

Chapter 1 · Solutions

CBSE Class 12 Chemistry (043) · Physical Chemistry · Unit 1 = 7 marks · Ultimate Revision Sheet

60-SECOND RECALL

Molarity vs molality	M = mol solute / L of SOLUTION · m = mol solute / kg of SOLVENT . Only m is temperature-independent.
Henry's law	p = K_H x · K_H ↑ with temperature ⇒ solubility of gas ↓
Raoult's law	Volatile: p_{total} = p°_Ax_A + p°_Bx_B · Non-volatile solute: p = p°_Ax_A
Four colligative properties	Relative lowering of VP · Elevation of b.p. · Depression of f.p. · Osmotic pressure
Water constants	K_b = 0.52 K kg mol⁻¹ · K_f = 1.86 K kg mol⁻¹
van't Hoff factor	i > 1 dissociation · i < 1 association · i = 1 neither
Best for molar mass	Osmotic pressure — measurable at room temperature, large values, works for macromolecules

1. Concentration — the five expressions

FORMULAS

Mass % = (mass of solute / mass of solution) × 100

ppm = (mass of solute / mass of solution) × 10⁶

Mole fraction x_A = n_A / (n_A + n_B) x_A + x_B = 1

Molarity M = moles of solute / volume of SOLUTION in litres

Molality m = moles of solute / mass of SOLVENT in kg

THE TRAP EXAMINERS RELY ON *Molarity changes with temperature; molality does not. Volume expands on heating, mass does not. So any question about a property measured at different temperatures wants **molality**.*

*Molarity uses the **solution** volume, molality uses the **solvent** mass. Writing "per kg of solution" loses the mark.*

2. Solubility and Henry's Law

WRITE THIS VERBATIM *Henry's law: the partial pressure of a gas in the vapour phase is **directly proportional to the mole fraction of the gas in the solution**. **p = K_H x***

WHAT THE CONSTANT MEANS *Higher K_H ⇒ **LOWER** solubility of that gas at the same pressure.*

*K_H increases with temperature, so the solubility of a gas **decreases** as temperature rises — which is why aquatic life prefers cold water.*

THE FOUR APPLICATIONS ASKED

1. Soft drinks are sealed under high CO_2 pressure to keep the gas dissolved.
2. Scuba divers (bends): at depth, more N_2 dissolves in blood; on rapid ascent it bubbles out and blocks capillaries. Divers' tanks use air diluted with helium.
3. Anoxia at high altitude: low partial pressure of $\text{O}_2 \rightarrow$ less O_2 in blood $\rightarrow$ weakness and poor thinking.
4. Deoxygenation in hot water — a consequence of K_H rising with temperature.

3. Vapour Pressure and Raoult's Law

FOR A SOLUTION OF TWO VOLATILE LIQUIDS

$$p_A = p_A^\circ x_A \quad p_B = p_B^\circ x_B$$

$$p_{\text{total}} = p_A^\circ x_A + p_B^\circ x_B = p_B^\circ + (p_A^\circ - p_B^\circ)x_A$$

In the vapour phase: $y_A = p_A / p_{\text{total}}$

FOR A NON-VOLATILE SOLUTE — relative lowering

$$p_{\text{solution}} = p_A^\circ x_A$$

$$(p_A^\circ - p) / p_A^\circ = x_B \quad \text{relative lowering} = \text{mole fraction of solute}$$

$$(p_A^\circ - p) / p_A^\circ = (w_B/M_B) / (w_A/M_A + w_B/M_B)$$

4. Ideal and Non-Ideal Solutions

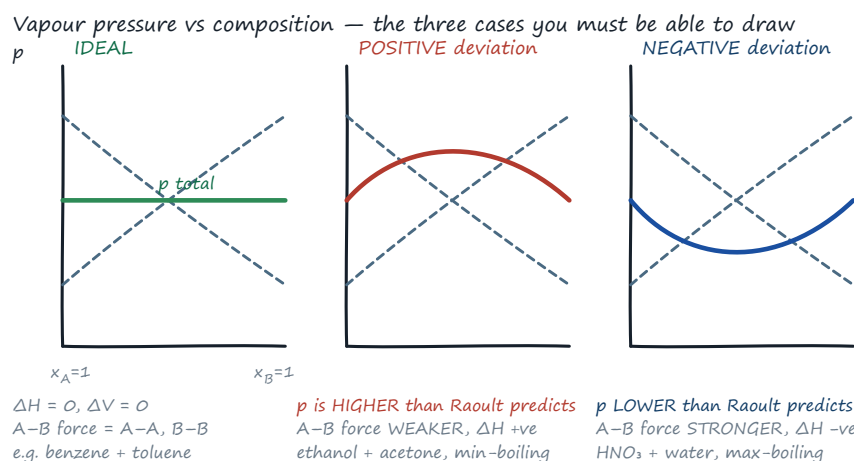
Basis	IDEAL	NON-IDEAL
Raoult's law	Obedied at all concentrations	Not obeyed
$\Delta_{\text{mix}}H$	Zero	Not zero
$\Delta_{\text{mix}}V$	Zero	Not zero
A–B forces	Same as A–A and B–B	Weaker (+ve) or stronger (–ve)
Examples	Benzene + toluene · n-hexane + n-heptane	See below

THE TWO DEVIATIONS — learn one example of each

	POSITIVE deviation	NEGATIVE deviation
A–B force	Weaker than A–A / B–B	Stronger than A–A / B–B
Vapour pressure	Higher than Raoult predicts	Lower than Raoult predicts
$\Delta_{\text{mix}}H$	Positive (endothermic)	Negative (exothermic)
$\Delta_{\text{mix}}V$	Positive (expands)	Negative (contracts)
Example	Ethanol + acetone · carbon disulphide + acetone	Chloroform + acetone · nitric acid + water
Azeotrope formed	Minimum boiling — ethanol–water (95% ethanol)	Maximum boiling — nitric acid–water (68% HNO_3)

TRAP — why chloroform + acetone deviates negatively The two form a **hydrogen bond** between them, which is **stronger** than the forces in either pure liquid. Stronger attraction → molecules escape less readily → **lower** vapour pressure. Say the words "hydrogen bonding between the unlike molecules" — that is the mark.

Azeotropes cannot be separated by fractional distillation, because the liquid and vapour have the same composition at that point.



Decide by the **A-B interaction**: weaker than the pure liquids → molecules escape more easily → pressure rises → **positive**. Stronger → **negative**. Everything else follows from that one line.

5. Colligative Properties

DEFINITION Properties that depend **only on the NUMBER** of solute particles, not on their nature.

ALL FOUR, WITH THEIR MOLAR-MASS FORMS

1. **Relative lowering of vapour pressure:** $(p^\circ - p)/p^\circ = x_B$

2. **Elevation of boiling point:** $\Delta T_b = K_b m \rightarrow M_B = (K_b \times w_B \times 1000) / (\Delta T_b \times w_A)$

3. **Depression of freezing point:** $\Delta T_f = K_f m \rightarrow M_B = (K_f \times w_B \times 1000) / (\Delta T_f \times w_A)$

4. **Osmotic pressure:** $\pi = CRT = (n/V)RT \rightarrow M_B = w_B RT / \pi V$

w_A = mass of solvent in grams, w_B = mass of solute in grams. The 1000 converts grams of solvent to kilograms.

OSMOSIS — the words that carry marks Osmosis: flow of **solvent** through a semipermeable membrane from **lower** to **higher** concentration.

Osmotic pressure: the **excess pressure** that must be applied to just **stop** osmosis.

Isotonic: same osmotic pressure · **Hypertonic:** higher · **Hypotonic:** lower.

Reverse osmosis: pressure **greater** than the osmotic pressure pushes solvent the other way — used for **desalination** of sea water.

TRAP Osmotic pressure is preferred for finding the molar mass of **polymers and proteins** because it is measured at **room temperature** and gives **large, easily measured** values, while ΔT_f and ΔT_b would be too small to read.

0.1 M NaCl is NOT isotonic with 0.1 M glucose — NaCl gives twice the particles.

6. Abnormal Molar Mass and the van't Hoff Factor

FORMULAS

$i = \text{normal molar mass} / \text{observed molar mass}$

$i = \text{observed colligative property} / \text{calculated colligative property}$

$i = \text{total particles after} / \text{total particles before}$

Every colligative formula is multiplied by i : $\Delta T_b = iK_b m$, $\Delta T_f = iK_f m$, $\pi = iCRT$

Behaviour	i	Observed molar mass	Example
Dissociation	> 1	Lower than normal	NaCl in water ($i \rightarrow 2$), K_2SO_4 ($i \rightarrow 3$)
Association	< 1	Higher than normal	Benzoic acid in benzene (dimer, $i \rightarrow 0.5$)
Neither	$= 1$	Normal	Glucose, urea in water

WORKED EXAMPLE — the standard depression question 1.8 g of glucose ($M = 180 \text{ g mol}^{-1}$) is dissolved in 100 g of water. $K_f = 1.86 \text{ K kg mol}^{-1}$. Find the freezing point.

Moles of glucose = $1.8 / 180 = 0.01 \text{ mol}$

Molality $m = 0.01 / 0.1 = 0.1 \text{ mol kg}^{-1}$

$\Delta T_f = K_f m = 1.86 \times 0.1 = 0.186 \text{ K}$

Freezing point = $273.15 - 0.186 = 272.96 \text{ K}$ (i.e. -0.186°C)

If the solute were NaCl instead, $i = 2$ and ΔT_f would double to 0.372 K.

7. Question Triggers which formula the wording wants

If the question says...	Use
"solubility of a gas", "pressure of the gas above the liquid"	Henry's law , $p = K_H x$
"vapour pressure of the solution", solute is non-volatile	$p = p^\circ x_A$
"both liquids are volatile", "composition of the vapour"	P_{total} , then $y_A = P_A / P_{\text{total}}$
"boils at..." / "freezes at..."	$\Delta T_b = iK_b m$ / $\Delta T_f = iK_f m$
"molar mass of a protein / polymer"	Osmotic pressure , $\pi = CRT$
"electrolyte" named (NaCl, K_2SO_4 , $CaCl_2$)	Insert i — never leave it out
"observed molar mass is double the expected"	Association , $i = 0.5$

MOST-ASKED BOARD QUESTIONS

1. [3M] State Henry's law. Give **two** applications, and explain why K_H rises with temperature.
2. [3M] Define an ideal solution. How do positive and negative deviations from Raoult's law arise?
3. [3M] Calculate the freezing point / boiling point of a given solution.
4. [2M] Why is **osmotic pressure** preferred for determining the molar mass of macromolecules?
5. [2M] Define the van't Hoff factor. What values does it take for NaCl in water and benzoic acid in benzene?
6. [1M] Which colligative property is used in **desalination**? → **Reverse osmosis**
7. [1M] Why is molality preferred over molarity in colligative calculations? → **It does not change with temperature**

THE HABIT THAT SCORES — Before touching a colligative numerical, write $i = ?$ at the top of your working. If the solute is an electrolyte and you forget i , every later line is wrong — and it is the single most common reason full-mark students lose a whole 3-marker in this chapter.