CHEM 211 UNIT 2 – THE PHYSICAL PROPERTIES OF LIQUIDS AND SOLUTIONS
PRACTICE QUESTIONS

Vapour Pressure, Boiling point, Raoult's Law and Azeotropes

1. The vapour pressure of ethoxyethane at 18 ^oC is 53 kPa and ΔH_{vap} for ethoxyethane is 26.0 $kJmol^{-1.}$ calculate the vapour pressure of ethoxyethane at 32 ^oC.
- (a) Calculate the vapour pressure of ethoxyethane at 32 ^oC.
- (b) Calculate the boiling point of ethoxyethane at 100 kPa

2. The vapour pressure of water at 25 ^oC is 3.1 kPa. Given that water boils at 100 ^oC at atmospheric pressure, calculate the molar heat of vaporisation of water.

3.
- (a) State Raoult's Law and define an ideal solution.
- (b) Pentane (C_5H_{12}) and heptane (C_7H_{16}) have vapour pressures of 55 kPa and 4.8 kPa respectively at 20 ^oC. A mixture is known to contain 252 g of pentane and 1400 g of heptane. Calculate:
  - (i) The mole fraction of each component in the liquid mixture
  - (ii) The total vapour pressure of the mixture
  - (iii) The mole fraction of each component in the vapour above the mixture
- (d) Sketch vapour pressure-composition and boiling point-composition diagrams for a mixture of pentane and heptane.
- (e) Hence explain how fractional distillation can be used to separate an ideal solution into its two components.

4. Ethyl ethanoate (bpt 77 ^oC) and water (bpt 100 ^oC) form an azeotrope containing 9% water with a boiling point of 70 ^oC.
- (a) Sketch vapour pressure-composition and boiling point-composition diagrams for a mixture of ethyl ethanoate and water.
- (b) Explain why the mixture forms an azeotrope.
- (c) Explain what is formed when a mixture of ethyl ethanoate and water containing 5% water is fractionally distilled.
- (d) Explain what is formed when a mixture of ethyl ethanoate and water containing 50% water is fractionally distilled.

5. Nitric acid (bpt 83 ^oC) and water (bpt 100 ^oC) form an azeotrope containing 32% water with a boiling point of 121 ^oC.
- (a) Sketch vapour pressure-composition and boiling point-composition diagrams for a mixture of nitric acid and water.
- (b) Explain why the mixture forms an azeotrope.
- (c) Explain what is formed when a mixture of nitric acid and water containing 5% water is fractionally distilled.
- (d) Explain what is formed when a mixture of nitric acid and water containing 50% water is fractionally distilled.

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Colligative Properties of Solutions

6. (a) The vapour pressure of pure water is 3.14 kPa at 25 ^{o}C. The vapour pressure of a solution of urea is 3.04 kPa at 25 ^{o}C. If the density of water is 1000 kgm^{-3} and assuming that the volume of water does not change when a small amount of urea is added, deduce the molarity of the urea solution.

(b) The addition of 114 g of sucrose to 1000 g of water reduces the vapour pressure from 3.173 kPa to 3.154 kPa. Calculate the molar mass of sucrose.

7. What mass of glucose ($C_6H_{12}O_6$) should be added to 552 g of water to reduce the vapour pressure of pure water at 20 ^{o}C from 2.33 kPa to 2.07 kPa?

8. Calculate the boiling point and freezing point of a solution containing 478 g of ethan-1,2-diol ($C_2H_6O_2$) in 3202 g of water, given that K_f and K_b for water are 1.86 K/m and 0.52 K/m respectively.

9. 7.85 g of a compound is dissolved in 301 g of benzene (C_6H_6) and the freezing point depression is found to be 1.05 ^{o}C. Given that K_f for benzene is 5.12 K/m, calculate the molar mass of the compound.

10. (a) Calculate the molarity of a solution of sodium chloride which has an osmotic pressure of 3000 kPa at 25 ^{o}C.

(b) Calculate the osmotic pressure of an 0.084 moldm^{-3} solution of sucrose at 16 ^{o}C.

(c) Calculate the molar mass of a polymer if 2.47 of the polymer has an osmotic pressure of 1.15 kPa when dissolved in 202 cm^{3} of benzene at 21 ^{o}C

11. (a) The freezing point depression of a 0.10 moldm^{-3} solution of $MgSO_4$ is 0.225 ^{o}C. Calculate the Van’t Hoff factor of $MgSO_4$ at this molarity.

(b) Calculate the freezing point and boiling point of a solution of 21.2 g NaCl in 135 cm^{3} of water, given that K_f and K_b for water are 1.86 K/m and 0.52 K/m respectively.

Faraday's Laws of Electrolysis

12. (a) Calculate the mass of copper, and the volume of oxygen at 298 K and 100 kPa, which can be produced by passing a current of 0.5 A through a solution of copper sulphate for 10 minutes.

(b) Calculate the time required for 56 g of silver to be deposited from $AgNO_3$ solution using a current of 4.5 A.

(c) How long must a current of 3 A be applied for through a solution of silver nitrate to coat a metal surface of 80 cm^2 with 0.005 cm thick layer? Density of silver is 10.5 g/$cm^{\mathbf{3}}$.

(d) Calculate the current used if 4.76 g of copper was deposited from copper sulphate solution in 5 hours.

(e) A current of 3.7 A is passed for 6 hours between platinum electrodes in 500 cm^3 of a 2 $moldm^{-3}$ solution of $Ni(NO_3)_2$. What will be the molarity of the solution at the end of the electrolysis?

Conductance, specific conductivity and molar conductivity

13. (a) Describe the method commonly used to measure the resistance of a solution. Explain why alternating current should be used and describe how the cell can be adjusted to deal with very high or very low conductances.

(b) A solution of 0.1 $moldm^{-3}$ H_2SO_4 in a cell containing electrodes with an area of 2 cm^2 and placed 1 cm apart is found to have a resistance of 50 Ω. Calculate:

(i) The cell constant
(ii) The specific conductivity of the solution
(iii) The molar conductivity of 0.1 $moldm^{-3}$ H_2SO_4.
(iv) The resistance obtained if 0.05 $moldm^{-3}$ KCl is placed in the same cell (Λ of 0.05 $moldm^{-3}$ KCl = 0.0133 $m^2\ \Omega^{-1}mol^{-1}$)

(c) The resistance of a cell containing 0.1 $moldm^{-3}$ $ZnSO_4$ was found to be 72.2 Ω. The resistance of the same cell containing 0.02 $moldm^{-3}$ KCl was 550 Ω. If the molar conductivity of 0.02 $moldm^{-3}$ KCl is 0.0140 $m^2\ \Omega^{-1}mol^{-1}$, calculate the cell constant and hence the molar conductivity of 0.1 $moldm^{-3}$ $ZnSO_4$.