



# Sarvan Sir – Chemistry For All

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## Solution Theory Questions

### Solution (Only Theory)

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#### 1. Define Solution

A **solution** is a homogeneous mixture of two or more substances in which one substance (solute) is uniformly dissolved in another substance (solvent).

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#### 2. Types of solution on the basis of physical states of solvent and solute, with examples \*

Solute	Solvent	Example
Gas	Gas	Air (O <sub>2</sub> in N <sub>2</sub> )
Gas	Liquid	CO <sub>2</sub> in water (soda water)
Gas	Solid	Hydrogen in palladium
Liquid	Liquid	Alcohol in water
Solid	Liquid	NaCl in water
Solid	Solid	Brass (Zn in Cu)

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#### 3. Define solubility

**Solubility** is the maximum amount of solute that can dissolve in a given amount of solvent at a specific temperature to form a saturated solution.

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#### 4. Factors affecting solubility



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1. Nature of solute and solvent
  2. Temperature
  3. Pressure (mainly for gases)
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### 5. What is saturated and unsaturated solution

- **Saturated solution:** A solution that contains the maximum amount of solute at a given temperature.
- **Unsaturated solution:** A solution that contains less solute than its maximum capacity at that temperature.

#### Equilibrium Concept

A solution in which the rate of dissolution of a solute equals the rate of crystallization, so a dynamic equilibrium is established between the solid solute and its ions/molecules in solution at a given temperature.

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### 6. Define Henry's Law and applications.

**Henry's Law:** At constant temperature, the solubility of a gas in a liquid is directly proportional to the pressure of the gas above the liquid.

Henry's Law Formula:

$$p = k_H x$$

Where:

- $p$  = partial pressure of the gas
- $x$  = mole fraction of the gas in the solution
- $k_H$  = Henry's law constant



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### Applications:

- Carbonated beverages
- Scuba diving
- High-altitude sickness

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### 7. Aquatic life feels more comfortable in cold water, why?

The solubility of oxygen increases at lower temperatures. Cold water contains more dissolved oxygen, which supports aquatic life better.

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### 8. Solubility of gas decreases on increasing temperature, why?

Dissolution of gases is an exothermic process. Increasing temperature provides energy to gas molecules, causing them to escape from the solution.

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### 9. Relation of Henry's law constant with temperature

Henry's law constant **generally increases** with increase in temperature, therefore solubility of gas decreases.

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### 10. Define Raoult's Law

For a solution of volatile liquids, the partial vapour pressure of each component is proportional to its mole fraction in the solution.



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### Raoult's Law Formula:

For a volatile component A in a solution:

$$p_A = x_A p_A^0$$

Where:

- $p_A$  = partial vapour pressure of component A in solution
- $x_A$  = mole fraction of component A
- $p_A^0$  = vapour pressure of pure component A

For a binary solution (A + B):

$$p_{\text{total}} = x_A p_A^0 + x_B p_B^0$$

Special case (non-volatile solute):

$$p = x_{\text{solvent}} p^0$$

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### 11. Define ideal and non-ideal solution with examples \*\*\*

- **Ideal solution:** Obeys Raoult's law at all concentrations.  
*Example:* Benzene + toluene
- **Non-ideal solution:** Does not obey Raoult's law.  
*Example:* Acetone + ethanol

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### 12. Properties of ideal solution

1. Obeys Raoult's law



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2. No heat change on mixing ( $\Delta H_{\text{mix}}=0$ )
  3. No volume change on mixing ( $\Delta V_{\text{mix}}=0$ )
  4. Intermolecular forces remain unchanged (Let Two components are A and B. If the intermolecular attractive forces between the A-A and B-B are nearly equal to those between A-B)
  5. Solution of n-hexane and n-heptane, bromoethane and chloroethane, benzene and toluene
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### 13. How many types of non-ideal solution? Explain with examples

Two types:

#### Positive Deviation from Raoult's Law

##### Definition:

A solution shows **positive deviation** from Raoult's law when its **vapour pressure is higher** than the value predicted by Raoult's law.

##### Features:

1. A-B interactions are weaker than those between A-A or B-B, i.e., in this case the intermolecular attractive forces between the solute-solvent molecules are weaker than those between the solute-solute and solvent-solvent molecules.
2. **Heat is absorbed** during mixing ( $\Delta H_{\text{mix}} > 0$ )
3. **Volume increases** on mixing ( $\Delta V_{\text{mix}} > 0$ )

#### 4. Examples:

- Acetone + ethanol
- Ethanol + water
- Carbon disulphide + acetone

#### 4. Negative Deviation from Raoult's Law

1. A-B interactions are stronger than those between A-A or B-B, i.e., in this case the intermolecular attractive forces between the solute-solvent molecules are stronger than those between the solute-solute and solvent-solvent molecules.
2. Heat is absorbed during mixing ( $\Delta H_{\text{mix}} < 0$ )



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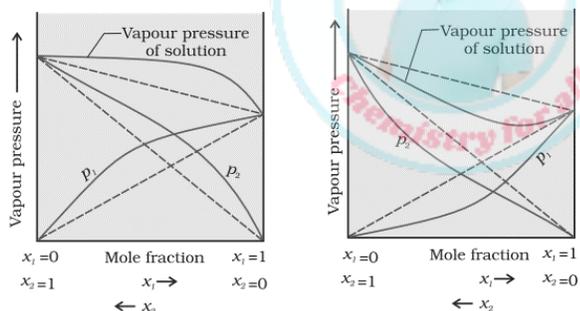
3. Volume increases on mixing ( $\Delta V_{\text{mix}} < 0$ )

4. Examples:

*Example:* Chloroform + acetone. Phenol and aniline

### 14. Draw graphs for non-ideal solution

- Positive deviation: Curve lies **above** Raoult's law line (Left)
- Negative deviation: Curve lies **below** Raoult's law line (Right)



### 15. Mixture of acetone and ethanol shows positive deviation from Raoult's law, why?

Because intermolecular attraction between acetone and ethanol is weaker than in pure components, leading to higher vapour pressure.

### 16. Mixture of chloroform and acetone shows negative deviation, why?



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Due to strong hydrogen bonding between chloroform and acetone molecules, vapour pressure decreases.

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### 17. Which has higher vapour pressure: pure solvent or solution when solute is non-volatile?

The vapour pressure of the solution at a given temperature is found to be lower than the vapour pressure of the pure solvent at the same temperature. In the solution, the surface has both solute and solvent molecules; there by the fraction of the surface covered by the solvent molecules gets reduced.

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### 18. What is colligative property? Write its four types

Colligative properties depend only on the number of solute particles.

Types:

1. Relative lowering of vapour pressure
2. Elevation of boiling point
3. Depression of freezing point
4. Osmotic pressure

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### 19. Why boiling point of solution is higher than pure solvent when solute is non-volatile? Explain with graph

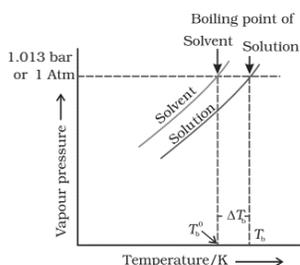
Non-volatile solute lowers vapour pressure. Higher temperature is required for vapour pressure to equal atmospheric pressure, so boiling point increases.



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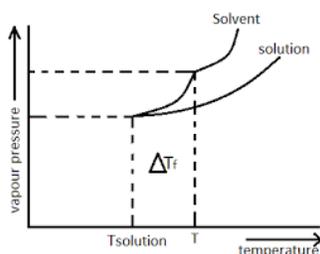
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### 20. Why freezing point of solution is lower than that of pure solvent when solute is non-volatile? Explain with graph.

Solute lowers the vapour pressure of solvent, delaying freezing, thus freezing point decreases.



### 21. Define osmosis

Osmosis is the movement of solvent molecules through a semipermeable membrane from lower solute concentration to higher solute concentration.

### 22. Define osmotic pressure

Osmotic pressure is the pressure required to stop the flow of solvent through a semipermeable membrane.



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### 23. Define isotonic, hypertonic and hypotonic solution

#### Isotonic solution

A solution having the **same osmotic pressure** as the cell or another solution, so **no net movement of water** occurs across the membrane.

*Example:* 0.9% NaCl solution with human red blood cells.

#### Hypertonic solution

A solution having **higher osmotic pressure** than the cell or another solution; **water moves out** of the cell, causing it to **shrink**.

*Example:* Concentrated salt solution around a cell.

#### Hypotonic solution

A solution having **lower osmotic pressure** than the cell or another solution; **water moves into** the cell, causing it to swell (may burst).

*Example:* Distilled water around a cell.

### 24. Applications of osmosis

The phenomena mentioned above can be explained on the basis of **osmosis**.

- When a **raw mango** is placed in a **concentrated salt solution**, water moves out of the mango cells by osmosis, causing it to **shrink and form pickle**.
- **Wilted flowers** revive when placed in **fresh water** because water enters their cells by osmosis, making them firm again.
- A **limp carrot**, which has lost water to the atmosphere, becomes **firm** when placed in water as water enters its cells through osmosis.
- When **blood cells** are placed in water containing **less than 0.9% salt solution**, water enters the cells by osmosis, causing them to **swell**.
- People who consume excess **salty food** experience **water retention** in tissue cells and intercellular spaces due to osmosis. This swelling or puffiness is called **edema**.
- The movement of water from **soil into plant roots** and then to the upper parts of the plant occurs partly due to osmosis.
- **Preservation of meat by salting** and **fruits by adding sugar** prevents



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### 25. Osmotic pressure method is used to find molar mass of solute, why?

The osmotic pressure method has the advantage over other methods as pressure measurement is around the room temperature and the molarity of the solution is used instead of molality. As compared to other colligative properties, its magnitude is large even for very dilute solutions

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### 26. Raoult's law is a special case of Henry's law. Explain

Raoult's law:  $p_i = p_i^0 x_i$

Henry's law:  $p_i = K_H x_i$

If we compare the equations for Raoult's law and Henry's law, it can be seen that the partial pressure of the volatile component or gas is directly proportional to its mole fraction in solution. Only the proportionality constant  $K_H$  differs from  $p_i^0$ . Thus, Raoult's law becomes a special case of Henry's law in which  $K_H$  becomes equal to  $p_i^0$

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### 27. Define van't Hoff factor

Van't Hoff factor is the ratio of the observed colligative property to the theoretical value.

van't Hoff factor (  $i$  )

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

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

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

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### 28. Define normal and abnormal molar mass \*\*\*



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- **Normal molar mass:** Calculated molar mass without association or dissociation
- **Abnormal molar mass:** Observed molar mass affected by association or dissociation

## 29. The standard formulas for expressing concentration of solutions\*\*\*

### 1. Mass percentage (w/w %)

$$\text{Mass \%} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$$

### 2. Volume percentage (v/v %)

$$\text{Volume \%} = \frac{\text{Volume of solute}}{\text{Volume of solution}} \times 100$$

### 3. Mass by volume percentage (w/v %)

$$\text{Mass by volume \%} = \frac{\text{Mass of solute (g)}}{\text{Volume of solution (mL)}} \times 100$$

### 4. Parts per million (ppm)

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

### 5. Molarity (M)

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

### 6. Molality (m)

$$m = \frac{\text{Number of moles of solute}}{\text{Mass of solvent (kg)}}$$

### 7. Mole fraction (X)

$$X_A = \frac{\text{Moles of component A}}{\text{Total moles of all components}}$$



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### **30. While sodium chloride and sugar dissolve readily in water, naphthalene and anthracene do not?**

Sodium chloride and sugar dissolve in water due to strong ion–dipole or hydrogen bonding interactions, whereas naphthalene and anthracene are non-polar and hence do not dissolve in water.

### **31. Naphthalene and anthracene dissolve readily in benzene but sodium chloride and sugar do not?**

Naphthalene and anthracene dissolve readily in benzene because both are non-polar substances, whereas sodium chloride and sugar are polar/ionic and therefore do not dissolve in non-polar benzene.

### **32. Naphthalene and anthracene dissolve readily in benzene but sodium chloride and sugar do not?**

Naphthalene and anthracene are non-polar like benzene, so they dissolve in it (“like dissolves like”), whereas sodium chloride and sugar are polar/ionic and therefore do not dissolve in non-polar benzene.

### **33. What are the bends in scuba diving?**

At high pressure underwater, nitrogen gas dissolves in the blood. If the diver ascends rapidly, the pressure suddenly decreases and nitrogen comes out of solution as bubbles in the blood and tissues, causing pain and other problems.

### **34. How to avoid bends in scuba diving?**

To avoid bends, as well as, the toxic effects of high concentrations of nitrogen in the blood, the tanks used by scuba divers are filled with air diluted with helium (11.7% helium, 56.2% nitrogen and 32.1% oxygen) as solubility of helium is low in liquids.

### **35. At higher altitudes people suffer from anoxia resulting in ability to think?**

At higher altitudes, people suffer from anoxia because the partial pressure of the oxygen is less than on the ground level, due to which the oxygen concentration reduces in the blood or tissue causing anoxia which may affect the brain and result in an inability to think.



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### 36. What is azeotropic mixture?

An azeotropic mixture is a mixture of two liquids that boils at a constant temperature and has the same composition in both liquid and vapour phases, so it cannot be separated by simple fractional distillation.

### 37. Types of azeotropic mixture?

- Minimum boiling azeotrope
  - Shows positive deviation from Raoult's law
  - Boils at a lower temperature than either component
  - *Example:* 95 % Ethanol + 5 % water mixture
- Maximum boiling azeotrope
  - Shows negative deviation from Raoult's law
  - Boils at a higher temperature than either component
  - *Example:* 68 % Nitric acid 32 % water mixture

### 37. Relation between degree of dissociation/association and van't Hoff factor.

For dissociation:

$$i = 1 + (n - 1)\alpha$$

For association:

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

### 38. Define $K_b$ and $K_f$

$K_b$  (Ebullioscopic Constant)

$K_b$  is the molal elevation constant of a solvent.

It is defined as the increase in boiling point of a solvent when 1 mole of a non-volatile solute is dissolved in 1 kg of the solvent.

$$\Delta T_f = K_f m$$



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### $K_f$ (Cryoscopic Constant)

$K_f$  is the molal depression constant of a solvent.

It is defined as the decrease in freezing point of a solvent when 1 mole of a non-volatile solute is dissolved in 1 kg of the solvent.

$$\Delta T_f = K_f m$$

- $K_b$  and  $K_f$  depend only on the solvent, not on the solute.
- Units of both  $K_b$  and  $K_f = K \text{ kg mol}^{-1}$

### 39. Why does molality remain constant with change in temperature whereas molarity does not?

**Molality** remains constant with change in temperature because it depends on the **mass of the solvent**, and mass does **not change with temperature**.

**Molarity**, on the other hand, depends on the **volume of the solution**, and volume **changes with temperature** due to expansion or contraction.

### 40. Define colligative properties. Why are they called colligative?

**Colligative properties** are the properties of solutions that depend **only on the number of solute particles present in the solution**, and **not on the nature of the solute**.

They are called **colligative** (from the Latin word *colligare*, meaning *to bind together*) because these properties are determined by the **collective effect of solute particles** present in the solution, irrespective of what the particles are.

### 41. Why does an aqueous solution of NaCl show abnormal molar mass?

An aqueous solution of **NaCl** shows **abnormal molar mass** because **NaCl dissociates into ions** in water.





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Due to dissociation, the **number of solute particles increases**, which increases the value of colligative properties. As a result, the **molar mass calculated from colligative properties appears lower than the actual molar mass**, hence it is called **abnormal molar mass**

