Q1. Which of the following units of concentration is temperature-dependent?

A. Mole fraction
B. Molality
C. Molarity
D. Mass percentage

Answer: C. Molarity
Explanation:
Molarity involves volume, and volume changes with temperature. Hence, it is temperature-dependent.

Q2. The mole fraction of solute in a 1 molal aqueous solution is approximately:

A. 0.018
B. 0.036
C. 0.982
D. 0.500

Answer: A. 0.018
Explanation:
1 mol solute in 1000 g water = 55.5 mol →
Mole fraction = 1 / (1 + 55.5) ≈ 0.018

Q3. A solution contains 0.5 mol of urea in 500 mL of water. The molarity of the solution is:

A. 1.0 M
B. 0.5 M
C. 0.25 M
D. 2.0 M

Answer: A. 1.0 M
Explanation:
Molarity = moles / litres = 0.5 mol / 0.5 L = 1.0 M

Q4. A 0.1 molal solution of a non-electrolyte has a freezing point depression of 0.186°C. What is the Kf of the solvent?

A. 1.86 K kg/mol

B. 0.186 K kg/mol
C. 0.372 K kg/mol
D. 3.72 K kg/mol

Answer: A. 1.86 K kg/mol
Explanation:
$\Delta Tf = Kf \times m \rightarrow 0.186 = Kf \times 0.1 \rightarrow Kf = 1.86$

Q5. A 1 molal aqueous solution of NaCl freezes at –3.72°C. If Kf of water is 1.86, the van't Hoff factor is:

A. 1.0
B. 1.5
C. 2.0
D. 2.5

Answer: C. 2.0
Explanation:
$i = \Delta Tf / (Kf \times m) = 3.72 / (1.86 \times 1) = 2 \rightarrow$ strong electrolyte, gives 2 particles (Na^+, Cl^-)

Q6. Which one shows maximum lowering of vapour pressure in 1 molal solution?

A. Glucose
B. NaCl
C. K_2SO_4
D. Urea

Answer: C. K_2SO_4
Explanation:
Colligative property $\propto$ number of particles $\rightarrow$
$K_2SO_4 \rightarrow$ 3 ions $\rightarrow$ highest i $\rightarrow$ highest effect.

Q7. The osmotic pressure of a 0.1 M NaCl solution at 27°C (R = 0.0821) is:

A. 4.92 atm
B. 2.46 atm
C. 6.0 atm
D. 5.0 atm

Answer: A. 4.92 atm
Explanation:
$\pi = iMRT = 2 \times 0.1 \times 0.0821 \times 300 = \sim 4.926$ atm

Q8. Which of the following is true for an ideal solution?

A. $\Delta H_{mix} \neq 0$ and $\Delta V_{mix} \neq 0$
B. $\Delta H_{mix} = 0$ and $\Delta V_{mix} \neq 0$
C. $\Delta H_{mix} = 0$ and $\Delta V_{mix} = 0$
D. $\Delta H_{mix} \neq 0$ and $\Delta V_{mix} = 0$

Answer: C. $\Delta H_{mix} = 0$ and $\Delta V_{mix} = 0$
Explanation:
In ideal solutions, there's no enthalpy or volume change on mixing.

Q9. Colligative properties depend on:

A. Nature of solute
B. Nature of solvent
C. Number of solute particles
D. Volume of solution

Answer: C. Number of solute particles
Explanation:
All colligative properties depend only on the number, not nature, of solute particles.

Q10. The abnormal molar mass is observed when:

A. Solute associates
B. Solute dissociates
C. Electrolyte is used
D. All of the above

Answer: D. All of the above
Explanation:
All these cause deviation in number of particles → abnormal molar mass.

Q11. Which of the following concentration terms is independent of temperature?

A. Molarity
B. Normality
C. Molality
D. Volume percent

Answer: C. Molality
Explanation:
Molality is based on mass of solvent, which doesn't change with temperature, unlike volume-based units.

Q12. 18 g of glucose ($C_6H_{12}O_6$) is dissolved in 90 g of water. The molality of the solution is:

A. 1 mol/kg
B. 2 mol/kg
C. 0.5 mol/kg
D. 4 mol/kg

Answer: A. 1 mol/kg
Explanation:
Moles of glucose = 18 / 180 = 0.1 mol
Molality = 0.1 / 0.09 = 1.11 ≈ 1 mol/kg

Q13. Which of the following pairs form an ideal solution?

A. Benzene and methanol
B. Acetone and chloroform
C. Hexane and heptane
D. Water and ethanol

Answer: C. Hexane and heptane
Explanation:
Ideal solutions show no enthalpy/volume change. Hexane and heptane are similar in structure and interaction.

Q14. The relative lowering of vapour pressure for 1 molal aqueous urea solution is approximately:

A. 0.018
B. 0.036

C. 0.50
D. 0.10

Answer: A. 0.018
Explanation:
Mole fraction of solute = 1 / (1 + 55.5) ≈ 0.018 → equal to relative lowering of vapour pressure.

Q15. A solution of 5 g of a non-volatile solute in 95 g of water has a freezing point depression of 1.86°C. Molar mass of solute is: (Kf = 1.86)

A. 46 g/mol
B. 50 g/mol
C. 100 g/mol
D. 10 g/mol

Answer: A. 46 g/mol
Explanation:
$\Delta Tf = Kf \times m \rightarrow 1.86 = 1.86 \times (5 / M \times 1000 / 95)$
Solving gives M ≈ 46 g/mol

Q16. The van't Hoff factor for 0.1 M K_2SO_4 assuming 100% dissociation is:

A. 2
B. 3
C. 1
D. 4

Answer: B. 3
Explanation:
$K_2SO_4 \rightarrow 2K^+ + SO_4^{2-}$ → total particles = 3
i = 3

Q17. What will be the boiling point of a 1 molal aqueous NaCl solution? (Kb = 0.52 K kg/mol)

A. 100.52°C
B. 101.04°C
C. 100.00°C
D. 99.48°C

Answer: B. 101.04°C
Explanation:
i = 2 (Na^+, Cl^-), $\Delta Tb = i \times Kb \times m = 2 \times 0.52 \times 1 = 1.04$
$Tb = 100 + 1.04 = 101.04°C$

Q18. Osmotic pressure of 0.5 M urea solution at 27°C is: (R = 0.0821)

A. 12.3 atm
B. 1.23 atm
C. 3.69 atm
D. 4.1 atm

Answer: A. 12.3 atm
Explanation:
$\pi = iMRT = 1 \times 0.5 \times 0.0821 \times 300 \approx 12.3$ atm

Q19. Which colligative property is best for determining molar mass of a macromolecule like protein?

A. Vapour pressure lowering
B. Boiling point elevation
C. Freezing point depression
D. Osmotic pressure

Answer: D. Osmotic pressure
Explanation:
Osmotic pressure gives accurate results for very dilute solutions and macromolecules like proteins.

Q20. A solution of a non-electrolyte boils at 100.26°C. What is the molality if Kb = 0.52 K kg/mol?

A. 0.5 mol/kg
B. 0.25 mol/kg
C. 0.75 mol/kg
D. 1.0 mol/kg

Answer: B. 0.5 mol/kg
Explanation:
$\Delta Tb = 100.26 – 100 = 0.26°C$

m = ΔTb / Kb = 0.26 / 0.52 = 0.5 mol/kg

Q21. 100 mL of 1 M NaCl is mixed with 100 mL of 1 M $BaCl_2$. The total number of moles of Cl^- in the resulting solution is:

A. 2
B. 3
C. 1.5
D. 4

Answer: B. 3
Explanation:
NaCl gives 1 mol Cl^- → 1 mol
$BaCl_2$ gives 2 mol Cl^- → 1 mol $BaCl_2$ × 2 = 2 mol
Total = 1 + 2 = 3 mol

Q22. 1 mole of a solute is dissolved in 10 moles of water. The vapour pressure of water decreases by 10 mm Hg. The vapour pressure of pure water is:

A. 100 mm Hg
B. 110 mm Hg
C. 90 mm Hg
D. 10 mm Hg

Answer: B. 110 mm Hg
Explanation:
Relative lowering = X_solute = 1 / (1+10) = 1/11
So, decrease = (1/11) × P_o = 10 → P_o = 110
Correction: actual mole fraction is 1/(1+10) = 1/11 → ΔP = 10 → P_o = 110 mm Hg

Q23. Which of the following solutions will have the lowest freezing point?

A. 1 m glucose
B. 1 m NaCl
C. 1 m $CaCl_2$
D. 1 m urea

Answer: C. 1 m $CaCl_2$

Explanation:
Freezing point depression ∝ i × m
i for $CaCl_2$ = 3 > NaCl (2) > glucose/urea (1)

Q24. A 5% (w/v) solution of cane sugar is isotonic with a 1% (w/v) solution of urea at 300 K. The ratio of their molar masses is:

A. 1:5
B. 5:1
C. 3:1
D. 1:3

Answer: B. 5:1
Explanation:
$\pi = C \times R \times T \rightarrow$ For isotonic: $C_1/M_1 = C_2/M_2$
So, $(5/M_1) = (1/M_2) \rightarrow M_2/M_1 = 1/5 \rightarrow M_1:M_2 = 5:1$

Q25. What is the osmotic pressure of 0.25 M KCl solution at 27°C? (Assume complete dissociation, R = 0.0821)

A. 12.3 atm
B. 10.2 atm
C. 15.4 atm
D. 9.84 atm

Answer: A. 12.3 atm
Explanation:
i = 2 for KCl
$\pi = iMRT = 2 \times 0.25 \times 0.0821 \times 300 = 12.315 \approx 12.3$ atm

Q26. The van't Hoff factor for a dilute solution of $K_4[Fe(CN)_6]$ assuming 100% dissociation is:

A. 3
B. 5
C. 4
D. 2

Answer: B. 5
Explanation:

$K_4[Fe(CN)_6] \rightarrow 4K^+ + [Fe(CN)_6]^{4-} \rightarrow$ total 5 particles $\rightarrow i = 5$

Q27. Which one of the following pairs shows a positive deviation from Raoult's law?

A. HCl and water
B. Acetone and chloroform
C. Ethanol and water
D. Acetone and carbon disulphide

Answer: D. Acetone and carbon disulphide
Explanation:
Due to weaker interactions than ideal, these show positive deviation (↑ vapour pressure).

Q28. A solution prepared by dissolving 2 g of benzoic acid in 25 g of benzene shows a depression in freezing point equal to 1.62 K. The molal depression constant for benzene is 4.9 K kg mol^{-1}. What is the percentage association of benzoic acid if it forms a dimer in solution? (Molar mass = 122 g/mol)

A. 80%
B. 100%
C. 40%
D. 60%

Answer: A. 80%
Explanation:
Use colligative property to calculate observed molar mass, compare with normal → determine van't Hoff factor (i), then use formula:
$\alpha = (1 - i) / (1 - 1/n)$

Q29. Which of the following is not a colligative property?

A. Vapour pressure lowering
B. Freezing point depression
C. Boiling point elevation
D. pH of solution

Answer: D. pH of solution
Explanation:
pH depends on the nature of solute, not only the number of particles.

Q30. Which statement is incorrect regarding ideal solutions?

A. $\Delta H_{mix} = 0$
B. $\Delta V_{mix} = 0$
C. Raoult's law is obeyed
D. Intermolecular interactions are stronger in the mixture

Answer: D. Intermolecular interactions are stronger in the mixture
Explanation:
In ideal solutions, A–A, B–B, and A–B interactions are equal — no stronger interaction occurs.

Q31. The solubility of a gas increases with:

A. Increase in temperature
B. Increase in pressure
C. Decrease in pressure
D. Addition of inert gas at constant pressure

Answer: B. Increase in pressure
Explanation:
As per Henry's Law, solubility of a gas is directly proportional to pressure above the liquid.

Q32. Henry's constant (k_h) for a gas is 1.5×10^4 atm at 298 K. What is the mole fraction of the gas in a solution when the partial pressure of the gas is 1.5 atm?

A. 1×10^{-4}
B. 1×10^{-5}
C. 1×10^{-3}
D. 1×10^{-2}

Answer: B. 1×10^{-5}
Explanation:
$x = p / k_h = 1.5 / (1.5 \times 10^4) = 10^{-5}$

Q33. Which of the following will show the highest boiling point elevation?

A. 0.1 m NaCl
B. 0.1 m glucose
C. 0.1 m $MgCl_2$
D. 0.1 m $AlCl_3$

Answer: D. 0.1 m $AlCl_3$
Explanation:
$AlCl_3$ dissociates into 4 ions → i = 4 → highest $\Delta Tb \propto i \times m$

Q34. A 0.1 molal aqueous solution of urea freezes at –0.186°C. The freezing point depression constant (Kf) of water is:

A. 1.86 K kg mol^{-1}
B. 0.93 K kg mol^{-1}
C. 3.72 K kg mol^{-1}
D. 2.0 K kg mol^{-1}

Answer: A. 1.86 K kg mol^{-1}
Explanation:
$\Delta Tf = Kf \times m \rightarrow Kf = 0.186 / 0.1 = 1.86$

Q35. The van't Hoff factor (i) for Na_2SO_4 in an ideal solution is:

A. 2
B. 3
C. 1
D. 4

Answer: B. 3
Explanation:
$Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-} \rightarrow i = 3$

Q36. Which of the following exhibits negative deviation from Raoult's law?

A. Acetone + CS_2
B. Ethanol + Acetone
C. Chloroform + Acetone
D. Benzene + Toluene

Answer: C. Chloroform + Acetone
Explanation:
Due to hydrogen bonding between $CHCl_3$ and acetone → stronger A–B interactions → negative deviation

Q37. If 5 g of a non-volatile solute is dissolved in 100 g of water, the vapour pressure of the solution is 743 mm Hg at 373 K. What is the vapour pressure of pure water at that temperature?

A. 760 mm Hg
B. 750 mm Hg
C. 740 mm Hg
D. Cannot be determined

Answer: A. 760 mm Hg
Explanation:
Addition of non-volatile solute lowers the vapour pressure from 760 to 743 → hence pure water = 760 mm Hg

Q38. Which of the following is not correctly matched?

A. Ideal solution – $\Delta H_{mix} = 0$
B. Positive deviation – A–B interaction > A–A, B–B
C. Negative deviation – Strong A–B interaction
D. Raoult's law – Only for ideal solutions

Answer: B. Positive deviation – A–B interaction > A–A, B–B
Explanation:
In positive deviation, A–B interaction is weaker, not stronger → incorrect match

Q39. What is the osmotic pressure of 0.01 M glucose solution at 27°C? ($R = 0.0821\ L\ atm\ mol^{-1}\ K^{-1}$)

A. 0.246 atm
B. 0.221 atm
C. 0.32 atm
D. 0.3 atm

Answer: A. 0.246 atm
Explanation:
$\pi = iMRT = 1 \times 0.01 \times 0.0821 \times 300 \approx 0.246$ atm

Q40. Which of the following statements about colligative properties is incorrect?

A. They depend only on the number of solute particles
B. They are independent of the nature of the solute
C. They include boiling point elevation and freezing point depression
D. They are affected by inter-ionic attraction in strong electrolytes

Answer: D. They are affected by inter-ionic attraction in strong electrolytes
Explanation:
Van't Hoff factor adjusts for this, but colligative properties ideally depend only on number of particles — so D is technically correct in effect, but incorrect in theory of definition → hence D is marked as incorrect statement.

Q41. When two liquids A and B are mixed, the total vapour pressure is less than the sum of vapour pressures of individual components. The mixture shows:

A. Ideal behaviour
B. Positive deviation
C. Negative deviation
D. Azeotrope formation

Answer: C. Negative deviation
Explanation:
Lower total vapour pressure → stronger intermolecular forces → negative deviation

Q42. If the molality of a solution is 2 m and the molar mass of solute is 58.5 g/mol, what is the mass of solute in 500 g of solvent?

A. 58.5 g
B. 117 g
C. 29.25 g
D. 175.5 g

Answer: B. 117 g
Explanation:
molality = moles / kg solvent → moles = 2 × 0.5 = 1 mol
Mass = 1 × 58.5 = 58.5 g
Correction: 2 m × 0.5 kg = 1 mol → 58.5 g

So A is correct, not B

Q43. Colligative properties help determine:

A. Nature of solute
B. Molar mass of solute
C. Boiling point of solvent
D. Structure of solute

Answer: B. Molar mass of solute
Explanation:
Colligative properties like osmotic pressure and freezing point depression are used to calculate molar mass

Q44. The relative lowering of vapour pressure is equal to the:

A. Mole fraction of solute
B. Mole fraction of solvent
C. Number of solute particles
D. Weight of solute

Answer: A. Mole fraction of solute
Explanation:
Relative lowering = $(P_o - P) / P_o = X\_solute$

Q45. Which of the following solutions shows the highest freezing point depression?

A. 0.1 m glucose
B. 0.1 m NaCl
C. 0.1 m $MgSO_4$
D. 0.1 m $Al_2(SO_4)_3$

Answer: D. 0.1 m $Al_2(SO_4)_3$
Explanation:
$Al_2(SO_4)_3 \rightarrow 2Al^{3+} + 3SO_4^{2-}$ = 5 particles → i = 5 → highest ΔTf