Problem Solving (24 marks)

1 In an experiment to determine the solubility of barium fluoride, 500.0 mL of the saturated solution was heated in an evaporating dish to remove the water. The evaporating dish and residue were heated two more times, to ensure all the water had been driven off.

I.	Volume of saturated solution of BaF_2	500.0 mL
II.	Mass of evaporating dish	72.540 g
III.	Mass of evaporating dish and BaF_2 after first heating	73.500 g
IV.	Mass of evaporating dish and BaF_2 after second heating	72.855 g
V.	Mass of evaporating dish and BaF_2 after third heating	72.855 g

Using the data above, calculate the K_{sp} for BaF_2. **(4 marks)**

mass of BaF_2 = 72.855 g − 72.540 g = .315 g } 1 mark

$.315\text{ g } BaF_2 \left(\frac{1\text{ mol}}{175.3\text{ g}}\right) = 0.001797\text{ mol}$

$\frac{0.001797\text{ mol}}{.5\text{ L}} = 0.00359\text{ M}$ } 1½ marks

$BaF_2 \rightleftharpoons Ba^{+2} + 2F^-$

.00359 2(.00359)

$K_{sp} = [Ba^{+2}][F^-]^2$

$= (.00359)(.00718)^2$

$= 1.86 \times 10^{-7}$

3 s.f.

SIG mark

} 1½ marks

2 Consider the following reaction:

$$Cu_{(s)} + 2AgCH_3COO_{(aq)} \rightarrow Cu(CH_3COO)_{2(aq)} + 2Ag_{(s)}$$

A piece of Cu wire is placed into 1.00 L of a saturated solution of silver acetate, $AgCH_3COO$. When all the Ag^+ has reacted, 2.00 g of Cu has been used.

a) Write the net ionic equation for the reaction between Cu and Ag^+. **(1 mark)**

$Cu_{(s)} + 2Ag^+_{(aq)} \rightarrow Cu^{+2}_{(aq)} + 2Ag_{(s)}$

b) Calculate the K_{sp} of $AgCH_3COO$. **(4 marks)**

$AgCH_3COO \rightleftharpoons Ag^+ + CH_3COO^-$

$$\text{mol Cu} = 2.00\text{g}\left(\frac{1\text{mol}}{63.5\text{g}}\right) = 3.15\times10^{-2}\text{ mol Cu}$$

$$\text{mol } Ag^+ = 3.15\times10^{-2}\text{mol Cu}\left(\frac{2\text{mol } Ag^+}{1\text{mol Cu}}\right) = 6.30\times10^{-2}\text{mol } Ag^+$$

$$K_{sp} = [Ag^+][CH_3COO^-]$$
$$= (6.30\times10^{-2})^2$$
$$K_{sp} = 3.97\times10^{-3}$$

3. A 100.00 mL sample of a saturated solution of $Ca(OH)_2$ is evaporated to dryness. The mass of the solid residue is 0.125 g. Calculate the solubility product of $Ca(OH)_2$.

(4 marks)

$0.125\,g\ Ca(OH)_2 \left(\frac{1\,mol}{74.1\,g}\right) = 0.001687\,mol$

$\frac{0.001687\,mol}{.1\,L} = 0.01678\,M$

$Ca(OH)_2 \rightleftharpoons Ca^{+2} + 2\,OH^-$

$.01678 \quad 2(.01678)$

$K_{sp} = [Ca^{+2}][OH^-]^2$

$= .01678\,(.0337)^2$

$K_{sp} = 1.92 \times 10^{-5}$

4. A 100.0 mL sample of 0.600 M $Ca(NO_3)_2$ is diluted by adding 400.0 mL of water. Calculate the concentration of ions in the resulting solution. **(2 marks)**

$$M_A = \frac{M_B L_B}{L_A}$$

$$= \frac{.600M(.1L)}{.5L}$$

$$= 0.120M$$

} 1 mark

$$Ca(NO_3)_2 \rightleftharpoons Ca^{+2} + 2NO_3^{-2}$$

$$[Ca^{+2}] = 0.120M$$

$$[NO_3^-] = 0.240M$$

} 1 mark

5. A maximum of 0.60 g $Pb(NO_3)_2$ can be added to 1.5 L of $NaBr_{(aq)}$ without forming a precipitate. Calculate the [NaBr]. **(4 marks)**

$$PbBr_2 \rightleftharpoons Pb^{+2} + 2Br^-$$

$$.60g\ Pb(NO_3)_2 \left(\frac{1\ mol}{331.2g}\right) = 1.81\times10^{-3}\ mol$$

$$[Pb^{+2}] = \frac{1.81\times10^{-3}\ mol}{1.5L} = 1.208\times10^{-3}M$$

} 2 marks

$$K_{sp} = [Pb^{+2}][Br^-]^2$$

$$6.6\times10^{-6} = (1.208\times10^{-3})(x^2)$$

$$x^2 = \frac{6.6\times10^{-6}}{1.208\times10^{-3}}$$

$$x = 0.074\ M = [Br^-] = [NaBr]$$

} 2 marks

6. A solution contains 0.020 M Ba^{2+} and an unknown concentration of Sr^{2+}. When dilute Na_2CO_3 is slowly added to the mixture, both Ba^{2+} and Sr^{2+} start to precipitate at the same time. **(3 marks)**

a) Calculate the $\left[CO_3^{2-}\right]$ when $BaCO_3$ starts to precipitate.

$BaCO_3 \rightleftharpoons Ba^{+2} + CO_3^{-2}$

$.02 \quad x$

$K_{sp} = [Ba^{+2}][CO_3^{-2}]$

$2.6\times10^{-9} = .02(x)$

$x = 1.3\times10^{-7}\ M = [CO_3^{-2}]$

b) Calculate the initial $\left[Sr^{2+}\right]$.

$SrCO_3 \rightleftharpoons Sr^{+2} + CO_3^{-2}$

$x \quad 1.3\times10^{-7}$

$K_{sp} = [Sr^{+2}][CO_3^{-2}]$

$5.6\times10^{-10} = x(1.3\times10^{-7})$

$x = 4.3\times10^{-3}\ M = [Sr^{+2}]$

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7. When 1.00 L of a saturated solution of CaF_2 was evaporated to dryness, 2.66×10^{-2} g of residue was formed. Calculate the value of K_{sp}. **(3 marks)**

$2.66\times10^{-2}\,g\,CaF_2\left(\frac{1\,mol}{78.1\,g}\right) = 3.41\times10^{-4}\,mol$

$\therefore\ M = \frac{3.41\times10^{-4}\,mol}{1.00\,L} = 3.41\times10^{-4}\,M$ } 1 mark.

$CaF_2 \rightleftharpoons Ca^{+2} + 2F^-$

$3.41\times10^{-4} \quad 2(3.41\times10^{-4})$

$K_{sp} = [Ca^{+2}][F^-]^2$

$= 3.41\times10^{-4}(6.82\times10^{-4})^2$

$K_{sp} = 1.58\times10^{-10}$ } 2 marks.