

Solutions of Nonelectrolytes

Practice Questions & Answer Key

Coverage: Slides 1-40 only

Part I - Circle the Correct Answer (10 Difficult MCQs)

Q1. Which of the following statements best describes a true solution?

- A. It must contain a liquid solvent
- B. It consists of two phases with uniformly dispersed particles
- C. It is a homogeneous molecular dispersion consisting of a single phase
- D. Its solute must always be present in a smaller amount than the solvent
- E. None of the above

Q2. A mixture behaves ideally when:

- A. U_{AB} is much greater than both U_{AA} and U_{BB}
- B. U_{AB} is much smaller than both U_{AA} and U_{BB}
- C. $2U_{AB} = U_{AA} + U_{BB}$, with no heat change and additive volumes
- D. Heat is evolved but the final volume is additive
- E. The vapor pressure is always lower than predicted by Raoult's law

Q3. Which statement concerning Molarity and Molality is CORRECT?

- A. Both are expressed per liter of solution
- B. Molality is the number of moles of solute per kilogram of solution
- C. Molarity is based on solvent volume, whereas molality is based on solution mass
- D. Molality is the number of moles of solute per kilogram of solvent
- E. None of the above

Q4. A nonvolatile solute is added to a volatile solvent. According to Raoult's law, which statement is correct?

- A. The solute contributes significantly to the total vapor pressure
- B. $P_{\text{total}} = P^{\circ}_{\text{solvent}}$ regardless of solute concentration
- C. $P_{\text{total}} = X_{\text{solvent}} P^{\circ}_{\text{solvent}}$
- D. Increasing X_{solute} increases the total vapor pressure
- E. $P_{\text{total}} = X_{\text{solute}} P^{\circ}_{\text{solvent}}$

Q5. For an ideal binary solution containing two volatile liquids A and B:

- A. $P_{\text{total}} = P^{\circ}_A + P^{\circ}_B$
- B. $P_{\text{total}} = X_A P^{\circ}_A + X_B P^{\circ}_B$
- C. $P_{\text{total}} = X_A X_B P^{\circ}_A P^{\circ}_B$
- D. Only the component present in greater amount contributes to vapor pressure
- E. $P_{\text{total}} = P^{\circ}_A / X_A + P^{\circ}_B / X_B$

Q6. Which situation is most consistent with a negative deviation from Raoult's law?

- A. A-B attractions are weaker than A-A and B-B attractions
- B. Molecules escape from the liquid more easily after mixing
- C. The observed vapor pressure is greater than the ideal vapor pressure
- D. A-B attractions are relatively strong, reducing the escaping tendency of molecules
- E. The total vapor pressure necessarily exhibits a maximum

Q7. Which statement about colligative properties is MOST accurate for nonelectrolyte solutions?

- A. They depend primarily on the molecular structure of the solute

- B. They depend mainly on the number of solute particles relative to solvent molecules
- C. They are independent of solute concentration
- D. They include vapor pressure elevation and boiling point depression
- E. They occur only in aqueous solutions

Q8. A nonvolatile solute is added to a pure volatile solvent. Which sequence correctly describes the resulting effects?

- A. Vapor pressure increases -> boiling point increases -> freezing point increases
- B. Vapor pressure decreases -> boiling point decreases -> freezing point decreases
- C. Vapor pressure decreases -> boiling point increases -> freezing point decreases
- D. Vapor pressure increases -> boiling point decreases -> freezing point increases
- E. Vapor pressure remains unchanged -> boiling point increases -> freezing point decreases

Q9. Which statement correctly explains boiling point elevation?

- A. Solute particles increase vapor pressure, so the atmospheric pressure is reached at a higher temperature
- B. Solute particles decrease vapor pressure, requiring a higher temperature for the vapor pressure to equal atmospheric pressure
- C. Solute particles increase atmospheric pressure above the solution
- D. Solute particles lower both vapor pressure and boiling point
- E. Boiling point elevation depends on the chemical identity of the nonelectrolyte rather than particle number

Q10. Which statement regarding osmosis and osmotic pressure is correct?

- A. Osmosis is the movement of solute through a membrane permeable only to solute
- B. Osmotic pressure is independent of temperature
- C. A semipermeable membrane allows both solute and solvent to cross freely
- D. Osmosis involves passage of solvent across a semipermeable membrane into the solution
- E. Osmotic pressure decreases as the number of solute particles increases

Part II - Fill in the Blank (5 Questions)

Q11. The ratio of the number of moles of one component to the total number of moles of all components is called the _____.

Q12. For a nonvolatile solute, the relative lowering of vapor pressure is:

$(P^\circ_1 - P_1) / P^\circ_1 = \underline{\hspace{2cm}}.$

Q13. The constant K_b in the equation $\Delta T_b = K_b m$ is called the _____ constant or _____ constant.

Q14. The lowering of the freezing point caused by addition of a solute is called _____, and its equation for a nonelectrolyte is _____.

Q15. According to the Van't Hoff equation, osmotic pressure is given by $\pi = \underline{\hspace{2cm}}$ when concentration is expressed as molarity.

Part III - Calculation MCQs (5 Questions)

Q16. Relative Vapor Pressure Lowering

20.0 g of sucrose (MW = 342 g/mol) is dissolved in 180 g of water (MW = 18.02 g/mol). What is the approximate relative lowering of vapor pressure?

- A. 5.82×10^{-4}
- B. 5.82×10^{-3}
- C. 5.82×10^{-2}
- D. 0.582
- E. 1.00×10^{-2}

Q17. Boiling Point Elevation

9.25 g of a nonelectrolyte drug (MW = 185 g/mol) is dissolved in 250 g of water. Given $K_b = 0.515\text{ }^{\circ}\text{C}\cdot\text{kg/mol}$, what is the boiling point of the solution, assuming pure water boils at $100.000\text{ }^{\circ}\text{C}$?

- A. $100.0515\text{ }^{\circ}\text{C}$
- B. $100.103\text{ }^{\circ}\text{C}$
- C. $100.206\text{ }^{\circ}\text{C}$
- D. $99.897\text{ }^{\circ}\text{C}$
- E. $100.515\text{ }^{\circ}\text{C}$

Q18. Freezing Point Depression

17.1 g of sucrose (MW = 342 g/mol) is dissolved in 250 g of water. Given $K_f = 1.86\text{ }^{\circ}\text{C}\cdot\text{kg/mol}$, what is the freezing point of the solution?

- A. $+0.372\text{ }^{\circ}\text{C}$
- B. $-0.186\text{ }^{\circ}\text{C}$
- C. $-0.372\text{ }^{\circ}\text{C}$
- D. $-0.744\text{ }^{\circ}\text{C}$
- E. $0\text{ }^{\circ}\text{C}$

Q19. Osmotic Pressure

A nonelectrolyte solution contains 0.010 mol of solute in 250 mL of solution at $27\text{ }^{\circ}\text{C}$. Using $R = 0.082\text{ L}\cdot\text{atm}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$, what is the osmotic pressure?

- A. 0.246 atm
- B. 0.492 atm
- C. 0.820 atm
- D. 0.984 atm
- E. 9.84 atm

Q20. Molecular Weight Determination

5.00 g of an unknown nonelectrolyte is dissolved in 100 g of water. The boiling point elevation is $\Delta T_b = 0.12875\text{ }^{\circ}\text{C}$. Given $K_b = 0.515\text{ }^{\circ}\text{C}\cdot\text{kg/mol}$, what is the molecular weight of the unknown?

- A. 100 g/mol
- B. 150 g/mol
- C. 200 g/mol
- D. 250 g/mol
- E. 400 g/mol

Answer Key

Part I - MCQs

Question	Answer	Question	Answer	
1	C	2	C	
3	D	4	C	
5	B	6	D	
7	B	8	C	
9	B	10	D	

Part II - Fill in the Blank

Q11. Mole fraction

Q12. X_2 (or X_{solute})

Q13. Molal elevation constant / Ebullioscopic constant

Q14. Freezing point depression; $\Delta T_f = K_f m$

Q15. cRT

Part III - Calculation Answers with Working

Q16. Answer: B

$$n_{\text{sucrose}} = 20/342 = 0.05848 \text{ mol}$$

$$n_{\text{water}} = 180/18.02 \approx 9.989 \text{ mol}$$

$$X_{\text{solute}} = 0.05848 / (9.989 + 0.05848) \approx 5.82 \times 10^{-3}$$

Q17. Answer: B

$$n = 9.25/185 = 0.050 \text{ mol}$$

$$m = 0.050/0.250 = 0.20 \text{ mol/kg}$$

$$\Delta T_b = (0.515)(0.20) = 0.103 \text{ }^{\circ}\text{C}$$

$$T_b = 100.000 + 0.103 = 100.103 \text{ }^{\circ}\text{C}$$

Q18. Answer: C

$$n = 17.1/342 = 0.050 \text{ mol}$$

$$m = 0.050/0.250 = 0.20 \text{ mol/kg}$$

$$\Delta T_f = (1.86)(0.20) = 0.372 \text{ }^{\circ}\text{C}$$

$$T_f = 0 - 0.372 = -0.372 \text{ }^{\circ}\text{C}$$

Q19. Answer: D

$$c = 0.010/0.250 = 0.040 \text{ M}$$

$$T = 27 + 273 = 300 \text{ K}$$

$$\pi = cRT = (0.040)(0.082)(300) = 0.984 \text{ atm}$$

Q20. Answer: C

$$M_2 = [K_b \times 1000 \times w_2] / [w_1 \times \Delta T_b]$$

$$M_2 = [(0.515)(1000)(5.00)] / [(100)(0.12875)]$$

$$M_2 = 200 \text{ g/mol}$$

High-Yield Traps

- Molality = mol of solute per kg of solvent, not kg of solution.
- Molarity = mol of solute per liter of solution.

- Raoult's law uses mole fraction, not weight fraction.
- Negative deviation: stronger A-B attraction -> lower vapor pressure.
- Adding a nonvolatile solute: vapor pressure decreases, boiling point increases, freezing point decreases.
- ΔT_f is a positive magnitude; the actual freezing temperature may be below 0 °C.
- For osmotic pressure calculations, use temperature in Kelvin.
- If the actual boiling point is given, calculate ΔT_b before using the molecular-weight equation.