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XII NEET

1 SOLUTIONS

CHEMISTRY

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CHEMISTRY

SOLUTIONS

NEET

The chapter Solutions is an essential part of the NEET Chemistry syllabus, covering concepts related to mixtures, solubility, colligative properties, and concentration expressions. Understanding this chapter is crucial for solving numerical problems and grasping real-world applications in medicine, environmental science, and industry.

A solution is a homogeneous mixture of two or more substances. The substance present in a larger amount is called the solvent, while the substance dissolved in it is the solute. Solutions can exist in different phases—solid, liquid, or gas—depending on the nature of the solute and solvent

KEY TOPIC IN SOLUTIONS:

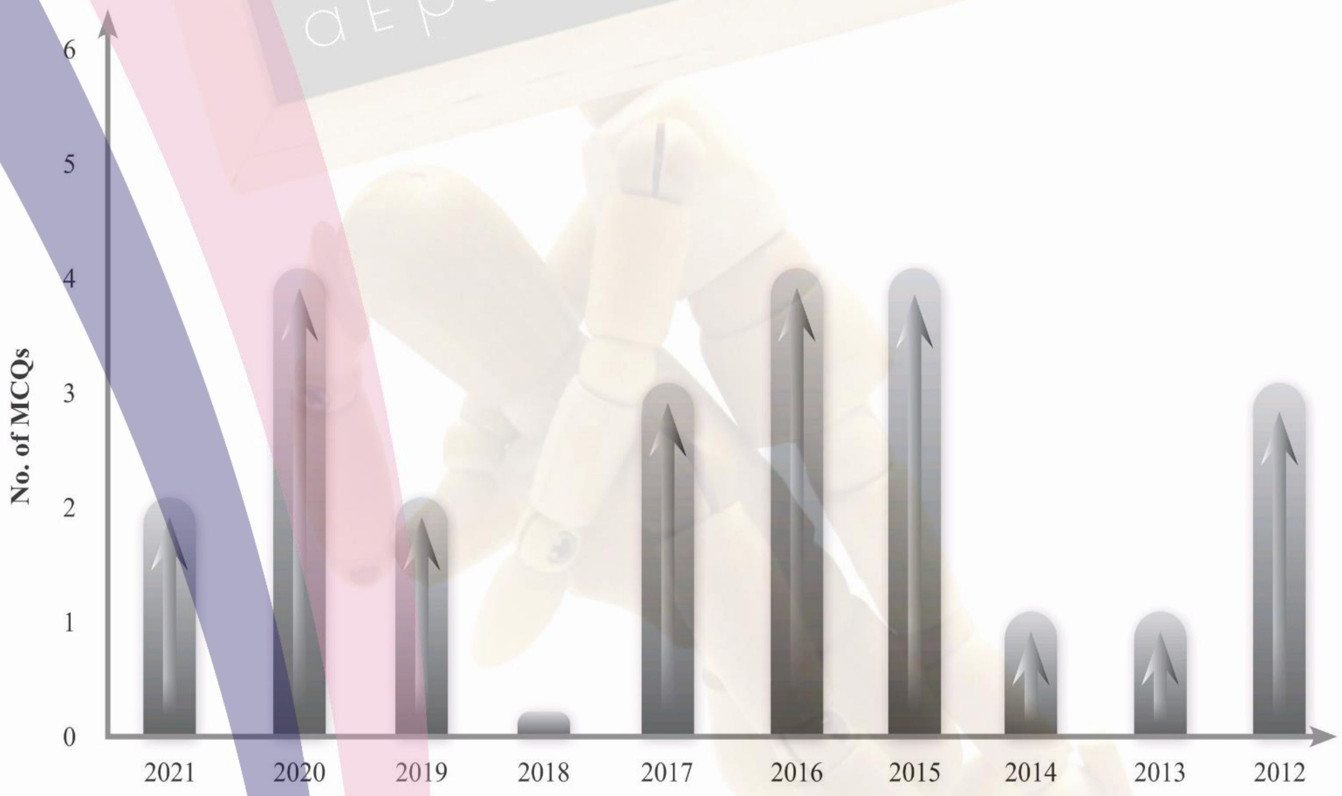
1. Types of Solutions (solid, liquid, gaseous)
2. Solubility and Factors Affecting It (temperature, pressure, nature of solute and solvent)
3. Concentration Expressions (molarity, molality, normality, mole fraction, mass percentage)
4. Colligative Properties (boiling point elevation, freezing point depression, osmotic pressure, relative lowering of vapor pressure)
5. Ideal and Non-Ideal Solutions
6. Abnormal Molar Masses (Van't Hoff factor)

TIPS FOR STUDYING SOLUTIONS FOR NEET

- **Understand the Basics** – Focus on the definitions and types of solutions before diving into numerical problems.
- **Master Concentration Terms** – Learn different ways to express concentration and practice converting between them.
- **Practice Numerical Problems** – Colligative properties often involve calculations, so solving problems regularly will help.
- **Use Mnemonics & Shortcuts** – Remember key formulas using simple tricks.
- **Refer to NCERT** – NCERT Chemistry is the best resource for NEET preparation, as most questions are based on its content.
- **Solve Previous Year Questions** – This will help you understand the pattern and difficulty level of NEET questions.
- **Revise Regularly** – Make concise notes and revise formulas frequently.

SOLUTIONS

Past Years NEET Trend



Investigation Report

TARGET EXAM	PREDICTED NO. OF MCQs	CRITICAL CONCEPTS
NEET	2-3	• Calculations based on Raoult's law of Relative lowering of vapour presure and other colligative properties

Perfect Practice Plan

Topicwise Questions	Learning Plus	Multiconcept MCQs	NEET Past 10 Years Questions	Total MCQs
120	35	23	24	202

INTRODUCTION

Homogeneous mixture of two or more substances whose composition vary within certain limits is known as **True Solution.** Eg: Salt in water, sugar in water.

In a homogeneous mixture composition is same throughout the mixture.

A binary solution contains two components-solute and solvent only.

Solute

The component that is present in a lesser amount or the component that loses its physical state (not always) (or) dissolved substance (or) dispersed phase.

Solvent

The component that is present in a greater amount or the component that retains its physical state or dispersion medium (or) dissolving medium.

PROPERTIES OF SOLUTION

It is a homogeneous mixture.

Formation of solution is only a physical change but not a chemical change.

Solute cannot be separated from solution by filtration.

The properties of a solution like density, vapour pressure, boiling point depend on relative amount of solute and solvent.

Variables like pressure, temperature and composition may affect the properties of the solutions.

The effect of pressure on solid solutions is negligible.

TYPES OF SOLUTION

Based on Physical States of Matter

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

✍ **KEY NOTE**

Gases on intermixing produce true solution.

METHODS OF EXPRESSING CONCENTRATIONS OF SOLUTIONS

The quantity of solute present in definite quantity of the solution relative to the solvent is known as **Concentration of solution** or **strength of solution**.

Standard Solutions: The solution whose concentration is known.

Dilute Solution: The solution containing relatively smaller quantity of solute compared to that of solvent.

Concentrated Solution: The solution that contain excess solute, in a fixed quantity of the solution.

Weight of Solution = Volume of the solution × density of solution (W = V × d).

There are several ways by which we can calculate the concentration of solution:-

(i) Percentage(%)

(*a*) **Mass Percentage (w/w):** It is defined as weight/mass of solute present in 100 g of solution.

$$\% w/w = \frac{weight\ of\ solute\ (g)}{weight\ of\ solution\ (g)} \times 100$$ = weight of solute/100 g of solution.

It does not change on changing temperature.

Ex. 10% w/w urea solution = 10 gm of urea is present in 100 gm of solution.

= 10 gm of urea is present in 90 gm of water.

(*b*) **Mass by Volume percentage (w/v):** It is mass of solute dissolved in 100 ml of solution.

% w/v = wt. of solute/100 mL of solution

$$\% w/v = \frac{gram\ \ of\ solutes}{vol. of\ solution\ in\ mL} \times 100$$

It changes on changing temperature.

Ex. 10% (w/v) urea solution. = 10 gm of urea is present in 100 mL of solution.

But not 10 gm of urea present in 90 ml of water

for dilute solution : vol. solution = vol. solvent.

(*c*) **Volume Percentage (v/v)**

If both solute & solvent are liquids = volume in (mL) of solute per 100 mL of solution.

$$V\% = \frac{Volume\ of\ component}{Total\ volume\ of\ solution} \times 100$$

Ex. 10% v/v ethanol aq solution = 10 ml of ethanol in 100 ml of solution.

≠ 10 ml of C_2H_5OH in 90 ml of H_2O

(ii) Strength of Solution

Weight of solute (in gram) in a per litre (1000 mL) of solution.

Strength

Weight of solute (in grams) dissolved in per litre of solution. (g/litre)

Strength = Equivalent weight × Normality

(iii) PPM (Parts per Million)

It is the mass of the solute present in million (10^6) parts by mass of the solution

$$ppm = \frac{Mass\ of\ solute \times 10^6}{Mass\ of\ solution}$$

(iv) Molarity (M)

It is number of gram moles of solute dissolved per litre of solution.

Unit = Moles/litre

Molarity decreases with increase in temperature.

$$M = \frac{n}{V_{(Lit)}}$$

Where, n = number of moles of solute; V= Volume of Solution in litres.

n = VM

$$M = \frac{W}{M.Wt} \times \frac{1}{V_{lit}}$$

$$\mathbf{M} = \frac{\mathbf{W}}{\mathbf{M.Wt}} \times \frac{\mathbf{1000}}{\mathbf{V_{ml}}}$$

(v) Normality (N)

It is number of gram equivalents of solute dissolved per litre of solution.

Unit = gm. equivalents / litre

Normality decreases as temperature increases.

$$N = \frac{No.\ of\ \ gm\ equivalents\ of\ \ solute}{volume\ of\ \ solution\ in\ litres}$$

$$N = \frac{W}{E.W} \times \frac{1}{V_{lits}}$$

$$\mathbf{N} = \frac{\mathbf{W}}{\mathbf{E.W}} \times \frac{\mathbf{1000}}{\mathbf{V_{ml}}}\ ;\ \ W = \frac{N \times E.W \times V}{1000}$$

> ✍ **KEY NOTE**
>
> When a solution is diluted or two solutions of different substances react, then $V_1N_1 = V_2N_2$

Equivalent Weight (E)

It is the number of parts by weight of a substance that combine or displace 1.008 parts by weight of hydrogen or 35.5 parts by weight of chlorine or 8 parts by weight of oxygen.

It is represented by E.

It is a relative value, no units.

Equivalent weight expressed in grams is known as gram equivalent weight or gram equivalent.

$$\text{Number of gram equivalents} = \frac{\textit{Weight of the substance in gms}}{\textit{Gram equivalent weight}}$$

Equivalent weight of Acids

$$E_{acid} = \frac{M\ Wt}{Basicity}$$

Basicity is the number of replaceable hydrogen atoms by metal ions in a molecule of an acid.

Equivalent weight of Base

$$E_{base} = \frac{M.wt}{Acidity}$$

Acidity is the number of hydroxyl groups present in a molecule of the base.

> ✍ **KEY NOTE**
>
> **Relation between Molarity and Normality**
>
> - M×M.wt. = N × E.W
>
> $$N = M \times \frac{M.W}{EW}$$
>
> Gram molecular wt = n × Gram equivalent wt
>
> Where n = Valency (or) Basicity (or) Acidity (or) number of electrons transferred.

(vi) Molality (m)

It is the number of gram moles of solute dissolved per kg of solvent.

Unit is Moles / kg of solvent.

It is a standard method of expressing concentration while molarity is a convenient method of expressing concentration.

$$m = \frac{n}{W_{Solvent(in\ Kg)}}$$

$$m = \frac{W}{M.wt} \times \frac{1}{W_{solvent\ in\ Kg}}$$

$$m = \frac{W}{M.W} \times \frac{1000}{W_{Solvent\ in\ g}}$$

(vii) Mole Fraction(x)

It is ratio between number of moles of one particular component to the total number of moles of all the components of solution.

It has no unit.

$$x_2 = \frac{No.\ of\ \ moles\ of\ \ solute(n_2)}{Total\ no.\ of\ \ moles\ in\ solution(n_1 + n_2)}$$

> ✍ **KEY NOTE**
>
> Molality, mole fraction and mass fraction do not change with temperature

TRAIN YOUR BRAIN

Q. If we have 6% w/w urea solution with density 1.060 gm/mL then calculate its strength in g/L.

Ans. 6 g in 100 gm solution.

$$6\ g\ in\ \frac{100}{1.060}\ mL$$

$$\frac{100}{1.060} mL \to 6\ gm$$

$$\therefore\ 1000\,mL = \frac{6}{100}\times 1.060\times 1000 = 10.6\times 6 = 63.6$$

Q. If we have 10 molal urea solution calculate mole fraction of urea in this solution & also calculate % w/w of urea. (MW = 60)

Ans. (*i*) 10 moles urea in 1000 gm of water

$$X_{urea} = \frac{10}{10+\frac{1000}{18}} = \frac{10}{65.55} = 0.152$$

$$\%\ \text{w/w weight of urea} = \frac{10\times 60}{10\times 60+1000}\times 100\% = 37.5\%$$

(viii) Formality (F)

This is the concentration unit for ionic compounds that dissolve in a polar solvent to give pair of ions. This represents number of gramformula - weight of the substance dissolved per litre of the solution. It is almost the same as molarity. It describes the solute that is mixed in a liquid rather than the solute present in solution after the dissolution process.

$$Formality = \frac{moles\ of\ substance\ added\ to\ solution}{volume\ of\ solution\,(in\ litres)}$$

SOLUBILITY

Solubility of Solid in Liquid

The amount of solute that is dissolved in 100g of a solvent to form a saturated solution at a given temperature is known as the solubility of solute.

Unsaturated Solution

A solution in which more solute can be dissolved without increasing temperature is called an unsaturated solution.

Saturated Solution

A solution in which no more solute can be dissolved further at a given temperature is called a saturated solution.

The maximum amount of a solute that can be dissolved in a given amount of solvent (generally 100g) at a given temperature is termed as its **"solubility"** at that temperature.

In a saturated solution there exists a dynamic equilibrium between the undissolved and dissolved ions or molecules in solution.

At equilibrium

Rate of dissolution $\rightleftharpoons$ Rate of crystallization

A supersaturated solution is metastable

Factors influencing solubility of solids:

(*a*) Temperature

If the dissolution, is endothermic ($\Delta H_{sol} > 0$) the solubility increases with increase in temperature e.g. $NaNO_2$, KNO_3, NaCl

If the dissolution process is exothermic ($\Delta H_{sol} < 0$), solubility is decreasing with increasing in temperature.

(*b*) Pressure

It has no significant effect on solubility because solids and liquids are highly incompressible.

(*c*) Nature of Solute / Solvent (solubilities of Ionic solids)

The smaller the value of lattice energy and more is the value of heat of hydration more is the solubility of ionic compounds.

Ionic solids dissolve more in a solvent having high dielectric constant

Solubilities of Molecular Solids (Non-Ionic Solids)

Molecular solids containing polar groups (e.g. OH) are soluble in polar solvents like water, methanol etc. Others are soluble in non polar solvents.

Solubility of Gases in Liquids

It is generally expressed in terms of absorption coefficient which is defined as the volume of the gas in ml which can be dissolved by 1ml of a liquid solvent at the temperature of the experiment at 1atmospheric pressure.

Absorption coefficient of some gases at 20°C

Factors Influencing the Solubility of a Gas

Nature of Gas

Easily liquifiable gases are more soluble. e.g. CO_2 is more soluble than O_2 and H_2

Nature of Solvent

Gases that are capable of forming ions in aqueous solution are more soluble in water than in other solvents .

eg.HCl, NH_3 etc.

Temperature

Solubility decreases with rise of temperature at constant pressure.

Pressure of the Gas

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.

$m \propto p$ or $m = K_H P$, where K_H is Henry's constant

The most commonly used form of Henry's law states that the **partial pressure of the gas in vapour phase (p) is proportional to the mole fraction of the gas (x) in the solution"** and is expressed as $p = K_H x$, here K_H is the Henry's law constant.

Higher the value of K_H at a given pressure, the lower is the solubility of the gas in the liquid.

Table: Value of Henry's Constant for Different Gases

Gas	Temperature / K	K_H/ Kbar	Gas	Temperature / K	K_H/kbar
He	293	144.97	Argon	298	40.3
H_2	293	69.16	CO_2	298	1.67
N_2	293	76.48	Formaldehyde	298	1.83×10^{-5}
N_2	303	88.84	Methane	298	0.413
O_2	293	34.86	Vinyl chloride	298	0.611

Limitations of Henry's Law

(*i*) Pressure is not very high and temperature should not very low
(*ii*) Gas not highly soluble
(*iii*) Gas should not form any compound with solvent
(*iv*) Gas should not undergo dissociation

Application of Henry's law

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

Sea divers use air diluted with He(11.7% He, 56.2% N_2 and 32.1% O_2) to avoid a condition known as **'bends'** to cope up with high 'P' under water.

At high altitudes, when partial pressure of O_2 is less, it leads to a condition known as **'Anoxia'**. They should carry O_2.

VAPOUR PRESSURE OF LIQUID SOLUTION

The pressure exerted by vapour over a liquid when they are in equilibrium with each other is known as vapour pressure.

Vaporization increases with surface area and temperature.

Vapour pressure is independent of surface area.

Vapour pressure varies exponentially with temperature.

When temperature is increased KE of molecules increases, more number of molecules convert to vapour form and more will be the vapour pressure.

The vapour pressure of a liquid is called **saturated vapour pressure**, because the atmosphere over liquid is saturated with vapour of the liquid, exerts pressure on the liquid.

The vapour pressure of water is known as **aqueous tension**.

Boiling Point

Volatile liquids have high Vapour Pressure and low Boiling Point.

Eg: - Ether, Methyl alcohol, Acetone, Benzene, Carbon tetrachloride, Carbon disulphide

Non volatile liquids have low vapour pressure and .high boiling point.

Eg: - H_2O, Aniline, Nitrobenzene

Vapor Pressure of Solid-Liquid Solutions

Raoult's Law for Non Volatile Solute

The relative lowering of vapour pressure of a dilute solution containing a non-volatile solute is equal to mole fraction of solute.

$$\frac{P^0-P}{P^0}=x_2 \qquad \frac{P^0-P}{P^0}=\frac{n_2}{n_1+n_2}$$

for very dilute solutions

$$\frac{P^0-P}{P^0}=\frac{n_2}{n_1} \Rightarrow \frac{P^0-P}{P^0}=\frac{w}{m}\times\frac{M}{W}$$

Where P^0 = V.P of pure solvent
P = V.P of pure solution
w = wt. of solute
m = M.Wt of solute
W = Wt. of solvent
M = M.Wt of solvent

Vapour Pressure of Liquid-Liquid Solution

Raoult's Law for Volatile Solute

The partial pressure of a volatile component of a solution is directly proportional to its mole fraction in solution at any temperature.

$P_A \propto X_A$ and $P_B \propto X_B$ and
$P_A = P_A^0 .X_A$, $P_B = P_B^0 .X_B$
Where P_A = partial pressure of component A,
P_A^0 = vapour pressure of component A in pure form,
$X_{A'}$ = mole fraction of component A in solution
$P_T = P_A + P_B$
$P_A = \gamma_A P_T$
$P_B = \gamma_B P_T$
Where, γ_A and γ_B are the mole fraction of components A and B in vapour phase respectively.

Particle concentration in Solution

Molar concentration of solution × number of ions formed from one molecule of Solute

Eg: - (1) In 0.01M Aqueous solution of $Al_2(SO_4)_3$

$$\left[Al^{3+}\right]=0.02;[SO_4^{2-}]=0.03\text{ M}$$

Total particle concentration =0.05M
Particle concentration of 0.01M glucose solution is 0.01M

✍ KEY NOTE

- LVP ∝ particle concentration.
- $VP \propto \dfrac{1}{particle\,concentration}$

Limitations of Raoult's Law

It is applicable for very dilute solutions only.

It is applicable for dilute solutions containing non-volatile solute only.

It is applicable for solutions containing solutes, which neither associate nor dissociate.

It is applicable for ideal solutions only.(Solutions in which solute and solvent do not have interaction).

AN IDEAL SOLUTION AND NON IDEAL SOLUTION

(1) The solution that obey Raoult's law at all temperatures and concentrations is known as ideal solution.
(2) ΔH_{mix} = 0 i.e. no heat is evolved or absorbed when components are mixed to form the solution.

(3) $\Delta V_{mix} = 0$ i.e. no change in volume. In ideal solution the A -B intermolecular interactions are the same as A -A and B -B inter molecular interactions

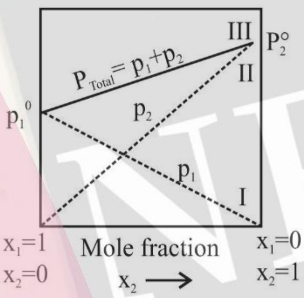


Fig.: The plot of vapour pressure and mole fraction of an ideal solution at constant temperature

In an ideal solution of two components A_2 and B_2, all interactions, i.e. (A -A, B -B and A -B) must be identical.

Two liquids on mixing will form an ideal solution if following conditions be satisfied:

(*i*) Both have similar structures

(*ii*) Both have similar molecular sizes

(*iii*) Both have identical intermolecular forces strictly there is no attraction and repulsions

The following pairs almost behave as ideal solutions:-

(*a*) Benzene and toluene

(*b*) Ethyl bromide and ethyl chloride

(*c*) n - Heptane and n- hexane

(*d*) Chlorobenzene and bromobenzene

(*e*) Ethyl iodide and ethyl bromide.

Non-ideal Solutions

1. Solutions which do not obey Raoult's law is known as non ideal solution
2. $\Delta H_{mix} \neq 0$
3. $\Delta V_{mix} \neq 0$

Type of non ideal solutions:

They are of two types

(I) Showing Positive Deviations from Raoult's law

For such solutions

(*a*) A- B inter - molecular interactions are weaker than A - A and B -B intermolecular interactions

(*b*) ΔH_{mix} is + ve & ΔV_{mix} is + ve

(*c*) $P_{total} > P_A^o.x_A + P_B^o.x_B$

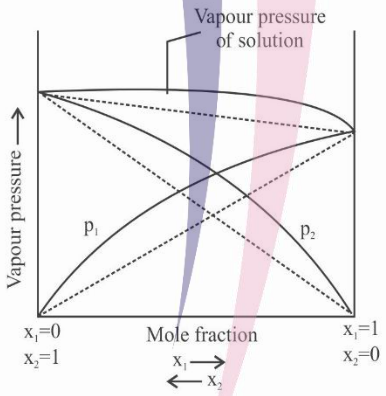


Fig.: A solution that shows +ve deviation from Raoult's Law

Examples:

(*i*) Carbon tetrachloride +benzene

(*ii*) Carbon tetrachloride + chloroform

(*iii*) Carbon tetrachloride + Toluene

(*iv*) Acetone + Carbon disulphide

(*v*) Acetone +Ethyl alcohol

(*vi*) Acetone + Benzene

(*vii*) Methyl alcohol + Water

(*viii*) Ethyl alcohol + Water

(II) Showing Negative Deviations From Raoult's Law

For such solutions

(*a*) A-B intermolecular interactions are stronger than A-A and B-B intermolecular interactions

(*b*) ΔH_{mix} is –ve & ΔV_{mix} is –ve

(*c*) $P_{total} < P_A^o.x_A + P_B^o.x_B$

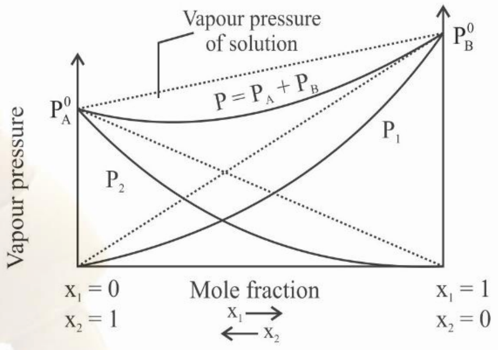


Fig.: A solution that show negative deviation from Raoult's Law

Examples:

(*i*) Chloroform + Acetone

(*ii*) Chloroform + Benzene

(*iii*) Chloroform + Diethyl ether

(*iv*) Acetone + Aniline

(*v*) HCl + Water

(*vi*) HNO_3 + Water

Azeotropic mixture or constant Boiling mixture

Mixture of two or more components that is like a pure chemical compound boils and distills over completely at the same temperature without change in composition is called an azeotrope. Non ideal solutions form azeotropes.

There are two types of azeotropes

Azeotropic mixture with minimum Boiling point

Formed by liquids showing positive deviation. An intermediate composition of liquids having highest vapour pressure, thus lowest boiling point gives this azeotrope . Such azeotropes have boiling points lower than either of the pure component eg. Rectified spirit (ethanol 95.5% + H_2O 4.50%) contstant boiling point 351.15 K.

Azeotropic mixture with maximum boiling point

It is formed by liquids showing negative deviation. An intermediate composition of liquids having minimum vapour pressure, thus highest boiling point gives this azeotrope. Such azeotropes have boiling points higher than either of the pure components.

e.g. Water & HNO_3 (HNO_3 68% + H_2O 32%) constant boiling point 393.5K

COLLIGATIVE PROPERTIES

The properties of dilute solutions that depend on the number of particles (ions or molecules) of the solute dissolved in the solution are called **colligative properties**.

1. Relative lowering of Vapour Pressure

Ostwald's dynamic method is based on the measurement of RLVP of a solution due to addition of a non volatile solute.

Lowering of Vapour Pressure

When a non volatile solute is added to a solvent, the vapour pressure decreases.

In a solution, the surface is not only occupied by solvent molecules but also by solute molecules.

The number of molecules of solvent present on surface are relatively less in solution than that of pure solvent as some solvent molecules on the surface are displaced by solute molecules.

The number of molecules converting to Vapour form are less (vaporization is less). Therefore vapour pressure is less.

RLVP as per Raoult's law, is equal to the mole fraction of solute

$$\frac{P^o - P}{P^o} = x_s$$

Where x_s = mole fraction of solute; $P_o - P$ is lowering of vapor pressure.

$$\frac{P^o - P}{P^o} = \frac{n_s}{n_o + n_s}$$

$$n_s = \frac{a}{M} : n_o = \frac{b}{W}$$

For dilute solutions $n_s < n_o$

$$\boxed{\frac{P^o - P}{P^o} = \frac{a}{M} \times \frac{W}{b}} \quad or \quad \boxed{M = \frac{a \times W}{b} \times \frac{P^o}{\left(P^o - P\right)}}$$

TRAIN YOUR BRAIN

Q. Dry air was passed through a solution of 5 g of a solute in 80 g of water & then it is passed through pure water loss in wt. of solution was 2.50 g & that of pure solvent was 0.04 g. Calculate M.W. of solute.

Ans. $\frac{P - P_s}{P_s} = \frac{loss\ in\ wt. of\ solvent}{loss\ in\ wt. of\ solution}$

$$\Rightarrow \frac{P - P_s}{P_s} = \frac{0.04}{2.50} = \frac{5}{M} \times \frac{18}{80}$$

$M = 70\ g\ mol^{-1}$

2. Elevation in Boiling Point

The temperature at which the vapour pressure of a liquid becomes equal to the atmospheric pressure (i.e., one atmosphere) is known as the **boiling point of the liquid.**

The vapour pressure (P) of a dilute solution of the non-volatile solute is less than the vapour pressure of the pure solvent (P°) in which the non-volatile solute is dissolved.

Boiling point of solution (T) is greater than the boiling point of solvent (T°)

$(T - T^o) = \Delta T_b$, where ΔT_b is elevation of Boiling point.

For dilute solution elevation of boiling point (ΔT_b) is directly proportional to the molal concentrarion of the solute in a solution.

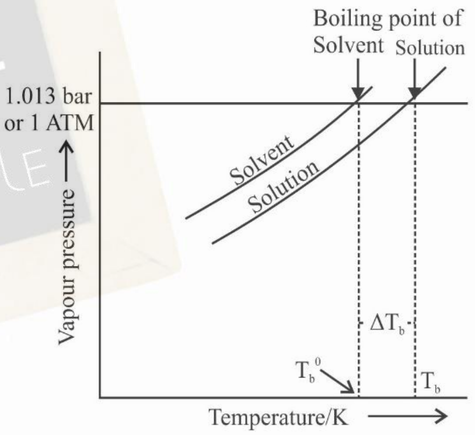


Fig.: The vapour pressure curve for solution lies below the curve for pure water

ΔT_b and K_b are related by the equation

$$\boxed{\Delta T_b = K_b \times m} \quad \text{or} \quad \boxed{\Delta T_b = K_b \times \frac{a}{M} \times \frac{1000}{b}}$$

Where, m is molality and Kb is molal elevation constant.

The elevation in boiling point observed in one molal solution of a non-volatile solute is called molal elevation constant (K_b) (or) Ebullioscopic constant.

$$K_b = \frac{RT_o^2}{1000 l_{vap}} = \frac{M_A RT_o^2}{1000 \Delta H_{vap}}$$

The molal elevation constant of a solvent does not change with the change in the nature of solute dissolved in it.

TRAIN YOUR BRAIN

Q. Calculate K_b of water if L_{vap} = 540 Cal/gm T_b = 100°C

Ans. $K_b = \frac{2 \times 373 \times 373}{1000 \times 540} = 0.52\,K\ kg\,mol^{-1}$

3. Depression of Freezing point

Freezing point is the temperature at which the solid form of liquid begins to separate out from the liquid. At this temperature solid and liquid will be in equilibrium.

When non volatile solute is dissolved in a solvent the freezing point decreases.

For dilute solutions the curves are considered almost linear.

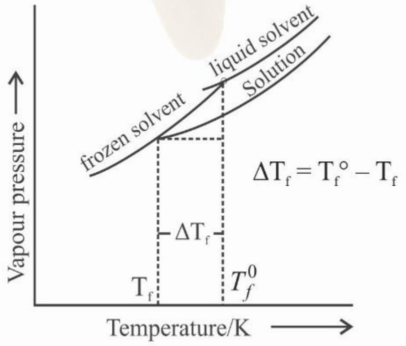


Fig.: Diagram showing ΔT_f depression of the freezing point of a solvent in a solution

ΔT_f and K_f are related by the equation

$$\boxed{\Delta T_f = K_f \times m} \text{ or } \boxed{\Delta T_f = K_f \times \frac{a}{M} \times \frac{1000}{b}} \text{ or } \boxed{K_f = \frac{MRT_f^2}{1000(\Delta_{\text{freezing}} H^o)}}$$

$\Delta_f H^o$ = standard enthlapy of freezing.

The depression of freezing point observed in 1 molal solution of a non volatile solute is known as K_f

K_f depends on chemical nature of solvent but not solute in the solution.

Rast method is used for measuring depression in freezing point

KEY NOTE

- Colligative property $\propto \dfrac{1}{\text{Molar mass of solute}}$
- Boiling point of solution ∝ no. of ions present in solute
- Freezing point of solution ∝ $\dfrac{1}{\text{no.of ions present in a solute}}$

TRAIN YOUR BRAIN

Q. Calculate the freezing point of a solution of a non-volatile solute in a unknown solvent of molar mass 30 g/mole having mole fraction of solvent equal to 0.8. Given that latent heat of fusion of solid solvent = 2.7 kcal mol^{-1}, freezing point of solvent = 27°C and R = 2cal mol^{-1} k^{-1}.

Ans. $\because K_f = \dfrac{MRT_f^2}{1000\,\Delta H_f} = \dfrac{2 \times 300 \times 300 \times 30}{1000 \times 2700} = 2.00 \text{ K kg mol}^{-1}$

mole fraction of water = 0.8

$\therefore$ mole fraction of solute = 0.2

$$or\ 0.2 = \frac{n}{n+N} \ and\ 0.8 = \frac{N}{n+N}$$

$$\therefore \frac{n}{N} = \frac{0.2}{0.8} = \frac{1}{4} = \frac{wM}{mW}$$

$$or\ \frac{1}{4} = \frac{w \times 30}{mW} \quad \therefore \frac{w}{mW} = \frac{1}{4 \times 30}$$

$$\therefore \Delta T_f = \frac{100 \times w \times K_f}{m \times W} = \frac{1000 \times 2.0}{4 \times 30} = 16.67$$

F.P of solution = 10.33°C

4. Osmosis

The spontaneous flow of the solvent through semipermeable membrane from pure solvent to solution (or) from a dilute solution to concentrated solution is known as **osmosis**.

The membranes which allow to pass only solvent molecules through it but not solute molecules is called semipermeable membrane.

Osmotic Pressure (π)

The hydrostatic pressure produced on the aqueous dilute solution at equilibrium state due to inflow of water when the solution is separated from the water by a semipermeable membrane.

(or)

The pressure required to be applied on the solution to prevent the inflow of solvent into the solution, when the solution is separated from the solvent by a semipermeable membrane.

Vant Hoff's theory of dilute Solutions

According to vant Hoff's, dilute solutions behave as gases. Hence the laws that applicable to gases are also applicable to dilute solutions.

Vant Hoff's Boyle's Law

At constant temperature the osmotic pressure (π) of a dilute solution is directly proportional to its concentration (C)

$\pi \propto C \qquad$ (C = mole / litre)

$$\pi \propto \frac{1}{V} \quad \left(\because C \propto \frac{1}{V}\right)$$

$$\pi V = K \qquad ...(1)$$

Vant Hoff's Charle's Law

The osmotic pressure (π) of a solution of constant concentration (C) is directly proportional to the temperature in Kelvin Scale (T)

$\pi \propto T$

$$\pi = KT \qquad ...(2)$$

from (1) and (2) $\pi \propto \dfrac{T}{V}$

$$\pi = S\frac{T}{V}$$

$$\therefore \pi = CST \quad \left(\because \frac{1}{V} = C\right)$$

here S = solution constant

The value of 'S' is similar to the value of 'R' (gas constant)

Hence $\pi V = RT$ for 1 mole

for 'n' mole $\boxed{\pi V = nRT}$

If 'a' is weight of the solute and 'M' is its molecular weight then

$$n = \frac{a}{M}$$

for 'n' moles $\pi V = \dfrac{a}{M} RT$

$$\boxed{\text{(a) } M = \frac{aRT}{\pi V} \qquad \text{(b) } M = \frac{aRTC}{\pi}}$$

Reverse Osmosis

When a pressure greater than that of osmotic pressure is applied on solution side, then the solvent from the solution flows into pure solvent and this process is called **reverse osmosis**.

It used in desalination of sea water

Isotonic Solutions

At a given temperature, solutions of same osmotic pressure are called isotonic solutions:

eg: Blood is isotonic with saline (0.9% w/v NaCl solution)

Consider two solutions I and II having n_1 and n_2 moles of the solute in V_1 and V_2 litres of the solution respectively. Let P_1 and P_2 be their osmotic pressures at the same temperature (T)

If $P_1 = P_2$ i.e., isotonic solutions

then $\frac{n_1}{V_1} = \frac{n_2}{V_2}$

$$\boxed{\frac{W_1}{M_1V_1} = \frac{W_2}{M_2V_2}}$$

Hypotonic solutions: Solutions having lower osmotic pressure

Hypertonic Solutions: Solutions having higher osmotic pressure

Plasmolysis

The flow of the liquid from the plant cell when placed in a hypertonic solution is called **plasmolysis**. The plant cell undergoes shrinkage. It is an example to **exo-osmosis.**

Haemolysis

When a plant cell is placed in hypotonic solution then the solvent flows into plant cell. This is known as **Haemolysis**. The plant cell finally bursts. It is an example to **endo-osmosis**.

TRAIN YOUR BRAIN

Q. Calculate osmotic pressure of 0.1 M urea aqueous solution at 300 K ,

Ans. R = 0.082 lit atm K^{-1}

$\pi = CRT$

$\pi = 0.1 \times 0.082 \times 300$

$\pi = 2.46$ atm

Osmotic pressure of very dilute solution is also quite significant so its measurement in lab is very easy.

ABNORMAL MOLAR MASS

Colligative properties are shown by dilute solutions.

Electrolytes undergo ionisation in aqueous solutions, as a result number of particle in the solution increases thus magnitude of colligative properties increases.

Colligative property and molar mass of solute are inversely proportional to each other.

So molar mass of electrolytic solutes determined experimentally is less than true value.

Some solutes when dissolved in solvents may undergo association i.e, solute molecules combine to form dimers or trimers etc.

Association of solute particles

Due to association number of particles in the solution decreases, as a result magnitude of colligative property decreases. So, molar mass of such solute will be higher than true value.

The dissociation result in the increase in total number of particles & thus value of colligative properties of solution will be higher. So, molar mass of such solute will be less than true value.

Van't Hoff Factor (*i*)

Van't Hoff introduced a factor '*i*' in the equations to equalise the experimental value and calculated value.

$$i = \frac{\text{experimental value of colligative property}}{\text{Calculated value of colligative property}}$$

$$i = \frac{\text{observed osmotic pressure}}{\text{Calculated osmotic pressure}}$$

Van't Hoff factor and degree of dissociation

For solutes which undergo dissociation: Let a solute on ionisation gives 'n' ions (particles) and 'α' is degree of ionisation at the given concentration, we will have [1+(n–1) α] particles (ions) after ionisation

$A_n \leftrightarrow nA$

$1 \qquad 0$

$1-\alpha \qquad n\alpha$

$$i = \frac{\text{no.of particles after dissociation}}{\text{no.of particles before dissociation}}$$

$$i = \frac{\left[1+(n-1)\alpha\right]}{1}$$

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

'α is degree of dissociation or ionisation.

Salt	Van't Hoff Factor i for complete dissociation of solute
NaCl	2.0
KCl	2.0
$MgSO_4$	2.0
K_2SO_4	3.0

Van't Hoff factor & degree of association

For solutes which undergo association

If 'n' molecules of 'A' combine to give A_n, we have

$nA \rightleftharpoons A_n$

$1 \qquad O$

$1-\alpha \qquad \frac{\alpha}{n}$

(α=degree of association at the given concentration)

$\therefore$ Total particle after association $= 1-\alpha+\frac{\alpha}{n}$

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

$$\boxed{\alpha_{association} = \frac{i-1}{\frac{1}{n}-1}} \quad or \quad \boxed{\alpha_{association} = \frac{1-i}{1-\frac{1}{n}}}$$

Topicwise Questions

EXPRESSING CONCENTRATIONS OF SOLUTIONS

1. The density of a solution prepared by dissolving 120 g of urea (molecular mass = 60 g) in 1000 g of water is 1.15 g/ml. The molarity of this solution is:
(*a*) 1.78 M (*b*) 1.02 M
(*c*) 2.05 M (*d*) 0.50

2. When the volume of the solution is doubled, the following becomes exactly half
(*a*) Molality (*b*) Mole-fraction
(*c*) Molarity (*d*) Weight percent

3. A semi molar solution is the one, which contains
(*a*) One mole solute in 2 litres
(*b*) 2 moles solute in 2 litres
(*c*) 0.1 mole solute in 1 litre
(*d*) 0.2 moles solute in 2 litres

4. 1 kg of NaOH is added to 10 ml of 0.1N HCl, the resulting solution will
(*a*) Turn blue litmus red
(*b*) Turn phenolphthalein solution pink
(*c*) Turn methyl orange red
(*d*) Will have no effect on red or blue litmus paper

5. What is the mole fraction of glucose in 10% w/w glucose solution?
(*a*) 0.01 (*b*) 0.02
(*c*) 0.03 (*d*) 0.04

6. Normality of 0.1M H_3PO_3 is
(*a*) 0.2N (*b*) 0.30N
(*c*) 0.033N (*d*) 0.05N

7. In a normal solution of $BaCl_2$, normalities of Ba^{2+} and Cl^- are in the ratio
(*a*) 2:1 (*b*) 1:2
(*c*) 1:1 (*d*) 2:3

8. Molarity of 0.1N oxalic acid is
(*a*) 0.05 M (*b*) 0.1 M
(*c*) 0.2 M (*d*) 0.3M

9. 138 g ethyl alcohol is mixed with 72 g of water. The ratio of mole fraction of alcohol to water is:
(*a*) 3 : 4 (*b*) 1 : 2
(*c*) 1 : 4 (*d*) 1 : 1

10. When an oxide M_2O_3 is oxidised to M_2O_5 its equivalent weight is
(*a*) M. w/1 (*b*) M. w/2
(*c*) M. w/4 (*d*) M. w/8

11. The equivalent weight of H_2SO_4 in the following reaction is
(*a*) 98 (*b*) 49
(*c*) 32.66 (*d*) 40

12. The equivalent weight of Mohr's salt during redox reaction is equal to its
(*a*) Molecular weight / 2 (*b*) Atomic weight / 2
(*c*) Molecular weight / 3 (*d*) Molecular weight

13. The equivalent weight of $MnSO_4$ is half its molecular weight, when it is converted to
(*a*) Mn_2O_3 (*b*) MnO_2
(*c*) MnO_4 (*d*) MnO_4^{-2}

14. 2.5 cm^3 of 0.2 M H_2SO_4 solution is diluted to 0.5 dm^3. Find normality of the diluted solution:
(*a*) 0.2 N (*b*) 0.02 N
(*c*) 0.002 N (*d*) 0.04 N

15. Number of moles of solute dissolved in 1000g. of the solvent is called
(*a*) Molarity (*b*) Molality
(*c*) Formality (*d*) Normality

16. Which of the following has no units?
(*a*) Molarity (*b*) Normality
(*c*) Molality (*d*) Mole fraction

17. Molarity of 4% (w/v) solution of NaOH is
(*a*) 0.1 (*b*) 0.5
(*c*) 0.001 (*d*) 1.0

18. The number of moles of solute present in 2.0 lits of 0.5M NaOH solution is
(*a*) 2 (*b*) 1
(*c*) 4 (*d*) 0.1

19. What is the molarity of 0.2 N Na_2CO_3 solution?
(*a*) 0.1 M (*b*) 0 M
(*c*) 0.4 M (*d*) 0.2 M

20. 10 millimoles of solute is present in the following volume of 0.08M solution
(*a*) 125ml (*b*) 625ml
(*c*) 500 ml (*d*) 1000ml

21. The concentration of a 100 ml solution containing X grams of Na_2CO_3 (mol. wt. = 106) is Y M. The values of X and Y are respectively:
(*a*) 2.12, 0.05 (*b*) 1.06, 0.2
(*c*) 1.06, 0.1 (*d*) 2.12, 0.1

22. Zinc reacts with $CuSO_4$ according to the equation $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$. If excess of zinc is added to 100ml, 0.05M $CuSO_4$, the amount of copper formed in moles will be
(*a*) 5 (*b*) 0.5
(*c*) 0.05 (*d*) 0.005

23. How many milli litres of 1M H_2SO_4 will be neutralised by 10ml of 1M NaOH solution?
(*a*) 10 (*b*) 20
(*c*) 2.5 (*d*) 5

24. The normality of orthophosphoric acid having purity of 70% by weight and specific gravity 1.54 gm/ml is:
(*a*) 11 N (*b*) 22 N
(*c*) 33 N (*d*) 44 N

25. The volume of water that must be added to a mixture of 250ml of 6M HCl and 650ml of 3M HCl to obtain 3M solution is
(*a*) 75ml (*b*) 150ml
(*c*) 300ml (*d*) 250ml

26. If 36.0 g of glucose is present in 400 ml of solution, molarity of the solution is
(*a*) 0.05M (*b*) 11.0 M
(*c*) 0.5M (*d*) 2.0 M

27. What volume of 0.8M solution contains 0.1 mole of the solute?
(*a*) 100 ml (*b*) 125 ml
(*c*) 500 ml (*d*) 62.5 ml

28. If 0.01 mole of solute is present in 500 ml of solution, its molarity is
(*a*) 0.01 M (*b*) 0.005M
(*c*) 0.02 M (*d*) 0.1M

29. Number of milli equivalents of solute in 0.5 litres of 0.2N solution is
(*a*) 10 (*b*) 1
(*c*) 100 (*d*) 1000

30. 0.126 g of an acid is titrated with 0.1 N 20 ml of a base. The equivalent weight of the acid is:
(*a*) 63 (*b*) 50
(*c*) 53 (*d*) 23

31. 250 ml of a solution contains 6.3 grams of oxalic acid (mol. wt. =126 g/mol). What is the volume (in litres) of water to be added to this solution to make it a 0.1 N solution?
(*a*) 750 (*b*) 7.5
(*c*) 0.075 (*d*) 0.75

32. Volume of 0.1 M $K_2Cr_2O_7$ required to oxidise 35ml of 0.5 M $FeSO_4$ solution is
(*a*) 35ml (*b*) 29ml
(*c*) 17.5ml (*d*) 175ml

33. The weight of $H_2C_2O_4.2H_2O$ required to prepare 500ml of 0.2N solution is
(*a*) 1.26g (*b*) 6.3g
(*c*) 1.575g (*d*) 3.15g

34. 3.42 g of a substance of molecular weight 342 g is present in 250g of water. Molality of this solution is
(*a*) 0.4m (*b*) 0.04 m
(*c*) 0.8 m (*d*) 4m

35. 3g of a salt [mol. wt. 30 g/mol] is dissolved in 250 g of water the molality of the solution is
(*a*) 0.4 (*b*) 0.2
(*c*) 0.6 (*d*) 0.8

36. Mole fraction of a solute in benzene is 0.2, then find molality of solution:
(*a*) 3.2 (*b*) 2
(*c*) 4 (*d*) 3.6

37. How much volume of 1 M H_2SO_4 is required to neutralise 20 ml of 1 M NaOH?
(*a*) 10 ml (*b*) 20 ml
(*c*) 5 ml (*d*) 15 ml

SOLUBILITY

38. How many grams of CO_2 gas is dissolved in a 1 L bottle of carbonated water if the manufacturer uses a pressure of 2.4 atmosphere in the bottling process at 25°C Given K_H of CO_2 water = 29.76 atm/mole/L at 25°C
(*a*) 3.52 (*b*) 4.2
(*c*) 3.1 (*d*) 2.5

39. H_2S is a toxic gas used in qualitative analysis. If solubility of H_2S in water at STP is 0.195 m, what is the value of K_H?
(*a*) 0.0263 bar (*b*) 69.16 bar
(*c*) 192 bar (*d*) 282 bar

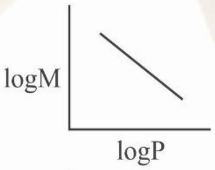
40. The law which indicates the relationship between solubility of a gas in liquid and pressure is:
(*a*) Raoult's law
(*b*) Henry's law
(*c*) Lowering of Vapour pressure
(*d*) Van't Hoff's law

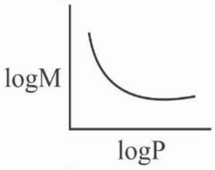
41. Among the following substance the lowest vapour pressure is exerted by:
(*a*) Water (*b*) Alcohol
(*c*) Ether (*d*) Mercury

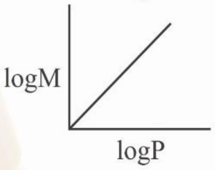
42. Partial pressure of a solution component is directly proportional to its mole fraction. This is known as:
(*a*) Henry's law (*b*) Raoult's law
(*c*) Distribution law (*d*) Ostwald's dilution law

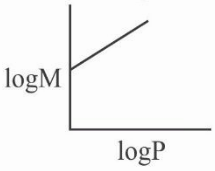
43. 3 moles of 'P' and 2 moles of "Q" are mixed, what will be their total vapour pressure in the solution if their partial vapour pressures in pure state are 80 and 60 torr respectively:
(*a*) 80 torr (*b*) 140 torr
(*c*) 72 torr (*d*) 70 torr

44. Which of these curves represents Henry's Law?

(*a*)


(*b*)


(*c*)


(*d*)


45. In which case Raoult's law is not applicable?
(*a*) 1 m NaCl (*b*) 1 m urea
(*c*) 1 m glucose (*d*) 1 m sucrose

46. Which one of the following gases has the lowest value of Henry's law constant?
(*a*) N_2 (*b*) He
(*c*) CO_2 (*d*) O_2

47. If two components A and B have $P_A^0 : P_B^0 = 1 : 2$ and have mole fraction in solution 1 : 2 then mole fraction of A in vapour is:
(*a*) 0.33 (*b*) 0.25
(*c*) 0.52 (*d*) 0.2

48. Henry's law constant of oxygen is 1.4×10^{-3} mol l^{-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*) 2.24 mg (*d*) 3.2 g

49. Vapour pressure of chloroform ($CHCl_3$) and dichloromethane (CH_2Cl_2) at 25°C are 200 mmHg and 41.5 mmHg respectively. Vapour pressure of the solution obtained by mixing 25.5 g of $CHCl_3$ and 40 g of CH_2Cl_2 at the same temperature will be (Molecular mass of $CHCl_3$ = 119.5 u and molecular mass of CH_2Cl_2 = 85 u):
(*a*) 173.9 mmHg (*b*) 615.0 mmHg
(*c*) 347.9 mmHg (*d*) 90.63 mmHg

VAPOUR PRESSURE OF LIQUID SOLUTIONS

50. The amount of solute (molar mass 60 g mol^{-1}) that must be added to 180 g of water so that the vapour pressure of water is lowered by 10% is:
(*a*) 30 g (*b*) 60 g
(*c*) 120 g (*d*) 12 g

51. The boiling point of C_6H_6,CH_3OH, $C_6H_5NH_2$ and $C_6H_5NO_2$ are 80°C, 65°C, 184°C and 212°C. Respectively. Which will show highest vapour pressure at room temperature?
(*a*) C_4H_6 (*b*) CH_3OH
(*c*) $C_6H_5NH_2$ (*d*) $C_6H_5NO_2$

52. 12g of urea is present in 1 litre of solution and 68.4 g of sucrose is separately dissolved in 1 litre of another sample of solution. The lowering of vapour pressure of first solution is
(*a*) Equal to second
(*b*) Greater than second
(*c*) Less than second
(*d*) Double that of second

53. Lowering of vapour pressures of equimolar solution of glucose, sodium chloride and barium nitrate are in the order.
(*a*) Glucose > NaCl > Ba $(NO_3)_2$
(*b*) Glucose = NaCl = Ba $(NO_3)_2$
(*c*) $Ba(NO_3)_2$ > NaCl > Glucose
(*d*) NaCl > $Ba(NO_3)_2$ > Glucose

54. The vapour pressure of water depends upon
(*a*) Surface area of container
(*b*) Volume of container
(*c*) Temperature
(*d*) All

55. 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*) 200 and 300 (*b*) 300 and 400
(*c*) 400 and 600 (*d*) 500 and 600

56. A solution is obtained by dissolving 0.2 moles of urea in a litre of water. Another solution is obtained by dissolving 0.4 moles of cane-sugar in a litre of water at the same temperature. The lowering of vapour pressure to the first solution is.
(*a*) Same as that of the second solution
(*b*) Half to that of the second solution
(*c*) Double to that of the second solution
(*d*) None

57. At a certain temperature, the vapour pressure of water is 90 mm. At the same temperature the vapour pressure of a solution containing a non-volatile solute is 81mm. The relative lowering of vapour pressure is
(*a*) 9 (*b*) 0.9
(*c*) 10 (*d*) 0.1

58. 3 gms of urea is added to 36 gms of boiling water. How much lowering in its vapour pressure is noticed?
(*a*) 19 mm (*b*) 38 mm
(*c*) 760 mm (*d*) 76 mm

59. Two liquids X and Y form an ideal solution. The mixture has a vapour pressure of 400 mm at 300 K when mixed in the molar ratio of 1 : 1 and a vapour pressure of 350 mm when mixed in the molar ratio of 1 : 2 at the same temperature. The vapour pressures of the two pure liquids X and Y respectively are:
(*a*) 250 mm, 550 mm (*b*) 350 mm, 450 mm
(*c*) 350 mm, 700 mm (*d*) 550 mm, 250 mm

IDEAL AND NON-IDEAL SOLUTIONS

60. The system that forms maximum boiling azeotrope is:
(*a*) Carbon disulphide - acetone
(*b*) Benzene - toluene
(*c*) Acetone - chloroform
(*d*) n - hexane - n heptane

61. 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

62. A solution of acetone in ethanol:
(*a*) Shows a negative deviation from Raoult's law
(*b*) Shows a positive deviation from Raoult's law
(*c*) Behaves like a near ideal solution
(*d*) Obey Raoult's law

63. Which of the following will show a negative deviation from Raoult's law?

(*a*) Acetone - benzene (*b*) Acetone - ethanol
(*c*) Benzene - methanol (*d*) Acetone - chloroform

64. A solution containing components A and B follows Raoult's law:

(*a*) A – B attraction is greater than A – A and B – B
(*b*) A – B attraction forces is less than A – A and B – B
(*c*) A – B attraction forces remains same as A – A and B – B
(*d*) Volume of solution is different from sum of volumes of solute and solvent

65. What are the conditions for an ideal solution which obeys Raoult's law over the entire range of concentration?

(*a*) $\Delta H_{mix} = 0, \Delta V_{mix} = 0, P_{total} = P_A^0 x_A + P_B^0 x_B$
(*b*) $\Delta H_{mix} = +ve, \Delta V_{mix} = 0, P_{total} = P_A^0 x_A + P_B^0 x_B$
(*c*) $\Delta H_{mix} = 0, \Delta V_{mix} = +ve, P_{total} = P_A^0 x_A + P_B^0 x_B$
(*d*) $\Delta H_{mix} = 0, \Delta V_{mix} = 0, P_{total} = P_B^0 x_B$

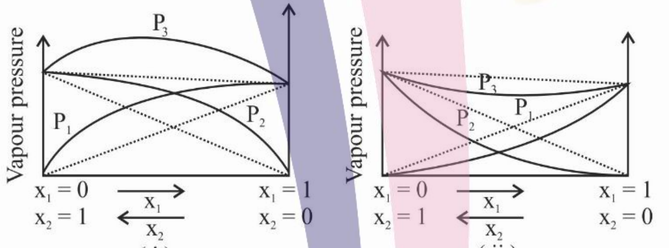
66. For an ideal solution with $P_A > P_B$, Which of the following is true?

(*a*) $(x_A)_{liquid} = (x_A)_{vapour}$ (*b*) $(x_A)_{liquid} > (x_A)_{vapour}$
(*c*) $(x_A)_{liquid} > (x_A)_{vapour}$ (*d*) $(x_A)_{liquid} < (x_A)_{vapour}$

67. Which of the following azeotropes is not correctly matched?

(*a*) HNO_3 (68%) + H_2O (32%): Maximum boiling azeotrope, B.P = 393.5 K
(*b*) H_2O (43%) + HI (56.7%): Minimum boiling azeotrope, B.P = 290 K
(*c*) C_2H_5OH(95.5%) + H_2O(4.5%): Minimum boiling azeotrope, B.P. = 351.15 K
(*d*) Chloroform (93.2%) + C_2H_5OH (6.8%): Minimum boiling azeotrope, B.P. = 332.3 K

68. Study the figures given below and mark the correct statement:



(i) (ii)

(*a*) (*i*) Nitric acid + water(*ii*) Acetone + ethyl alcohol
(*b*) (*i*) Water + ethyl alcohol(*ii*) Acetone + Benzene
(*c*) (*i*) Acetone + ethyl alcohol(*ii*) Acetone + chloroform
(*d*) (*i*) Benzene + chloroform(*ii*) Acetone + chloroform

69. Which of the following gas mixture is used by the divers inside the sea?

(*a*) O_2 + He (*b*) O_2 + Xe
(*c*) O_2 + Ar (*d*) $O_2 + N_2$

70. The vapour pressure of pure solvent is 0.8 mm of Hg at a particular temperature. On addition of a non - volatile solute 'A' the vapour pressure of solution becomes 0.6 mm of Hg. The mole fraction of component 'A' is:

(*a*) 0.25 (*b*) 0.75
(*c*) 0.5 (*d*) 0.35

71. Lowering of vapour pressure of an aqueous solution of a non-volatile, non-electrolyte 1 M aqueous solution at 100^0C is:

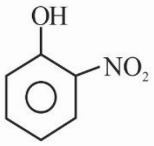
(*a*) 14.12 torr (*b*) 312 torr
(*c*) 13.45 torr (*d*) 352 torr

72. A solution of two liquids boils at a temperature more than the boiling point of either of them. Hence, the binary solution shows:

(*a*) Negative deviation from Raoult's law
(*b*) Positive deviation from Raoult's law
(*c*) No deviation from Raoult's law
(*d*) Positive or negative deviation from Raoult's law depending upon the composition.

73. Out of the compounds given below, the vapour pressure of (B) at a particular temperature is:

(A)



(B)

(*a*) Higher than that of A
(*b*) Lower than that of B
(*c*) Higher of lower than (A), depending on the size of the vessel
(*d*) Same as that of (A)

COLLIGATIVE PROPERTIES AND DETERMINATION OF (MOLAR) MASS

74. Camphor is used as solvent to determine the molecular mass of non volatile solute by Rast method because for Camphor

(*a*) Molal depression constant is high
(*b*) Melting point is high
(*c*) Being cheap
(*d*) All the above

75. If the elevation in boiling point of a solution of 10gm of solute (mol. wt.=100) in 100 gm of water is ΔT_b, the ebullioscopic constant of water is

(*a*) 10 (*b*) $10\Delta T_b$
(*c*) ΔT_b (*d*) $\frac{\Delta T_b}{10}$

76. 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*) -0.360°C (*b*) - 0.260°C
(*c*) +0.480°C (*d*) -0.480°C

77. A solution containing 12.5 g of non-electrolyte substance in 185 g of water shows boiling point elevation of 0.80 K. Calculate the molar mass of a substance: (k_b = 0.52 k kg mol^{-1})

(*a*) 53.06 g mol^{-1} (*b*) 25.3 g mol^{-1}
(*c*) 16.08 g mol^{-1} (*d*) 43.92 g mol^{-1}

78. 10% solution of urea is isotonic with 6% solution of a non-volatile solute X, what is the molecular mass of solute X?
(*a*) 6 g mol^{-1} (*b*) 60 g mol^{-1}
(*c*) 36 g mol^{-1} (*d*) 32 g mol^{-1}

79. Choose the correct statement
(*a*) The boiling point of the solution falls on increasing the amount of the solute
(*b*) The freezing point of the solution is lowered on adding more of solvent
(*c*) The freezing point of the solution is raised on adding more of solute
(*d*) The freezing point of the solution decreases on increasing the amount of the solute

80. Osmotic pressure of a solution containing 2 g dissolved protein per 300 cm^3 of solution is 20 mm of Hg at 27°C. The molecular mass of protein is:
(*a*) 6239.3 g mol^{-1} (*b*) 12315.5 g mol^{-1}
(*c*) 3692.1 g mol^{-1} (*d*) 7368.4 g mol^{-1}

81. A solution is made by dissolving 20 g of a substance in 500ml of water. Its osmotic pressure was found to be 600 mm of Hg at 15°C. Find the molecular weight of the substance:
(*a*) 1198 g mol^{-1} (*b*) 500 g mol^{-1}
(*c*) 1200 g mol^{-1} (*d*) 1000 g mol^{-1}

82. An aqueous solution of 2% non-volatile solute exerts a pressure of 1.004 bar at a normal boiling point of the solvent. What is the molecular mass of the solute?
(*a*) 23.4 g mol^{-1} (*b*) 41.35 g mol^{-1}
(*c*) 10 g mol^{-1} (*d*) 20.8 g mol^{-1}

83. Which of the following statement is correct?
(*a*) A saturated solution will remain saturated at all temperatures
(*b*) A plant cell swells when placed in hypertonic solution
(*c*) The depression in freezing point is directly proportional to molality of the solution
(*d*) Lowering in vapour pressure is a colligative property.

84. A solution containing 10.2 g glycerine per litre is isotonic with a 2% (w/v)solution of glucose. What is the molecular mass of glycerine?
(*a*) 91.8 g (*b*) 1198 g
(*c*) 83.9 g (*d*) 890.3 g

85. Which among the following will show maximum osmotic pressure?
(*a*) 1M NaCl (*b*) 1M $MgCl_2$
(*c*) 1M $(NH_4)_3PO_4$ (*d*) 1M Na_2SO_4

86. What weight of glycerol should be added to 600 g of water in order to lower its freezing point by 10°C? (k_f = 1.86 K kg mol^{-1})
(*a*) 496 g (*b*) 297 g
(*c*) 310 g (*d*) 426 g

87. If 1 g of solute (molar mass = 50 g mol^{-1}) is dissolved in 50 g of solvent and the elevation in boiling point is 1 K. The molal elevation constant of the solvent is:
(*a*) 2 (*b*) 3
(*c*) 2.5 (*d*) 5

88. The colligative property is not represented by:
(*a*) Elevation in boiling point
(*b*) Osmotic pressure
(*c*) Optical activity
(*d*) Relative lowering of vapour pressure

89. Isotonic solutions have
(*a*) Same boiling point
(*b*) Same vapour pressure
(*c*) Same melting point
(*d*) Same osmotic pressure

90. Distribution law was given by:
(*a*) Ostwald (*b*) Nernst
(*c*) Henry (*d*) Van't hoff

91. If the elevation in boiling point of a solution of 1 g of solute (molecular weight = 100) in 100 g of water is ΔT_b, the ebullioscopic constant of water is:
(*a*) 10 (*b*) 100 T_b
(*c*) 10 ΔT_b (*d*) $\frac{\Delta T_b}{10}$

92. The osmotic pressure is expressed in the unit of:
(*a*) MeV (*b*) Calorie
(*c*) cm/sec (*d*) atm

93. Which of the following will have highest boiling point at 1 atm pressure?
(*a*) 0.1M NaCl
(*b*) 0.1 M Sucrose
(*c*) 0.1M $BaCl_2$
(*d*) 01. M Glucose

94. The freezing point of one molal NaCl, assuming NaCl to be 100% dissociated in water is: (molar depression constant is 1.86)
(*a*) – 2.72°C (*b*) – 3.72°C
(*c*) 2.72°C (*d*) 3.72°C

95. What happens to freezing point of benzene when naphthalene is added?
(*a*) Increases
(*b*) Decreases
(*c*) Remain unchanged
(*d*) First decreases and then increases

96. The order of boiling point of four equimolar aqueous solutions is $C < B < A < D$. The correct order of their freezing point is:
(*a*) $D < C < B < A$ (*b*) $D > C < B < A$
(*c*) $D < A < B < C$ (*d*) $D > A > B > C$

97. The boiling point of a solution of 0.11g of a substance in 15 g of ether was found to be 0.1°C higher than that of pure ether. The molecular weight of the substance will be (K_b = 2.16 K kg mol^{-1}).
(*a*) 148 (*b*) 158
(*c*) 168 (*d*) 178

98. Dissolution of 1.5 g of a non-volatile solute (molecular weight = 60) in 250 g of a solvent reduces its freezing point by 0.01°C. Find the molal depression constant of the solvent:
(*a*) 0.01 (*b*) 0.001
(*c*) 0.0001 (*d*) 0.1

99. A solution has higher osmotic pressure than its standard solution. Which of the following term will be used for this solution?
(*a*) Isotonic (*b*) Hypertonic
(*c*) Dilute (*d*) Hypotonic

100. The boiling point of 0.1molal $K_4[Fe(CN)_6]$ solution will be (Given K_b for water = 0.52 K kg mol^{-1}.
(*a*) 100.52°C (*b*) 100.104°C
(*c*) 100.26°C (*d*) 102.6°C

101. 20 g of an non-volatile solute is added to 500 g of solvent, freezing point of pure solvent = 5.48°C and that of solution is 4.47°C, K_f = 1.93 k kg mol^{-1} molecular mass of solute is:
(*a*) 77.2 (*b*) 76.4
(*c*) 73.2 (*d*) 70.6

102. Which has the least freezing point?
(*a*) 1% sucrose (*b*) 1% NaCl
(*c*) 1% $CaCl_2$ (*d*) 1% glucose

103. Which of the following solutions will have the highest boiling point
(*a*) 0.1M $Al_2(SO_4)_3$
(*b*) 0.1M $FeCl_3$
(*c*) 0.1M NaCl
(*d*) 0.1 M Urea

104. The molality of the solution prepared by dissolving 125 mL of pure methanol (d = 0.8gmL^{-1}) in 375 g of ethanol is :
(*a*) 10.8 (*b*) 11.2
(*c*) 8.33 (*d*) 10.4

105. A compound MX_2 has observed and normal molar masses 65.6 and 164 respectively. Calculate the apparent degree of ionization of MX_2 :
(*a*) 75% (*b*) 85%
(*c*) 65% (*d*) 25%

106. An ideal solution was obtained by mixing methanol and ethanol. If the partial vapour pressure of methanol and ethanol in solution are 2.619 kPa and 4.556 kPa respectively, the composition of vapour (in terms of mole fraction) will be:
(*a*) 0.635 MeOH, 0.365 EtOH
(*b*) 0.365 MeOH, 0.635 EtOH
(*c*) 0.574 MeOH, 0.326 EtOH
(*d*) 0.173 MeOH, 0.827 EtOH

107. What is the normal b.p of an aqueous solution whose freezing point is –2.48°C ?
(K_f = 1.86°C.kg/mol, K_b = 0.512°C.kg/mol)
(*a*) 100.7°C (*b*) 102.5°C
(*c*) 109.0°C (*d*) 99.3°C

108. The mass of glucose that should be dissolved in 100 g of water in order to produce same lowering of vapour pressure as is produced by dissolving 1 g of urea (mol. Mass = 60) in 50 g of water is : (Assume dilute solution in both cases)
(*a*) 1 g (*b*) 2 g
(*c*) 6 g (*d*) 12 g

109. The osmotic pressure of a decimolar solution of urea at 27°C is
(*a*) 2.49 bar (*b*) 5 bar
(*c*) 3.4 bar (*d*) 1.25 bar

110. What is the volume of solution containing 1 gm mole of sugar that will give rise to an osmotic pressure of 1 atm at 0°C?
(*a*) 11.2 lit (*b*) 112 lit
(*c*) 224 lit (*d*) 22.4 lit

ABNORMAL MOLAR MASS

111. Which of following representations of i (van't hoff factor) is not correct?
(*a*) $i = \dfrac{\text{Observed colligative property}}{\text{Expected colligative property}}$
(*b*) $i = \dfrac{\text{Normal molecular mass}}{\text{Observed molecular mass}}$
(*c*) $i = \dfrac{\text{No. of molecules actually present}}{\text{Observed of molecules expected to be present}}$
(*d*) $i = \dfrac{\text{Total number of particles taken before association / dissociation}}{\text{Total number of particles taken after association / dissociation}}$

112. Which of the following will have same value of Van't Hoff factor as that of $K_4\,[Fe(CN)_6]$?
(*a*) $Al_2\,(SO_4)_3$ (*b*) $AlCl_3$
(*c*) $Al\,(NO_3)_3$ (*d*) $Al(OH)_3$

113. What will be the degree of dissociation of 0.1 M $Mg(NO_3)_2$ solution if Van't Hoff factor is 2.74?
(*a*) 75% (*b*) 87%
(*c*) 100% (*d*) 92%

114. Which of the following has the highest freezing point?
(*a*) 1M NaCl solution (*b*) 1M KCl solution
(*c*) 1M $AlCl_3$ solution (*d*) 1M $C_6H_{12}O_6$ solution

115. If α is the degree of dissociation of Na_2SO_4, the van't Hoff's factor (*i*) used for calculating the molecular mass is:
(*a*) 1 + α (*b*) 1 - α
(*c*) 1+ 2 α (*c*) 1 - 2α

116. The Van't Hoff factor of 0.005 M aqueous solution of KCl is 1.95. The degree of ionisation of KCl is:
(*a*) 0.95 (*b*) 0.97
(*c*) 0.94 (*d*) 0.96

117. 0.2 molal aq. HA acid ionises to the extent of 20%. K_f for acid is 1.86, then calculate the freezing point of the solution:
(*a*) –0.45°C (*b*) –0.50°C
(*c*) –0.31°C (*d*) –0.53°C

118. Van't Hoff factor more than unity indicates that the solute in solution is:
(*a*) Dissociated (*b*) Associated
(*c*) Both (a) and (*b*) (*d*) Cannot say anything

119. KBr is 80% dissociated in aqueous solution of 0.5 m concentration (given, K_f for water = 1.86 K Kg mol^{-1}). The solution freezes at:
(*a*) 271.326 K (*b*) 272 K
(*c*) 270.5 K (*d*) 268.5 K

120. Van't Hoff factor of $Ca(NO_3)_2$ is:
(*a*) One (*b*) Two
(*c*) Three (*d*) Four

Learning Plus

1. Which of the following units is useful in relating concentration of solution with its vapour pressure?
(*a*) Mole fraction (*b*) Parts per million
(*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*) Powdered sugar in cold water
(*c*) Sugar crystals in hot 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 amount of a given liquid solvent does not depend upon:
(*a*) Temperature (*b*) Nature of solute
(*c*) Pressure (*b*) 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 solute 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 times (*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 pressure 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*) Is same as that of a dilute solution
(*d*) Cannot be compared with osmotic pressure of dilute solution

14. Which of the following statements is false?
(*a*) Two different solutions of sucrose of same molality prepared in different 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 $BaCl_2 > KCl > CH3COOH >$ sucrose
(*d*) According to Raoult's law, the vapor pressure exerted by a volatile component of a solution is directly proportional to its mole fraction in the solution

15. The values 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 statements is false?
(*a*) Units of atmospheric pressure and osmotic pressure are the 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 represents the decrease in solubility

(*b*) Decreases with increase in temperature the decrease in solubility

(*c*) Remains constant

(*d*) First increases then decreases

18. The value of Henry's constant, *KH* is:

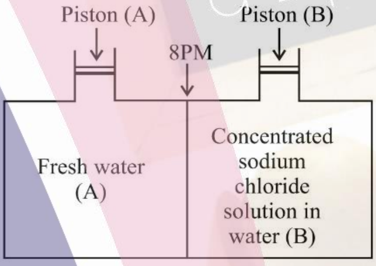
(*a*) Greater for gases with higher solubility

(*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 from 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 (*b*)

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

(*a*) $iA < iB < iC$ (*b*) $iA > iB > iC$

(*c*) $iA = iB = iC$ (*d*) $iA < iB > iC$

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:

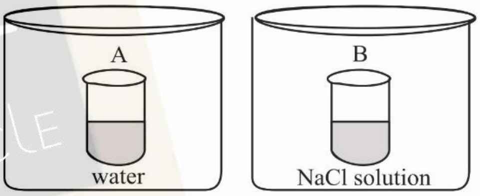
(*a*) Solution (*i*) will follow Raoult's law

(*b*) Solution (*ii*) will show positive deviation from Raoult's law

(*c*) Solution (*i*) 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 2 M 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?

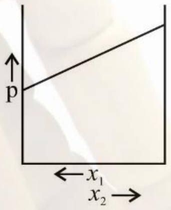
(*a*) Vapour pressure in container (A) is more than that in container (B)

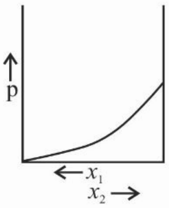
(*b*) Vapour pressure in container (A) is less than that in container (B)

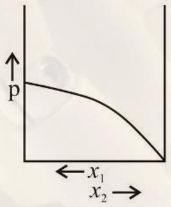
(*c*) Vapour pressure is equal in both the containers

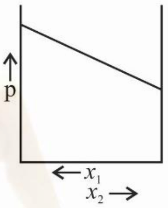
(*d*) Vapour pressure in container (B) is twice the vapour pressure in container (A)

23. For a binary ideal liquid solution, the variation in total vapour pressure versus composition of solution is given by which of the curves?

(*a*)


(*b*)


(*c*)


(*d*)


24. 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 minimum boiling azeotrope and will show negative deviation from Raoult's law

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

25. 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

26. Isotonic solutions must have the same:

(*a*) Solute (*b*) Density

(*c*) Elevation in boiling point (*d*) None of these

27. Which of the following binary mixtures will have same composition in liquid and vapour phase?

(*a*) Benzene-toluene

(*b*) Water-methanol

(*c*) Water-ethanol

(*d*) *n*-hexane – *n*-heptane

28. Discounting economic considerations, which of the following would be the best to shrink an icy road, in quantities proportion to their respective formula weights-

(*a*) NaCl

(*b*) $CaCl_2$

(*c*) $CuSO_4.5H_2O$

(*d*) $Al_2(SO_4)_3$

29. Van't Hoff factor of Hg_2Cl_2 in its aqueous solution will be : (Hg_2Cl_2 is 80% ionized in the solution)

(*a*) 1.6 (*b*) 2.6

(*c*) 3.6 (*d*) 4.6

30. Which of the following solutions will have the highest boiling point?

(*a*) 1% of glucose in water (*b*) 1% sucrose in water

(*c*) 1% NaCl in water (*d*) 1% $CaCl_2$ in water

31. Benzoic acid is dissolved in benzene, van't Hoff factor will be:

(*a*) 1 (*b*) 0.5

(*c*) 1.5 (*d*) 2

32. The freezing point depression constant for water is 1.86 K kg mol^{-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*) 0.381 (*b*) 2.05

(*c*) 2.63 (*d*) 3.11

33. The van't Hoff factor (*i*) for a compound which undergoes dissociation in one solvent and association in other solvent is respectively:

(*a*) Greater than one and greater than one

(*b*) Less than one and less greater than one

(*c*) Less than one and less than one

(*d*) Greater than one and less than one

34. What is the freezing point of a solution containing 8.1 g of HBr in 100 g water, assuming the acid to be 90% ionised ? (K_f for water = 1.86 K kg mol^{-1})

(*a*) 0.85°C (*b*) –3.53°C

(*c*) 0°C (*d*) –0.35°C

35. Maximum lowering of vapour pressure is observed in the case of:

(*a*) 0.1 M glucose (*b*) 0.1 M $BaCl_2$

(*c*) 0.1 M $MgSO_4$ (*d*) 0.1 M NaCl

Multiconcept MCQs

1. Equal weight of a solute are dissolved in equal weight of two solvents A & B and formed a very dilute solution. The relative lowering of vapour pressure for solution B has twice the relative lowering of vapour pressure for solution A.

If M_A and M_B are molecular weights of solvents A & B respectively, then:

(*a*) $M_B = 2M_A$ (*b*) $M_A = 4M_B$

(*c*) $M_A = 2M_B$ (*d*) $M_A = M_B$

2. If M_{normal} is the normal molecular mass and α is the degree of ionization of $K_3[Fe(CN)_6]$, then the abnormal molecular mass of complex is:

(*a*) $M_{normal}\ (1+3\alpha)^{-1}$ (*b*) $M_{normal}\ (1+2\alpha)^{-1}$

(*c*) $M_{normal}\ (1+\alpha)^{-1}$ (*d*) None of these

3. A living cell contains a solution which is isotonic with 0.2 M glucose solution. What osmotic pressure develops when the cell is placed in 0.05 M $BaCl_2$ solution at 300 K?

(*a*) 1.23 atm (*b*) 6.15 atm

(*c*) 3.69 atm (*d*) None of these

4. The vapour pressure of water is 12.3 kPa at 300 K. What is the vapour pressure of 1 molal aqueous solution of a non-volatile solute at 300 K?

(*a*) 1.208 kPa (*b*) 12.08 kPa

(*c*) 1208 kPa (*d*) 2.08 kPa

5. Which one of the following aqueous solutions will show the highest boiling point?

(*a*) 0.015 M glucose

(*b*) 0.10 M Na_2SO_4

(*c*) 0.01 M KNO_3

(*d*) 0.015 M urea

6. Calculate the number of moles of sodium sulphate required to be dissolved in 12 moles of water to lower its vapour pressure by 10 mmHg at a 300 K temperature (V.P. of H_2O at 300K = 50 mmHg):

(*a*) 2 moles (*b*) 3 moles

(*c*) 1 moles (*d*) 1.5 moles

7. For an ideal binary liquid solution with $P_A^0 > P_B^0$, which relation between X_A (mole fraction of A in liquid phase) and Y_A (mole fraction of A in vapour phase) is correct?

(*a*) $Y_A = Y_B$ (*b*) $\frac{Y_A}{Y_B} = \frac{X_A}{X_B}$

(*c*) $\frac{Y_A}{Y_B} > \frac{X_A}{X_B}$ (*d*) $\frac{Y_A}{Y_B} < \frac{X_A}{X_B}$

8. 18 g glucose ($C_6H_{12}O_6$) is added to 178.2 g water. The vapour pressure of water (in torr) for this aqueous solution is:

(*a*) 76 (*b*) 752.4

(*c*) 759 (*d*) 760.4

9. How many grams of sucrose (M. mass = 342) should be dissolved in 100grams H_2O in order to produce a solution with 105°C difference between the freezing point & boiling point temperature?

(K_f = 1.86 k kg/mole) & ($K6_b$ = 0.51 k kg/mole)

(*a*) 34.2 gm (*b*) 72 gm

(*c*) 342 gm (*d*) 460 gm

10. The vapour pressure of a saturated solution of sparingly soluble salt (XCl_3) was 17.20 mm Hg at 27°C. If the vapour pressure of pure H_2O is 17.25 mm Hg at the same temperature, what is the solubility of sparingly soluble salt XCl_3, in moles per ltr. (Assume solution to be dilute)

(*a*) 4.02×10^{-2} (*b*) 6×10^{-7}

(*c*) 8×10^{-5} (*d*) 2×10^{-4}

11. To 500 cm^3 of water, 3×10^{-3} kg of CH_3COOH is added. If 23% of CH_3COOH is disociated, what will be the depression in freezing point- (K_f for water is 1.86 k kg mol^{-1})

(*a*) 0.372 K (*b*) 0.228 K

(*c*) 0.328 K (*d*) 0.556 K

12. An aqueous solution of a compound AB freezes at 0.48°C. At this temperature, AB behaves as a Non-electrolyte. The same solution boils at 100.26°C at a P of 1 atm (for water, $\frac{K_f}{K_b} = 3.7$) we can conclude that compound AB at the boiling point of solution,

(*a*) Behaves as a non-electrolyte

(*b*) Ionises to the extent of 50%

(*c*) Behaves as a strong electrolyte

(*d*) Dissociates in solution

13. If all the four compounds were sold at the same price, which would be cheapest for preparing an antifreeze solution for a car radiator?

(*a*) CH_3OH (*b*) C_2H_5OH

(*c*) $C_2H_4(OH)_2$ (*d*) $C_3H_5(OH)_3$

14. The volume of water (K_f = 18.6 k/molal in 100 g solvent) required to dissolve 3 g of urea to produce a depression of 0.186°C in freezing point is:

(*a*) 1 L (*b*) 200 ml

(*c*) 500 ml (*d*) 300 ml

15. Aqueous solution of HNO_3 is 63% by mass (density = 1.1 g/cc). What volume of this solution should be taken to prepare 1 L solution which exerts osmotic pressure of 49.2 atm at 27°C.

(*a*) 90.9 ml (*b*) 90.9 L

(*c*) 0.9 ml (*d*) 909 ml

16. The pH of 1 m solution of a weak monobasic acid (HA) is 2. Then, what is its van't hoff factor?

(*a*) 1.01 (*b*) 2.3

(*c*) 3.5 (*d*) 7

17. A solution is prepared by mixing 100 mL each of methanol (d = 0.791 g/mL) and ethanol (d = 0.998 g/mL). If M_1 is molarity of solution described as MeOH solute in EtOH solvent and M_2 is molarity of solution described as EtOH solute in MeOH solvent. Then :

(*a*) $M_1 < M_2$ (*b*) $M_1 > M_2$

(*c*) $M_1 = M_2$ (*d*) $M_1 + M_2 > 50$

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

(*a*) 0.6 (*b*) 0.4

(*c*) 0.2 (*d*) 1

19. $PtCl_4 \cdot 6H_2O$ can exist as a hydrated complex 1 molal aqueous solution of the salt has value of ΔT_f of 3.72°. Assuming 100% ionisation of the salt and K_f (H_2O) = 1.86° mol^{-1} kg, the correct representation of the complex is

(*a*) $[Pt(H_2O)_6]Cl_4$ (*b*) $[Pt(H_2O)_4Cl_2].2H_2O$

(*c*) $[Pt(H_2O)_3Cl_3]Cl.3H_2O$ (*d*) $[Pt(H_2O)_2Cl_4].4H_2O$

20. The boiling point of an aqueous solution of a non volatile solute is 100.15°C. What is the freezing point of an aqueous solution obtained by diluting the above solution with an equal volume of water? The values of K_b and K_f for water are 0.512 and 1.86 K $molality^{-1}$

(*a*) –0.544°C (*b*) –0.512°C

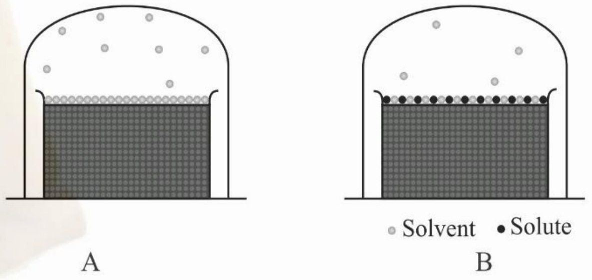
(*c*) –0.272°C (*d*) –1.86°C

21. 1 mol CH_3COOH is added in 250 g benzene. Acetic acid dimerises in benzene due to hydrogen bond, K_b of benzene is 2 K $kgmol^{-1}$. The boiling point has increased by 6.4K. % dimerisation of acetic acid is:

(*a*) 50 (*b*) 40

(*c*) 30 (*d*) 20

22. Interpret the correct statement for the following figure.



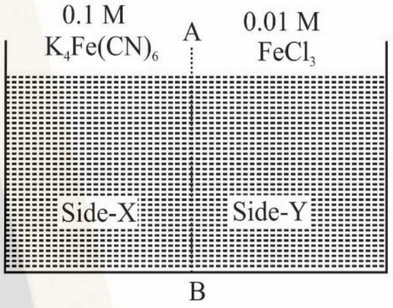
(*a*) Vapour pressure of the solution in beaker A is more than in the beaker B

(*b*) Vapour pressure of the solution in beaker A is less than in the beaker B

(*c*) Vapour pressure of the solution in both the beaker is same

(*d*) None of the above

23. $FeCl_3$ on reaction with $K_4[Fe(CN)_6]$in aqueous solution gives blue colour. These are separated by a semi-permeable membrane AB as shown. Due to osmosis, there is



(*a*) Blue colour formation in side X

(*b*) Blue colour formation in side Y

(*c*) Blue colour formation in both of sides X and Y

(*d*) No blue colour formation

NEET Past 10 Years Questions

1. The following solutions were prepared by dissolving 10 g of glucose ($C_6H_{12}O_6$) in 250 ml of water (P_1), 10 g of urea (CH_4N_2O) in 250 ml of water (P_2) and 10 g of sucrose ($C_{12}H_{22}O_{11}$) in 250 ml of water (P_3). The right option for the decreasing order of osmotic pressure of these solutions is: ***(2021)***

(*a*) $P_1 > P_2 > P_3$ (*b*) $P_2 > P_3 > P_1$
(*c*) $P_3 > P_1 > P_2$ (*d*) $P_2 > P_1 > P_3$

2. The correct option for the value of vapour pressure of a solution at 45°C with benzene to octane in molar ratio 3 : 2 is: ***(2021)***

[At 45°C vapour pressure of benzene is 280 mm Hg and that of octane is 420 mm Hg. Assume Ideal gas]

(*a*) 168 mm of Hg (*b*) 336 mm of Hg
(*c*) 350 mm of Hg (*d*) 160 mm of Hg

3. The mixture which shows positive deviation from Raoult's law is: ***(2020)***

(*a*) Benzene + Toluene

(*b*) Acetone + Chloroform

(*c*) Chloroethane + Bromoethane

(*d*) Ethanol + Acetone

4. The freezing point depression constant (K_f) of benzene is 5.12 K kg mol^{-1}. The freezing point depression for the solution of molality 0.078 m containing a non-electrolyte solute in benzene is (rounded off upto two decimal places) : ***(2020)***

(*a*) 0.80 K (*b*) 0.40 K
(*c*) 0.60 K (*d*) 0.20 K

5. If 8 g of a non-electrolyte solute is dissolved in 114 g of n-octane to reduce its vapour pressure to 80%, the molar mass (in g mol^{-1}) of the solute is
[Given that molar mass of n-octane is 114 g mol^{-1}] ***(2020 Covid Re-NEET)***

(*a*) 60 (*b*) 80
(*c*) 20 (*d*) 40

6. Isotonic solutions have same ***(2020 Covid Re-NEET)***

(*a*) Freezing temperature (*b*) Osmotic pressure
(*c*) Boiling temperature (*d*) Vapour pressure

7. For an ideal solution, the correct option is : ***(2019)***

(*a*) $\Delta_{mix} S = 0$ at constant T and P

(*b*) $\Delta_{mix} V \neq 0$ at constant T and P

(*c*) $\Delta_{mix} H = 0$ at constant T and P

(*d*) $\Delta_{mix} G = 0$ at constant T and P

8. The mixture that forms maximum boiling azeotrope is: ***(2019)***

(*a*) Water + Nitric acid

(*b*) Ethanol + Water

(*c*) Acetone + Carbon disulphide

(*d*) Heptane + Octane

9. If molality of the dilute solution is doubled, the value of molal depression constant (K_f) will be: ***(2017-Delhi)***

(*a*) Unchanged (*b*) Doubled
(*c*) Halved (*d*) Tripled

10. Which of the following is dependent on temperature? ***(2017-Delhi)***

(*a*) Weight percentage (*b*) Molality
(*c*) Molarity (*d*) Mole fraction

11. Toluene in the vapour phase is in equilibrium with a solution of benzene and toluene having mole fraction of toluene 0.50. If vapour pressure of pure benzene is 119 torr and that of toluene is 37.0 torr at the same temperature, mole fraction of toluene in vapour phase will be: ***(2017-Gujarat)***

(*a*) 0.325 (*b*) 0.462
(*c*) 0.237 (*d*) 0.506

12. Which one of the following is incorrect for ideal solution? ***(2016 - II)***

(*a*) $\Delta P = P_{obs} - P_{\text{calculated by Raoult's law}} = 0$

(*b*) $\Delta G_{mix} = 0$

(*c*) $\Delta H_{mix} = 0$

(*d*) $\Delta U_{mix} = 0$

13. The van't Hoff factor (*i*) for a dilute aqueous solution of the strong electrolyte barium hydroxide is: ***(2016 - II)***

(*a*) 2 (*b*) 3
(*c*) 0 (*d*) 1

14. At 100°C, the vapour pressure of a solution of 6.5 g of a solute in 100 g water is 732 mm. If K_b = 0.52, the boiling point of this solution will be: ***(2016 - I)***

(*a*) 103° C (*b*) 101° C
(*c*) 100° C (*d*) 102° C

15. Which of the following statements about the composition of the vapour over an ideal 1 : 1 molar mixture of benzene and toluene is correct? Assume that the temperature is at 25°C. (Given, vapour pressure data at 25°C, benzene = 12.8 kPa, toluene = 3.85 kPa) ***(2016-I)***

(*a*) The vapour will contain equal amounts of benzene and toluene
(*b*) Not enough information is given to make a prediction
(*c*) The vapour will contain a higher percentage of benzene
(*d*) The vapour will contain a higher percentage of toluene

16. What is the mole fraction of the solute in a 1.00 m aqueous solution? ***(2015 Re)***

(*a*) 0.0177 (*b*) 0.177
(*c*) 1.770 (*d*) 0.0354

17. Which one of the following electrolytes has the same value of van't Hoff's factor (*i*) as that of $Al_2(SO_4)_3$ (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

18. 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}

19. 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

20. Of the following 0.10 m aqueous solutions, which one will exhibit the largest freezing point depression? ***(2014)***

(*a*) $C_6H_{12}O_6$ (*b*) $Al_2(SO_4)_3$
(*c*) K_2SO_4 (*d*) KCl

21. How many grams of concentrated nitric acid solution should be used to prepare 250 mL of 2.0 M HNO_3? The concentrated acid is 70% HNO_3. ***(2013)***

(*a*) 70.0 g conc. HNO_3 (*b*) 54.0 g conc. HNO_3
(*c*) 45.0 g conc. HNO_3 (*d*) 90.0 g conc. HNO_3

22. Vapour pressure of chloroform ($CHCl_3$) and dichloromethane (CH_2Cl_2) at 25°C are 200 mm Hg and 41.5 mm Hg respectively. Vapour pressure of the solution obtained by mixing 25.5 g of $CHCl_3$ and 40 g of CH_2Cl_2 at the same temperature will be: (Molecular mass of $CHCl_3$ = 119.5 u and molecular mass of CH_2Cl_2 = 85 u): ***(2012 Mains)***

(*a*) 285.5 mm Hg (*b*) 173.9 mm Hg
(*c*) 615.0 mm Hg (*d*) 90.3 mm Hg

23. 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: ***(2012 Pre)***

(*a*) $p_B + x_A (p_A - p_B)$ (*b*) $p_A + x_A (p_B - p_A)$
(*c*) $p_A + x_A (p_A - p_B)$ (*d*) $p_B + x_A (p_B - p_A)$

24. Molecular weight of glucose is 180. A solution of glucose which contains 18 g per litre is: ***(2012 Pre)***

(*a*) 2 molal (*b*) 1 molal
(*c*) 0.1 molal (*d*) 18 molal

ANSWER KEYS

Topicwise Questions

1. (*c*) **2.** (*c*) **3.** (*a*) **4.** (*b*) **5.** (*a*) **6.** (*a*) **7.** (*c*) **8.** (*a*) **9.** (*a*) **10.** (*c*)
11. (*b*) **12.** (*d*) **13.** (*b*) **14.** (*c*) **15.** (*b*) **16.** (*d*) **17.** (*d*) **18.** (*b*) **19.** (*a*) **20.** (*a*)
21. (*c*) **22.** (*d*) **23.** (*d*) **24.** (*c*) **25.** (*d*) **26.** (*c*) **27.** (*b*) **28.** (*c*) **29.** (*c*) **30.** (*a*)
31. (*d*) **32.** (*b*) **33.** (*b*) **34.** (*b*) **35.** (*a*) **36.** (*a*) **37.** (*a*) **38.** (*a*) **39.** (*d*) **40.** (*b*)
41. (*d*) **42.** (*b*) **43.** (*c*) **44.** (*d*) **45.** (*a*) **46.** (*c*) **47.** (*d*) **48.** (*c*) **49.** (*d*) **50.** (*b*)
51. (*b*) **52.** (*a*) **53.** (*c*) **54.** (*c*) **55.** (*c*) **56.** (*b*) **57.** (*d*) **58.** (*a*) **59.** (*d*) **60.** (*c*)
61. (*b*) **62.** (*b*) **63.** (*d*) **64.** (*c*) **65.** (*a*) **66.** (*d*) **67.** (*b*) **68.** (*c*) **69.** (*a*) **70.** (*a*)
71. (*c*) **72.** (*a*) **73.** (*a*) **74.** (*a*) **75.** (*c*) **76.** (*d*) **77.** (*d*) **78.** (*c*) **79.** (*d*) **80.** (*a*)
81. (*a*) **82.** (*b*) **83.** (*c*) **84.** (*a*) **85.** (*c*) **86.** (*b*) **87.** (*c*) **88.** (*c*) **89.** (*d*) **90.** (*b*)
91. (*c*) **92.** (*d*) **93.** (*c*) **94.** (*b*) **95.** (*b*) **96.** (*c*) **97.** (*b*) **98.** (*d*) **99.** (*b*) **100.** (*c*)
101. (*b*) **102.** (*c*) **103.** (*a*) **104.** (*c*) **105.** (*a*) **106.** (*b*) **107.** (*a*) **108.** (*c*) **109.** (*a*) **110.** (*d*)
111. (*d*) **112.** (*a*) **113.** (*b*) **114.** (*d*) **115.** (*c*) **116.** (*a*) **117.** (*a*) **118.** (*a*) **119.** (*a*) **120.** (*c*)

Learning Plus

1. (*a*) **2.** (*d*) **3.** (*c*) **4.** (*b*) **5.** (*c*) **6.** (*b*) **7.** (*a*) **8.** (*b*) **9.** (*b*) **10.** (*a*)
11. (*c*) **12.** (*d*) **13.** (*a*) **14.** (*a*) **15.** (*b*) **16.** (*b*) **17.** (*a*) **18.** (*b*) **19.** (*b*) **20.** (*b*)
21. (*b*) **22.** (*a*) **23.** (*d*) **24.** (*a*) **25.** (*c*) **26.** (*c*) **27.** (*c*) **28.** (*d*) **29.** (*b*) **30.** (*d*)
31. (*b*) **32.** (*c*) **33.** (*d*) **34.** (*b*) **35.** (*b*)

Multiconcept MCQs

1. (*a*) **2.** (*a*) **3.** (*a*) **4.** (*b*) **5.** (*b*) **6.** (*c*) **7.** (*c*) **8.** (*b*) **9.** (*b*) **10.** (*a*)
11. (*b*) **12.** (*d*) **13.** (*a*) **14.** (*c*) **15.** (*a*) **16.** (*a*) **17.** (*b*) **18.** (*a*) **19.** (*c*) **20.** (*c*)
21. (*b*) **22.** (*a*) **23.** (*d*)

NEET Past Years Questions

1. (*d*) **2.** (*b*) **3.** (*d*) **4.** (*b*) **5.** (*d*) **6.** (*b*) **7.** (*c*) **8.** (*a*) **9.** (*a*) **10.** (*c*)
11. (*c*) **12.** (*b*) **13.** (*b*) **14.** (*b*) **15.** (*c*) **16.** (*a*) **17.** (*c*) **18.** (*a*) **19.** (*d*) **20.** (*b*)
21. (*c*) **22.** (*d*) **23.** (*a*) **24.** (*c*)

Solutions

Topicwise Questions

1. (*c*) Mass of solute taken = 120 g
Molecular mass of solute = 60 g
Mass of solvent = 1000 g
Mass of solution = 1000 + 120 = 1120 g

$$\text{Volume of solution} = \frac{\text{mass}}{\text{Density}} = \frac{1120}{1.15}\text{ml}$$

$$= 973.9\text{ ml} = 0.9739\text{ L}$$

$$\text{Now, no. of moles } = \frac{120\text{g}}{60\text{g}} = 2$$

$$\therefore \text{Molarity} = \frac{n}{V(L)} = \frac{2}{0.9739} = 2.05\text{M}$$

2. (*c*) $M \propto \frac{1}{v}$

3. (*a*) $n = 1\text{mole}$
$v = 2\text{ lit}$

$$\therefore M = \frac{1}{2} = 0.5 \text{ semi molar}$$

4. (*b*)

5. (*a*) $\text{No. of moles of glucose} = \frac{10}{180} = 0.0555$

$$\text{No. of moles of water} = \frac{90}{18} = 5$$

No. of moles of solution = 5.0555

$$\text{Mole fraction of glucose} = \frac{\text{No. of moles of Glucose}}{\text{No. of moles of solution}}$$

$$= \frac{0.0555}{5.0555} = 0.01$$

6. (*a*) N = M ×n (relation between molarity and normality) (N = 2)

7. (*c*) Gram equiavalents are always equal

8. (*a*) $M = \frac{N}{2}$ (relation between molarity and normality)

9. (*a*) Molecular mass of ethyl alcohol = 46 g/mol
Molecular mass of water = 18 g/mol

$$\text{Number of moles of } C_2H_5OH = \frac{138}{46} = 3$$

$$\text{Number of moles of } H_2O = \frac{72}{18} = 4$$

$$\text{Mole fraction, } \chi_{C_2H_5OH} = \frac{3}{3+4} = \frac{3}{7}$$

$$\chi_{H_2O} = \frac{4}{3+4} = \frac{4}{7}$$

$$\frac{\chi_{C_2H_5}OH}{\chi_{H_2O}} = \frac{\frac{3}{7}}{\frac{4}{7}} = \frac{3}{4} \Rightarrow 3:4$$

10. (*c*) The oxidation state of a metal atom changes from +3 to +5

11. (*b*) Here the basicity of H_2SO_4 is 2

$$E.W = \frac{M.W}{2} = (98/2) = 49$$

12. (*d*) $Fe^{+2} \rightarrow Fe^{3+} + e^-$

$$\text{So } E.W = \frac{M.W}{1}$$

13. (*b*) Total change in oxidation number is ‘2’

14. (*c*) $V_1 = 2.5\text{ cm}^3 = 2.5 \times 10^{-3}\text{ dm}^3$
$M_1 = 0.2\text{ M}$
$N_1 = 2 \times M_1 = 0.4\text{ N}$
$V_2 = 0.5\text{ dm}^3$
$N_1V_1 = N_2V_2$
$0.4 \times 2.5 \times 10^{-3} = N_2 \times 0.5$
$N_2 = 2 \times 10^{-3} = 0.002\text{ N}$

15. (*b*) $\text{molality} = \frac{\text{Wt}}{\text{GMW}} \times \frac{1000}{\text{Wt of solvent in grams}}$

16. (*d*) $X_{solute} = \dfrac{\text{no. moles of solute}}{\text{no. moles of solute} + \text{no. moles of solvent}}$

mole fraction is a ratio

$\therefore$ No units

17. (*d*) $M = \dfrac{\left(\%\dfrac{w}{v}\right)\times 10}{M.wt}$

18. (*b*) $n = M \times V$ in litres

19. (*a*) Molarity = Normality × *nf*

$\Rightarrow \text{Molarity} = \dfrac{\text{Normality}}{n_f} \quad \left(\begin{array}{l}\because n_f = 2 \\ \text{for } Na_2CO_3\end{array}\right)$

$\therefore \text{Molarity} = 0.2 \times \dfrac{M}{2M} = 0.1M$

20. (*a*) No of mill moles = M × vol in mL

21. (*c*) $\dfrac{X}{106} \times 100 \times 10^{-3}$

22. (*d*) $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

$\quad\quad$ 1 mole $\quad\quad\quad\quad$ 1 mole

$0.05 \times \dfrac{100}{1000}$ mole

23. (*d*) $V_1N_1 = V_2N_2$

$V_1 \times 1 \times 2 = 10 \times 1 \times 1$

24. (*c*) 70% by weight means 70 g of orthophosphoric acid is present in 100 g of acid.

$N = \dfrac{w}{eq.wt.} \times \dfrac{1000}{V_{(cc)}} \Rightarrow w = 70\text{ g}$

$\text{Eq. wt.} = \dfrac{\text{molecular mass}}{\text{number of replaceable H} - \text{atom}} = \dfrac{98}{3}$

$V = \dfrac{\text{mass}}{\text{density}} = \dfrac{100}{1.54}$

$N = \dfrac{70 \times 1000 \times 1.54}{98 \times 100} = 33\text{ N}$

25. (*d*) $V_1M_1 = V_2M_2$

volume of water to be added $= V_2 - V_1$

26. (*c*) $M = \dfrac{w}{GMW} \times \dfrac{1000}{V.inml}$ $C_6H_{12}O_6 = 180$ g (M.Wt)

27. (*b*) $M = \dfrac{n \times 1000}{V} \Rightarrow V = \dfrac{n}{M} \times 1000\text{ml}$

28. (*c*) $M = \dfrac{n \times 1000}{\text{vol in ml}}$

29. (*c*) No of milli equivalents = normality × volume in ml

30. (*a*) $W = \dfrac{ENV}{1000}$

$\text{Equivalent weight of acid} = \dfrac{W \times 1000}{NV} = \dfrac{0.126 \times 1000}{0.1 \times 20} = 63$

31. (*d*) $V_1N_1 = V_2N_2$

$V_2 - V_1$ = volume of water to be added

32. (*b*) $V_1N_1 = V_2N_2$

33. (*b*) $W = \dfrac{N \times E.W \times V(ml)}{1000}$

34. (*b*) $\text{molality} = \dfrac{w}{M.wt} \times \dfrac{1000}{\text{Wt of solvent in grams}}$

35. (*a*) $\text{molality} = \dfrac{w}{M.wt} \times \dfrac{1000}{\text{Wt of solvent in grams}}$

36. (*a*) Let the solution be x molal then moles of benzene present

in 1000g of benzene $= \dfrac{1000}{78} = 12.82$ moles

$\therefore$ Mole fraction of solute $= \dfrac{x}{x + 12.82}$

$$0.2 = \frac{x}{x + 12.82}$$

$$0.2\,(x + 12.82) = x$$

$$0.2 + 2.564 = x$$

$$2.564 = x - 0.2x = 0.8x$$

$$x = \frac{2.564}{0.8} = 3.2$$

37. (*a*) For H_2SO_4

N = M × basicity

N = 2

For NaOH

N = M × acidity

N = 1 × 1 = 1

Now from normality equation

$N_1V_1 = N_2V_2$

$2 \times V_1 = 1 \times 20$

$V_1 = \dfrac{20}{2} = 10\text{ ml of } H_2SO_4$

38. (*a*) $p = K_H.C$

39. (*d*) No. of moles of $H_2S = 0.195$

No. of moles of $H_2O = \dfrac{1000}{18} = 55.55$ mol

Mole fraction of $H_2S = \dfrac{0.195}{0.195 + 55.55} = 0.0035$

Pressure at STP = 0.987 bar

According to Henry's law, $P = K_Hx$

or $K_H = \dfrac{P_{H_2S}}{x_{H_2S}} = \dfrac{0.+987}{0.0035} = 282\text{ bar}$

40. (*b*) Mass of a gas dissolved per unit volume of a solvent is directly proportional to the pressure of the gas at that temperature is stated by Henry's law.

$m \propto P \quad \text{or } m = K_HP$

41. (*d*) Mercury is non-volatile.

42. (*b*) According to Raoult's law

$P_A \propto x_A$ and $P_B \propto x_B$ for a binary solution of A and B

43. (*c*) Mole fraction of P $= \frac{3}{3+2} = 0.6$

Mole fraction of Q $= \frac{2}{3+2} = 0.4$

$$P_{\text{Total}} = P_p + P_Q$$
$$= P_P^0 x_p + P_Q^0 x_Q$$
$$= 80 \times 0.6 + 60 \times 0.4$$
$$= 72 \text{ torr}$$

44. (*d*) Conceptual

45. (*a*) If the total number of particles of solute changes in the solution due to association or dissociation. Raoult's law is not applicable, among the given compounds NaCl undergoes dissociation and forms Na^+ and Cl^- ions. Thus, Raoult's law is not applicable for NaCl.

46. (*c*) In the solubility K_H decreases. Among the given set of gases, CO_2 is the most soluble in water.

47. (*d*) Mole fraction of component 'A' in vapour phase

$$= \frac{\text{Partial pressure of 'A'}}{\text{Total Vapour pressure}} = \frac{P_A}{P_A + P_B}$$

$$\text{but; } P_A = P_A^0 x_A$$

$$P_B = P_B^0 x_B = \frac{P_A^0 x_A}{P_A^0 x_A + P_B^0 x_B}$$

$$P_A^0 = 1,\ x_A = 1,\ P_B^0 = 2,\ x_B = 2$$

on substituting the values, we get

mole fraction of component 'A' in vapour phase

$$= \frac{1 \times 1}{1 \times 1 + 2 \times 2} = \frac{1}{1+4} = \frac{1}{5} = 0.2$$

48. (*c*) $C = K_H . P_{O_2}$

$$= 1.4 \times 10^{-3} \times 0.5 = 7 \times 10^{-4} \text{ mol /L}$$

$\therefore$ Number of moles of oxygen dissolved in 1000 ml

$= 7 \times 10^{-4}$

$\therefore$ Number of moles of oxygen dissolved in 100ml

$$= \frac{7 \times 10^{-4} \times 100}{1000} = 7 \times 10^{-5}$$

$\therefore$ Weight of oxygen in 100 ml

$$= 7 \times 10^{-5} \times 32$$
$$= 2.24 \times 10^{-3} \text{g} = 2.24 \text{ mg.}$$

49. (*d*) Number of moles of $CHCl_3$,

$$n_A = \frac{W}{M} = \frac{25.5}{119.5} = 0.213$$

Number of moles of CH_2Cl_2,

$$n_B = \frac{40}{85} = 0.47$$

Mole fraction of $CHCl_3$,

$$x_A = \frac{n_A}{n_A + n_B} = \frac{0.213}{0.684} = 0.31$$

mole fraction of CH_2Cl_2

$$X_B = 1 - x_A$$
$$= 1 - 0.31 = 0.69$$
$$P_{\text{Total}} = P_A x_A + P_B x_B$$
$$= 200 \times 0.31 + 41.5 \times 0.69$$
$$= 62 + 28.63 = 90.63 \text{ mm Hg.}$$

50. (*b*) If $p° = 100$ mm, $p_s = 100 - 10 = 90$ mm

$$\frac{p° - p_s}{p°} = \frac{w_2 / M_2}{w_1 / M_1} = \frac{w_2}{M_2} \times \frac{M_1}{w_1}$$

$$\frac{100 - 90}{100} = \frac{w_2}{60} \times \frac{18}{180}$$

$$\text{or} \quad w_2 = \frac{10}{100} \times 60 \times 10 = 60 \text{ g}$$

51. (*b*) Vapour pressure $\propto \frac{1}{\text{B.P}}$

52. (*a*) Partical concentration is same

$$\frac{12}{60} \times \frac{1}{1} = \frac{68.4}{342} \times \frac{1}{1}$$

53. (*c*) Number of ions $\propto$ Lowering of vapour pressure.

54. (*c*) Lowering of vapour pressure depends on number of moles of solute and temperature

55. (*c*) $x_X = \frac{1}{4} = 0.25,\ x_Y = 0.75$

$$P_{\text{total}} = x_X \times p_X° + x_Y \times p_Y°$$

i.e., $550 = 0.25\ p_X° + 0.75\ p_Y°$

or $2200 = p_X° + 3\ p_Y°$ ...(i)

After adding 1 mol of Y,

$$x_X = \frac{1}{5} = 0.20,\ x_Y = 0.80$$

$\therefore$ $560 = 0.20\ p_X° + 0.80\ p_Y°$

or $2800 = p_X° + 4\ p_Y°$ ...(ii)

Solving the two equations, we get

$p_Y° = 600$ mm, $p_X° = 400$ mm

56. (*b*) lowering of vapour pressure depends on numbers of moles of solute

57. (*d*) Relative lowering of vapour pressure $= \frac{P^0 - P}{P^0}$

58. (*a*) $\frac{P^0 - P}{P^0}$ = mole fraction of solute

59. (*d*) Molar ratio of 1 : 1 means $x_X = x_Y = 0.5$

$$P_{\text{total}} = x_X p_X° + x_Y p_Y°$$

$\therefore$ $400 = 0.5\ p_X° + 0.5\ p_Y°$

or $p_X° + p_Y° = 800$ ...(i)

Molar ratio of 1 : 2 means, $x_X = \frac{1}{3}, x_Y = \frac{2}{3}$

$\therefore \quad 350 = \frac{1}{3} p_X{}^\circ + \frac{2}{3} p_Y{}^\circ$

or $p_X{}^\circ + 2\, p_Y{}^\circ = 1050$ ...(ii)

Eqn (ii) - Eqn. (i) gives $p_Y{}^\circ = 250$ mm

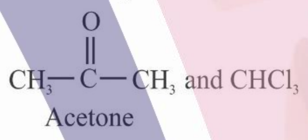
Putting in (i), we get $p_X{}^\circ = 550$ mm

60. (*c*) Maximum boiling azeotropes solution show negative deviation from Raoult's law.

61. (*b*) Chloroform and acetone form a non-ideal solution in which A...B type interactions are more than A ....A and B....B type interaction due to H-bonding. Hence, the solution shows negative deviation from Raoult's law i.e., $\Delta V_{mix} = -ve; \Delta H_{mix} = -ve$
$\therefore$ Total volume of mixture = < (30 + 50) mℓ

62. (*b*) A solution of acetone in ethanol shows a positive deviation from Raoult's law with difference of polarity and length of hydrocarbon chair. This is due to miscibility of these liquids.

63. (*d*)



$CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-CH_3$ and $CHCl_3$

Acetone

Acetone and chloroform will show a negative deviation due to their association after mixing.

64. (*c*) Raoult's law is applicable only for ideal solution only. These two components A and B follows the condition of Raoult's law, if the force of attraction between A and B is similar to the force of attraction between A-A & B-B.

65. (*a*) For an ideal solution ΔH and ΔV for mixing should be zero. $P_{Total} = P_A + P_B$ and A-A, B-B and A-B interactions are nearly same.

66. (*d*) Vapour phase would be richer in A.

Hence; (X_A) liquid < (X_A) vapour.

67. (*b*) H_2O (43%) and HI (57%) make maximum boiling azeotropic mixture on boiling at 400K.

68. (*c*) Acetone + chloroform shows negative deviation while Acetone + ethyl alcohol solution shows positive deviation.
Other examples:
Positive deviations: Acetone + ethyl alcohol, acetone + benzene, water + ethyl alcohol.
Negative deviations: Nitric acid + water, benzene + chloroform.

69. (*a*) Deep sea divers use mixture of helium-oxygen because of its very low solubility in blood.

70. (*a*) $\frac{P^0 - P_s}{P^0} = x_{solute} \Rightarrow \frac{0.8 - 0.6}{0.8} = x_{solute} \Rightarrow 0.25$

71. (*c*) $P^0 = 760$ torr; 1 M aqueous solution contains 1 mole of solute in 1000 g (55.5 mol) of water.

$$x_B = \frac{1}{1+55.5} = \frac{1}{56.5}$$

$$\frac{\Delta P}{P} = X_B,\ \Delta P = pX_B \Rightarrow \frac{760 \times 1}{56.5} = 13.45\,\text{torr}$$

72. (*a*) The solution shows negative deviation from Raoult's law because the vapour pressure of the solution is lower than that of either of two liquids.

73. (*a*) In (A) Para-nitrophenol intermolecular (between two molecules) H-bonding exists, while in (B) ortho-nitrophenol, intramolecular H-bonding exists. The boiling point of (B) is lower than (A) and, thus, (B) is more volatile, i.e., (B) has higher vapour pressure as compared to (A).

74. (*a*) Camphor is having high molal depression constant

75. (*c*) $\Delta T_b = K_b \times$ molality

76. (*d*) $T_f^0 - T_f = iK_f m,$

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

77. (*d*) $M = \frac{K_b \times W_B}{\Delta T_b \times W_A} = \frac{0.52 \times 12.5}{0.80 \times 0.185}$

$$= \frac{52 \times 125}{0.80 \times 185} = 43.92\,\text{g mol}^{-1}$$

(185 g = 0.185 Kg)

78. (*c*) No. of moles of urea $= \frac{10}{60} = \frac{1}{6}$

Weight of solute, X = 6 g

No. of moles of $= \frac{6}{M}$

For isotonic solution, $n_1 = n_2$

or $\frac{1}{6} = \frac{6}{M}$ or M = 36 g mol^{-1}

79. (*d*) The freezing point of solution decreases on increasing the amount of a solute

80. (*a*) $\pi = \frac{n_B RT}{V} : n_B = \frac{w_B}{M_B}$

$$\pi = \frac{w_B}{M_B} \times \frac{RT}{V} \Rightarrow M_B = \frac{W_B}{V} \times \frac{RT}{\pi} = \frac{2 \times 0.0821 \times 300 \times 760}{0.3 \times 20}$$

$= 0.0821 \times 100 \times 760 = 6239.6$ g mol^{-1}

81. (*a*) $M = \frac{W_B RT}{\pi V} = \frac{20 \times 0.0821 \times 288 \times 1000}{(600/760) \times 500} = 1198\,\text{g mol}^{-1}$

82. (*b*) Vapour pressure of pure water at boiling point = 1 atm = 1.013 bar

Vapour pressure of solution (P_s) = 1.004 bar

Let the mass of solution = 100 g

Mass of solute = 100 – 2 = 98 g

$$\frac{P^0 - P_s}{p^0} = \frac{n_2}{n_1 + n_2} = \frac{w_2 / M_2}{w_1 / M_1}$$

$$\frac{1.013 - 1.004}{1.013} = \frac{2 \times 18}{M_2 \times 98}$$

$$\Rightarrow M_2 = \frac{2 \times 18}{98} \times \frac{1.013}{0.009} = 41.35\text{g mol}^{-1}$$

83. (*c*) Solubility is temperature dependent. A plant cell shrinks in hypertonic solution. Relative lowering of vapour pressure is a colligative property.

84. (*a*) $P_{Glycerine} = P_{Glucose}$

$$\frac{n_1RT}{v_1} = \frac{n_2RT}{v_2}$$

$$\frac{10.2}{M} \times \frac{1}{1} = \frac{2}{180} \times \frac{1000}{100}$$

$$M = \frac{10.2 \times 18}{2} = 91.8\,g \ \ (\text{Density of water} = 1\ g/cm^3)$$

85. (*c*) Osmotic pressure depends on number of particles

86. (*b*) $\Delta T_f = \frac{K_f \times W_2 \times 1000}{M_2 \times W_1} \Rightarrow W_2 = \frac{\Delta T_f \times M_2 \times W_1}{k_f \times 1000}$

$$W_2 = \frac{10 \times 92 \times 600}{1.86 \times 1000} = 296.77g$$

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

$$K_b = \frac{\Delta T_b}{m} = \frac{1}{\frac{1}{50} \times \frac{1000}{50}} = \frac{5}{2} = 2.5$$

88. (*c*) Properties of dilute solutions of non-volatile solutes whose values depend upon the concentration and number of solute particles in the solution but not on the individuals identity of the solute. These can be known as colligative pressure. Various colligative properties are

(i) Relative lowering of vapour pressure
(ii) Elevation in boiling point
(iii) Depression in freezing point
(iv) Osmotic pressure

So; optical activity is not a colligative property.

89. (*d*) Same osmotic pressure solutions are called isotonic solutions.

90. (*b*) If a solute X distributes itself between non-miscible A and B, at constant temperature X is the same molecular condition in both the solvents, then, this law is known as Nernst distribution law.

$$\frac{\text{Concentration of } x \text{ in A}}{\text{Concentration of } x \text{ in B}} = k'd$$

Where; k'd is the distribution coefficient.

91. (*c*) $\Delta T_b = \frac{1000 \times K_b \times w}{w \times m}$

$$\Delta T_b = K_b \left[\frac{1 \times 1000}{100 \times 100}\right]$$

$$K_b = 10\Delta T_b$$

92. (*d*) The osmotic pressure is expressed in the unit of atmosphere.

93. (*c*) Elevation in boling point depends on number of solute particle

Number of particles are more in 0.1 M $BaCl_2$

∴ highest boiling point

94. (*b*) For NaCl, i = 2

$\Delta T_f = iK_f m$

$= 2 \times 1.86 \times 1 = 3.72$

$T_{f_{sol}} = \Delta T^0_f - \Delta T_f = 0 - 3.72 = -3.72°C$

95. (*b*) The freezing point of a pure solvent decreases on addition of solute.

96. (*c*) Elevation in boiling point and depression in freezing point, both are the colligative properties. In other words, as the number of particles increases, boiling point increase but freezing point decreases since, the order of boiling point is-

$C < B < A < D$

∴ The order of freezing point is

$D < A < B < C$

97. (*b*) $\Delta T_b = K_b \times \frac{\text{wt of solute}}{\text{m.wt of solute}} \times \frac{1000}{\text{wt.of solvent}}$

98. (*d*) Depression in freezing point,

$\Delta T_f = K_f \times m$

Where, m = molalilty =

$$\frac{\text{Weight of solute} \times 1000}{\text{molicular weight of solute} \times \text{weight of soluent}}$$

$$= \frac{1.5 \times 1000}{60 \times 250} = 0.1$$

$$\Delta T_f = K_f \times 0.1 \Rightarrow 0.01 = K_f \times 0.1 \Rightarrow K_f = 0.1$$

99. (*b*) Hypertonic is a solution having higher osmotic pressure than the other.

100. (*c*) $\Delta T_b = i \times K_b \times m$

101. (*b*) $\Delta T_f = 5.48 - 4.47 = 1.01, \Delta T_f = K_f \times m$

$$1.01 = 1.93 \times \frac{20 \times 1000}{m \times 50} \Rightarrow m = 76.4$$

102. (*c*) Depression in freezing point is a colligative property. Thus, the compound which produces maximum ions has the least freezing point.

∴ Concentration is same

Sucrose → No ions

$$NaCl \rightarrow \underbrace{Na^+ + Cl^-}_{\text{Two ions}}$$

$$CaCl_2 \rightarrow \underbrace{Ca^{2+} + 2Cl^-}_{\text{Three ions}}$$

Glucose → No ions.

Thus; 1% $CaCl_2$ has the least freezing point.

103. (*a*) Boiling point depends on number of solute particles hence highest in 0.1M $Al_2(SO_4)_3$

104. (*c*) $m = \frac{125 \times 0.8 \times 1000}{32 \times 375} = 8.33$

105. (*a*) $i = \frac{\text{Normal molar mass}}{\text{Observed molar mass}}$

$$= \frac{164}{65.6} = 2.5$$

$$\alpha = \frac{i-1}{n-1}, n = 3 \text{ (number of ions)}$$

$$= \frac{2.5-1}{3-1} = \frac{1.5}{2} = 0.75$$

∴ Percentage ionization of MX_2 will be 75%

106. (*b*) $P_{Total} = 2.619 + 4.556 = 7.175$ kPa

$$X_{MeOH} = \frac{P_{MeOH}}{P_{Total}} = \frac{2.619}{7.175} = 0.365$$

$$X_{EtOH} = 1 - 0.365 = 0.635$$

107. (*a*) $\frac{\Delta T_f}{\Delta T_b} = \frac{K_f}{K_b}$

108. (*c*) In order to produce same lowering in vapour pressure for same solvent, the mole fraction of solute should be same.

Thus, $\frac{W_B' M_A}{M_B' W_A} = \frac{W_B M_A}{M_B W_A}$

or $W_B' = \frac{W_B M_B' W_A'}{M_B W_A} = \frac{1 \times 180 \times 100}{60 \times 50} = 6\,g$

109. (*a*) $\pi = CST$

110. (*d*) $V = \frac{nRT}{\pi}$

111. (*d*) i = $\frac{\text{Total number of particles after association / dissociation}}{\text{Total number of particles before association / dissocition}}$

112. (*a*) $K_4[Fe(CN)_6] \rightarrow 4K^+ + [Fe(CN)_6]^{4-}$
$Al_2(SO_4)_3 \rightarrow 2Al^{3+} + 3SO_4^{2-}$

113. (*b*)

114. (*d*) $C_6H_{12}O_6$ is a non-electroyte hence furnishes minimum number of particles and will have maximum freezing point.
$\Delta T_f = iK_f m$ or $\Delta T_f \propto i$

115. (*c*) $Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$

$$\begin{array}{ccc} 1 & 2 & 0 \\ 1-\alpha & 2\alpha & \alpha \end{array}$$

Van't hoff factor (i) = $\frac{1-\alpha+2\alpha+\alpha}{1} = 1 + 2\alpha$

116. (*a*) $KCl \rightleftharpoons K^+ + Cl^- \quad (n = 2)$

$$\alpha = \frac{i-1}{n-1} = \frac{1.95-1}{2-1} = 0.95$$

117. (*a*) Since, HX is 20% ionised, van't hoff factor, $i = 1 + (y - 1)$
($\therefore$ y = 2, as two particles are produced)
$= 1 + (2 - 1)\,0.2 = 1.2$
$\Delta T_f = ik_f m = 1.2 \times 1.86 \times 0.2 = 0.45°\,C$
$\Delta T_f = T_1 - T_2$
$T_2 = 0°\,C - 0.45°\,C = -0.45°\,C$

118. (*a*) Van't Hoff factor (i)
i = 1, for non-electrolytes
i > 1, for dissociation
i < 1, for association

119. (*a*) $\Delta T_f = i \times k_f \times m$
Here; degree of dissociation = 80%
$\because i = 1 - \alpha + n\alpha \rightleftharpoons K^+ + Br^-$
$\therefore\ i = \frac{1 - 0.8 + 2 \times 0.8}{1} = 1.8$
$\therefore \Delta T_f = 1.8 \times 1.86 \times 0.5 \Rightarrow \Delta T_f = 1.674$ k
$\Delta T_f = T^0_f - T_f \Rightarrow 1.674 = 273 - T_f$
$T_f = 273.1.674 \Rightarrow T_f = 271.326$ K

120. (*c*) $Ca(NO_3)_2 \rightleftharpoons Ca^{2+} + 2NO_3^-$
Its van't hoff factor is 3 because it furnishes three ions per formula unit.

Learning Plus

1. (*a*) According to Henry's law, partial pressure of gas in the solution is proportional to the mole fraction of gas in the solution.

p = KH x

Where, *KH* = Henry's constant

2. (*d*) Dissolution of sugar in water will be most rapid when it dissolved hot water in powdered form because powder form can easily insert in the vacancies of liquid particles. Further dissolution of sugar in water is an endothermic process. Hence temperature will favour the dissolution of sugar in water.

3. (*c*) At equilibrium the rate of dissolution of solid in a volatile liquid solvent is equal to the rate of crystallization.

4. (*b*) When solute is added to the solution three cases may arise
(i) It dissolves into solution then solution is unsaturated.
(ii) It does not dissolve in the solution then solution is known as saturated.
(iii) When solute get precipitated solution is known as supersaturated solution.

5. (*c*) Maximum amount of solid that can be dissolved in a amount of a given solvent. This is because solid and liquid are highly incompressible.

6. (*b*) Low concentration of oxygen in the blood and tissues of people living at high altitude is atmospheric pressure. Because 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.

7. (*a*) In Pure methanol, molecules are hydrogen bonded. On adding acetone, its molecules get 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.

8. (*b*) Colligative properties depend upon number of solute particles in solution irrespective of their nature. Colligative property is used to determine the molecular mass of particle.

9. (*b*) Greater the value of van't Hoff factor higher will be the elevation in boiling point and hence higher will be the boiling point of solution.

Solution	Van't Hoff factor (i)
1.0 M NaOH	2
1.0 M Na_2SO_4	3
1.0 M NH_4NO_3	2
1.0 M KNO_3	2

Hence, 1.0 M Na_2SO_4 has highest value of boiling point.

10. (*a*) As we know from elevation in boiling point that U $\Delta T_b = K_b m$

$$\text{Unit of } K_b = \frac{\text{Unit of } \Delta T_b}{\text{Unit of m}}$$

$$= \frac{K}{\text{mol kg}^{-1}} = \text{K mol}^{-1}\text{ kg}$$

11. (*c*) Depression in freezing point is directly related to van't Hoff factor (*i*) according to which greater the value of *i* greater will be the depression in freezing point.

Solution	*i*
0.01 M glucose	1
0.01 M $MgCl_2$	3

Hence, depression in freezing point of glucose is about 3 times of glucose.

12. (*d*) When an unripe mango is pieced in a concentrated salt solution to prepare pickle then mango loose water due to osmosis and get shrivel.

13. (*a*) According to definition of osmotic pressure that $\pi = CRT$. For concentrated solution C has higher value than dilute solution.

14. (*a*) According to definition of depression in freezing point

$$\Delta Tf = Kf\, m$$

where, Kf = freezing point depression constant, value of Kf depends upon nature of solvent. The solution have same molality two different solutions of sucrose of same molality prepared in different solvents will have different depression in freezing point.

15. (*b*)

Substances	van't Hoff factor (*i*)
For *KCl*	2
For *NaCl*	2
For K_2SO_4	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*) Value Henry's constant (*KH*) increases with increase in temperature representing the decrease in solubility.

18. (*b*) According to Henry's law

$$\Rightarrow \quad p = KH\, x$$

As value of *KH* rises solubility of gases decreases.

19. (*b*) We know that, 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.

20. (*b*) Van't Hoff factor is the measurement of total number of ions present in the solution.

	Concentration NaCl	
A	0.1 M	On moving top to bottom
B	0.01 M	Concentration decreases
C	0.001 M	Van't Hoff factor decreases

21. (*b*) For an ideal solution, the A–A or B–B type intermolecular interaction is near by equal to A–B type interaction. Here, a mixture of bromoethane and chloroethane is an example of ideal solution.

On the other hand chloroform and acetone mixture is an example of non-ideal solution having negative deviation. So, (A–A) or (B–B) interaction must be stronger than interaction. While ethanol-acetone mixture shows positive deviation due to weaker A–B interaction in comparison to A–A or A–B interaction.

22. (*a*) When salt is added to water to make the solution the vapour pressure of solution get decreases. This is due to decrease in surface covered by solvent molecule which lead to decrease in number of solvent molecule escaping from the surface corresponding to pure solvent.

23. (*d*) Depending on the vapour pressures of the pure components 1 and 2, total vapour pressure over the solution decreases.

24. (*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 or B – B interaction. *i.e.*, A – B < A – A and B – B.

25. (*c*) Value of K_H depends upon nature of gases dissolved in water

Gas	Temperature (K)	KH/k bar
Ar	298 K	40.3
CO_2	298 K	1.67
CH_4	298 K	0.413
HCHO	298 K	1.83×10^{-5}

26. (*c*) Isotonic solutions have same osmotic pressure and same concentration. Elevation in boiling point and depression in freezing point are the colligative properties. These two colligative properties depend upon concentration.

As the molar concentration is same for isotonic solutions, so elevation in boiling point and depression in freezing point of isotonic solutions must be same.

27. **(c)** Mixtures having same composition in liquid and vapour phase are known as azeotropes. Azeotropes boils at same temperature.

Here, water-nitric acid and water-ethanol mixtures are non-ideal solution. Hence, water-nitric acid and water-ethanol are examples of azeotropes.

While benzene-toluene and n-hexane—*n*-heptane are examples of ideal solution.

28. (*d*) Molar mass of solute should not be significant here because 'discounting economic considerations' is mentioned which means molar mass can be compensated by 'given mass of solute'. Greater the value of (i), greater will be the depression in F.P.

29. (*b*) $Hg_2Cl_2 \underset{n=3}{\rightleftharpoons} Hg_2^{2+} + 2Cl^-$

$$\alpha = \frac{i-1}{n-1};\quad 0.8 = \frac{i-1}{3-1};\quad i = 2.6.$$

30. (*d*) 1% solution of $CaCl_2$ has maximum concentration of particles in the solution. $CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$

$$\Rightarrow \left(T_b \propto \Delta T_b \propto \frac{1\times\%}{\text{mol. wt}}\right)$$

31. (*b*) When benzoic acid dissolves in benzene it will be dimerised due to the inter molecular hydrogen bonding

$$2C_6H_5COOH \rightleftharpoons (C_6H_5COOH)_2$$

Von't Hoff factor =

$$\frac{\text{number of particles after dissociation / association}}{\text{number of particles before dissociation / association}} = \frac{1}{2} = 0.5$$

32. (*c*) using; $\Delta T_f = i \times K_f \times m$

$$i = \frac{\Delta T_f \times w_A}{K_f \times n_B \times 1000}$$

$$= \frac{3.82\times 45}{1.86\times\frac{5}{142}\times 1000} = 2.63$$

33. (*d*) In case of dissociation, Van't Hoff factor i > 1.

In case of association, Van't Hoff factor i < 1.

34. (*b*) $\Delta T_f = i \times K_f \times m$

$$\begin{array}{ccccc} HBr & \rightarrow & H^+ & + & Br^- \\ & & & & \\ 1-\alpha & & \alpha & & \alpha \end{array}$$

Total ions $= 1 - \alpha + \alpha + \alpha = 1 + \alpha$

$\therefore\ i = 1 + \alpha$

Given; $K_f = 1.86\ K\ mol^{-1}$

mass of HBr = 8.1 g

mass of H_2O = 100 g

(α) = degree of ionisation = 90%

$$m(\text{molality}) = \frac{\text{mass of solute / mol wt. of solute}}{\text{mass of solvent in kg}}$$

$$= \frac{8.1/81}{100/1000}$$

$$i = 1+\alpha = 1+\frac{90}{100} = 1.9$$

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

$$= 1.9\times 1.08\times\frac{8.1/81}{100/1000} = 3.534°C$$

ΔT_f (depression in freezing point) = freezing point of water- freezing point of solution.

3.534 = 0 – freezing point of sol^n

$\therefore$ freezing point = –3.534

35. (*b*) Depends only upon the number of particles of solute and not on the nature of solute to lowering of vapour pressure is a colligative property.

0.1 M glucose $\rightarrow$ remains undissociated

0.1 M $BaCl_2 \rightarrow Ba^{2+} + 2Cl^- \Rightarrow$ 3 ions

0.1 M $MgSO_4 \rightarrow Mg^{2+} + SO_4^{2-} \Rightarrow$ 2 ions

0.1 M $NaCl \rightarrow Na^+ + Cl^- \Rightarrow$ 2 ions

$\therefore$ 0.1 M $BaCl_2$ gives maximum number of particles, hence it exhibies maximum lowering of vapour pressure.

Multiconcept MCQs

1. (*a*)

Solution in 'A' solvent	Solution in 'B' solvent
w_{solute}	w_{solute}
M_{solute}	M_{solute}

$$\left(\frac{P^0 - P_s}{P^0}\right)_A = X_{solute}\text{ in solvent A}\ (\because \text{solute is same})$$

$$\left(\frac{P^0 - P_s}{P^0}\right)_B = 2\left(\frac{P^0 - P_s}{P^0}\right)_A$$

$$\left(\frac{n_{solute}}{n_{solute}+n_{solvent}}\right)_{in\,B} = 2\left(\frac{n_{solute}}{n_{solute}+n_{solvent}}\right)_{in\,A}$$

X_{solute} in solvent B = 2 X_{solute} in solvent A

Since solution is very dilute-

$n_{solute} + n_{solvent} \approx n_{solvent}$

$$\therefore \left(\frac{n_{solute}}{n_{solvent}}\right)_{in\,B} = 2\left(\frac{n_{solute}}{n_{solvent}}\right)_{in\,A}$$

Now, no. of moles of solute in solvent A & B are same,

$$\therefore \frac{1}{n_{\text{solvent in B}}} = \frac{1}{n_{\text{solvent in A}}}$$

$$\frac{1}{w_{\text{solvent}}} \times M_{\text{solvent}_B} = \frac{1}{w_{\text{solvent}}} \times M_{\text{solvent}_A}$$

(gives weights of solvents are also equal)

$$\therefore M_B = 2M_A$$

2. (*a*) $K_3[Fe(CN)_6]$ ionises as

$$K_3[Fe(CN)_6] \rightarrow 3K^+ + [Fe(CN)_6]^{3-}$$

For dissociation,

$$\alpha = \frac{i-1}{n-1} \Rightarrow \alpha = \frac{i-1}{u-1}$$

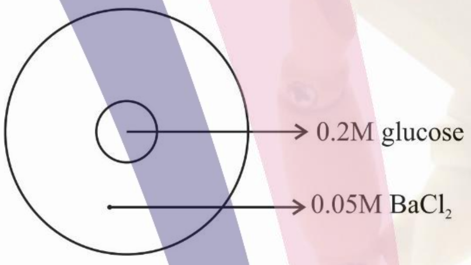
$$\therefore (3\alpha + 1) = i$$

$$\text{Now, } i = \frac{\text{Normal molar mass of solute}}{\text{Abnormal molar mass of solute}}$$

$$1 + 3\alpha = \frac{\text{Normal molar mass of solute}}{\text{Abnormal molar mass of solute}}$$

Abnormal molar mass of solute = $M_{\text{normal}}\ (1 + 3\alpha)^{-1}$

3. (*a*)



$$\begin{aligned} \pi &= (C_2 - C_1)RT \\ &= (0.2 - 0.05 \times 3) \times 0.0821 \times 300 \\ &= (0.2) - 0.15) \times 0.0821 \times 300 \\ &= 0.05 \times 0.0821 \times 300 \\ &= 1.23 \text{ atm} \end{aligned}$$

4. (*b*) $\dfrac{P^0 - P_S}{P_S} = \dfrac{n_B}{n_A}$

1 molar means 1 mole of solute is dissolved in 1 kg of solvent (water here)

$$\frac{12.3 - P_S}{P_S} = \frac{1}{\frac{1000}{18}}$$

$$\frac{12.3 - P_S}{P_S} = \frac{1}{55.5}$$

$$682.65 - 55.5\ P_S = P_S$$

$$682.65 = 56.5\ P_S$$

$$\frac{682.65}{56.5} = P_S = 12.08 \text{ kPa}$$

5. (*b*) $\Delta T_b = iK_b \times m$

$T_s - T^0 = iK_b m$

$T_s = iK_b m + T^0$

In option a:

For glucose i = 1

$T_s = 1 \times K_b \times 0.015 + T^0$

For option b:

i = 3

$T_s = 3K_b \times 0.10 + T^0$

$T_s = 0.3K_b + T^0$

For option c:

i = 2

$T_s = 2 \times K_b \times 0.01 + T^0$

$Ts = 0.02K_b + T^0$

For option d:

i = 1

$T_s = 1 \times K_b \times 0.015 + T^0$

$T_s = 0.015\ K_b + T^0$

6. (*c*) $\dfrac{P^0 - P_s}{P^0} = \dfrac{in_B}{in_B + n_A}$

$$\frac{10}{50} = \frac{3n_B}{3n_B + 12}$$

$$30\ n_B + 120 = 150\ n_B$$

$$120 = 120\ n_B$$

$$\frac{120}{120} = n_B$$

7. (*c*) $P_A = P_A^0 X_A$ (Raoult's law)

$P_A = P_{\text{total}}\ Y_A$ (Daltons law)

$\therefore P_A^0 X_A = P_{\text{total}} Y_A$

$$P_A^0 = \frac{P_{\text{total}} Y_A}{X_A} \text{ ......(1)}$$

$$\text{Similarly, } P_B^0 = \frac{P_{\text{total}} Y_B}{X_B} \text{ ......(2)}$$

Now, $P_A^0 > P_B^0$

$$\therefore P_{\text{Total}} \frac{Y_A}{X_A} > P_{\text{Total}} \frac{Y_B}{X_B}$$

$$\frac{Y_A}{X_A} > \frac{Y_B}{X_B}$$

8. (*b*) $n_{C_6H_{12}O_6} = 0.1$

$$n_{H_2O} = \frac{178.2}{18} = 9.9$$

$$\frac{P^0 - P}{P^0} = x_B \Rightarrow \frac{P^0 - P}{P^0} = \frac{0.1}{10}$$

$$P^0 - P = \frac{0.1}{10} \times 760 = 7.6$$

$$\begin{aligned} P &= P^0 - 7.6 \\ &= 760 - 7.6 \\ &= 752.4 \text{ torr} \end{aligned}$$

9. (*b*) $T_b - T_s = 105°C$ (given)

$\Delta T_b - K_b \times m$

$$T_b^s - T_b^o = K_b \times m \quad ......(1)$$

$\Delta T_f = K_f \times m$

$$T_f^o - T_f^s = K_f \times m \quad ....(2)$$

Add 1 & 2-

$$\left(T_b^s - T_b^o\right) + \left(T_f^o - T_f^s\right) = K_b \times m + K_f \times m$$

$$T_b^s - 373 + 273 - T_f^s = m\left(K_b + K_f\right)$$

$$105 - 100 = \frac{\frac{W}{342}}{\frac{100}{1000}} \times 2.37 \quad \Rightarrow W = 72 \text{ gm}$$

10. (*a*) $\underset{(s)}{XCl_3} \rightleftharpoons X^{3+} + 3Cl^-$

Apply, $\frac{P^o - P_s}{P^o} = \frac{in_B}{in_B + n_A}$

$$\frac{17.25 - 17.20}{17.20} = \frac{in_B}{n_A} \quad (\because \text{solution is very dilute})$$

$$\frac{0.05}{17.20} = 4\frac{n_B}{n_A}$$

$$\frac{n_B}{n_A} = 0.000726 \quad ......(1)$$

$$\text{molality} = \frac{n_B}{w_{A_{(g)}}} \times 1000$$

Putting value of molality in (1)-

$$m.\frac{w_A}{1000} \times \frac{1}{n_A} = 0.000726$$

$$m.\frac{\frac{w}{A}}{1000} \times \frac{1}{\frac{w}{A}} \times m_A = 0.000726$$

$$m = \frac{0.000726 \times 1000}{13} = 0.04037$$

Since solution is dilute, m = molarity

So, solubility = 4.03×10^{-2}

11. (*b*) Apply $\Delta T_f = i\, k_f\, m$

$\Delta T_f = i \times 1.86$

$$\Delta T_f = i \times 1.86 \times \frac{\frac{3}{60}}{\frac{500}{1000}} \quad ......(1) \qquad (\rho \text{ of } H_2O = 1 \text{ g/cm}^3)$$

So, 500 cm^3 water will weigh 500g

Also, $\alpha = \frac{i-1}{n-1} \Rightarrow 0.23 = \frac{i-1}{2-1}$

$i = 1.23$

Placing the value of (i) in equation 1, we get

$$\Delta T_f = 1.23 \times 1.86 \times \frac{3}{60} \times \frac{1000}{500}$$

$\Delta T_f = 0.228$ K

12. (*d*) Apply, $\Delta T_f = K_f m$

$0.48 = K_f \times m \quad .....(1)$

$\Delta T_b = i\,K_b m$

$0.26 = i\,K_b m \quad ......(2)$

Divide $\frac{1}{2}$

$$\frac{0.48}{0.26} = \frac{1}{i} \times 3.7 \quad \left(\because \frac{K_f}{K_b} = 3.7\right)$$

$$i = \frac{3.7}{1.84} = 2$$

Since vant hoff factor, i > 1, its a case of dissociation.

13. (*a*) $\Delta T_f = K_f \times m$

$$\Delta T_f = K_f \times \frac{w_{solute}}{m_{solute}} \times \frac{1000}{w_{solvent}}$$

Lesser the molar mass of the solute, greater will be the freezing point depression.

14. (*c*) $10\,\Delta T_f = K_f\,.m$

$$10 \times 0.186 = 18.6 \times \frac{\frac{3}{60}}{\frac{\text{wt. of solvent (g)}}{1000}}$$

$$1.86 = 18.6 \times \frac{3}{60} \times \frac{1000}{\text{wt. of solvent}}$$

$$\text{wt. of solvent} = \frac{18.6}{1.86} \times \frac{3}{60} \times \frac{1000}{10} \times 100 = 500\,\text{g} = 500\,\text{ml water}$$

15. (*a*) $\pi = icRT$

$$49.2 = \frac{i \times n}{V} \times 0.0821 \times 300$$

$$49.2 = 2 \times \frac{n}{1} \times 0.0821 \times 300$$

$$n = \frac{49.2}{49.2} = 1$$

So, no. of moles of HNO_3 should be = 1

Since, solution is 63% by mass

$\therefore$ 63g of HNO_3 is present in 100 gm of solution

So, 1 mole $\left(63/63 = 1\right)$ is present in 100 gm of solution

Volume of solution reqd.

ρ of solution = 1.1 g/ml

1.1 gm of solution is present in volume = 1 ml

100 gm of solution is present in volume =

$$\frac{1}{1.1} \times 100 \text{ ml} = 90.9 \text{ ml}$$

16. (*a*) $HA_{(aq.)} \rightleftharpoons H^+ + A^-$

$$\begin{array}{llll} & (aq.) & (aq.) & (aq.) \\ \text{At } t=0 & C & 0 & 0 \\ \text{At } t=t & C-C\alpha & C\alpha & C\alpha \end{array}$$

$pH = 2$

$\therefore (H^+) = 10^{-2} m$

$\therefore C\alpha = 10^{-2} \Rightarrow 1 \times \alpha = 10^{-2}$

$\alpha = 0.01$

$\alpha = \dfrac{i-1}{n-1} \Rightarrow 0.01 = \dfrac{i-1}{2-1}$

$i = 1.01$

17. (*b*) Mass of MeOH = 100 × 0.791 = 79.1 g

Mass of EtOH = 100 × 0.998 = 99.8 g

$M_1 = \dfrac{79.1 \times 1000}{32 \times 100} = 24.7;$

$M_2 = \dfrac{99.8 \times 1000}{46 \times 100} = 21.6$, Thus $M_1 > M_2$.

18. (*a*) $P^\circ - P_s = 10$

Apply, $\dfrac{P^\circ - P_s}{P^\circ} = x_B$

$\dfrac{10}{P^\circ} = 0.2 \Rightarrow P^\circ = 50$

Then, $P^\circ - P_s = 20$

$\dfrac{P^\circ - P_s}{P^\circ} = x_B \Rightarrow \dfrac{20}{50} = x_B = 0.4 \quad (\because x_A + x_B = 1)$

$\therefore x_A = 0.6$

19. (*c*) Observed $\Delta T_f = 3.72^\circ$; calculated $\Delta T_f = 1.86^\circ$

$i = \dfrac{\Delta T_f \text{ (obs.)}}{\Delta T_f \text{ (cal.)}} = \dfrac{3.72}{1.86} = 2$

This means that the salt ionizes to give two particles. The formula pertaining this observation is $[Pt(H_2O)_3Cl_3]Cl{\bullet}3H_2O$ which ionises in solution as $[Pt(H_2O)_3Cl_3]^+$ and Cl^- ions.

20. (*c*) $\Delta T_b = K_b \times M \quad ...(1)$

If solution is diluted with equal volume of water, then concentration of solutions is $\dfrac{M}{2}$

So, $\Delta T_f = K_f \times \dfrac{M}{2} \quad ...(2)$

$\dfrac{(1)}{(2)} : \dfrac{\Delta T_b}{\Delta T_b} = \dfrac{K_b \times M}{K_f \times \dfrac{M}{2}}$

$= \dfrac{0.15}{\Delta T_f} = \dfrac{0.512 \times 2}{1.86}$

$\Delta T_f = 0.272$

$\Delta T_f = (F.P.)_{solution} - (F.P.)_{solution}$

$0.272 = 0^\circ C - (F.P.)_{solution}$

$(F.P.)_{solution} = -0.272^\circ C.$

21. (*b*) $\Delta T_b = i\, K_b.m$

Given molality $= \dfrac{1 \times 1000}{250} = 4\,m,\ 6.4 = i \times 2 \times 4$ or $i = 0.8$

For dimerisation

$i = 1 - \dfrac{\beta}{2} \Rightarrow 0.8 - 1 = \dfrac{-\beta}{2}$ or $\beta = 0.4 \Rightarrow 40\%$

22. (*a*) **23.** (*d*)

NEET Past 10 Years Questions

1. (*d*) $\pi = iCRT$

$P_1 = 1 \times \dfrac{10}{180} \times R \times T$ (For Glucose)

$P_2 = 1 \times \dfrac{10}{60} \times R \times T$ (For Urea)

$P_3 = 1 \times \dfrac{10}{342} \times R \times T$ (For Sucrose)

$\therefore \quad P_2 > P_1 > P_3$

2. (*b*)

3. (*d*) While ethanol-acetone mixture shows positive deviation due to weaker A-B interaction in comparison to A-A or B-B interaction.

Pure ethanol molecules are hydrogen bonded. When acetone is added, its molecules get in between the ethanol molecules and break some of the hydrogen bonds between them. Thus, the intermolecular attractive interactions are weakens and the solution shows positive deviation from Raoult's law.

4. (*b*) $\Delta T_f = K_f \times$ molality(m)

$\Delta T_f = 5.12 \times 0.078$

$\Rightarrow 0.3993$

$= 0.40$ K

5. (*d*) Assuming dilute solution

$\dfrac{\Delta P}{P_A^0} = \dfrac{n_B}{n_A} = \dfrac{w_B}{m_B} . \dfrac{m_A}{w_A}$

$\dfrac{20}{100} = \dfrac{8}{m_B} . \dfrac{114}{114}$

$m_B = \dfrac{8 \times 100}{20} = 40 \text{ g mol}^{-1}$

6. (*b*) Solutions that have same osmotic pressure at a given temperature are called isotonic solutions

7. (*c*) For ideal solution,

Δ_{mix} H = 0, i.e., no heat should be absorbed or evolved during mixing

Δ_{mix} V = 0

8. (*a*) Maximum boiling azeotrope will forms by solutions that show negative deviation from Raoult's law.

Water and Nitric acid → forms maximum boiling azeotrope

9. (*a*) If molality of a dilute solution is doubled, the value of molal depression constant (K_f) will be unchanged because the value of molal depression constant will depend only on number of solute and solvent particle, as it is colligative property

10. (*c*) Molarity will depend upon temperature as molarity will depend upon the volume of the solution which change with temperature.

11. (*c*)

$P_b^o = 37$ torr, $P_b^o = 119$ torr.

$$y_t = \frac{P_t^o X_t}{P_t^o X_t + P_b^o X_b}, \quad X_t = 0.5$$

$$y_t = \frac{37 \times 0.5}{(37)(0.5)+(119)(0.5)} = \frac{37}{37+119} = 0.237$$

12. (*b*) In case of an ideal solution $\Delta Hmix = 0$

$\Delta Umix = 0$ but $\Delta Smix \neq 0$

According to 3rd law of thermodynamics:

$\Delta G = \Delta H - T\Delta S$

$\Delta Gmix \neq 0$

13. (*b*) $Ba(OH)_2$ is a strong electrolyte. It will 100% dissociate in aqueous solution:

$$Ba(OH)_2 \rightleftharpoons Ba^{2+} + 2OH^-$$

van't Hoff factor becomes 3.

14. (*b*) Two colligative properties will be used to solve the question.

$$\frac{p_0 - p_s}{p_s} = \frac{w_A/M_A}{w_B/M_B}$$

$$\frac{760-732}{732} = \frac{6.5 \times m}{100/18}$$

m = 32 g/mol

Also for lowering in boiling point:

$\Delta Tb = k_b \times m$

$$= 0.52 \times \frac{6.5}{32} \times \frac{1000}{100} = 1.06°C$$

T_b = 100 + 1.06 = 101.06°C

So, boiling point = 101°C

15. (*c*) $P_{Benzene} = x\,P^o$

$P_{Toluene} = x\,P^o$

For an ideal 1 : 1 molar mixture of Benzene and Toluene.

$$X_{Benzene} = \frac{1}{2};\ X_{Toluene} = \frac{1}{2}$$

$$P_{Benzene} = \frac{1}{2} \times 12.8\ KPa = 6.4\ KPa$$

$$P_{Toluene} = \frac{1}{2} \times 3.85\ KPa = 1.925\ KPa$$

Thus, the vapour will contain a high percentage of Benzene than Toluene.

16. (*a*) $X_{solution} = \frac{1}{55.5+1} = \frac{1}{56.5} = 0.0177$

17. (*c*) $Al_2(SO_4)_3 \rightleftharpoons \underset{i=5}{2Al^{3+}} + 3SO_4^{2-}$

$$K_4[Fe(CN)_6] \rightleftharpoons \underset{i=5}{4K^+} + [Fe(CN)_6]^-$$

18. (*a*) $\Delta S_{mix} > 0$

As entropy increases after mixing.

19. (*d*) X must be going dissociation in water thus increasing vant's Hoff factor (*i*) as after dissolution the number of solute particles increases.

20. (*b*) Depression in freezing point depends on vant's Hoff factor which depends on dissociation entities. So, among 4 options

$Al_2(SO_4)_3$ will have $2Al^{3+} + 3SO_4^{2-} = 5$ entities exhibiting maximum depression in freezing point.

21. (*c*) Molarity $= \frac{W \times 1000}{M \times V_{(mL.)}}$

$$2 = \frac{W}{63} \times \frac{1000}{250}$$

$$W = \frac{63}{2}$$

Because 70% HNO_3;

$$\text{Mass of acid} \times \frac{70}{100} = \frac{63}{2}$$

Mass of acid = 45 g

22. (*d*)

$$= P_A^o \times \frac{\frac{25.5}{119.5}}{\frac{25.5}{119.5} + \frac{40}{85}} + P_B^o \times \frac{\frac{40}{85}}{\frac{25.5}{119.5} + \frac{40}{85}}$$

= 90.3 mmHg

23. (*a*) According to Raoult's Law $Pt = p_A x_A + p_B x_B$

$x_A + x_B = 1$

$x_A = (1 - x_B)$

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

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

24. (*c*) Molality $= \frac{18}{180} = 0.1$ molal