# Vapour Pressure, Boiling point, Raoult’s Law and Azeotropes

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| **1.** | The vapour pressure of ethoxyethane at 18 oC is 53 kPa and ΔHvap 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 (C5H12) and heptane (C7H16) 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. | |

# Colligative Properties of Solutions

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| **6.** | (a) | The vapour pressure of pure water is 3.14 kPa at 25 oC. The vapour pressure of a solution of urea is 3.04 kPa at 25 oC. 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 (C6H12O6) should be added to 552 g of water to reduce the vapour pressure of pure water at 20 oC 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 (C2H6O2) in 3202 g of water, given that Kf and Kb 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 (C6H6) and the freezing point depression is found to be 1.05 oC. Given that Kf 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 oC. |
|  | (b) | Calculate the osmotic pressure of an 0.084 moldm-3 solution of sucrose at 16 oC. |
|  | (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 cm3 of benzene at 21 oC |
| **11.** | (a) | The freezing point depression of a 0.10 moldm-3 solution of MgSO4 is 0.225 oC. Calculate the Van’t Hoff factor of MgSO4 at this molarity. |
|  | (b) | Calculate the freezing point and boiling point of a solution of 21.2 g NaCl in 135 cm3 of water, given that Kf and Kb for water are 1.86 K/m and 0.52 K/m respectively. |

## Faraday’s Laws of Electrolysis

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| **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 AgNO3 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 cm2 with 0.005 cm thick layer? Density of silver is 10.5 g/cm**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 cm3 of a  2 moldm-3 solution of Ni(NO3)2. What will be the molarity of the solution at the end of the electrolysis? |

## Conductance, specific conductivity and molar conductivity

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| **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 H2SO4 in a cell containing electrodes with an area of 2 cm2 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 H2SO4. |
|  |  | (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 m2 Ω-1mol-1) |
|  | (c) | The resistance of a cell containing 0.1 moldm-3 ZnSO4 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 m2 Ω-1mol-1, calculate the cell constant and hence the molar conductivity of 0.1 moldm-3 ZnSO4. | |