Marks 4

- Order the following salts from lowest to highest molar solubility.

Salt	CuCl	$Cd(IO_3)_2$	$BaSO_4$	Ag_2CrO_4
K_{sp}	1.9×10^{-7}	2.3×10^{-8}	1.1×10^{-10}	2.6×10^{-12}

(1) For CuCl, K_{sp} refers to the dissolution reaction:

$$CuCl(s) \rightleftharpoons Cu^+(aq) + Cl^-(aq) \qquad K_{sp} = [Cu^+(aq)][Cl^-(aq)]$$

If the solubility is x mol L^{-1} then x mol of CuCl(s) dissolves in one litre. From the dissolution equation, this leads to $[Cu^+(aq)] = x$ M and $[Cl^-(aq)] = x$ M. Hence,

$$K_{sp} = (x)(x) = x^2 = 1.9 \times 10^{-7} \quad \text{or } x = (1.9 \times 10^{-7})^{1/2} \text{ M} = 4.4 \times 10^{-4} \text{ M}$$

(2) For $Cd(IO_3)_2$, K_{sp} refers to the dissolution reaction:

$$Cd(IO_3)_2(s) \rightleftharpoons Cd^{2+}(aq) + 2IO_3^-(aq) \qquad K_{sp} = [Cd^{2+}(aq)][IO_3^-(aq)]^2$$

If the solubility is x mol L^{-1} then x mol of $Cd(IO_3)_2$ (s) dissolves in one litre. From the dissolution equation, this leads to $[Cd^{2+}(aq)] = x$ M and $[IO_3^-(aq)] = x$ M. Hence,

$$K_{sp} = (x)(2x)^2 = 4x^3 = 2.3 \times 10^{-8} \quad \text{or } x = (2.3 \times 10^{-8} / 4)^{1/3} \text{ M} = 1.8 \times 10^{-3} \text{ M}$$

(3) For $BaSO_4$, K_{sp} refers to the dissolution reaction:

$$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq) \qquad K_{sp} = [Ba^{2+}(aq)][SO_4^{2-}(aq)]$$

If the solubility is x mol L^{-1} then x mol of $BaSO_4$(s) dissolves in one litre. From the dissolution equation, this leads to $[Ba^{2+}(aq)] = x$ M and $[SO_4^{2-}(aq)] = x$ M. Hence,

$$K_{sp} = (x)(x) = x^2 = 1.1 \times 10^{-10} \quad \text{or } x = (1.1 \times 10^{-10})^{1/2} \text{ M} = 1.0 \times 10^{-5} \text{ M}$$

(4) For Ag_2CrO_4, K_{sp} refers to the dissolution reaction:

$$Ag_2SO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq) \qquad K_{sp} = [Ag^+(aq)]^2[CrO_4^{2-}(aq)]$$

If the solubility is x mol L^{-1} then x mol of Ag_2CrO_4(s) dissolves in one litre. From the dissolution equation, this leads to $[Ag^+(aq)] = 2x$ M and $[CrO_4^{2-}(aq)] = x$ M. Hence,

$$K_{sp} = (2x)^2(x) = 4x^3 = 2.6 \times 10^{-12} \quad \text{or } x = (2.6 \times 10^{-12} / 4)^{1/2} \text{ M} = 8.7 \times 10^{-5} \text{ M}$$

Overall, solubility increases in the order:

$$BaSO_4 < Ag_2CrO_4 < CuCl < Cd(IO_3)_2$$