

Answers to exam questions for Chapter 10 Solubility equilibria

Question 1

a $K_s = [\text{Pb}^{2+}][\text{CrO}_4^{2-}]$ A

b $[\text{Pb}^{2+}][\text{CrO}_4^{2-}] = 1.8 \times 10^{-14}$
 $[\text{Pb}^{2+}] = [\text{CrO}_4^{2-}]$ (concentrations are equal, see equation)
 $[\text{CrO}_4^{2-}]^2 = 1.8 \times 10^{-14}$ (square root both sides)
 $[\text{CrO}_4^{2-}] = 1.3 \times 10^{-7} \text{ mol L}^{-1}$

A = correct method used with minor error, M = correct value with unit

c i Amount of Pb^{2+} present: $n(\text{Pb}^{2+}) = 0.100 \text{ mol L}^{-1} \times 30 \times 10^{-3} \text{ L}$
Amount of CrO_4^{2-} present: $n(\text{CrO}_4^{2-}) = 0.100 \text{ mol L}^{-1} \times 20 \times 10^{-3} \text{ L}$
Hence excess Pb^{2+} present: $n(\text{Pb}^{2+}) = 0.100 \text{ mol L}^{-1} \times 10 \times 10^{-3} \text{ L}$ ($\text{Pb}^{2+} : \text{CrO}_4^{2-}$ react 1:1)
 $= 0.00100 \text{ mol}$

$V_{\text{tot}} = 30 \times 10^{-3} \text{ L} + 20 \times 10^{-3} \text{ L}$ $V(\text{Pb}^{2+}) + V(\text{CrO}_4^{2-})$
 $= 0.050 \text{ L}$

$[\text{Pb}^{2+}] = \frac{0.00100 \text{ mol}}{0.050 \text{ L}}$

$= 0.020 \text{ mol L}^{-1}$

A = correct method used with minor error, M = correct value with unit

ii $[\text{CrO}_4^{2-}] = \frac{K_s}{[\text{Pb}^{2+}]}$ (rearranging equation from a)

$= \frac{1.8 \times 10^{-14}}{0.020 \text{ mol L}^{-1}}$ (substitute known values)

$= 9.0 \times 10^{-13} \text{ mol L}^{-1}$

A = correct method used with minor error, M = correct value with unit

Question 2

Ionic Product = $[\text{Ag}^+][\text{Cl}^-]$
 $= 0.0018 \text{ mol L}^{-1} \times 0.00020 \text{ mol L}^{-1}$
 $= 3.6 \times 10^{-7}$

Ionic Product $> K_s$ (1.6×10^{-10}), so a precipitate will form (compare IP with K_s)
A = correct value for IP, M = plus correct conclusion

Question 3

a $K_s = [\text{Mg}^{2+}][\text{OH}^-]^2$ A

b Mg^{2+} A (1 mole of $\text{Mg}(\text{OH})_2$ contains 1 mole of Mg^{2+} and 2 moles of OH^-)

c $K_s = [\text{Mg}^{2+}][\text{OH}^-]^2$

Let the solubility of $\text{Mg}(\text{OH})_2$ be s

$[\text{Mg}^{2+}] = s$ $[\text{OH}^-] = 2s$ (concentrations are 1:2, see equation)

$K_s = 4s^3$ and K_s for $\text{Mg}(\text{OH})_2 = 1.8 \times 10^{-11}$ (cube root both sides after dividing by 4)

$$s = \sqrt[3]{\frac{1.8 \times 10^{-11}}{4}}$$

$= 1.7 \times 10^{-4} \text{ mol L}^{-1}$ (round to 2 sig.fig. and don't forget the units)

A = correct method used with minor error, M = correct throughout

d $[\text{OH}^-] = 2 [\text{Mg}^{2+}]$
 $= 3.4 \times 10^{-4} \text{ mol L}^{-1}$

$[\text{H}_3\text{O}^+] = \frac{1 \times 10^{-14}}{\text{OH}^-}$ ($K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$)

$= 2.92 \times 10^{-11} \text{ mol L}^{-1}$

$\text{pH} = -\log_{10}[\text{H}_3\text{O}^+]$

$= 10.5$

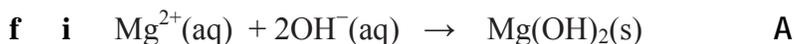
$= 11$

(round to 2 sig.fig.)

e i the same A

(solid $\text{Mg}(\text{OH})_2$ present – saturated)

ii The solution is still saturated with Mg^{2+} because more solid $\text{Mg}(\text{OH})_2$ will dissolve to keep the concentration of Mg^{2+} unchanged. M



ii Lower, because beaker A contains less OH^- , (pH of 0.10 mol L⁻¹ KOH = 13). (KOH strong base)
A = correct answer, M = correct reasoning

iii Lower, because in beaker B the precipitation of $\text{Mg}(\text{OH})_2$ has removed some of the Mg^{2+} ions from the solution.
(common ion effect)

A = correct answer, M = correct reasoning