Marks

- A specific variety of haemoglobin associated with heart disease was isolated from a blood sample. A sample of this haemoglobin (21.5 mg) is dissolved in water at 25 °C to make 1.50 mL of solution. The osmotic pressure of the solution was measured and found to be 3.61 mmHg. What is the molar mass of this particular type of haemoglobin? **4**

**The osmotic pressure, *Π*, is related to the molarity *M* by $\Pi = MRT$**

**As 1 atm = 760 mmHg, $\Pi = 3.81 \text{ mmHg} = \frac{3.81}{760} \text{ atm} = 5.01\times10^{-3} \text{ atm}$**

**Hence, $M = \frac{(5.01\times10^{-3} \text{ atm})}{(0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1})\times((25+273)\text{ K})} = 2.05\times10^{-4} \text{ M}$**

**The number of moles of haemoglobin in 1.50 mL is thus:**

**$n(\text{haemoglobin}) = V \times c = \left(\frac{1.50}{1000} \text{ L}\right)\times(2.05\times10^{-4} \text{ M}) = 3.08\times10^{-7} \text{ mol}$**

**This amount corresponds to 21.5 mg so the molar mass is:**

**$\text{molar mass} = \frac{\text{mass}}{\text{number of moles}} = \frac{(21.5\times10^{-3} \text{ g})}{(3.08\times10^{-7} \text{ mol})} = 6.99\times10^{4} \text{ g mol}^{-1}$**

Answer: **$6.99 \times 10^{4}$ g mol$^{-1}$**

- Calcium oxalate ($CaC_2O_4$) is only slightly soluble in water (5.73 mg L$^{-1}$ at 25 °C) and can be deposited in renal calculi (kidney stones). What is the molar solubility of calcium oxalate? **3**

**The formula mass is 40.08 (Ca) + (2×12.01 (C)) + (4×16.00 (O)) g mol$^{1}$**
**= 128.1 g mol$^{-1}$**

**The molar solubility is = $\frac{\text{solubility}}{\text{formula mass}} = \frac{(5.73\times10^{-3} \text{ g L}^{-1})}{(128.1 \text{ g mol}^{-1})} = 4.47\times10^{-5} \text{M}$**

Answer: **$4.47 \times 10^{-5}$ M**

Calculate the solubility product constant ($K_{sp}$) of calcium oxalate at 25 °C.

**The solubility equilibrium is $CaC_2O_4(s) \rightleftharpoons Ca^{2+}(aq) + C_2O_4^{2-}(aq)$**

**As 1 mol of $Ca^{2+}$(aq) and 1 mol of $C_2O_4^{2-}$(aq) is produced by every mole of $CaC_2O_4$(s) that dissolves, $[Ca^{2+}(aq)] = [C_2O_4^{2-}(aq)] = 4.47 \times 10^{-5}$ M.**

**Hence, $K_{sp} = [Ca^{2+}(aq)][C_2O_4^{2-}(aq)] = (4.47 \times 10^{-5}) \times (4.47 \times 10^{-5}) = 2.00 \times 10^{-9}$**

$K_{sp}$ = **$2.00 \times 10^{-9}$**