SOLUTIONS

CHAPTER
02

INTRODUCTION

Solutions are mixtures where different substances are evenly spread out at a molecular level. They consist of a solvent (the substance in larger quantity) and solutes (substances dissolved in the solvent). Solutions can be liquids, gases, or solids, and examples include saltwater, sugar in tea, and air. They are important in various fields and have applications in chemistry, biology, industry, and daily life.

TYPES OF SOLUTIONS

1. **Homogeneous Solution:** A solution where the solute is uniformly distributed throughout the solvent, resulting in a mixture that appears the same throughout.
2. **Heterogeneous Solution:** A solution where the solute is unevenly distributed in the solvent, leading to visible variations in composition.
3. **Saturated Solution:** A solution in which the solvent has dissolved the maximum amount of solute possible at a given temperature and pressure.
4. **Unsaturated Solution:** A solution capable of dissolving more solute than it currently contains at a given temperature and pressure.

SOLUBILITY

The ability of a solid to dissolve in a liquid is influenced by two factors: "lattice energy" and "hydration energy." When the hydration energy exceeds the lattice energy, the solid is soluble in the liquid. It's important to note that a lower heat of dissolution corresponds to a higher solubility.

In accordance with Henry's law, which pertains to the solubility of a gas in a liquid, the solubility of a gas in a liquid increase when the pressure is increased or the temperature is decreased.

DIFFERENT METHODS OF EXPRESSING THE CONCENTRATION OF A SOLUTION:

Method of Concentration Expression	Description	Formula/Explanation
Molarity (M)	Moles of solute per liter of solution	Molarity (M) = Moles of Solute / Volume of Solution (L)
Molality (m)	Moles of solute per kilogram of solvent	Molality (m) = Moles of Solute / Mass of Solvent (kg)
Mass Percent (%)	Mass of solute divided by mass of solution, multiplied by 100	Mass Percent (%) = (Mass of Solute / Mass of Solution) x 100
Volume Percent (%)	Volume of solute divided by volume of solution, multiplied by 100	Volume Percent (%) = (Volume of Solute / Volume of Solution) x 100
Parts per Million (ppm)	Moles of solute per one million moles of solution	Parts per Million (ppm) = (Moles of Solute / Moles of Solution) x 10^6
Mole Fraction (X)	Moles of solute divided by total moles of solution	Mole Fraction (X) = Moles of Solute / Total Moles of Solution
Normality (N)	Gram equivalent weight of solute per litre of solution	Normality (N) = (Gram Equivalent Weight of Solute / Volume of Solution (L)
Mole Ratio	Ratio of moles of different components in a chemical reaction	Dependent on the specific reaction and stoichiometry

RELATIONS

(1) Relation between molality and molarity –

$$m = \frac{1000 \times M}{[1000 \times d - m \times \text{molecular mass of solute}]} \; ; \quad M = \frac{1000 \times m \times d}{1000 + m \times M_B}$$

(2) Relation between Molarity and Normality –

M × Molecular wt. = S g /L

N × Eq. wt. = S g /L

∴ M × mole. wt. = N × eq. wt.

$$\therefore \; \frac{N}{M} = \frac{\text{mol. wt.}}{\text{eq. wt.}}, \; \frac{N}{M} = n, \; \boxed{N = n \times M} \; ; \; M = \frac{N}{n}$$

(3) Relation between mole fraction, molarity and molality

$$\text{Mole fraction of solute} = \frac{\text{Molality} \times \text{Mol. wt. of solvent}}{1 + \text{molality} \times \text{Mol. wt. of solvent}}$$

$$= \frac{\text{Molarity} \times \text{Mol. wt. of solvent}}{\text{Molarity (Mol. wt. of solvent - Mol. wt. of solute)} \times d}$$

where $d =$ density of solution

VAPOUR PRESSURE AND RAOULT'S LAW

Vapor pressure is the pressure exerted by the vapor in equilibrium with a liquid or solution at a specific temperature. When a non-volatile solute is dissolved in a liquid, the vapor pressure of the liquid decreases. This occurs because some molecules of the solvent on the liquid surface are replaced by molecules of the solute, reducing the number of solvent molecules available to escape into the vapor phase.

According to Raoult's law, which applies to volatile solutes, the vapor pressure of a component in a solution is equal to the mole fraction of that component multiplied by its vapor pressure in its pure state. In a solution with components A and B, the vapor pressure of component A can be calculated as follows: $p_A = X_A \times p^0{}_A$, $p_B = X_B \times p^0{}_B$

$$\therefore \quad P_{Total} = P_A + P_B = X_A P^0{}_A + X_B P^0{}_B = (1 - X_B)\, P^0{}_A + X_B P^0{}_B$$

or $$P_{Total} = (P^0{}_B - P^0{}_A)\, X_B + P^0{}_A$$

Raoult's law for non-volatile solutes states "The relative lowering of vapour pressure of a solution containing a non-volatile is equal to the mole fraction of the solute in the solution". Mathematically

$$\frac{P_A^0 - P_A}{P_A^0} = \frac{n_B}{n_A + n_B} = X_B$$

<u>**IDEAL AND NON – IDEAL SOLUTIONS**</u>

Ideal and non-ideal solutions are classifications based on the behavior of components within a mixture.

An ideal solution is one that follows Raoult's law, which states that the vapor pressure of each component in the solution is directly proportional to its mole fraction. In an ideal solution, the components do not interact significantly with each other and behave independently. The interactions between the solvent and solute molecules, as well as the interactions between the solute molecules themselves, are similar to those in their pure states. Additionally, the volume changes upon mixing are negligible. Examples of ideal solutions include mixtures of volatile solvents that do not exhibit strong intermolecular forces.

On the other hand, a non-ideal solution deviates from Raoult's law. Non-ideal solutions occur when the interactions between the solvent and solute molecules, as well as between the solute molecules themselves, differ from those in their pure states. These interactions can be either attractive or repulsive and can significantly affect the behaviour of the solution. Non-ideal solutions can be classified further into two types: positive deviation and negative deviation.

1. **Positive Deviation:** In a solution exhibiting positive deviation from Raoult's law, the interactions between the components are stronger than expected. This leads to a higher vapor pressure than predicted by Raoult's law. Positive deviation is commonly observed when the components have dissimilar molecular structures or exhibit significant intermolecular forces, such as hydrogen bonding. For example, mixing ethanol and water shows positive deviation due to the formation of hydrogen bonds.
2. **Negative Deviation:** In a solution displaying negative deviation from Raoult's law, the interactions between the components are weaker than anticipated. This results in a lower vapor pressure than predicted by Raoult's law. Negative deviation is often observed when the components have similar molecular structures and exhibit weak intermolecular forces. For instance, mixing chloroform and acetone shows negative deviation.
3. It's important to note that non-ideal solutions can exhibit deviations from Raoult's law in other properties as well, such as boiling point elevation or depression and colligative properties. To describe the behaviour of non-ideal solutions accurately, more complex models, such as activity coefficients or equations of state, are used. These models take into account the specific interactions between the components and provide a better understanding of the solution's behaviour.

DIFFERENCE BETWEEN IDEAL AND NON- IDEAL SOLUTIONS

	Ideal Solutions	Non-Ideal Solutions
Raoult's Law	Follows Raoult's law: vapor pressure is proportional to mole fraction of each component	Deviates from Raoult's law: vapor pressure does not strictly follow the mole fraction of each component
Component Behaviors	Components behave independently and do not interact significantly	Components exhibit interactions different from their behaviour in pure states
Intermolecular Interactions	Weak intermolecular forces or no significant interactions between components	Strong or different intermolecular forces between components, such as hydrogen bonding
Volume Changes upon Mixing	Negligible volume changes upon mixing	Significant volume changes upon mixing
Deviation Types	-	Positive Deviation: Higher vapor pressure than predicted by Raoult's law. Negative Deviation: Lower vapor pressure than predicted by Raoult's law.
Examples	Mixtures of volatile solvents without strong intermolecular forces	Mixtures with dissimilar molecular structures, hydrogen bonding, or weak intermolecular forces between similar components

AZEOTROPES

An azeotrope is a mixture of two or more liquids that boils at a constant temperature and maintains a constant composition in the vapor phase. In other words, an azeotrope is a liquid mixture that cannot be separated into its individual components by simple distillation.

Azeotropes are formed due to the interaction between the components in the mixture, which leads to a unique boiling point and vapor composition. When an azeotropic mixture is heated, the vapor that is produced has the same composition as the liquid mixture. This behavior results in a constant boiling point for the azeotrope, even if the individual components have different boiling points.

There are two main types of azeotropes:

1. **Minimum Boiling Azeotrope:** In a minimum boiling azeotrope, the mixture has a lower boiling point than the boiling points of the individual components. This type of azeotrope is also known as a positive azeotrope. Ethanol-water mixture, which has a boiling point lower than that of pure ethanol or pure water, is an example of a minimum boiling azeotrope.
2. **Maximum Boiling Azeotrope:** In a maximum boiling azeotrope, the mixture has a higher boiling point than the boiling points of the individual components. This type of azeotrope is also known as a negative azeotrope. An example of a maximum boiling azeotrope is the hydrochloric acid-water mixture, which has a boiling point higher than that of pure hydrochloric acid or pure water.

Azeotropes can pose challenges in separation processes because simple distillation cannot be used to separate the components. However, techniques such as azeotropic distillation, extractive distillation, or the addition of third components (azeotropic agents) can be employed to break or modify the azeotropic behavior and separate the components effectively.

It's important to note that azeotropes can exist in both liquid-liquid and vapor-liquid systems, and they have implications in various industries, including chemical engineering, pharmaceuticals, and petroleum refining.

COLLIGATIVE PROPERTIES

Colligative Property	Description	Formula
Vapor Pressure Lowering	The decrease in vapor pressure of a solvent when a non-volatile solute is added. This occurs because the solute molecules occupy space on the liquid surface, reducing the number of solvent molecules able to escape into the vapor phase.	$\Delta P = x_{solute} * P°_{solvent}$
Boiling Point Elevation	The increase in the boiling point of a solvent when a non-volatile solute is added. This is due to the solute particles raising the solution's boiling point by disrupting the vapor pressure equilibrium between the liquid and vapor phases.	$\Delta T_b = K_b * m * i$
Freezing Point Depression	The decrease in the freezing point of a solvent when a non-volatile solute is added. The presence of solute particles interferes with the formation of the solvent's crystal lattice structure, preventing it from freezing at the usual temperature.	$\Delta T_f = K_f * m * i$
Osmotic Pressure	The pressure required to prevent the flow of solvent molecules across a semipermeable membrane, caused by the difference in solute concentration on either side of the membrane. It is the driving force for osmosis, the movement of solvent molecules from an area of lower solute concentration to an area of higher solute concentration.	$\pi = i * M * R * T$

In the formulas,

- ΔP represents the vapor pressure lowering,
- x_{solute} is the mole fraction of the solute,
- $P°_{solvent}$ is the vapor pressure of the pure solvent,
- ΔT_b represents the boiling point elevation,
- K_b is the boiling point elevation constant, m is the molality of the solute,
- i is the can't Hoff factor (the number of particles the solute dissociates into in the solution),
- $\Delta T_{f\ represents}$ the freezing point depression,
- K_f is the freezing point depression constant,
- π represents the osmotic pressure,
- M is the molarity of the solute,
- R is the ideal gas constant,
- T is the temperature in Kelvin.

Van't Hoff factor (*i*) – It is the ratio of the experiments value of the colligative properties to the calculated value of the colligative property

i.e. $i = \frac{\text{Experimental value of the colligative property}}{\text{Calculated value of the colligative property}}$.

As molecular mass $\propto \frac{1}{\text{Colligative property}}$, Hence $i = \frac{\text{Calculated molecular mass } (M_c)}{\text{obs. molecular mass } (M_o)}$,

$\Delta T_b = ik_b m$; $\Delta T_f = ik_f m$; $\pi = i\frac{n}{V}RT$,where i (Vant Hoff factor)>1 [for solutes undergoing dissociation $i < 1$ [for solutes undergoing association

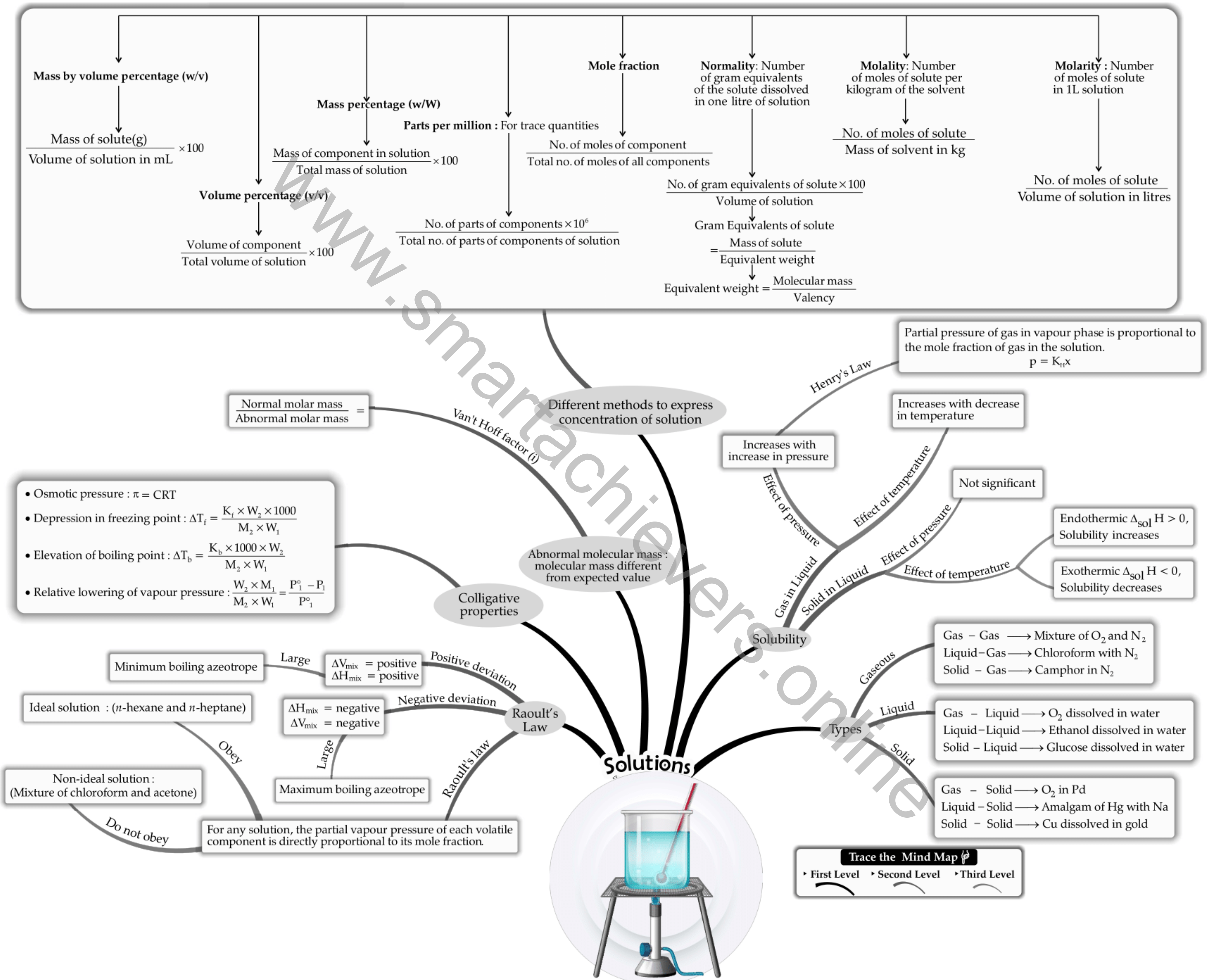
1. In case of non-electrolyte (glucose, sugar, urea etc), the value of colligative property depends directly on the concentration. If the substance is an electrolyte $[NaCl, BaCl_2$ etc$]$, it dissociation to colligative property depends upon concentration of ions [*e.g.* – 0.1 *M* $NaCl$ = 0.2 M ions, 0.1 *M* $BaCl_2 = 0.3\,M$ ions].
2. $i_{(Na_3PO_4)} \rightarrow$ Highest (It give max. ions)
3. $i_{(\text{assocation})} < i_{(\text{dissociation})}$.
4. For 0.1 *M* solution, the colligative property will follow the order $NaCl < Na_2SO_4 < Na_3PO_4$.
5. 1 *M* has higher concentration than 1 *m* (aq. Solution).
6. Mole fraction of any component in the vapour phase $= \frac{\text{Partial V.P. of that component}}{\text{Total vapour pressure}}$.
7. $D = \frac{M}{V}$.
8. Ethylene glycol (anti freeze) lowers the F. Pt.
9. α = 1 [For 100% dissociation of solute]
10. Camphor has the maximum value of $K_f(39.7^o)$(Maximum F. P. falls in camphor).
11. For water, $K_b = 0.52^0$; $K_f = 1.86^0$
12. K_f and K_b not colligative property.
13. Relationship between different colligative properties

    a. π with relative lowering of V. P. ; $\pi = \frac{P_A^0 - P_A}{P_A^0} \times \frac{dRT}{M_B}$; where *d*=density of the solution at temperature *T*

    b. π with ΔT_b; $\pi = \Delta T_b \times \frac{dRT}{1000\,K_b}$. (iii) π with ΔT_f; $\pi = \Delta T_f \times \frac{dRT}{1000\,K_f}$

    c. ΔT_b with relative lowering of V. P. $\Delta T_b = \frac{1000\,K_b}{M_A}\left(\frac{P_A^0 - P_A}{P_A^0}\right)$. (v)

    $\Delta T_f = \frac{1000\,k_f}{M_A}\left(\frac{P_A^0 - P_A}{P_A^0}\right)$.


Solutions
Different methods to express concentration of solution
Mass by volume percentage (w/v)
$\frac{\text{Mass of solute(g)}}{\text{Volume of solution in mL}} \times 100$
Volume percentage (v/v)
$\frac{\text{Volume of component}}{\text{Total volume of solution}} \times 100$
Mass percentage (w/W)
$\frac{\text{Mass of component in solution}}{\text{Total mass of solution}} \times 100$
Parts per million : For trace quantities
$\frac{\text{No. of parts of components} \times 10^6}{\text{Total no. of parts of components of solution}}$
Mole fraction
$\frac{\text{No. of moles of component}}{\text{Total no. of moles of all components}}$
Normality: Number of gram equivalents of the solute dissolved in one litre of solution
$\frac{\text{No. of gram equivalents of solute} \times 100}{\text{Volume of solution}}$
Gram Equivalents of solute $= \frac{\text{Mass of solute}}{\text{Equivalent weight}}$
Equivalent weight $= \frac{\text{Molecular mass}}{\text{Valency}}$
Molality: Number of moles of solute per kilogram of the solvent
$\frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$
Molarity : Number of moles of solute in 1L solution
$\frac{\text{No. of moles of solute}}{\text{Volume of solution in litres}}$
Abnormal molecular mass : molecular mass different from expected value
Van't Hoff factor (i)
$\frac{\text{Normal molar mass}}{\text{Abnormal molar mass}} =$
Colligative properties
• Osmotic pressure : $\pi = CRT$
• Depression in freezing point : $\Delta T_f = \frac{K_f \times W_2 \times 1000}{M_2 \times W_1}$
• Elevation of boiling point : $\Delta T_b = \frac{K_b \times 1000 \times W_2}{M_2 \times W_1}$
• Relative lowering of vapour pressure : $\frac{W_2 \times M_1}{M_2 \times W_1} = \frac{P^\circ_1 - P_1}{P^\circ_1}$
Raoult's Law
Positive deviation
ΔV_{mix} = positive
ΔH_{mix} = positive
Large
Minimum boiling azeotrope
Negative deviation
ΔH_{mix} = negative
ΔV_{mix} = negative
Large
Maximum boiling azeotrope
Raoult's law
For any solution, the partial vapour pressure of each volatile component is directly proportional to its mole fraction.
Obey
Ideal solution : (n-hexane and n-heptane)
Do not obey
Non-ideal solution : (Mixture of chloroform and acetone)
Solubility
Gas in Liquid
Henry's Law
Partial pressure of gas in vapour phase is proportional to the mole fraction of gas in the solution.
$p = K_H x$
Effect of pressure
Increases with increase in pressure
Effect of temperature
Increases with decrease in temperature
Solid in Liquid
Effect of pressure
Not significant
Effect of temperature
Endothermic $\Delta_{sol} H > 0$, Solubility increases
Exothermic $\Delta_{sol} H < 0$, Solubility decreases
Types
Gaseous
Gas – Gas ⟶ Mixture of O_2 and N_2
Liquid – Gas ⟶ Chloroform with N_2
Solid – Gas ⟶ Camphor in N_2
Liquid
Gas – Liquid ⟶ O_2 dissolved in water
Liquid – Liquid ⟶ Ethanol dissolved in water
Solid – Liquid ⟶ Glucose dissolved in water
Solid
Gas – Solid ⟶ O_2 in Pd
Liquid – Solid ⟶ Amalgam of Hg with Na
Solid – Solid ⟶ Cu dissolved in gold
Trace the Mind Map
First Level
Second Level
Third Level

PRACTISE QUESTIONS

1. The partition coefficient of solute X in between immiscible liquids A and B is 10 in favour of A. The partition coefficient of X in favour of B is:
   a) 0.1 b) 10 c) 0.01 d) 100

2.. Which one is a colligative property?
   a) Raoult's law states that the vapor pressure of a component over a solution is proportional to its mole fraction
   b) The osmotic pressure $(\pi)$of a solution is given by the equation $\pi = MRT$, where, $M$is the molarity of the solution
   c) The correct order of osmotic pressure for 0.01 M aqueous solution of each compound is $BaCl_2 > KCl > CH_3COOH >$ sucrose
   d) Two sucrose solutions of same molality prepared in different solvents will have the same freezing point depression

3. Which type of solution has a solute that completely dissolves in a solvent?

a) Saturated solution
b) Unsaturated solution
c) Supersaturated solution
d) Dilute solution

4. What is the solubility of a substance?

a) The amount of solute that dissolves in a given amount of solvent
b) The volume of solvent used in a solution
c) The density of a solution
d) The temperature at which a solute dissolve

5. Which factor does NOT affect the solubility of a solid solute in a liquid solvent?

a) Temperature
b) Pressure
c) Nature of the solute and solvent
d) Surface area of the solute

6. According to Henry's law, the solubility of a gas in a liquid:

a) Increases with increasing temperature
b) Increases with decreasing temperature
c) Decreases with increasing pressure
d) Decreases with decreasing pressure

7. Which of the following factors does NOT affect the rate of dissolution of a solute?

a) Temperature
b) Pressure
c) Stirring or agitation
d) Surface area of the solute

8. Which colligative property depends on the number of solute particles, rather than their identity?

a) Vapor pressure lowering
b) Boiling point elevation
c) Freezing point depression
d) Osmotic pressure

9. Which of the following is an example of a non-electrolyte?

a) Sodium chloride (NaCl)
b) Hydrochloric acid (HCl)
c) Ethanol (C2H5OH)
d) Calcium chloride (CaCl2)

10. The van's Hoff factor represents:

a) The extent of dissociation or association of solute particles
b) The molar mass of the solute
c) The volume of the solution
d) The color of the solute

11. A solution that contains the maximum amount of solute at a given temperature is called:

a) Unsaturated solution
b) Saturated solution
c) Dilute solution
b) Concentrated solution

12. What is the boiling point elevation?

a) The increase in boiling point of a solution compared to the pure solvent
b) The decrease in boiling point of a solution compared to the pure solvent
c) The difference between the boiling points of two solvents
d) The temperature at which a solute starts to boil

13. The osmotic pressure of a solution depends on:

a) The molar mass of the solute

b) The temperature of the solution

c) The volume of the solvent

d) The concentration of the solute

14. Which of the following is an example of an ideal solution?

a) Saltwater

b) Oil and water

c) Ethanol and water

d) Carbon dioxide gas in water

15. What is an azeotrope?

a) A mixture of two or more liquids that cannot be separated by distillation

b) A type of solid solution

c) The maximum amount of solute that can dissolve in a solvent

d) The ratio of the mass of a solute to the volume of the solution

16. What is the molarity of a solution?

a) The ratio of the mass of a solute to the volume of the solution

b) The ratio of the moles of solute to the volume of the solution

c) The ratio of the mass of a solute to the moles of the solvent

d) The ratio of the moles of solute to the moles of the solvent

17. The solubility of a gas in a liquid generally:

a) Decreases with increasing temperature

b) Increases with increasing temperature

c) Increases with decreasing pressure

d) Decreases with decreasing pressure

18. What is the molality of a solution?

a) The ratio of the mass of a solute to the volume of the solution

b) The ratio of the moles of solute to the volume of the solution

c) The ratio of the moles of solute to the moles of the solvent

d) The ratio of the mass of a solute to the moles of the solvent

19. The phenomenon of solvent molecules surrounding solute particles is known as:

a) Dissociation b) Association c) Hydration d) Aggregation

20. What is the role of a catalyst in a chemical reaction?

a) It increases the rate of the reaction

b) It decreases the rate of the reaction

c) It consumes the reactants

d) It produces the products

21. What is the critical point of a substance?

a) The temperature at which a substance changes from solid to liquid

b) The temperature at which a substance changes from liquid to gas

c) The temperature and pressure above which a substance cannot exist as a liquid

d) The temperature and pressure below which a substance cannot exist as a gas

22. The process of converting a gas directly into a solid is called:

a) Sublimation b) Deposition c) Condensation d) Evaporation

23. What is the difference between a solute and a solvent?

a) A solute dissolve in a solvent

b) A solute is a liquid, and a solvent is a solid

c) A solute is a solid, and a solvent is a liquid

d) A solute is a gas, and a solvent is a liquid

24. What is the molar mass of a substance?

a) The mass of one mole of the substance

b) The mass of one molecule of the substance

c) The mass of one atom of the substance

d) The mass of one gram of the substance

25. Which of the following is an example of a supersaturated solution?

a) Sugar dissolved in water

b) Salt dissolved in water until no more salt can dissolve

c) Sodium acetate dissolved in water and heated, then cooled slowly

d) Alcohol dissolved in water

26. Which of the following is NOT a colligative property?

a) Vapor pressure lowering

b) Boiling point elevation

c) Melting point depression

d) Specific heat capacity

27. What is the formula for calculating molarity?

a) $M = \frac{moles\ of\ solute}{moles\ of\ solvent}$

b) $M = \frac{mass\ of\ solute}{volume\ of\ solution}$

c) $M = \frac{moles\ of\ solute}{volume\ of\ solution}$

d) $M = \frac{mass\ of\ solute}{moles\ of\ solvent}$

28. What is the effect of adding a solute on the boiling point of a solvent?

a) The boiling point increases

b) The boiling point decreases

c) The boiling point remains the same

d) It depends on the nature of the solute

29. What is the unit of molarity?

a) moles

b) liters

c) moles per liter

d) grams

30. Which of the following is a colligative property?

a) Density
b) Color
c) Viscosity
d) Freezing point depression

31. Which of the following statements is true for an ideal solution?

a) The solute-solute interactions are stronger than the solute-solvent interactions
b) The solute-solvent interactions are stronger than the solute-solute interactions
c) The solute and solvent form separate layers in the solution
d) The solute and solvent do not interact with each other

32. What is the formula for calculating molality?

a) $M = \frac{moles\ of\ solute}{moles\ of\ solvent}$
b) $M = \frac{mass\ of\ solute}{volume\ of\ solution}$
c) $M = \frac{moles\ of\ solute}{volume\ of\ solution}$
d) $M = \frac{mass\ of\ solute}{moles\ of\ solvent}$

33. What is the effect of adding a non-volatile solute on the vapor pressure of a solvent?

a) The vapor pressure increases
b) The vapor pressure decreases
c) The vapor pressure remains the same
d) It depends on the nature of the solute.

34. What is the role of a catalyst in a chemical reaction?

a) It increases the activation energy of the reaction
b) It decreases the activation energy of the reaction
c) It increases the rate of the reaction
d) It decreases the rate of the reaction

35. Which of the following solutions is considered to be the most dilute?

a) 0.1 M
b) 1 M
c) 0 M
d) 100 M

36. What is the formula for calculating volume percent?

a) $Volume\ percent = \frac{volume\ of\ solute}{volume\ of\ solution} \times 100$

b) $Volume\ percent = \frac{mass\ of\ solute}{volume\ of\ solution} \times 100$

c) $Volume\ percent = \frac{volume\ of\ solute}{mass\ of\ solution} \times 100$

d) $Volume\ percent = \frac{mass\ of\ solute}{mass\ of\ solution} \times 100$

37. What is the effect of increasing the temperature on the solubility of most solid solutes in water?

a) The solubility increases
b) The solubility decreases
c) The solubility remains the same
d) It depends on the nature of the solute

38. What is the formula for calculating the number of moles in a solution?

a) $M = \frac{moles\ of\ solute}{moles\ of\ solvent}$
b) $M = \frac{mass\ of\ solute}{volume\ of\ solution}$
c) $M = \frac{moles\ of\ solute}{volume\ of\ solution}$
d) $M = \frac{mass\ of\ solute}{moles\ of\ solvent}$

39. What is the boiling point of water at sea level?

a) 0°C
b) 100°C
c) -273°C
d) 373°C

40. Which of the following statements is true for a saturated solution?

a) The solution contains the maximum amount of solute at a given temperature
b) The solution contains a small amount of solute compared to the solvent
c) The solute particles settle at the bottom of the container
d) The solution cannot dissolve any more solute

41. What is the freezing point of water at sea level?

a) 0°C
b) 100°C
c) -273°C
d) 373°C

42. A solution contains 0.1 moles of sucrose ($C_{12}H_{22}O_{11}$) dissolved in 250 mL of water. What is the boiling point elevation of the solution? (Assume the boiling point elevation constant, Kb, for water is 0.52 °C/m)

a) 0.13 °C   b) 0.26 °C   c) 0.52 °C   d) 1.3 °C

43. A solution is prepared by dissolving 2.5 grams of sodium chloride (NaCl) in 100 mL of water. What is the freezing point depression of the solution? (Assume the freezing point depression constant, Kf, for water is 1.86 °C/m)

a) 0.47 °C   b) 0.93 °C   c) 1.86 °C   d) 3.72 °C

44. A solution contains 0.2 moles of potassium iodide (KI) dissolved in 500 mL of water. What is the osmotic pressure of the solution at 25°C? (Assume the ideal gas constant, R, is 0.0821 L·atm/(mol·K))

a) 0.041 atm   b) 0.082 atm   c) 0.164 atm   d) 0.328 atm

45. A solution is prepared by dissolving 15 grams of glucose (C6H12O6) in 500 mL of water. What is the vapor pressure lowering of the solution? (Assume the vapor pressure of pure water is 23.8 mmHg)

a) 2.38 mmHg   b) 4.76 mmHg   c) 11.9 mmHg   d) 23.8 mmHg

46. A solution contains 0.3 moles of calcium chloride (CaCl2) dissolved in 250 mL of water. What is the boiling point elevation of the solution? (Assume the boiling point elevation constant, Kb, for water is 0.52 °C/m)

a) 0.078 °C   b) 0.156 °C   c) 0.26 °C   d) 0.39 °C

47. Insulin $(C_2H_{10}O_5)_n$ is dissolved in a suitable solvent and the osmotic pressure (π) of solutic concentrations C (g/cm^3) is measured at 20°C. the slope of a plot of π against C is formed to be The molecular weight of the insulin is :
a) 4.8×10^5
b) 9×10^5
c) 3×10^5
d) $5.17 \times 10^{}$

48. Volume of 0.6 M NaOH required to neutralise 30 cm^3 of 0.4 M HCl is
a) 20 cm^3
b) 40 cm^3
c) 45 cm^3
d) 30 cm^3

49. The freezing point of the 0.05 molal solution of non-electrolyte in water is
a) −0.093℃
b) 1.86℃
c) 0.93℃
d) 0.093℃

50. A molar solution of NaCl has a density of 1.21 g mL^{-1}. The molarity of this solution is
a) 2.35
b) 1.143
c) 2.95
d) 1.356

51. Osmotic pressure of blood is 7.65 atm at 310 K. An aqueous solution of glucose that will be blood is ……….wt./vol.
a) 5.41%
b) 3.54%
c) 4.53%
d) 53.4%

52. A solution containing 4 g of polyvinyl chloride in 1 litre of dioxane was found to have an osmotic pressure of 6×10^{-4} atm at 300 K. The molecular mass of the polymer is :
a) 3×10^3
b) 1.6×10^5
c) 5×10^4
d) 6.4×10^2

53. The normality of mixture obtained by mixing 100 mL of 0.2 M H_2SO_4 + 100 mL of 0.2 M NaOH is
a) 0.2
b) 0.01
c) 0.1
d) 0.3

ANSWERS

1. b) 10 - The partition coefficient of X in favor of B is the reciprocal of the coefficient in favor of A, so it's 1/10.

2. b) The osmotic pressure (π) of a solution is given by the equation $\pi = MRT$, where M is the molarity of the solution - This equation defines osmotic pressure, a colligative property dependent on solute concentration.

3. b) Unsaturated solution - An unsaturated solution has not reached its maximum solute concentration and can still dissolve more solute.

4. a) The amount of solute that dissolves in a given amount of solvent - Solubility refers to the maximum amount of solute that can dissolve in a given amount of solvent under specific conditions.

5. c) Nature of the solute and solvent - The nature (chemical composition) of the solute and solvent strongly affects solubility, whereas pressure does not significantly affect the solubility of solid solutes in liquid solvents.

6. c) Decreases with increasing pressure - According to Henry's law, the solubility of a gas in a liquid decreases with increasing pressure.

7. b) Pressure - Pressure does not significantly affect the rate of dissolution. Temperature, stirring, and surface area all influence the rate of dissolution.

8. d) Osmotic pressure - Osmotic pressure is dependent on the number of solute particles, regardless of their identity, making it a colligative property.

9. c) Ethanol (C2H5OH) - Ethanol is a non-electrolyte because it does not dissociate into ions in solution. Sodium chloride, hydrochloric acid, and calcium chloride are electrolytes as they dissociate into ions when dissolved.

10. a) The extent of dissociation or association of solute particles - The van't Hoff factor (i) is a measure of how many particles a solute dissociates into in solution.

11. b) Saturated solution - A saturated solution contains the maximum amount of solute that can dissolve at a given temperature.

12. a) The increase in boiling point of a solution compared to the pure solvent - Boiling point elevation is a colligative property that describes the increase in boiling point of a solution compared to the pure solvent due to the presence of a non-volatile solute.

13. b) The temperature of the solution - Osmotic pressure is directly proportional to temperature.

14. c) Ethanol and water - An ideal solution is one where the interactions between the components are similar, leading to no deviation from Raoult's law.

15. a) A mixture of two or more liquids that cannot be separated by distillation - An azeotrope is a specific type of mixture that has a constant boiling point and composition.

16. b) The ratio of the moles of solute to the volume of the solution - Molarity (M) is defined as moles of solute per liter of solution.

17. b) Increases with increasing temperature - According to Henry's law, the solubility of a gas in a liquid generally increases with increasing temperature.

18. c) The ratio of the moles of solute to the moles of the solvent - Molality (m) is defined as moles of solute per kilogram of solvent.

19. c) Hydration - Hydration is the process in which solvent molecules surround and interact with solute particles.

20. a) It increases the rate of the reaction - A catalyst speeds up a chemical reaction without itself being consumed in the process.

21. c) The temperature and pressure above which a substance cannot exist as a liquid - The critical point is the specific temperature and pressure at which a substance transitions from a gas to a supercritical fluid.

22. b) Deposition - Deposition is the process where a gas transforms directly into a solid without passing through a liquid state.

23. c) A solute is a solid, and a solvent is a liquid - A solute is the substance that is dissolved in a solution, while a solvent is the substance that does the dissolving.

24. a) The mass of one mole of the substance - Molar mass is the mass of one mole of a substance and is expressed in grams per mole.

25. c) Sodium acetate dissolved in water and heated, then cooled slowly - A supersaturated solution contains more solute than it should be able to dissolve at a given temperature. It is created by dissolving the solute in hot solvent and then slowly cooling it.

26. d) Specific heat capacity - Specific heat capacity is not a colligative property. It is the amount of heat energy required to raise the temperature of a unit mass of a substance by one degree Celsius.

27. c) M=(moles of solute)/(volume of solution) - Molarity (M) is defined as moles of solute per liter of solution.

28. a) The boiling point increases - Adding a solute to a solvent increases the boiling point of the solution compared to the pure solvent. This is known as boiling point elevation, a colligative property.

29. moles per liter: (b) The unit of concentration for molarity.

30. Freezing point depression: (a) The phenomenon of lowering the freezing point of a solvent when a solute is added.

31. The solute-solvent interactions are stronger than the solute-solute interactions: (c) The reason for the deviation from ideal behavior in non-ideal solutions.

32. $m = \frac{moles\ of\ solute}{moles\ of\ solvent}$: (c) The formula for molality, a measure of concentration.

33. The vapor pressure decreases: (d) The effect of adding a solute to a solvent on its vapor pressure.

34. c) It increases the rate of the reaction by lowering the activation energy barrier.

35. c) 0 M - A solution with 0 M concentration is the most dilute as it contains the lowest amount of solute.

36. d) Volume percent= $\frac{(Mass\ of\ Solute)}{Mass\ of\ Solution} \times 100$

This formula calculates volume percent by dividing the mass of the solute by the total mass of the solution, multiplied by 100.

37. a) The solubility increases.Generally, increasing temperature enhances the solubility of solid solutes in water by providing more energy for the dissolution process.

38. c) M= $\frac{Mass\ of\ Solute}{Volume\ of\ Solution}$. This formula defines molarity (M) as the ratio of moles of solute to the volume of the solution in liters.

39. b) 100°C. At sea level, water boils at 100°C due to the atmospheric pressure.

40. a) The solution contains the maximum amount of solute at a given temperature.

A saturated solution has dissolved the maximum possible amount of solute at a specific temperature.

41. a) 0°C. At sea level, water freezes at 0°C under standard atmospheric pressure.

42. (b) 0.26 °C

The boiling point elevation is calculated using the formula: ΔTb = Kb * molality. Given the molality of the solution and the boiling point elevation constant for water, we can calculate the boiling point elevation.

43. (a) 0.47 °C

The freezing point depression is calculated using the formula: ΔTf = Kf * molality. Given the molality of the solution and the freezing point depression constant for water, we can calculate the freezing point depression.

44. (c) 0.164 atm

The osmotic pressure is calculated using the formula: π = nRT/V. Given the number of moles of solute, the gas constant, temperature, and volume, we can calculate the osmotic pressure.

45. (b) 4.76 mmHg

The vapor pressure lowering is calculated using the formula: ΔP = Xsolute * vapor pressure of solvent. Given the mass of solute, the molar mass of solute, and the vapor pressure of pure solvent, we can calculate the vapor pressure lowering.

46. (b) 0.156 °C

The boiling point elevation is calculated using the formula: ΔTb = Kb * molality. Given the molality of the solution and the boiling point elevation constant for water, we can calculate the boiling point elevation.

47. (d): $\pi V = \frac{w}{m} ST$

$\therefore \pi = \frac{w}{V} . \frac{ST}{m}$

$\pi = c' . \frac{ST}{m}$ (c' is in g/litre.)

The plots of π $vs. c$ (g/cm^3) have slope $= \frac{ST \times 1000}{m}$

$\therefore \frac{ST \times 1000}{m} = 4.65 \times 10^{-3}$

$m = \frac{0.0821 \times 293 \times 1000}{4.65 \times 10^{-3}} = 5.17 \times 10^{6}$

48. (a): According to molarity equation

$$NaOH = HCl$$
$$M_1V_1 = M_2V_2$$
$$0.6 \times V_1 = 0.4 \times 30$$
$$V_1 = \frac{0.4 \times 30}{0.6} = 20cm^3$$

49. (a): For non-electrolyte

$$\Delta T_f = k_f \times m$$

Given, m =0.05,

$\therefore$ $\Delta T_f = 1.86 \times 0.05 = 0.093°C$

Freezing point of solution

$k_f = 1.86 = 0 - \Delta T_f$

=0-0.093=-0.093°C

50. (b): $M = \frac{m \times d}{1+\frac{mM_2}{1000}} = \frac{1\times1.21}{1+\frac{1\times58.5}{1000}}$

$= \frac{1.21 \times 1000}{1000 + 58.5}$

$= 1.143$ M

51. (a): $\pi V = nST$ for glucose and blood; If isotonic $\pi_{glucose} = \pi_{blood}$;

Thus, $7.65 \times V = \frac{w}{180} \times 0.0821 \times 310$

$\therefore \frac{w}{V} = 54.1$ g/litre or 5.41%

52. (b): $\pi V = \frac{w}{m} ST$;

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

$$m = 1.64 \times 10^5$$

53. (c): Given

H_2SO_4 - V=100mL, N=0.2 M

NaOH - V=100mL, N=0.2 M

Milliequivalent of $H_2SO_4 = 100 \times 0.2 \times 2 = 40$

($\therefore$ It is dibasic acid)

Milliequivalent of NaOH $= 100 \times 0.1 \times 2 = 20$

$\therefore$ Moilliequivalent Of H_2SO_4 left =40-20=20

Total volume = 100mL+100mL=200mL

Normality of H_2SO_4 (left0)=$\frac{20}{200}$ =0.1 N