# Solutions

NCERT Class 12 Chemistry · Chapter 1

Easy notes · Formulas · Solved numericals · Questions to memorise

**Board weightage:** about 7 marks.

**How to use this booklet:**

- Day 1: Parts A–B (concentration terms, Henry's law). Learn the formula table by heart.
- Day 2: Parts C–D (Raoult's law, ideal / non-ideal, azeotropes).
- Day 3: Parts E–F (colligative properties, van't Hoff factor). Solve every numerical once on paper.

| Colour | Meaning |
|---|---|
| Yellow highlight | Must remember – examiners look for these words |
| Blue card | A reaction: general reaction → reagents above arrow → example with names |
| Orange box | Values / data to remember |
| Purple box | A difficult word explained simply |
| Brown box | Solved numerical / mechanism, step by step |
| Green box | Hinglish mein samjho |
| Red box | Exam tip |

# Start Here · Difficult Words Made Easy

| Word | Simple meaning | Example |
|---|---|---|
| Solution | A homogeneous mixture of two or more substances (same everywhere). **Hinglish:** Solution = ek jaisa mixture, kahin bhi sample lo, same. | sugar in water |
| Solute / solvent | Solute = the smaller part that dissolves; solvent = the larger part that dissolves it. **Hinglish:** Kam wala solute, zyada wala solvent. | salt / water |
| Molality (m) | Moles of solute in 1 kg of solvent. **Hinglish:** Molality mein kg solvent – temperature se nahi badalta. | 1 m = 1 mol per kg |
| Molarity (M) | Moles of solute in 1 L of solution. **Hinglish:** Molarity mein litre solution – temperature se badalta hai. | 1 M NaOH |
| Mole fraction (x) | Moles of one part ÷ total moles. All mole fractions add to 1. **Hinglish:** Hissa nikaalo – total moles mein kitna is component ka. | $x_A + x_B = 1$ |
| Vapour pressure | Pressure of the vapour above a liquid, when evaporation and condensation are balanced. **Hinglish:** Liquid ke upar bhaap ka pressure, jab aana-jaana barabar. | water: 23.8 mm Hg at 298 K |
| Colligative property | A property that depends only on the number of solute particles, not on what they are. **Hinglish:** Sirf particles ki ginti matter karti hai, unki pehchaan nahi. | $\Delta T_f$, $\pi$ |

| Word | Simple meaning | Example |
|---|---|---|
| Osmosis | Flow of solvent through a semipermeable membrane from dilute to concentrated solution. **Hinglish:** Paani patle se gaadhe ki taraf jaata hai membrane se. | raisins swell in water |
| Azeotrope | A liquid mixture that boils at a constant temperature with the same composition in liquid and vapour. **Hinglish:** Aisa mixture jo distillation se alag nahi hota. | 95% ethanol |
| van't Hoff factor (i) | How many particles one formula unit gives in solution (or the correction factor). **Hinglish:** Ek molecule kitne tukde banata hai – wahi i. | NaCl: i = 2 |

## Values to Remember · Data and Tests

## ATOMIC MASSES AND ELECTRONEGATIVITY

| Element | Symbol | Atomic mass (u) | Electronegativity |
|---|---|---|---|
| Hydrogen | H | 1 | 2.1 |
| Carbon | C | 12 | 2.5 |
| Nitrogen | N | 14 | 3.0 |
| Oxygen | O | 16 | 3.5 |
| Fluorine | F | 19 | 4.0 |
| Sodium | Na | 23 | 0.9 |
| Magnesium | Mg | 24 | 1.2 |
| Sulphur | S | 32 | 2.5 |
| Chlorine | Cl | 35.5 | 3.0 |
| Potassium | K | 39 | 0.8 |
| Bromine | Br | 80 | 2.8 |
| Silver | Ag | 108 | 1.9 |
| Iodine | I | 127 | 2.5 |

## CONSTANTS FOR SOLUTIONS

| Quantity | Value |
|---|---|
| Gas constant R | 8.314 J $K^{-1}$ $mol^{-1}$ = 0.0821 L atm $K^{-1}$ $mol^{-1}$ = 0.083 L bar $K^{-1}$ $mol^{-1}$ |
| $K_b$ of water (ebullioscopic) | 0.52 K kg $mol^{-1}$ |
| $K_f$ of water (cryoscopic) | 1.86 K kg $mol^{-1}$ |
| $K_b$ / $K_f$ of benzene | 2.53 / 5.12 K kg $mol^{-1}$ |
| Normal b.p. / f.p. of water | 373.15 K / 273.15 K |
| 1 atm | 1.013 bar = 760 mm Hg = 101.3 kPa |

## VAN'T HOFF FACTOR i (complete dissociation)

| Solute | i |
|---|---|
| Glucose, urea, sucrose (non-electrolyte) | 1 |
| NaCl, KCl, $MgSO_4$ | 2 |
| $CaCl_2$, $K_2SO_4$, $Na_2SO_4$ | 3 |
| $K_3[Fe(CN)_6]$, $AlCl_3$ | 4 |
| Acetic acid in benzene (dimer) | ≈ 1/2 |

i > 1 → dissociation; i < 1 → association.

## HANDY FACTS

- Molality (m) does not change with temperature; molarity (M) does (volume changes).
- 1 mol of solute in 1 kg water: $\Delta T_b$ = 0.52 K, $\Delta T_f$ = 1.86 K.
- Isotonic solutions have the same osmotic pressure; 0.9% NaCl is isotonic with blood (normal saline).

**Hinglish mein samjho:**
R, $K_b$ aur $K_f$ ki value yaad rakho – har numerical mein lagti hai. i: NaCl 2, $CaCl_2$ 3, glucose 1.

# Part A · Types of Solutions and Concentration

## 1. Types of solutions

- Solute and solvent can be solid, liquid or gas – 9 types of solutions.
- Gas in gas: air ($O_2$ in $N_2$). Liquid in gas: chloroform mixed with $N_2$. Solid in gas: camphor in $N_2$.
- Gas in liquid: $O_2$ in water. Liquid in liquid: ethanol in water. Solid in liquid: glucose in water.
- Gas in solid: $H_2$ in palladium. Liquid in solid: amalgam of Hg with Na. Solid in solid: copper in gold (alloy).

**Hinglish mein samjho:**
Solvent ki state = solution ki state. Hawa gas solution hai, alloy solid solution.

## 2. Concentration terms – learn the formulas

| Quantity | Formula | Unit |
|---|---|---|
| Mass percentage | $w\% = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$ | % |
| Volume percentage | $V\% = \frac{V_{solute}}{V_{solution}} \times 100$ | % |
| Parts per million | $\text{ppm} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$ | ppm |
| Mole fraction | $x_A = \frac{n_A}{n_A + n_B}$ | no unit |
| Molarity | $M = \frac{n_{solute}}{V_{solution}\,(\text{L})}$ | mol $L^{-1}$ |
| Molality | $m = \frac{n_{solute}}{W_{solvent}\,(\text{kg})}$ | mol $kg^{-1}$ |

### Difficult word → Why molality is better than molarity

Volume changes with temperature (liquids expand), so molarity changes with temperature. Mass does not change, so molality, mole fraction and mass % are temperature-independent.

**Hinglish mein samjho:**
Garam karo to volume badhta hai, molarity badal jaati hai. Mass nahi badalta – molality same.

### SOLVED NUMERICAL – Molarity of NaOH

**Step 1:** 5 g NaOH is dissolved in 450 mL solution. Moles of NaOH (M = 40 g $mol^{-1}$):

$$n = \frac{5}{40} = 0.125 \text{ mol}$$

**Step 2:** Volume in litres = 0.450 L. Molarity = moles ÷ litres:

$$M = \frac{0.125}{0.450} = 0.278 \text{ mol L}^{-1}$$

**Answer:** 0.278 M

### SOLVED NUMERICAL – Molality of ethanoic acid in benzene

**Step 1:** 2.5 g $CH_3COOH$ (M = 60) in 75 g benzene. Moles of solute:

$$n = \frac{2.5}{60} = 0.0417 \text{ mol}$$

**Step 2:** Mass of solvent = 75 g = 0.075 kg:

$$m = \frac{0.0417}{0.075} = 0.556 \text{ mol kg}^{-1}$$

*Why: molality uses kg of SOLVENT, not solution*

**Answer:** 0.556 mol $kg^{-1}$

**SOLVED NUMERICAL – Mole fraction of ethylene glycol (20% by mass)**

**Step 1:** Take 100 g solution: 20 g glycol $C_2H_6O_2$ (M = 62) and 80 g water (M = 18).

$$n_{glycol} = \frac{20}{62} = 0.322, \quad n_{water} = \frac{80}{18} = 4.444$$

**Step 2:** Mole fractions:

$$x_{glycol} = \frac{0.322}{0.322 + 4.444} = 0.068, \quad x_{water} = 1 - 0.068 = 0.932$$

**Answer:** x(glycol) = 0.068, x(water) = 0.932

## Part B · Solubility and Henry's Law

### 1. Solubility of a solid in a liquid

- Like dissolves like: polar solutes dissolve in polar solvents (salt in water); non-polar in non-polar (naphthalene in benzene).
- When no more solute dissolves, the solution is saturated (dynamic equilibrium between dissolving and crystallising).
- Effect of temperature: if dissolving is endothermic (ΔH > 0), solubility increases with temperature; if exothermic, it decreases (Le Chatelier).
- Pressure has almost no effect on solubility of solids in liquids (they are incompressible).

**Hinglish mein samjho:**
Jaisa solvent, waisa solute ghulta hai. Temperature ka asar ΔH se decide hota hai.

## 2. Gas in a liquid – Henry's law

**Henry's law:** at constant temperature, the partial pressure of a gas above a liquid is proportional to its mole fraction in the solution.

$$p = K_H x$$

- $K_H$ = Henry's law constant (unit: bar or kbar). Higher $K_H$ → lower solubility of the gas.
- $K_H$ increases with temperature → gases are less soluble in hot water (fish need cold water).
- Solubility of a gas increases with pressure.

**Hinglish mein samjho:**
p = $K_H$ x. Pressure badhao, gas zyada ghulegi. $K_H$ bada matlab gas kam ghulti hai. Garam paani mein gas kam ghulti hai.

| Application of Henry's law | Why |
|---|---|
| Soda bottles are sealed at high pressure | to dissolve more $CO_2$; fizz comes out when opened |
| Bends in scuba divers | high pressure underwater dissolves more $N_2$ in blood; on rising fast, $N_2$ forms bubbles in blood |
| Divers' tanks contain air diluted with helium (11.7% He, 56.2% $N_2$, 32.1% $O_2$) | He is less soluble in blood |
| Anoxia at high altitude | low partial pressure of $O_2$ → less $O_2$ in blood → weakness, unclear thinking |

**SOLVED NUMERICAL – Henry's law – $N_2$ dissolved in water**

**Step 1:** $K_H$ for $N_2$ at 293 K = 76.48 kbar; partial pressure of $N_2$ = 0.987 bar. Mole fraction of $N_2$:

$$x = \frac{p}{K_H} = \frac{0.987}{76480} = 1.29 \times 10^{-5}$$

**Step 2:** 1 L water = 1000/18 = 55.5 mol. Since x is tiny, n($N_2$) ≈ x × n(water):

$$n_{N_2} = 1.29 \times 10^{-5} \times 55.5 = 7.16 \times 10^{-4} \text{ mol}$$

**Answer:** 0.716 mmol $N_2$ per litre of water

## Part C · Vapour Pressure and Raoult's Law

### 1. Two volatile liquids (A + B)

- Raoult's law: the partial vapour pressure of each volatile component is proportional to its mole fraction in the solution.
- Total vapour pressure p = $p_A$ + $p_B$ changes in a straight line with the mole fraction (see the formula table).
- Mole fraction in the vapour: $y_A = p_A / p_{total}$. The vapour is richer in the more volatile component.

**Hinglish mein samjho:**
Har liquid apne hisse ke hisaab se bhaap deta hai. Total = dono ka jod.

| Quantity | Formula | Unit |
|---|---|---|
| Raoult's law (each component) | $p_A = x_A p_A^\circ$ | bar / mm Hg |
| Total vapour pressure | $p_{total} = p_A^\circ + (p_B^\circ - p_A^\circ) x_B$ | bar / mm Hg |

| Quantity | Formula | Unit |
|---|---|---|
| Mole fraction in vapour | $y_A = \frac{p_A}{p_{total}}$ | – |

**SOLVED NUMERICAL – Vapour pressure of a $CHCl_3$ + $CH_2Cl_2$ mixture (298 K)**

**Step 1:** 25.5 g $CHCl_3$ (M = 119.5) and 40 g $CH_2Cl_2$ (M = 85). p° = 200 and 415 mm Hg.

$$n_{CHCl_3} = 0.213, \quad n_{CH_2Cl_2} = 0.470$$

**Step 2:** Mole fractions in the liquid:

$$x_{CH_2Cl_2} = \frac{0.470}{0.683} = 0.688, \quad x_{CHCl_3} = 0.312$$

**Step 3:** Total pressure:

$$p = 200 + (415 - 200)(0.688) = 347.9 \text{ mm Hg}$$

**Step 4:** Mole fraction in vapour:

$$y_{CH_2Cl_2} = \frac{0.688 \times 415}{347.9} = 0.82, \quad y_{CHCl_3} = 0.18$$

*Why: vapour is richer in the more volatile $CH_2Cl_2$*

**Answer:** p = 347.9 mm Hg; vapour: 0.82 $CH_2Cl_2$, 0.18 $CHCl_3$

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

- Henry: $p = K_H x$. Raoult: $p = p^\circ x$. Both say $p \propto x$ – only the constant differs ($K_H = p^\circ$ in Raoult's case).

**Hinglish mein samjho:**
Dono mein $p \propto x$. Raoult mein constant $p^\circ$ hai, Henry mein $K_H$.

## 3. Solution with a non-volatile solute

- Solute particles occupy part of the surface → fewer solvent molecules escape → vapour pressure decreases.
- Only the solvent makes vapour: p = x(solvent) × p°(solvent).

**Hinglish mein samjho:**
Surface par solute baith jaata hai, solvent kam udta hai – vapour pressure kam.

# Part D · Ideal and Non-ideal Solutions

| Point | Ideal | Positive deviation | Negative deviation |
|---|---|---|---|
| Raoult's law | Obeyed at all compositions | p higher than expected | p lower than expected |
| A–B attraction | Same as A–A, B–B | Weaker than A–A, B–B | Stronger than A–A, B–B |
| $\Delta H_{mix}$ | 0 | > 0 (endothermic) | < 0 (exothermic) |
| $\Delta V_{mix}$ | 0 | > 0 (expands) | < 0 (contracts) |
| Examples | n-hexane + n-heptane; benzene + toluene | ethanol + acetone; ethanol + water; $CS_2$ + acetone | chloroform + acetone (H-bond forms); $HNO_3$ + water; phenol + aniline |

| Point | Ideal | Positive deviation | Negative deviation |
|---|---|---|---|
| Azeotrope | – | Minimum boiling (95% ethanol, 351.3 K) | Maximum boiling (68% $HNO_3$, 393.5 K) |

**Hinglish mein samjho:**
Positive: A–B dosti kamzor → molecules aasaani se udte hain → zyada vapour pressure, min-boiling azeotrope. Negative: A–B dosti mazboot → kam udte hain → kam vapour pressure, max-boiling azeotrope.

**Exam tip:** Chloroform + acetone shows negative deviation because a new H-bond forms between $CHCl_3$'s H and acetone's O – very common 2-mark question.

## Part E · Colligative Properties

Four properties depend only on the number of solute particles: (1) relative lowering of vapour pressure, (2) elevation of boiling point, (3) depression of freezing point, (4) osmotic pressure.

| Quantity | Formula | Unit |
|---|---|---|
| Relative lowering of v.p. | $\frac{p_1^\circ - p_1}{p_1^\circ} = x_2 \approx \frac{w_2 M_1}{M_2 w_1}$ | – |
| Elevation of boiling point | $\Delta T_b = K_b\, m$ | K |
| Depression of freezing point | $\Delta T_f = K_f\, m$ | K |
| Molar mass from ΔT | $M_2 = \frac{1000\, K\, w_2}{\Delta T\, w_1}$ | g $mol^{-1}$ |
| Osmotic pressure | $\pi = CRT = \frac{n_2 RT}{V}$ | bar / atm |
| Molar mass from π | $M_2 = \frac{w_2 RT}{\pi V}$ | g $mol^{-1}$ |

### Difficult word → Why does a solute raise the boiling point and lower the freezing point?

The solute lowers the vapour pressure. To boil, the vapour pressure must reach 1 atm – so the solution must be heated to a higher temperature. At the freezing point, solid and liquid must have the same vapour pressure – the solution's lower vapour pressure meets the solid's curve at a lower temperature.

**Hinglish mein samjho:**
Vapour pressure kam hua → ubalne ke liye zyada garam karna padega, jamne ke liye zyada thanda.

### SOLVED NUMERICAL – Molar mass from relative lowering of vapour pressure

**Step 1:** Pure benzene p° = 0.850 bar; 0.5 g solute in 39 g benzene (M = 78) gives p = 0.845 bar.

$$\frac{p^\circ - p}{p^\circ} = \frac{0.005}{0.850} = 0.00588$$

**Step 2:** Use the formula and solve for $M_2$:

$$M_2 = \frac{w_2 M_1}{w_1 \times 0.00588} = \frac{0.5 \times 78}{39 \times 0.00588} = 170 \text{ g mol}^{-1}$$

**Answer:** $M_2$ = 170 g $mol^{-1}$

**SOLVED NUMERICAL – Boiling point of glucose solution**

**Step 1:** 18 g glucose (M = 180) in 1 kg water → molality:

$$m = \frac{18/180}{1} = 0.1 \text{ mol kg}^{-1}$$

**Step 2:** $\Delta T_b = K_b \times m$:

$$\Delta T_b = 0.52 \times 0.1 = 0.052 \text{ K}$$

**Step 3:** New boiling point:

$$T_b = 373.15 + 0.052 = 373.202 \text{ K}$$

**Answer:** 373.202 K

**SOLVED NUMERICAL – Freezing point of an antifreeze solution**

**Step 1:** 45 g ethylene glycol (M = 62) in 600 g water:

$$m = \frac{45/62}{0.600} = \frac{0.726}{0.600} = 1.21 \text{ mol kg}^{-1}$$

**Step 2:** $\Delta T_f = K_f \times m$:

$$\Delta T_f = 1.86 \times 1.21 = 2.25 \text{ K}$$

**Step 3:** Freezing point:

$$T_f = 273.15 - 2.25 = 270.90 \text{ K}$$

**Answer:** 270.9 K

## Osmosis and osmotic pressure

- Semipermeable membrane (SPM): lets solvent pass but not solute (e.g. animal bladder, cellophane, parchment).
- Osmotic pressure (π): the extra pressure that must be applied on the solution side to stop osmosis.
- π is the best method for molar masses of proteins / polymers – measured at room temperature and gives large values even for dilute solutions.
- Isotonic: same π (0.9% NaCl = normal saline with blood). Hypertonic (more concentrated) → cells shrink; hypotonic → cells swell and burst.
- Reverse osmosis: apply pressure greater than π → pure water is pushed out of the solution. Used in desalination of sea water (cellulose acetate membrane).

**Hinglish mein samjho:**
Osmosis mein paani patle se gaadhe ki taraf. Ulta dabaav π se zyada lagao to paani bahar – yahi RO water purifier.

**SOLVED NUMERICAL – Molar mass of a protein from osmotic pressure**

**Step 1:** 1.26 g protein in 200 $cm^3$ solution has π = 2.57 × $10^{-3}$ bar at 300 K. V = 0.200 L, R = 0.083 L bar $K^{-1}$ $mol^{-1}$.

**Step 2:** Use $M_2 = w_2RT / (\pi V)$:

$$M_2 = \frac{1.26 \times 0.083 \times 300}{2.57 \times 10^{-3} \times 0.200} = 61\,022 \text{ g mol}^{-1}$$

**Answer:** ≈ 61 022 g $mol^{-1}$

## Part F · Abnormal Molar Mass and van't Hoff Factor

- If the solute dissociates (NaCl → $Na^+ + Cl^-$), there are more particles → bigger colligative effect → lower calculated molar mass.
- If the solute associates ($2CH_3COOH$ → dimer in benzene), fewer particles → smaller effect → higher molar mass.
- van't Hoff factor i = normal molar mass ÷ abnormal molar mass = observed colligative property ÷ calculated.

| Quantity | Formula | Unit |
|---|---|---|
| van't Hoff factor | $i = \frac{M_{normal}}{M_{observed}}$ | – |
| Modified equations | $\Delta T_f = iK_f m, \quad \Delta T_b = iK_b m, \quad \pi = iCRT$ | – |
| Degree of dissociation | $\alpha = \frac{i-1}{n-1}$ | – |
| Degree of association | $\alpha = \frac{1-i}{1-1/n}$ | – |

**SOLVED NUMERICAL – Association of benzoic acid in benzene**

**Step 1:** 2 g benzoic acid (M = 122) in 25 g benzene lowers the freezing point by 1.62 K; $K_f$ = 4.9 K kg $mol^{-1}$.

$$M_2 = \frac{1000 \times 4.9 \times 2}{1.62 \times 25} = 242 \text{ g mol}^{-1}$$

**Step 2:** van't Hoff factor:

$$i = \frac{122}{242} = 0.504$$

**Step 3:** Dimerisation (n = 2): i = 1 − α/2

$$\alpha = 2(1 - 0.504) = 0.992$$

*Why: i < 1 means association*

**Answer:** 99.2% of benzoic acid is associated (dimer)

**Hinglish mein samjho:**
i > 1: molecule toota (dissociation), molar mass kam aata hai. i < 1: molecule jude (association), molar mass zyada aata hai.

## Part G · "Give Reasons" – Board Favourites

**Q1. Give reason: Molality is preferred over molarity.** [2]

**Ans.** Molality depends on mass, which does not change with temperature; molarity depends on volume, which changes.

**Q2. Give reason: Aquatic species are more comfortable in cold water than in warm water.** [2]

**Ans.** $K_H$ of $O_2$ increases with temperature → less $O_2$ dissolves in warm water.

**Q3. Give reason: Scuba divers' tanks contain helium.** [2]

**Ans.** He is much less soluble in blood than $N_2$ – avoids bends.

**Q4. Give reason: A mixture of chloroform and acetone shows negative deviation.** [2]

**Ans.** New H-bonds form between them (stronger A–B attraction) → lower vapour pressure, $\Delta H_{mix} < 0$.

**Q5. Give reason: Osmotic pressure is preferred for determining molar masses of proteins.** [2]

**Ans.** Measured at room temperature (proteins don't decompose) and π is large even for very dilute solutions.

**Q6. Give reason: NaCl is spread on icy roads.** [2]

**Ans.** It depresses the freezing point of water, so ice melts at a lower temperature.

**Q7. Give reason: 0.1 M NaCl has a lower freezing point than 0.1 M glucose.** [2]

**Ans.** NaCl gives 2 ions (i = 2), glucose i = 1 → double $\Delta T_f$.

**Q8. Give reason: Raw mango shrivels in brine but raisins swell in water.** [2]

**Ans.** Brine is hypertonic → water leaves mango (exosmosis); water is hypotonic for raisins → water enters (endosmosis).

## Part H · Question Bank to Memorise

### 1-mark questions

**Q1. State Henry's law.** [1]

**Ans.** At constant temperature, partial pressure of a gas = $K_H$ × its mole fraction in solution ($p = K_H x$).

**Q2. Which concentration term is independent of temperature?** [1]

**Ans.** Molality (also mole fraction and mass %).

**Q3. Give an example of a maximum-boiling azeotrope.** [1]

**Ans.** 68% $HNO_3$ + 32% water (boils at 393.5 K).

**Q4. What is the van't Hoff factor of $K_2SO_4$ (complete dissociation)?** [1]

**Ans.** 3 ($2K^+ + SO_4^{2-}$).

**Q5. Define isotonic solutions.** [1]

**Ans.** Solutions having the same osmotic pressure at the same temperature.

**Q6. What happens when a pressure greater than osmotic pressure is applied on the solution?** [1]

**Ans.** Reverse osmosis – pure solvent flows out of the solution.

## Assertion–Reason

*A: both true, R explains A. B: both true, R doesn't explain A. C: A true, R false. D: A false, R true.*

**QAR1. A: 0.1 M KCl has a higher boiling point than 0.1 M glucose. R: KCl dissociates into two ions.** [1]

**Ans.** A

**QAR2. A: Azeotropes can be separated by fractional distillation. R: Azeotropes boil at constant temperature.** [1]

**Ans.** D (azeotropes CANNOT be separated)

**QAR3. A: Gases are more soluble in cold water. R: $K_H$ increases with temperature. [1]**

**Ans.** A

## 3-mark and 5-mark questions

**QL1. Define colligative properties. Why is the molar mass found by them sometimes abnormal? (3) [3]**

**Ans.** Depend only on number of solute particles. Dissociation (more particles) → lower M; association (fewer particles) → higher M; corrected by van't Hoff factor i.

**QL2. Differentiate between ideal and non-ideal solutions with one example each of positive and negative deviation. (3) [3]**

**Ans.** Ideal: obeys Raoult, $\Delta H_{mix} = 0$, $\Delta V_{mix} = 0$ (benzene + toluene). Positive: ethanol + acetone. Negative: chloroform + acetone. See Part D table.

**QL3. Calculate the freezing point of a solution containing 60 g glucose (M = 180) in 250 g water. $K_f = 1.86$ K kg mol$^{-1}$. (3) [3]**

**Ans.** m = (60/180)/0.25 = 1.333; $\Delta T_f = 1.86 \times 1.333 = 2.48$ K; $T_f = 273.15 - 2.48 =$ 270.67 K.

**QL4. Calculate the osmotic pressure of 0.01 M glucose at 27 °C (R = 0.0821 L atm K$^{-1}$ mol$^{-1}$). (2) [3]**

**Ans.** $\pi = CRT = 0.01 \times 0.0821 \times 300 =$ 0.246 atm.

## Last-Minute Checklist

- I can write all 6 concentration formulas and say which are temperature-independent.
- I can state Henry's law and give 3 applications.
- I can draw / explain positive and negative deviation with examples and azeotropes.
- I know all 4 colligative formulas, $K_b = 0.52$ and $K_f = 1.86$ for water.
- I can calculate i and degree of dissociation / association.