

AS91393 Demonstrate understanding of equilibrium principles in aqueous systems

Solubility and solubility product questions from past papers

(2018:1)

- (b) (i) Write the equation for the equilibrium occurring in a saturated solution of calcium fluoride,  $\text{CaF}_2$ .
- (ii) Calculate the solubility of  $\text{CaF}_2$  in water at  $25^\circ\text{C}$ .  $K_s(\text{CaF}_2) = 3.20 \times 10^{-11}$

(2018:3)

- (a) (i) Write the solubility product expression,  $K_s$ , for silver chloride,  $\text{AgCl}$ .

(2017:2)

- (b) (i) Write the equation for the equilibrium occurring in a saturated solution of copper(II) hydroxide,  $\text{Cu}(\text{OH})_2$ .
- (ii) Write the expression for  $K_s(\text{Cu}(\text{OH})_2)$ .
- (iii) Calculate the solubility of  $\text{Cu}(\text{OH})_2$  in water at  $25^\circ\text{C}$ .  
 $K_s(\text{Cu}(\text{OH})_2) = 4.80 \times 10^{-20}$ .

(2016:1)

Silver carbonate,  $\text{Ag}_2\text{CO}_3$ , is a sparingly soluble salt.  $K_s(\text{Ag}_2\text{CO}_3) = 8.10 \times 10^{-12}$  at  $25^\circ\text{C}$   
 $M(\text{Ag}_2\text{CO}_3) = 276 \text{ g mol}^{-1}$

- (a) Write the solubility product expression,  $K_s$ , for silver carbonate ( $\text{Ag}_2\text{CO}_3$ ).
- (b) Calculate the mass of  $\text{Ag}_2\text{CO}_3$  that will dissolve in 50 mL of water to make a saturated solution at  $25^\circ\text{C}$ .

(2015:2)

Sufficient calcium carbonate,  $\text{CaCO}_3(\text{s})$ , is dissolved in water to make a saturated solution.

- (a) (i) Write the equation for the equilibrium occurring in a saturated solution of  $\text{CaCO}_3$ .
- (ii) Write the expression for  $K_s(\text{CaCO}_3)$ .
- (iii) Calculate the solubility product of  $\text{CaCO}_3$ ,  $K_s(\text{CaCO}_3)$ . The solubility of  $\text{CaCO}_3$  is  $5.74 \times 10^{-5} \text{ mol L}^{-1}$ .

**(2014:2)**

A flask contains a saturated solution of  $\text{PbCl}_2$  in the presence of undissolved  $\text{PbCl}_2$ .

- (a) (i) Write the equation for the dissolving equilibrium in a saturated solution of  $\text{PbCl}_2$ .
- (ii) Write the expression for  $K_s(\text{PbCl}_2)$ .
- (iii) Calculate the solubility (in  $\text{mol L}^{-1}$ ) of lead(II) chloride in water at  $25^\circ\text{C}$ , and give the  $[\text{Pb}^{2+}]$  and  $[\text{Cl}^-]$  in the solution.  $K_s(\text{PbCl}_2) = 1.70 \times 10^{-5}$  at  $25^\circ\text{C}$ .

**(2013:2)**

In an experiment, a saturated solution was made by dissolving  $1.44 \times 10^{-3}$  g of  $\text{Ag}_2\text{CrO}_4$  in water, and making it up to a volume of 50.0 mL.

$M(\text{Ag}_2\text{CrO}_4) = 332 \text{ g mol}^{-1}$ .

- (a) Write the  $K_s$  expression for  $\text{Ag}_2\text{CrO}_4(\text{s})$ .
- (b) (i) Calculate the solubility of  $\text{Ag}_2\text{CrO}_4(\text{s})$ , and hence give the  $[\text{Ag}^+]$  and  $[\text{CrO}_4^{2-}]$  in the solution.
- (ii) Determine the  $K_s(\text{Ag}_2\text{CrO}_4)$ .

*From expired AS90700 (but still useful practice)*

**(2012: 2)**

Iron(II) hydroxide,  $\text{Fe}(\text{OH})_2$ , has a  $K_s$  of  $4.10 \times 10^{-15}$  at  $25^\circ\text{C}$ .

- (a) (i) Write the equation for  $\text{Fe}(\text{OH})_2$  dissolving in water.
- (ii) Write the expression for  $K_s(\text{Fe}(\text{OH})_2)$ .
- (b) Calculate the solubility (in  $\text{mol L}^{-1}$ ) of iron(II) hydroxide in water at  $25^\circ\text{C}$ .

**(2011:2)**

Zinc hydroxide,  $\text{Zn}(\text{OH})_2$ , has a  $K_s$  of  $3.00 \times 10^{-17}$  at  $25^\circ\text{C}$ .

- (a) (i) Write an equation for zinc hydroxide dissolving in water.
- (ii) Write the  $K_s$  expression for zinc hydroxide.
- (b) Calculate the solubility (in  $\text{mol L}^{-1}$ ) of zinc hydroxide at  $25^\circ\text{C}$ .

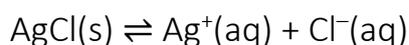
**(2010:2)**

- (a) Sufficient  $\text{Ag}_2\text{CrO}_4$  is dissolved in water to form a saturated solution.

- (i) Write the equation for the equilibrium present in a saturated solution of  $\text{Ag}_2\text{CrO}_4$ .
- (ii) Write the expression for  $K_s$  ( $\text{Ag}_2\text{CrO}_4$ ).
- (c) Calculate the solubility of  $\text{Ag}_2\text{CrO}_4$  in a saturated solution in  $\text{mol L}^{-1}$ .  
 $K_s(\text{Ag}_2\text{CrO}_4) = 3.00 \times 10^{-12}$ .

**(2009:2)**

Addition of chloride ions to a solution of silver nitrate often results in the formation of a white precipitate of silver chloride ( $\text{AgCl}$ ).



$$K_s(\text{AgCl}) = 1.56 \times 10^{-10}$$

- (a) Calculate the concentration, in  $\text{mol L}^{-1}$ , of silver ions in a saturated solution of silver chloride at  $25^\circ\text{C}$ .

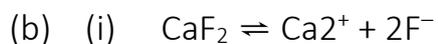
**(2008:3)**

- (a) (i) Write an equation for the sparingly soluble salt lead(II) chloride ( $\text{PbCl}_2$ ) dissolving in water.
- (ii) Write the solubility product expression for lead(II) chloride.
- (b) Calculate the solubility, in  $\text{mol L}^{-1}$ , of  $\text{PbCl}_2$  in water at  $25^\circ\text{C}$ .  
 $K_s(\text{PbCl}_2) = 1.60 \times 10^{-5}$  at  $25^\circ\text{C}$

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- I can recognise AB and  $\text{AB}_2 / \text{A}_2\text{B}$  type ionic substances
- I can recall  $K_s = s^2$  and  $s = \sqrt{K_s}$  (for AB type) and  $K_s = 4s^3$  and  $s = \sqrt[3]{K_s/4}$  (for  $\text{AB}_2 / \text{A}_2\text{B}$  type)
- I can calculate  $s$  from  $K_s$  and vice versa
- I know that the units of  $s$  are  $\text{mol L}^{-1}$
- I can convert solubility in  $\text{mol L}^{-1}$  to  $\text{g L}^{-1}$  & vice versa ( $\text{mol L}^{-1}$  to  $\text{g L}^{-1} \times M$ ,  $\text{g L}^{-1}$  to  $\text{mol L}^{-1} \div M$ )

Selected Answers

**(2018:1)**



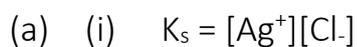
(ii)  $K_s = [\text{Ca}^{2+}][\text{F}^-]^2$

Let solubility be 's':

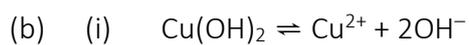
$$[\text{Ca}^{2+}] = s, [\text{F}^-] = 2s, K_s = 4s^3$$

$$s = 2.00 \times 10^{-4} \text{ mol L}^{-1}$$

**(2018:3)**



**(2017:2)**



(ii)  $K_s = [\text{Cu}^{2+}][\text{OH}^-]^2$

(iii) Let s = solubility  $[\text{Cu}^{2+}] = s$

$$[\text{OH}^-]^2 = (2s)^2$$

$$K_s = 4s^3$$

$$4s^3 = 4.80 \times 10^{-20} \text{ So; } s = 2.29 \times 10^{-7} \text{ mol L}^{-1}$$

**(2016,1)**



(b) Let s = solubility

$$[\text{Ag}^+] = 2s \quad [\text{CO}_3^{2-}] = s \quad K_s = 4s^3$$

$$s = 1.27 \times 10^{-4} \text{ mol L}^{-1}$$

$$n = c \times v = 6.33 \times 10^{-6} \text{ mol} \quad m = n \times M = 1.75 \times 10^{-3} \text{ g}$$

OR

$$g \text{ L}^{-1} = c \times M = 0.0349 \text{ g L}^{-1}$$

$$\text{so mass in 50 mL} = \frac{0.0349 \times 50}{1000} = 1.75 \times 10^{-3} \text{ g}$$