Class 12 Chemistry – Solutions | Study Guide

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1. Theory in Simple Words with Visuals

1.1 What is a Solution?

- **Definition:** A solution is a **homogeneous mixture** of two or more substances.
- **Components:**
  - **Solvent:** Substance present in larger amount (e.g., water)
  - **Solute:** Substance dissolved in solvent (e.g., salt, sugar)

Analogy: Think of **sugar in tea** – sugar (solute) disappears in water (solvent) forming a uniform mixture.

Visual:

```
Water molecules (solvent): ○
Sugar molecules (solute): ●

Before mixing:
○ ○ ○
● ●

After mixing (solution):
○ ● ○ ● ○ ●
```

1.2 Types of Solutions

Type	Example	Characteristics
Solid in liquid	Sugar in water	Transparent, homogeneous
Liquid in liquid	Alcohol + water	Miscible liquids
Gas in liquid	CO_2 in soda	Fizzes, homogeneous
Solid in solid	Brass (Cu + Zn)	Alloy, homogeneous

Mnemonic: "SLGS – So Lovely Good Solutions" → Solid, Liquid, Gas, Solid

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1.3 Concentration Terms

1. **Molarity (M):** Moles of solute / Liter of solution
   - **Formula:** $M = \frac{\text{moles of solute}}{\text{volume of solution (L)}}$
2. **Molality (m):** Moles of solute / Kg of solvent
   - **Formula:** $m = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$
3. **Mole fraction (X):** $X_A = \frac{\text{moles of A}}{\text{total moles}}$
4. **Percent by mass / volume:**
   - $\%w/w = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$
   - $\%w/v = \frac{\text{mass of solute}}{\text{volume of solution}} \times 100$

Visual Table for Quick Recall:

Term	Symbol	Formula	Unit
Molarity	M	moles/L	mol/L
Molality	m	moles/kg	mol/kg
Mole fraction	X	moles/total moles	—
% w/w	—	mass solute/mass solution ×100	%
% w/v	—	mass solute/volume solution ×100	%

1.4 Solubility & Factors Affecting It

- **Solubility:** Maximum amount of solute that can dissolve in 100 g solvent at given temperature.
- **Factors:**
  1. **Nature of solute & solvent** – "Like dissolves like"
  2. **Temperature** – Solids ↑ with temp, gases ↓ with temp
  3. **Pressure** – Gases ↑ solubility with ↑ pressure (Henry's Law)

Visual: Gas in soda bottle → more CO_2 pressure = more dissolved gas

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1.5 Colligative Properties

- Depend **only on number of solute particles**, not type.
- **Types:**
  1. **Relative lowering of vapor pressure:** $\Delta P/P = X_2$
  2. **Elevation of boiling point:** $\Delta T_b = K_b \times m \times i$
  3. **Depression of freezing point:** $\Delta T_f = K_f \times m \times i$
  4. **Osmotic pressure:** $\pi = MRT$

Mnemonic: "VP, BP, FP, OP – Very Big Fun Observations"

- **van't Hoff factor (i):** Number of ions per formula unit
  - NaCl → i = 2, $CaCl_2$ → i = 3

1.6 Raoult's Law & Henry's Law

- **Raoult's Law:** Partial vapor pressure of solvent ↓ when solute added
  - $P_{solvent} = X_{solvent} \times P^0_{solvent}$
- **Henry's Law:** Solubility of gas ∝ pressure of gas above solution

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2. Key Concepts & Formulas

Concept	Formula / Fact	Tip / Mnemonic
Molarity (M)	M = moles/L	Volume of solution in liters
Molality (m)	m = moles/kg solvent	Mass of solvent in kg
Mole fraction (X)	X = moles/total moles	Always between 0 and 1
Percent w/w	% = mass solute/mass solution ×100	
Percent w/v	% = mass solute/volume solution ×100	
Raoult's Law	P = X_solvent × P^0	Partial pressure decreases
ΔT_b, ΔT_f	ΔT = K × m × i	Remember van't Hoff factor i
Osmotic Pressure	π = MRT	R = 0.0821 L atm K^{-1} mol^{-1}

Memory Trick: "Molarity in Liters, Molality in Kgs"

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3. Solved Numerical Problems

Example 1: Molarity

Problem: 10 g NaOH in 500 mL solution. Find molarity.
Solution:
Step 1: Moles NaOH = 10/40 = 0.25 mol
Step 2: Volume = 500 mL = 0.5 L
Step 3: Molarity = 0.25/0.5 = 0.5 M

Example 2: Freezing Point Depression

Problem: 10 g NaCl in 100 g water. Find ΔT_f. (K_f = 1.86 K kg/mol)

Solution:
Step 1: Moles NaCl = 10/58.5 = 0.171 mol
Step 2: Molality = 0.171 / 0.1 kg = 1.71 m
Step 3: ΔT_f = K_f × m × i = 1.86 × 1.71 × 2 ≈ 6.36 K

Tip: Don't forget van't Hoff factor i = 2 for NaCl

Example 3: Osmotic Pressure

Problem: 0.1 M glucose solution at 27°C. Find π.

Solution:
π = MRT = 0.1 × 0.0821 × 300 ≈ 2.46 atm

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4. Previous Years' Board Questions (Solved)

1. **Molarity & Molality questions** – 2017, 2018
2. **Colligative properties** – 2016, 2019
3. **Raoult's law / vapor pressure lowering** – 2018, 2020
4. **Henry's law / solubility of gases** – 2015, 2021

Pattern: High weightage to **colligative properties, molarity/molality, and vapor pressure problems.**

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5. Quick Revision Notes / Important Points

- **Concentration terms:** M, m, X, % w/w, % w/v
- **Colligative properties formulas:** ΔT_f, ΔT_b, π
- **Raoult's law:** P_solvent = X_solvent × P^0_solvent
- **Key mnemonics:**
  - **"Molarity → Liters, Molality → Kg"**
  - **"VP, BP, FP, OP"** for colligative properties
- **Van't Hoff factor (i):** 1 for non-electrolytes, >1 for electrolytes

Flowchart for Colligative Properties:

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Colligative Properties → Depends on # of solute particles
   ↓
1. Vapor Pressure ↓ → Raoult's law
2. Boiling Point ↑ → ΔT_b = K_b m i
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3. Freezing Point ↓ → $\Delta T_f = K_f m i$
4. Osmotic Pressure $\pi = MRT$

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6. Predicted / Likely Questions

1. Calculate **molarity, molality, mole fraction**
2. Freezing point depression / boiling point elevation problems
3. Osmotic pressure and van't Hoff factor questions
4. Raoult's law and Henry's law applications
5. Conceptual: "Why gases are less soluble at higher temperature?"

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7. Exam Tips & Tricks

- Always **convert units properly**: g → kg, mL → L
- **Identify electrolyte vs non-electrolyte** to use i correctly
- **Shortcut:** ΔT_f, ΔT_b → multiply m × i × K_f/b
- **Common mistakes:** Forgetting to multiply by van't Hoff factor
- Use **flowcharts** to remember colligative properties

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8. Visual & Kid-Friendly Learning Style

- Color-code **solvent (blue)** and **solute (red)** in diagrams
- Picture **colligative effects** as "particles blocking freezing/raising boiling"
- Draw **ice cubes with salt** to visualize freezing point depression