ANSWER KEY & MARKING SCHEME · CBSE CLASS 12

Solutions

Chemistry · Chapter 1 · Use this with the Board Paper · Companion to Quick Drill

HOW TO USE

Attempt the Board Paper first (closed-book, full time). Then come here. For 2-mark+ questions, compare your answer to the model. For 3-4 mark questions, also consult the **Topper Templates** below — these show the exact step-by-step structure that scores full marks per CBSE marking-scheme conventions.

MODEL ANSWERS · BOARD PAPER

Section A — Very Short Answer (1 mark × 4)

Q1. Define molality. Write its SI unit. ***[1 mark]***

Ans: Molality (m) = moles of solute per kg of solvent. SI unit: mol/kg.

Q2. State Henry's law. ***[1 mark]***

Ans: At constant temperature, the partial pressure of a gas above a liquid is proportional to the mole fraction of the dissolved gas: $p = K_H \cdot x_{gas}$.

Q3. What is the value of the van't Hoff factor (i) for a non-electrolyte that neither associates nor dissociates? ***[1 mark]***

Ans: $i = 1$.

Q4. Why is osmotic pressure preferred over freezing-point depression for determining the molar mass of a polymer? ***[1 mark]***

Ans: Polymers give very dilute solutions; ΔT_f would be too small to measure accurately. Osmotic pressure π is large enough to measure even for low concentrations.

Section B — Short Answer I (2 marks × 3)

Q5. State Raoult's law for a solution containing volatile components. ***[2 marks]***

Ans: For a solution of two volatile liquids A and B: at constant temperature, the partial vapour pressure of each component is proportional to its mole fraction in the liquid phase. $P_A = x_A \cdot P_A^\circ$ and $P_B = x_B \cdot P_B^\circ$, where P_A° and P_B° are the vapour pressures of pure A and B. Total vapour pressure: $P_{total} = P_A + P_B = x_A \cdot P_A^\circ + x_B \cdot P_B^\circ$.

Q6. Why do gases dissolve less in warm water than in cold water? Explain in terms of Henry's law. ***[2 marks]***

Ans: Henry's law: $p_{gas} = K_H \cdot x_{gas}$. K_H is temperature-dependent and INCREASES with T for most gases. So at higher T, for the same p_{gas}, x_{gas} (solubility) decreases. Physically: dissolution of gas is exothermic; by Le Chatelier's principle, raising T shifts equilibrium toward less dissolution.

Q7. Distinguish between an ideal solution and a non-ideal solution with one example each. ***[2 marks]***

Ans: Ideal: obeys Raoult's law over the entire composition range; $\Delta H_{mix} = 0$; $\Delta V_{mix} = 0$. Example: n-hexane + n-heptane. Non-ideal: deviates from Raoult's law (vapour pressure higher or lower than predicted). $\Delta H_{mix} \neq 0$ and/or $\Delta V_{mix} \neq 0$. Example: ethanol + water (positive deviation).

Section C — Short Answer II (3 marks × 3)

Q8. Calculate the molar mass of a non-volatile solute, given that 2.0 g of it dissolved in 100 g of benzene depresses the freezing point by 0.30 °C. (K_f for benzene = 5.12 °C·kg/mol) ***[3 marks]***

Ans: Formula: $M = (1000 \cdot K_f \cdot w_{solute}) / (\Delta T_f \cdot W_{solvent\_g})$. Substitute: $M = (1000 \times 5.12 \times 2.0) / (0.30 \times 100) = 10240 / 30 \approx 341.3$ g/mol. Final: molar mass ≈ 341 g/mol.

Q9. A 5% (by mass) aqueous solution of glucose at 27°C is found to have an osmotic pressure of π atm. Calculate π. (Glucose: M = 180 g/mol; R = 0.0821 L·atm/(mol·K); $\rho_{solution} \approx 1$ g/mL) ***[3 marks]***

Ans: 5% w/w means 5 g glucose in 100 g solution. Volume ≈ 100 mL = 0.1 L. Moles of glucose = 5/180 = 0.0278 mol. Molarity M = 0.0278/0.1 = 0.278 mol/L. T = 27 + 273 = 300 K. $\pi = MRT = 0.278 \times 0.0821 \times 300 = 6.85$ atm. Final: $\pi \approx 6.85$ atm.

Q10. **Define van't Hoff factor. Calculate the freezing-point depression of a 0.1 m solution of K_2SO_4 in water, assuming complete dissociation. (K_f for water = 1.86 °C·kg/mol)** ***[3 marks]***

> **Ans:** van't Hoff factor i = (observed colligative property) / (theoretical for non-electrolyte). For complete dissociation $K_2SO_4 \rightarrow 2K^+ + SO_4^{2-}$ gives 3 particles per formula unit ⇒ i = 3. Modified formula: ΔT_f = i·K_f·m = 3 × 1.86 × 0.1 = 0.558 °C. Final: ΔT_f ≈ 0.56 °C.

Section D — Long Answer (5-6 marks × 2)

Q11. **(a) Define azeotrope with one example. (b) Two liquids A and B form an ideal solution. At 300 K, the vapour pressures of pure A and B are 100 mmHg and 250 mmHg respectively. Find the vapour pressure of the solution and the composition of the vapour phase when mole fraction of A in the liquid is 0.4.** ***[5 marks]***

> **Ans:** (a) Azeotrope: a binary solution that boils at a constant temperature, with liquid and vapour having the same composition; cannot be separated by simple distillation. Example: ethanol + water (95.6% ethanol by mass, b.p. 78.2°C) — minimum-boiling azeotrope due to positive deviation. (b) Using Raoult's law: P_A = x_A·P_A° = 0.4 × 100 = 40 mmHg. P_B = x_B·P_B° = 0.6 × 250 = 150 mmHg. P_total = P_A + P_B = 190 mmHg. Vapour-phase composition: y_A = P_A/P_total = 40/190 ≈ 0.211. y_B = 1 − 0.211 = 0.789. Note: vapour is richer in B (the more volatile component).

Q12. **A solution containing 30 g of a non-volatile solute exactly in 90 g of water has a vapour pressure of 2.8 kPa at 298 K. Further, 18 g of water is added to the solution, and the new vapour pressure becomes 2.9 kPa at the same temperature. Calculate: (a) the molar mass of the solute (b) vapour pressure of water at 298 K.** ***[6 marks]***

> **Ans:** Let M = molar mass of solute, P° = vapour pressure of pure water at 298 K. Using Raoult's law: ΔP/P° = x_solute = n_solute / (n_solute + n_water). Case 1: n_solute = 30/M, n_water = 90/18 = 5. So (P° − 2.8)/P° = (30/M)/((30/M) + 5). Case 2 (after adding 18 g water): n_water_new = (90+18)/18 = 6. So (P° − 2.9)/P° = (30/M)/((30/M) + 6). Solving these two simultaneously: let r = 30/M. From case 1: 1 − 2.8/P° = r/(r+5). From case 2: 1 − 2.9/P° = r/(r+6). Subtract: 0.1/P° = r/(r+5) − r/(r+6) = r/[(r+5)(r+6)]. Combined with case 2: 2.9/P° = 1 − r/(r+6) = 6/(r+6). So P° = 2.9(r+6)/6. Substitute into 0.1/P° = r/[(r+5)(r+6)]: 0.1 · 6/[2.9(r+6)] = r/[(r+5)(r+6)] ⇒ 0.6/(2.9) = r(r+6)/[(r+5)(r+6)] ⇒ 0.207 = r/(r+5) ⇒ 0.207(r+5) = r ⇒ 0.207r + 1.034 = r ⇒ 0.793r = 1.034 ⇒ r = 1.305. So 30/M = 1.305 ⇒ M ≈ 23 g/mol. (Likely Na, but it must be a non-volatile MOLECULAR solute — answer remains ~23 g/mol per calculation.) P° = 2.9(1.305+6)/6 = 2.9 × 7.305 / 6 ≈ 3.53 kPa. Final: M ≈ 23 g/mol; P° ≈ 3.53 kPa.

★ TOPPER ANSWER TEMPLATES

3 TEMPLATES · MEMORISE THE FORMAT

★ TOPPER TEMPLATE — 5-mark numerical: 'Calculate molar mass of solute from freezing-point depression data.'

Annual since 2017

Step 1 *[1 mark]*	**Write the formula**	ΔT_f = K_f · m, where m is molality. Combined: M_solute = (1000 · K_f · w_solute) / (ΔT_f · W_solvent_grams). State each symbol's meaning.
Step 2 *[1 mark]*	**List given data + convert units**	Tabulate: w_solute = X g, W_solvent = Y g, ΔT_f = Z °C, K_f = K °C·kg/mol. Confirm temperature in °C (since ΔT, sign doesn't matter), masses in grams.
Step 3 *[1 mark]*	**Substitute carefully**	Write: M_solute = (1000 × K × X) / (Z × Y). Show the substitution explicitly — examiners give 1 method mark even if arithmetic is wrong.
Step 4 *[1 mark]*	**Compute + units**	Calculate the numerical value. State final answer with UNIT (g/mol). Round to appropriate significant figures.
Step 5 *[1 mark]*	**Comment + verification**	If the answer is much higher than the expected molar mass, the solute is likely associating (dimerises). If much lower, it dissociates. Mention van't Hoff factor i if relevant.

COMMON LOSS OF MARKS:

- Using W_solvent in kg but plugging the 1000 factor — double-counts kg → grams.
- Forgetting K_f units (°C·kg/mol vs K·kg/mol — should be same numerically since ΔT is invariant).
- Not stating final answer's unit.
- Skipping the verification step on a 5-marker.

★ TOPPER TEMPLATE — 3-mark question: 'Calculate the osmotic pressure of a solution of given molarity at given T.'

2018, 2020, 2022, 2024

Step 1 ***[1 mark]***	**Write $\pi = MRT$**	Osmotic pressure $\pi = M \cdot R \cdot T$, where M = molarity (mol/L), R = 0.0821 L·atm/(mol·K), T = absolute temperature (K). State each symbol.
Step 2 ***[1 mark]***	**Convert T to Kelvin if given in °C**	$T(K) = T(°C) + 273$. Forgetting this is the most common error.
Step 3 ***[1 mark]***	**Substitute + compute + units**	$\pi = M \times 0.0821 \times T(K)$. Final answer in atm; convert to Pa or kPa if asked. Watch unit-system if R is given in J/(mol·K) — then π comes in Pa.

COMMON LOSS OF MARKS:

- Forgetting °C → K conversion (−1 mark).
- Using wrong R value for the units asked.
- No final units.

★ TOPPER TEMPLATE — 3-mark conceptual: 'State Raoult's law. Distinguish between ideal and non-ideal solutions with examples.'

2018, 2019, 2022, 2023

Step 1 ***[1 mark]***	**State Raoult's law**	For a solution of two volatile liquids A and B: partial vapour pressure of each is proportional to its mole fraction in the liquid. $P_A = x_A \cdot P_A°$, $P_B = x_B \cdot P_B°$, $P_{total} = P_A + P_B$.
Step 2 ***[1 mark]***	**Ideal solution criteria + example**	Ideal: obeys Raoult's law over the entire composition range; $\Delta H_{mix} = 0$; $\Delta V_{mix} = 0$; A-B interactions = average of A-A and B-B. Example: n-hexane + n-heptane (similar non-polar liquids).
Step 3 ***[1 mark]***	**Non-ideal + +ve/−ve deviation examples**	Non-ideal: deviates from Raoult's law. +ve deviation (A-B weaker than A-A, B-B) → vapour pressure higher than predicted → minimum-boiling azeotrope. Example: ethanol + water. −ve deviation (A-B stronger than A-A, B-B) → vapour pressure lower → maximum-boiling azeotrope. Example: HNO_3 + water.

COMMON LOSS OF MARKS:

- Stating Raoult's law without the proportionality constant ($P_A°$).
- Confusing positive deviation with negative deviation (very common — minimum-boiling = +ve, maximum-boiling = −ve).
- Missing the azeotrope link.

MARKING SCHEME — GENERAL NOTES

- Always state the formula before substitution (1 method-mark even if arithmetic wrong).
- Units mandatory on final answer (−0.5 if missing).
- Temperature in K, not °C, for $\pi = MRT$ and any equilibrium-related work.
- Use molality (NOT molarity) for ΔT_b and ΔT_f problems.
- When asked to 'state' a law, give the full mathematical form including the proportionality constant (P° in Raoult, K_H in Henry).