Delta T_f = 1.85 \times 0.2 \times 1.3 = 0.481^\circ C$

$\therefore T_f = T_f^\circ - \Delta T_f = 0 - 0.481^\circ C = -0.481^\circ C$

67. (c) $\Delta T_b = K_b \times m$

Elevation in boiling point is a colligative property, which depends upon the no. of particles (concentration of solution). Thus greater the number of particles, greater is the elevation in boiling point and hence greater will be its boiling point.

$$Na_2SO_4 \rightleftharpoons 2Na^+ + SO_4^{2-}$$

Since Na_2SO_4 has maximum number of particles (c) hence has maximum boiling point.

68. (b) $\text{Normality} = \dfrac{\text{No. of equivalents}}{\text{Volume of solution in litre}}$

$\Rightarrow$ No. of equivalents
= Normality × Volume of solution in litre
$= 0.1 \times 0.1 = 0.01$

$\Rightarrow \dfrac{\text{Wt}}{\text{Equivalent wt.}} = 0.01$

$\Rightarrow \text{w t} = 0.01 \times \dfrac{\text{Molecular wt.}}{\text{basicity}}$

$\text{wt.} = 0.01 \times \dfrac{200}{2} = 1\,\text{gm}$

69. (a) (i) $i = \dfrac{\text{No. of particles after ionisation}}{\text{No. of particles before ionisation}}$

(ii) $\Delta T_b = i \times K_b \times \text{m}$

$$\begin{array}{lcc} CuCl_2 \longrightarrow & Cu^{2+} + & 2Cl^- \\ 1 & 0 & 0 \\ (1-\alpha) & \alpha & 2\alpha \end{array}$$

$i = \dfrac{1+2\alpha}{1}, \; i = 1 + 2\alpha$

Assuming 100% ionization
So, $i = 1 + 2 = 3$

$\Delta T_b = 3 \times 0.52 \times 0.1 = 0.156 \approx 0.16 \quad [m = \dfrac{13.44}{134.4} = 0.1]$

70. (b) Benzoic acid exists as dimer in benzene.

71. (b) $\Delta T_f = K_f \times m = 1.86 \times 0.5 = 0.93^\circ C; \; T_f = -0.93^\circ C$

72. (c) $K_b = \dfrac{0.1 \times 180 \times 100}{1.8 \times 1000} = 1\,K/m$

73. (b) Isotonic solutions are those solutions which have same osmotic concentrations.
The solution with higher osmotic concentration is called hypertonic and lower is called hypotonic solution.

74. (d) Boiling temperature is a temperature at which vapour pressure is equal to the atmospheric pressure when external pressure is equal to 1 atm.

75. (b) $\pi = \dfrac{nRT}{V}$ or $T = \dfrac{\pi V}{nR}$

10% (w/v) aqueous solution of glucose means 10 g glucose is present in 100 mL of H_2O

$= \dfrac{14 \times 100 \times 10^{-3} \times 180}{0.082 \times 10} = 307.3\,K$

76. (c) Normality

$= \dfrac{\text{Mass}}{\text{Equivalant mass}} \times \dfrac{1000}{\text{Volume of solution}}$

$= \dfrac{4}{40} \times \dfrac{1000}{100} = 1$

77. (c) Solvent molecules flow from low concentration solution to high concentration solution.

78. (d) $\Delta T_f = iK_f m$

$$\begin{array}{lcc} KBr \longrightarrow & K^+ + & Br^- \\ 1 & 0 & 0 \\ (1-\alpha) & \alpha & \alpha \end{array}$$

$i = 1 + \alpha$
Here $\alpha = 0.8$ (80% ionization)
$i = 1.8$
$\Delta T_f = (1.8)(1.86)(0.4) = 1.339$
$T_f = -1.339^\circ C$

79. (a) The solution which provide same number of ions are isotonic.
$Ca(NO_3)_2 \longrightarrow Ca^{2+} + 2\,NO_3^-$
Total ions produced = 3
$Na_2SO_4 \longrightarrow 2\,Na^+ + SO_4^{2-}$
Total ions produced = 3
$\therefore$ 0.1 M $Ca(NO_3)_2$ and 0.1 M Na_2SO_4 are isotonic.

80. (b) KNO_3 is a strong electrolyte which dissociates into two ions. Therefore, its van't Hoff factor is 2. Acetic acid (CH_3COOH) is a weak electrolyte, it does not dissociate completely. So, its van't Hoff factor is less than that of KNO_3
$\therefore$ Osmotic pressure of 0.1 M KNO_3 >
Osmotic pressure of 0.1 M CH_3COOH
or $P_1 > P_2$

81. (a) For highest boiling point of a solution, the ΔT_b should be highest, Since, ΔT_b is directly proportional to the molality of solution.

$$\Delta T_b \propto m$$

Of the given solutions urea and glucose remain unionized and remain as one particle in solution. In case of Na_2SO_4 (a strong electrolyte) there are three particles for each molecule (2 Na^+ and one SO_4^{2-}) whereas for KNO_3 (strong electrolyte) there are 2 particles (one K^+ and one NO_3^-). Thus for equimolar solutions of these two, the number of particles is more in Na_2SO_4 (aq) and so is molality. Thus it will exhibit highest boiling point.

82. (b) Given mass of solute = 8.1 g
Mass of solvent = 100 g
For HBr

$$\underset{(1-\alpha)}{\overset{1}{HBr}} \longrightarrow \underset{\alpha}{\overset{0}{H^+}} + \underset{\alpha}{\overset{0}{Br^-}}$$

$\alpha = 90\% = 0.9$

$i = 1 + \alpha = 1 + 0.9 = 1.9$

$\Delta T_f = K_f \times m \times i$

$$= 1.86 \times \frac{\text{moles of solute}}{\text{mass of solvent in kg}} \times 1.9$$

$$= 1.86 \times \frac{8.1/81}{100/1000} \times 1.9$$

$= 1.86 \times 1 \times 1.9 = 3.534\,K$

$T_f = T_f{}^\circ - \Delta T_f$

or $T_f = 0 - 3.534$ K

$\therefore$ $T_f = -3.534\,K$

83. (d) Osmotic pressure is a colligative property. Hence resulting osmotic pressure of the solution is given by

$\pi_T = \pi_1 + \pi_2 + \pi_3$ ....

$\pi_T = 1.64 + 2.46 = 4.10$ atm.

84. (d) Addition of solute to water decreases the freezing point of water (pure solvent).

$\therefore$ When 1% lead nitrate (solute) is added to water, the freezing point of water will be below 0°C.

85. (b) As $\Delta T_f = K_f . m$

$\Delta T_b = K_b . m$

Hence, we have $m = \dfrac{\Delta T_f}{K_f} = \dfrac{\Delta T_b}{K_b}$

or $\Delta T_f = \Delta T_b \dfrac{K_f}{K_b}$

$\Rightarrow [\Delta T_b = 100.18 - 100 = 0.18°C]$

$$= 0.18 \times \frac{1.86}{0.512} = 0.654°C$$

As the Freezing Point of pure water is 0°C,

$\Delta T_f = 0 - T_f$

$0.654 = 0 - T_f$

$\therefore T_f = -0.654$

Thus the freezing point of solution will be – 0.654°C.

86. (c) Applying the law of equivalence,

$N_1V_1 + N_2V_2 + N_3V_3 = N_RV_R$

$$\frac{N}{10} \times 50 + \frac{N}{3} \times 30 + \frac{N}{2} \times 10 = N_R \times 1000$$

$5N + 10N + 5N = 1000 \times N_R$

$$\Rightarrow N_R = \frac{N}{50}$$

87. (a) Given : $K_b = 0.52$, molarity $= 2$m

Here, molality = molarity = 2 molal

Now, using $\Delta T_b = K_b \times m$, we get

$\Delta T_b = 0.52 \times 2 = 1.04$ °C

Now, ΔT_b

= Boiling pt. of solution – Boiling pt. of solvent (pure water)

$\Rightarrow$ Boiling pt. of solution (2M sucrose solution)

$= \Delta T_b +$ Boiling pt. of pure water

$= 1.04°C + 100°C = 101.04°C$

88. (d) $\Delta T_f = 0 - (0.00732°C) = 0.00732$

$\Delta T_f = i \times K_f \times m$

$$i = \frac{\Delta T_f}{K_f \times m} = \frac{0.00732}{1.86 \times 0.002} = 1.97 \approx 2$$

89. (d) When the aqueous solution of one molal KI is diluted with water, concentration decreases, therefore the vapour pressure of the resulting solution increases.

90. (a) $\Delta T_f = K_f \dfrac{1000 W_2}{M_2 W_1} = \dfrac{1.86 \times 1000 \times 68.5}{342 \times 1000} = 0.372$

$T_f = T°_f - \Delta T_f$

$T_f = -0.372°C$

91. (b) Concentration of $Na_2CO_3 = \dfrac{25.3}{106} \times \dfrac{1000}{250} = 0.955$ M

$[Na^+] = 2 \times 0.955 = 1.91$ M

$\left[CO_3^{2-}\right] = 0.955$ M

92. (b) Given $K_f = -1.86°C\,m^{-1}$, mass of solute = 5.00 g, mass of solvent = 45.0 g and $\Delta T_f = -3.82°C$

$\Delta T_f = i \times K_f . m$

$$3.82 = i \times 1.86 \times \frac{5 \times 1000}{142 \times 45}$$

$\therefore i = 2.62$ (Molecular mass of $Na_2SO_4 = 142$ g)

93. (c) If compound dissociates in solvent $i > 1$ and on association $i < 1$.

94. (b) 1 molal solution means 1 mole of solute dissolved in 1000 gm solvent.

$\therefore$ $n_{\text{solute}} = 1$ $w_{\text{solvent}} = 1000$ gm

$$\therefore n_{\text{solvent}} = \frac{1000}{18} = 55.56$$

$$x_{\text{solute}} = \frac{1}{1 + 55.56} = 0.0177$$

95. (d) Given $\alpha = 30\%$ i.e., 0.3

$HA \longrightarrow H^+ + A^-$

$1 - \alpha$ α α

$1 - 0.3$ 0.3 0.3

$i = 1 - 0.3 + 0.3 + 0.3$

$i = 1.3$

$\Delta T_f = 1.3 \times 1.86 \times 0.1 = 0.2418$

$T_f = 0 - 0.2418 = -0.2418$ °C

96. (d) $M = \dfrac{WRT}{\pi V} = \dfrac{1.26 \times 0.083 \times 300}{2.57 \times 10^{-3} \times 200 \times 10^{-3}}$

$$= \frac{31.374 \times 10^6}{514} = 61038 \text{ g}$$

97. (d) $p = p_A x_A + p_B x_B$

$= p_A x_A + p_B (1 - x_A)$

$\Rightarrow$ $p_A x_A + p_B - p_B x_A$

$\Rightarrow$ $p_B + x_A (p_A - p_B)$

98. (b) $p_A^\circ = ?$, Given $p_B^\circ = 200$ mm of Hg, $x_A = 0.6$, $x_B = 1 - 0.6 = 0.4$, $P = 290$ of Hg

$$P = P_A + P_B = P_A^\circ x_A + P_B^\circ x_B$$

$$\Rightarrow\ 290 = P_A^\circ \times 0.6 + 200 \times 0.4 \ \therefore\ p_A^\circ = 350 \text{ mm of Hg.}$$

99. (b) For this solution intermolecular interactions between *n*-heptane and ethanol are weaker than *n*-heptane-*n*-heptane & ethanol-ethanol interactions hence the solution of *n*-heptane and ethanol is non-ideal and shows positive deviation from Raoult's law.

100. (a) From molarity equation :

$$M_1V_1 + M_2V_2 = M \times V$$

$$M = \frac{M_1V_1 + M_2V_2}{V} \text{ where V = total volume}$$

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

$$= 0.875 \text{ M}$$

EXERCISE - 2

1. (c) Moles of urea $= \frac{5}{60}$; moles of fructose $= \frac{5}{180}$;

moles of sucrose $= \frac{5}{342}$;

moles of KCl(effective) $= 2 \times \frac{5}{74.5} = \frac{5}{37.25}$

2. (b) Using the relation,

$$M = \frac{w.R.T}{\pi V}, \text{ we get } M = \frac{6 \times 0.080 \times 300}{2 \times 10^{-3} \times 0.2} = 3.6 \times 10^5$$

3. (d) The salt that ionises to least extent will have highest freezing point. [i.e., minimum ΔT_f]

4. (b) Greater is the effective molarity ($i \times C$), higher the ΔT_f value and lower the freezing point.

5. (c) $N_1V_1 + N_2V_2 = NV$

$4x + 10(1 - x) = 6 \times 1; -6x = -4 ; x = 0.67$

Thus 0.67 litre of 4N HCl

$1 - x = 1 - 0.67 = 0.33$ litre of 10 N HCl

6. (a) $$\text{Molarity} = \frac{\% \times 10 \times d}{\text{GMM}} = \frac{22 \times 10 \times 1.253}{342} = 0.805\text{M.}$$

$$\text{Normality} = \frac{\% \times 10 \times d}{\text{GEM}} = \frac{22 \times 10 \times 1.253}{342/6} = 4.83\text{N}$$

$$\text{Molality} = \frac{22 \times 1000}{342(100 - 22)} = 0.825\text{m}$$

7. (b) $$\text{Mole fraction of } H_2O = \frac{\frac{80}{18}}{\frac{80}{18} + \frac{20}{34}} = \frac{68}{77}.$$

8. (c) $$\text{Molality (m)}\frac{\text{Molarity}}{\text{Density} - \frac{\text{Molarity} \times \text{Molecular mass}}{1000}}$$

$$= \frac{18}{1.8 - \frac{18 \times 98}{1000}} = 5000$$

9. (b) $$\pi V = \frac{w}{m}RT$$

$$\therefore 6 \times 10^{-4} \times 1 = \frac{4}{m} \times 0.0821 \times 300 \text{ ; m} = 1.64 \times 10^5.$$

10. (b) $\pi V = CRT$

$$\frac{\pi_1}{\pi_2} = \frac{C_1T_1}{C_2T_2}$$

$$\pi_1 = P, \pi_2 = 2 \ atm.\ C_1 = C,\ C_2 = \frac{C}{2}$$

$$T_1 = 600\,K,\ T_2 = 700\,K$$

$$\frac{P}{2} = \frac{2 \times C \times 600}{C \times 700}$$

$$P = \frac{24}{7}.$$

11. (a) $CaCl_2$ acts as a non-volatile solute and results in depression in freezing point. Thus, snow fall is reduced and prevents blocking of roads in the polar region.

12. (c)

	$Na_2SO_4 \longrightarrow$	$2Na^+ +$	SO_4^{2-}
Mol. before dissociation	1	0	0
Mol. after dissociation	$1 - \alpha$	2α	1α

$i = 1 - \alpha + 2\alpha + \alpha = 1 + 2\alpha$

13. (b) $AlCl_3$ furnishes more ions than $CaCl_2$ and thus possess higher boiling point i.e., $T_1 > T_2$.

14. (a) Van't Hoff equation is

$\pi V = inRT$

For depression in freezing point.

$\Delta T_f = i \times K_f \times m$

For elevation in boiling point.

$\Delta T_b = i \times K_b \times m$

For lowering of vapour pressure,

$$\frac{P^\circ_{\text{solvent}} - P_{\text{solution}}}{P^\circ_{\text{solvent}}} = i\left(\frac{n}{N+n}\right).$$

15. (b) $\Delta T_f = i.K_f.m$; $0.0054 = i \times 1.8 \times 0.001$

$i = 3$ so it is $[Pt(NH_3)_4Cl_2]Cl_2$.

16. (c) Given, $W = 500$ cc $= 500$ g

($\because$ density of water = 1g/cc)

$$\text{As, Density} = \frac{\text{Weight}}{\text{Volume}}$$

$$\text{Weight} = \text{Density} \times \text{Volume} = \frac{1\text{g}}{\text{cc}} \times 500\,\text{cc} = 500\,\text{g}$$

w = amount of urea = ?

$K_f = 1.86°\text{C}$; $\Delta T_f = 0.186°\text{C}$

M = Molecular mass of urea = 60

$$M = \frac{1000 \times K_f \times w}{W \times \Delta T_f}$$

$$60 = \frac{1000 \times 1.86 \times w}{500 \times 0.186}$$

$60 = 20 \times w$

$$\therefore \quad w = \frac{60}{20} = 3\text{g}$$

17. (b) Among the given options, $CaCl_2$ solution will produce maximum (three) ions per molecule, so it will show minimum freezing point.

18. (d) $\Delta T_b = K_b \dfrac{w}{M} \times \dfrac{1000}{W}$

$$0.52 = 0.6 \times \frac{3}{M} \times \frac{1000}{200} \left(W = 200 \times 1\right))$$

$$M = \frac{1.8 \times 5}{0.52} = 17.3\text{g mol}^{-1}$$

19. (d) The value of ΔT_b depends upon two factors 'i' and 'm'. It is given that 1 mol of each compound is dissolved in 1 L of solution. Hence molarity is same for all the compounds. Now the van't Hoff factor depends on number of particle i.e. on degree of ionisation which further depends on the bond dissociation energy which is in the order

$HI < HBr < HCl < HF$

i.e., bond dissociation energy of HI is least. Lower the bond dissociation energy, higher is the degree of ionisation and hence higher the number of particles, thus i will be maximum for HI and hence ΔT_b value will be larger for HI.

20. (d) Let the mass of methane and oxygen = m gm.

Mole fraction of O_2

$$= \frac{\text{Moles of } O_2}{\text{Moles of } O_2 + \text{Moles of } CH_4}$$

$$= \frac{m/32}{m/32 + m/16} = \frac{m/32}{3m/32} = \frac{1}{3}$$

Partial pressure of O_2 = Total pressure × mole fraction of O_2, $P_{O_2} = P \times \dfrac{1}{3} = \dfrac{1}{3}P$

21. (a) Osmotic pressure (π) of isotonic solutions are equal. For solution of unknown substance C_1(concentration).

$$C_1 = \frac{5.25/M}{V}$$

Where M represents molar mass.

For solution of urea, C_2 (concentration) = $\dfrac{1.5/60}{V}$

Given, $\pi_1 = \pi_2$ $\qquad \because \pi = CRT$

$$\therefore \ C_1RT = C_2RT \text{ or } C_1 = C_2 \text{ or } \frac{5.25/M}{V} = \frac{1.5/60}{V}$$

$\therefore$ M = 210 g/mol

22. (d) At 1 atmospheric pressure the boiling point of mixture is 80°C.

At boiling point the vapour pressure of mixture, $p_T = 1$ atmosphere = 760 mm Hg.

Using the relation,

$p_T = p_A^\circ x_A + p_B^\circ x_B$, we get

$p_T = 520x_A + 1000(1 - x_A)$

$\{\because p_A^o = 520 \text{ mm Hg},$

$p_B^\circ = 1000 \text{ mm Hg}, \ x_A + x_B = 1\}$

or $760 = 520x_A + 1000 - 1000x_A$ or $480x_A = 240$

or $x_A = \dfrac{240}{480} = \dfrac{1}{2}$ or 50 mol. percent

i.e., the correct answer is (d)

23. (a) The vapour pressure of a solution of glucose in water can be calculated using the relation

$$\frac{p^\circ - p_s}{p_s} = \frac{\text{Moles of glucose in solution}}{\text{Moles of water in solution}}$$

or $\dfrac{17.5 - p_s}{p_s} = \dfrac{18/180}{178.2/18}$ $\qquad [\because p^\circ = 17.5]$

or $17.5 - p_s = \dfrac{0.1 \times p_s}{9.9}$ or $p_s = 17.325$ mm Hg.

Hence (a) is correct answer.

24. (b) $p_{\text{total}} = p_A^\circ x_A + p_B^\circ x_B$

$$550 = p_A^\circ \times \frac{1}{4} + p_B^\circ \times \frac{3}{4}$$

$p_A^\circ + 3p_B^\circ = 550 \times 4$ ...(i)

In second case

$$p_{\text{total}} = p_A^\circ \times \frac{1}{5} + p_B^\circ \times \frac{4}{5}$$

$p_A^\circ + 4p_B^\circ = 560 \times 5$ ...(ii)

Subtract (i) from (ii)

$\therefore p_B^\circ = 560 \times 5 - 550 \times 4 = 600$

$\because p_A^\circ = 400$

25. (a) $p_{\text{Total}} = p^\circ_A x_A + p^\circ_B x_B$

$= p^\circ_{\text{Heptane}} \, x_{\text{Heptane}} + p^\circ_{\text{Octane}} \, x_{\text{Octane}}$

$$= 105 \times \frac{25/100}{\frac{25}{100} + \frac{35}{114}} + 45 \times \frac{35/114}{\frac{25}{100} + \frac{35}{114}}$$

$$= 105 \times \frac{0.25}{0.25 + 0.3} + 45 \times \frac{0.3}{0.25 + 0.3}$$

$$= \frac{105 \times 0.25}{0.55} + \frac{45 \times 0.3}{0.55} = \frac{26.25 + 13.5}{0.55}$$

= 72 kPa

26. (b) For isotonic solutions

$\pi_1 = \pi_2$

$C_1 = C_2$

$$\frac{5/342}{0.1} = \frac{1/M}{0.1}$$

$$\frac{5}{342} = \frac{1}{M}$$

$$\Rightarrow \quad M = \frac{342}{5} = 68.4 \text{ gm/mol}$$

27. (b) $\Delta T_f = i \times K_f \times m$
Given $\Delta T_f = 2.8$, $K_f = 1.86$ K kg mol^{-1} $i = 1$
(ethylene glygol is a non- electrolyte)
wt. of solvent = 1 kg
Let of wt of solute = x
Mol. wt of ethylene glycol = 62

$$2.8 = 1 \times 1.86 \times \frac{x}{62 \times 1}$$

$$\text{or } x = \frac{2.8 \times 62}{1.86} = 93 \text{ gm}$$

28. (a) Molecular weight of naphthoic acid
$C_{11}H_8O_2 = 172$ g mol^{-1}.
The theoretical value of depression in freezing point

$$= K_f \times \text{ molality} = 1.72 \times \frac{20 \times 1000}{172 \times 50} = 4\text{K}$$

Van't Hoff factor,

$$i = \frac{\text{Observed value of colligative property}}{\text{Theoretical value of colligative property}}$$

$$= \frac{2}{4} = 0.5.$$

29. (a) $P_{N_2} = \kappa_H x_{N_2}$
$0.8 \times 5 = 1 \times 10^5 \times x_{N_2}$
$\therefore\ x_{N_2} = 4 \times 10^{-5}$
Solubility in 10 moles = 4×10^{-4}.

30. (c) Number of moles of urea $= \frac{120}{60} = 2$
Total mass of solution = 1000 + 120 = 1120 g

$$\text{Total volume of solution (in L)} = \frac{\text{Mass}}{\text{Density}}$$

$$= \frac{1120}{1.15 \times 10^3} = \frac{112}{115} \text{L}$$

$$\text{Molarity of the solution} = \frac{\text{Number of moles}}{\text{Volume of solution in litre}}$$

$$= \frac{2 \times 115}{112} = 2.05 \text{ mol L}^{-1}$$

31. (a) $\Delta T_f = i \times K_f \times m$
Where m = Molality of the solution
(*i.e.* number of moles of solute per 1000 g of the solvent)

$$\text{Here } m = \frac{0.1}{329} \times 10$$

$$\text{Thus } \Delta T_f = 4 \times 1.86 \times \frac{0.1 \times 10}{329} = 2.3 \times 10^{-2}$$

Thus $T_f = 0 - 2.3 \times 10^{-2} = -2.3 \times 10^{-2}$ °C

32. (a) From Raoult law

$$\frac{p^\circ - p}{p^\circ} = \frac{\text{No.of moles of solute}}{\text{No. of moles of solvent+ No. of moles of solute}}$$

When the concentration of solute is much lower than the concentration of solvent,

$$\frac{p^\circ - p}{p^\circ} = \frac{\text{No. of moles of solute}}{\text{No. of moles of solvent}}$$

$$\Delta T_b = K_b \times m$$

$$m = \frac{\text{Number of moles of the solute}}{\text{Mass of solvent in grams}} \times 1000$$

$$\Delta T_b = K_b \times \frac{\text{Number of moles of the solute}}{\text{Mass of solvent in grams}} \times 1000$$

Number of moles of solute

$$= \frac{\Delta T_b \times \text{Mass of solvent in grams}}{K_b \times 1000}$$

$$= \frac{2 \times 100}{0.76 \times 1000} = 0.26,$$

Number of moles of solvent $= \frac{100}{18} = 5.56$

From equation (i) we get, $\frac{760 - p}{760} = \frac{0.26}{5.56}$

On solving, $p = 724.46 \approx 724$

33. (b) Sodium sulphate dissociates as

$$Na_2SO_4 \longrightarrow 2Na^+ + SO_4^{--}$$

hence van't hoff factor $i = 3$

Now $\Delta T_f = i K_f . m$

$= 3 \times 1.86 \times 0.01 = 0.0558$ K

34. (d) Colligative properties depends upon the no. of particles. Since methanol is non electrolyte hence cannot be considered.

35. (a) $k_H = 100$ kbar $= 10^5$ bar, p = 1 bar
$p = k_H \times x_A$

$$x_A = \frac{p}{k_H} = \frac{1}{100 \times 10^3} = 10^{-5}$$

$$\text{Moles of water} = \frac{1000}{18} = 55.5$$

Weight of water = 1000 g ($\because$ 1000 mL = 1000 g)

$$\text{Mole fraction} = 10^{-5} = \frac{x}{55.5 + x}$$

As 55.5 >>> x, thus neglecting x from denominator

$$10^{-5} = \frac{x}{55.5} \Rightarrow x = 55.5 \times 10^{-5} \text{ moles}$$

or 0.555 millimoles.

36. (d) $\Delta T_b = k_b.m$

$$\Delta T_b = k_b \times \frac{\text{weight of solute} \times 1000}{\text{molecular weight of solute} \times \text{weight of solvent}}$$

$$0.75 = 2.5 \times \frac{1.5}{M} \times \frac{1000}{50}$$

$$M = \frac{2.5 \times 1.5 \times 1000}{0.75 \times 50} = 100$$

37. (b) $\Delta T_f = K_f \times m$

K_f is a characteristic of a particular solvent *i.e.*, it will be different for different solvents.

38. (a) According to Raoult's law,

$P_T = x_A p_A^\circ + x_B p_B^\circ$

Given, = P_{T_1} 500 mm Hg

$n_A = 1$ and $n_B = 2 \therefore x_A = 1/3$ and $x_B = 2/3$

$$\Rightarrow 500 = \frac{1}{3} p_A^\circ + \frac{2}{3} p_B^\circ$$

$$\Rightarrow 1500 = p_A^\circ + 2p_B^\circ \qquad \text{... (i)}$$

Also given Qn that one more mole of B is added to the solution, the pressure of the ideal solution increases by 25 mm Hg.

$\therefore P_{T_2} = 500 + 25 = 525$ mm Hg

Also, $n_B = 3 \therefore x_A = 1/4$ and $x_B = 3/4$

$$525 = \frac{1}{4} p_A^\circ = \frac{3}{4} p_B^\circ \qquad \text{... (ii)}$$

$$2100 = P_A^\circ + 3P_B^\circ$$

Subtract (i) and (ii),

$p_B^\circ = 600$ mm Hg

$p_A^\circ + 2p_B^\circ = 1500 \Rightarrow p_A^\circ = 300$ mm Hg.

39. (d) According to Henry's law,

$m = k \times p$

given $K_H = 1.4 \times 10^{-3}$

$p_{O_2} = 0.5$ or

$p_{O_2} = K_H \times x_{O_2}$

$$\therefore \quad x_{O_2} = \frac{0.5}{1.4 \times 10^{-3}}$$

No. of moles; $n = \frac{m}{M}$

$$0.7 \times 10^{-4} = \frac{m}{32}$$

$m = 22.4 \times 10^{-4}$ g = 2.24 mg

40. (d) Mass of non-volatile solute = 1g

Molar mass of solute = 250g mol^{-1}

Mass of benzene = 51.2g, $K_f = 5.12$ K kg mol^{-1}

$$\Delta T_f = \frac{K_f \times 1000 \times w_2}{M_2 \times w_1}$$

where, w_2 = mass of the solute

M_2 = molar mass of solute

w_1 = mass of the solvent

On substituting given values, $\Delta T_f = \frac{5.12 \times 1000 \times 1}{51.2 \times 250}$

$\therefore \quad \Delta T_f = 0.4$K

41. (c) Acetone and chloroform shows negative deviation from Raoult's law when these are mixed, the hydrogen bonding takes place between the two molecular species due to which escaping tendency of either liquid molecules becomes less and boiling point of solution increases.

42. (c)

43. (d) According to Henry's law the mass of a gas dissolved per unit volume of solvent is proportional to the pressure of the gas at constant temperature $m = K p$ i.e. as the solubility increases, value of Henry's law constant decreases. Since CO_2 is most soluble in water among the given set of gases. Therefore CO_2 has the lowest value of Henry's law constant.

44. (a) Given w = 10 g Mol. mass = 40

Weight of solvent = 1250 × 0.8 g = 10000 g = 1 kg

$$\therefore \text{molality} = \frac{10}{40 \times 1} = 0.25$$

45. (d) Glucose is non electrolyte hence depression in freezing point will be minimum, hence freezing point will be highest.

46. (b)

47. (b) Both assertion and reason are correct but reason is not the correct explanation of assertion.

The relationship between lowering of vapour pressure and osmotic pressure can be derived as follows:

Van't Hoff equation for dilute solutions is

$$\pi = \frac{n}{V} RT \qquad \text{....(i)}$$

In case of a dilute solution, the volume of solution can be taken as equal to that of solvent. If *N* is the number of moles of solvent of molecular weight *M* and density ρ, the volume *V* is given by

$$V = \frac{NM}{\rho} \qquad \text{....(ii)}$$

or $$\frac{n}{N} = \frac{\pi M}{\rho.R.T.} \qquad \text{....(iii)}$$

From Raoult's law,

$$\frac{P^\circ - P}{P^\circ} = \frac{n}{N} \qquad \text{....(iv)}$$

$$\therefore \frac{P^\circ - P}{P^\circ} = \frac{\pi M}{\rho RT} \qquad \text{[From (iii) and (iv)]}$$

or $$\left(P^\circ - P\right) = \frac{\pi M}{\rho RT} \times P^\circ$$

The factor $\frac{MP^\circ}{\rho RT}$ is constant at constant temperature.

$\therefore \left(P^\circ - P\right) \propto \pi$

or lowering of V.P. $\propto$ osmotic pressure

Thus assertion is correct.

Osmotic pressure is a colligative property is correct.

48. (c) Both the solute and solvent will form the vapours but vapour phase will become richer in the more volatile component.

49. (b)

50. (c) Camphor has high molal depression constant.

EXERCISE - 3

Exemplar Questions

1. (a) According to Henry's law partial pressure of a gas in the solution is proportional to the mole fraction of gas in the solution.
$p = K_H x$; K_H = (Henry's constant)

2. (d) Dissolution of sugar in water will be most rapid when powdered sugar is dissolved in hot water because in powdered form it can easily insert in the vacancies of water particle.
Also, dissolution of sugar in water is an endothermic process. So it is favourable at high temperature.

3. (c)

4. (b) When solute gets precipitated in the solution, then the solution is known as supersaturated solution.

5. (c) Maximum amount of solid that can be dissolved in a specified amount of a given solvent does not depend upon pressure. The reason is solid and liquid are highly incompressible and practically remain unaffected by change in pressure.

6. (b) At high altitude, the partial pressure of oxygen is less than at the ground level. This decreased atmospheric pressure causes release of oxygen from blood. Hence people living at high altitude have low concentration of oxygen in the blood and tissues.

7. (a) Mixture of methanol and acetone show a positive deviation from Raoult’s law. Molecules in pure methanol are hydrogen bonded. On adding acetone, its molecules enters in between the host molecules and break some of the hydrogen bonds between them.
Therefore, the intermolecular attractive forces between the solute-solvent molecules are weaker than those between the solute-solute and solvent-solvent molecules.
Other three remaining options will show negative deviation.

8. (b) Colligative properties depend upon number of solute particles in solution irrespective of their nature.

9. (b) Colligative properties depends upon the number of particles. As we know greater the value of van't Hoff factor higher will be elevation in boiling point and hence higher will be the boiling point of solution. Among the given solution 1.0M Na_2SO_4 have highest no. of particles i.e highest value of ‘*i*’.
Hence, 1.0 M Na_2SO_4 has highest value of boiling point.

10. (a) $\Delta T_b = K_b m$ elevation in boiling point

$$K_b = \frac{\Delta T_b}{m}$$

$$\text{Unit of } K_b = \frac{\text{unit of } \Delta T_b}{\text{unit of m}} = \frac{K}{\text{molality}}$$

$$= \frac{K}{\text{mol kg}^{-1}} = \text{K mol}^{-1}\text{ kg}$$

11. (c) $\Delta T_f = iK_f m$ i.e., depression in freezing point is directly related to van't Hoff factor (i). Glucose is a non-electrolyte hence will remain undissociated. Hence for glucose value of i is 1 whereas for $MgCl_2$ value of *i* is 3. Hence, depression in freezing point of $MgCl_2$ is about 3 times of glucose.

12. (d) When an unripe mango is placed in a concentrated salt solution to prepare pickle then mango loose water due to osmosis and get shrivel.

13. (a) Osmotic pressure (π) = CRT.
For concentrated solution C has higher value than dilute solution.
Hence, as concentration of solution increases osmotic pressure also increase.

14. (a) The value of molal depression constant, K_f depends upon nature of solvent. Therefore two different solutions of sucrose of same molality prepared in different solvents will have different depression in freezing point.

15. (b) Number of total ions present in the solution is known as van't Hoff factors (i).

for KCl,	i = 2
for NaCl,	i = 2
for K_2SO_4,	i = 3

16. (b) In reverse osmosis, solvent molecules move through a semipermeable membrane from a region of higher concentration of solute to lower concentration.

17. (a) The value of Henry's constant (K_H) increases with increase in temperature.

18. (b) According to Henry's law
$p \propto x$
$\Rightarrow\ p = K_H x$
As value of K_H rises solubility of gases decreases.

19. (b) If a pressure higher than the osmotic pressure is applied on the solution, the solvent will flow from the solution into the pure solvent through the semi-permeable membrane. This process is called reverse osmosis.
Thus, in this case, if a pressure greater than osmotic pressure is applied on piston (B). Water will move from side (B) to side (A).

20. (c) As van’t hoff factor depends only on no. of dissociated ions. Hence, *i* will be independent on concentration of solutions.

21. (b) A mixture of bromoethane and chloroethane is an example of ideal solution. For an ideal solution, the A — A or B — B type intermolecular interaction is nearly equal to A — B type interaction.
Chloroform and acetone mixture is an example of non-ideal solution having negative deviation while ethanol-acetone mixture shows positive deviation.

22. (a) On adding salt to water to make the salt solution the vapour pressure of solution gets lowered. This is due

to the decrease in surface covered by solvent molecule which leads to decrease in number of solvent molecule escaping from the surface corresponding to pure solvent.

Hence, vapour pressure also get reduces.

23. (a) If two liquids A and B form minimum boiling azeotrope at some specific composition then A — B interactions are weaker than those of A — A and B — B. Because in case of positive deviation, we get minimum boiling azeotropes whereas in case of negative deviation we get maximum boiling azeotropes.

24. (d) As we know, $M_1V_1 = M_2V_2$

On putting values, we get

$0.02 \times 4\,L = M_2 \times 5L$

$$M_2 = \frac{0.08}{5} = 0.016\ M$$

25. (a) At specific composition methanol-acetone mixture will form minimum boiling azeotrope and will show positive deviation. This is due to weaker A — B interaction than A — A and B — B interaction.

26. (c) Value of K_H depends upon nature of gases dissolved in water. Higher the value of K_H at a given temperature the lower is the solubility of the gas in the liquid. Hence, correct order is :

$Ar < CO_2 < CH_4 < HCHO$.

NEET/AIPMT (2013-2017) Questions

27. (d) $$\text{Molarity (M)} = \frac{\text{wt} \times 1000}{\text{mol. wt.} \times \text{vol (ml)}}$$

$$2 = \frac{\text{wt.}}{63} \times \frac{1000}{250}$$

$$\text{wt.} = \frac{63}{2}\ \text{gm}$$

$$\text{wt. of 70\% acid} = \frac{100}{70} \times 31.5 = 45\ \text{gm}$$

28. (c) An ideal solution is that solution in which each component obeys Raoult's law under all conditions of temperatures and concentrations. For an ideal solution. $\Delta H_{mix} = 0$ and $\Delta V_{mix} = 0$.

29. (c) Colligative properties $\propto$ no. of particles. Since $Al_2(SO_4)_3$ contains maximum number of particles, hence will have the largest value of freezing point depression.

30. (c) $K_4[Fe(CN)_6] \rightleftharpoons 4K^+ + [Fe(CN)_6]^-$

and $Al_2(SO_4)_3 \rightarrow 2Al^{3+} + 3SO_4^{2-}$

$\therefore$ van't Hoff factor is 5 for both $Al_2(SO_4)_3$ and $K_4[Fe(CN)_6]$

31. (d) $\Delta T_b = iK_b m$

Given, $(\Delta T_b)_x > (\Delta T_b)_y$

$\therefore\ i_x K_b m > i_y K_b m$

(K_b is same for same solvent)

$i_x > i_y$

So, x is undergoing dissociation in water.

32. (a) For an ideal solution $\Delta S_{mix} > 0$

33. (d) $$\text{Molality} = \frac{W}{M} \times \frac{1}{V(kg)}$$

$$= \frac{n}{V(kg)} \qquad (\text{where } n_{solute} = W/M)$$

$$1.00\,m = \frac{n}{V(kg)} \quad \text{i.e., 1 mole in 1 kg of water}$$

Moles of 1 kg H_2O

$$= \frac{1000g}{18g / mol} = 55.55 \text{ mole}$$

Moles of solute = 1

Mole fraction

$$= \frac{n_{solute}}{n_{solute} + n_{water}} = \frac{1}{(1 + 55.55)}$$

$= 0.01768 = 0.0177$

34. (a) $$\left(\frac{P^\circ - P_s}{P^\circ}\right) = \frac{n}{N} = \frac{W_1}{M_1} \times \frac{M_2}{W_2}$$

Where, W_1 = wt of solute

W_2 = wt of solvent

M_1 = Mass of solute

M_2 = Mass of solvent

at 100°C, $P^\circ = 760$ mm

$$\frac{760 - 732}{760} = \frac{6.5 \times 18}{M_1 \times 100}$$

$$M_1 = 31.75\ g\,mol^{-1}$$

$$\Delta T_b = m \times K_b = \frac{W_1 \times 1000}{M_1 \times W_2} \times K_b$$

$$\Delta T_b = \frac{0.52 \times 6.5 \times 1000}{31.75 \times 100} = 1.06°C$$

$\therefore$ boiling point of solution

$= 100°C + 1.06°C = 101°C$

35. (c) K_f (molal depression constant) only depends on the nature of the solvent and is independent of the concentration of the solution.

36. (a) Molarity depends on the volume of a solution which can be changed with change in temperature.

37. (a) Let us consider that A is benzene and B is toluene

1 : 1 molar mixture of A and B

$$\therefore \quad x_A = \frac{1}{2} \text{ and } x_B = \frac{1}{2}$$

Total pressure of solution (P) = $P_A^0 x_A + P_B^0 x_B$

$$P = 12.8 \times \frac{1}{2} + 3.85 \times \frac{1}{2} = 8.325\ kPa$$

$$Y_A = \frac{P_A^0 x_A}{P} = \frac{12.8 \times \frac{1}{2}}{8.325} = 0.768$$

$\therefore\ y_B = 1 - y_A = 1 - 0.768 = 0.232$

so, the vapour will contain higher percentage of benzene.