



Attempt all questions before checking the answer key. Use $R = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$ where needed. State assumptions for ideal/dilute solutions.

A. Very short answers - 1 mark each

1. Define molality.
2. What is an ideal solution?
3. State Henry's law in the form involving mole fraction.
4. What are isotonic solutions?
5. Why are colligative properties independent of solute identity in ideal dilute solutions?
6. What does a van't Hoff factor greater than one usually indicate?

B. Short answers / practice - 2 marks each

7. Find the mole fraction of ethanol in 46 g ethanol mixed with 54 g water; molar masses are 46 and 18 g/mol.
8. Explain why molarity changes with temperature but molality does not.
9. State two conditions obeyed by an ideal liquid solution.
10. Why does a solution of a non-volatile solute have a higher boiling point than its pure solvent?
11. Distinguish positive and negative deviations from Raoult's law with one example each.
12. Why is osmotic pressure useful for determining molar masses of proteins?
13. Find molality of 0.2 mol solute in 500 g solvent.
14. Can an ideal solution show a non-zero enthalpy of mixing?
15. Find ideal i for completely dissociated K_2SO_4 .
16. Find osmotic pressure for 0.01 M solute at 300 K, $i=1$.
17. Find freezing depression for 0.20 m glucose in water, $K_f=1.86$.
18. Explain reverse osmosis and state the direction of solvent flow under applied pressure.

C. Short answers - 3 marks each

19. An ideal binary solution has $x_A = 0.4$, $p_A^\circ = 200 \text{ mm Hg}$ and $p_B^\circ = 100 \text{ mm Hg}$. Find total vapour pressure and the mole fraction of A in the vapour.
20. Find the freezing-point depression of 9 g glucose, molar mass 180 g/mol, in 100 g water. Use $K_f = 1.86 \text{ K kg/mol}$.

21. A solution contains 3 g non-electrolyte in 250 mL solution at 300 K and has osmotic pressure 0.984 atm. Find its molar mass.

22. For NaCl at a given concentration, observed $i = 1.8$. Find degree of dissociation under the simple two-ion model.

23. A solute dimerises in benzene and has $i = 0.60$. Find its degree of association.

24. Explain why a gas becomes less soluble when its Henry-law constant p/x increases, and connect this to dissolved gas in a sealed soft-drink bottle.

D. Long answers - 5 marks each

25. State Raoult's law for two volatile liquids. Derive total vapour pressure as a function of mole fraction and sketch the ideal pressure-composition graphs.
26. Explain relative lowering of vapour pressure, boiling-point elevation, freezing-point depression and osmotic pressure. Write their dilute-solution relations and indicate how each yields molar mass.
27. A 2.0 g sample dissolved in 100 g benzene lowers its freezing point by 0.512 K; $K_f = 5.12 \text{ K kg/mol}$. Find apparent molar mass. If true molar mass is 120 g/mol and only dimers form, find degree of association.
28. A 0.10 molal aqueous CaCl_2 solution has $i = 2.5$. Find degree of dissociation and freezing-point depression for $K_f = 1.86 \text{ K kg/mol}$. Explain why the ideal complete-dissociation factor is 3.
29. Describe minimum- and maximum-boiling azeotropes and connect them to deviations from Raoult's law. Explain why ordinary fractional distillation cannot change azeotropic composition.
30. An ideal solution contains liquids A and B with pure vapour pressures in ratio 1 : 3 and liquid mole fractions in ratio 2 : 1. Find each vapour mole fraction; explain which component is enriched in vapour and why.

ANSWER KEY - Numerical / short answers

7) 0.25. 13) 0.40 mol/kg. 14) No; $\Delta H_{\text{mix}}=0$. 15) 3. 16) 0.2463 atm. 17) 0.372 K. 19) 140 mm Hg; vapour $x_A=4/7 \approx 0.5714$. 20) 0.93 K. 21) $\approx 300.4 \text{ g/mol}$. 22) 0.80 or 80%. 23) 0.80 or 80%. 27) Apparent mass 200 g/mol; association 80%. 28) $\alpha=0.75$; depression 0.465 K. 30) Vapour fractions $A=0.40, B=0.60$; B enriched.