

## 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 $\text{BaF}_2$	500.0 mL
II.	Mass of evaporating dish	72.540 g
III.	Mass of evaporating dish and $\text{BaF}_2$ after first heating	73.500 g
IV.	Mass of evaporating dish and $\text{BaF}_2$ after second heating	72.855 g
V.	Mass of evaporating dish and $\text{BaF}_2$ after third heating	72.855 g

Using the data above, calculate the  $K_{sp}$  for  $\text{BaF}_2$ .

(4 marks)

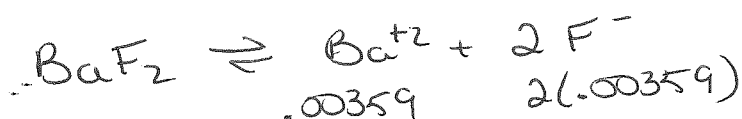
$$\begin{array}{r} \text{mass of BaF}_2 = 72.855 \text{ g} \\ - 72.540 \text{ g} \\ \hline .315 \text{ g} \end{array}$$

} 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

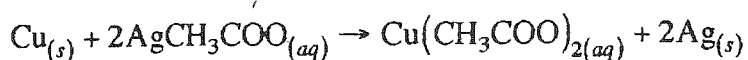


$$\begin{aligned} K_{sp} &= [\text{Ba}^{+2}][\text{F}^-]^2 \\ &= (.00359)(.00718)^2 \\ &= 1.86 \times 10^{-7} \end{aligned}$$

} 1½ marks

3 sig.  
sig mark

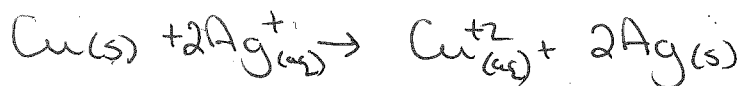
2 Consider the following reaction:



A piece of Cu wire is placed into 1.00 L of a saturated solution of silver acetate,  $\text{AgCH}_3\text{COO}$ . When all the  $\text{Ag}^+$  has reacted, 2.00 g of Cu has been used.

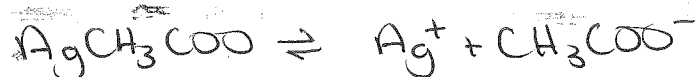
a) Write the net ionic equation for the reaction between Cu and  $\text{Ag}^+$ .

(1 mark)



b) Calculate the  $K_{sp}$  of  $\text{AgCH}_3\text{COO}$ .

(4 marks)



$$\text{mol Cu} = 2.00 \text{ g} \left( \frac{1 \text{ mol}}{63.5 \text{ g}} \right) = 3.15 \times 10^{-2} \text{ mol Cu}$$

$$\text{mol Ag}^+ = 3.15 \times 10^{-2} \text{ mol Cu} \left( \frac{2 \text{ mol Ag}^+}{1 \text{ mol Cu}} \right) = 6.30 \times 10^{-2} \text{ mol Ag}^+$$

$$K_{sp} = [\text{Ag}^+][\text{CH}_3\text{COO}^-]$$
$$= (6.30 \times 10^{-2})^2$$

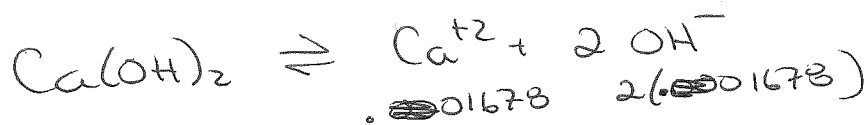
$$K_{sp} = 3.97 \times 10^{-3}$$

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

(4 marks)

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

$$\frac{0.001687 \text{ mol}}{0.1 \text{ L}} = 0.01687 \text{ M}$$



$$K_{sp} = [\text{Ca}^{2+}][\text{OH}^-]^2$$
$$= 0.01687 (0.0337)^2$$

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

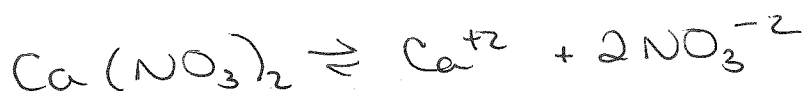
4. A 100.0 mL sample of 0.600 M  $\text{Ca}(\text{NO}_3)_2$  is diluted by adding 400.0 mL of water. Calculate the concentration of ions in the resulting solution. (2 marks)

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

$$= \frac{0.600 \text{ M} (0.1 \text{ L})}{0.5 \text{ L}}$$

$$= 0.120 \text{ M}$$

1 mark



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

$$[\text{NO}_3^-] = 0.240 \text{ M}$$

1 mark

5. A maximum of 0.60 g  $\text{Pb}(\text{NO}_3)_2$  can be added to 1.5 L of  $\text{NaBr}_{(aq)}$  without forming a precipitate. Calculate the  $[\text{NaBr}]$ . (4 marks)



$$0.60 \text{ g Pb}(\text{NO}_3)_2 \left( \frac{1 \text{ mol}}{331.2 \text{ g}} \right) = 1.81 \times 10^{-3} \text{ mol}$$

$$[\text{Pb}^{+2}] = \frac{1.81 \times 10^{-3} \text{ mol}}{1.5 \text{ L}} = 1.208 \times 10^{-3} \text{ M}$$

2 marks

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

$$6.6 \times 10^{-6} = (1.208 \times 10^{-3})(x^2)$$

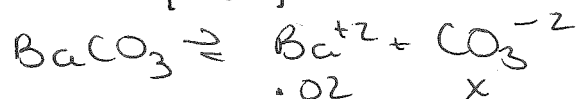
$$x^2 = \frac{6.6 \times 10^{-6}}{1.208 \times 10^{-3}}$$

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

2 marks

6. A solution contains 0.020 M  $\text{Ba}^{2+}$  and an unknown concentration of  $\text{Sr}^{2+}$ . When dilute  $\text{Na}_2\text{CO}_3$  is slowly added to the mixture, both  $\text{Ba}^{2+}$  and  $\text{Sr}^{2+}$  start to precipitate at the same time. (3 marks)

a) Calculate the  $[\text{CO}_3^{2-}]$  when  $\text{BaCO}_3$  starts to precipitate.

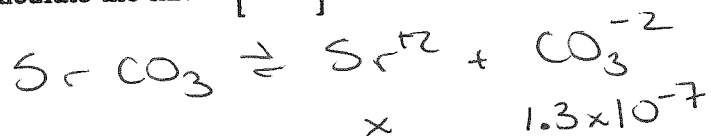


$$K_{sp} = [\text{Ba}^{+2}][\text{CO}_3^{-2}]$$

$$2.6 \times 10^{-9} = .02(x)$$

$$x = 1.3 \times 10^{-7} \text{ M} = [\text{CO}_3^{-2}]$$

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



$$K_{sp} = [\text{Sr}^{+2}][\text{CO}_3^{-2}]$$

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

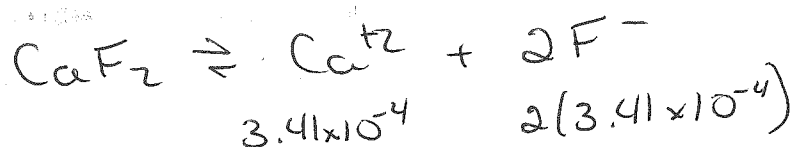
$$x = 4.3 \times 10^{-3} \text{ M} = [\text{Sr}^{+2}]$$

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7. When 1.00 L of a saturated solution of  $\text{CaF}_2$  was evaporated to dryness,  $2.66 \times 10^{-2} \text{ g}$  of residue was formed. Calculate the value of  $K_{sp}$ . (3 marks)

$$2.66 \times 10^{-2} \text{ g CaF}_2 \left( \frac{1 \text{ mol}}{78.1 \text{ g}} \right) = 3.41 \times 10^{-4} \text{ mol}$$
$$\therefore M = \frac{3.41 \times 10^{-4} \text{ mol}}{1.00 \text{ L}} = 3.41 \times 10^{-4} \text{ M}$$

} 1 mark.



$$K_{sp} = [\text{Ca}^{2+}][\text{F}^{-}]^2$$
$$= 3.41 \times 10^{-4} (6.82 \times 10^{-4})^2$$
$$K_{sp} = 1.58 \times 10^{-10}$$

} 2 marks.