Olympiads: Grade 12 Chemistry Homework Name: Answer Key Mark: ____/50

G12 Chemistry: Class 14 Homework

1. a) Show the balanced equation for the solubility equilibrium that would occur when a solution of $Ba(NO_3)_2$ (aq) is mixed with a solution of Na_2SO_4 (aq). **[2 marks]**

$Ba(NO_3)_2 + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaNO_3(aq)$ ✓

$BaSO_4(s) \rightleftharpoons Ba^{2+} + SO_4^{2-}$ ✓

b) Write the solubility product constant equation for this equilibrium system. **[1 mark]**

$K_{sp} = [Ba^{2+}][SO_4^{2-}]$ ✓

2. Calculate the K_{sp} at 25°C for AgI (s), given that its solubility at this temperature is 2.14×10^{-7} g/100mL. **[4 marks]**

$AgI(s) \rightleftharpoons Ag^+ + I^-$

I	0	0
C	+x	+x
E	9.12×10^{-9}	9.12×10^{-9}

$2.14 \times 10^{-7}\ g \times \frac{1000\ mL}{100\ mL} \times \frac{1\ mol}{1\ L} \times \frac{1}{234.77\ g}$ ✓

$= 9.12 \times 10^{-9}\ \frac{mol}{L}$ (molar solubility) ✓

$K_{sp} = [Ag^+][I^-]$ ✓

$= (9.12 \times 10^{-9})^2$

$= 8.31 \times 10^{-17}$ ✓

∴ K_{sp} is 8.31×10^{-17}

3. K_{sp} for $PbCl_2$ is 1.7×10^{-5} at 25°C. Calculate the molar solubility of $PbCl_2$.

a. In pure water **[3 marks]**

$PbCl_2(s) \rightleftharpoons Pb^{2+} + 2Cl^-$

$x \quad 2x$ ✓

$K_{sp} = [Pb^{2+}][Cl^-]^2$ ✓

$K_{sp} = (x)(2x)^2 = 4x^3$

$\sqrt[3]{\frac{1.7 \times 10^{-5}}{4}} = \sqrt[3]{\frac{4x^3}{4}}$

$x = 1.62 \times 10^{-2}\ \frac{mol}{L}$ ✓

b. In 0.10 mol/L $CaCl_2$ **[4 marks]**

$CaCl_2 \rightleftharpoons Ca^{2+} + 2Cl^-$

0.10M 0.20M ✓

$PbCl_2(s) \rightleftharpoons Pb^{2+} + 2Cl^-$

I	0	0.20
C	+x	+2x
E	x	(0.20+2x) ✓

$K_{sp} = [Pb^{2+}][Cl^-]^2$ ✓

$1.7 \times 10^{-5} = (x)(0.20 + 2\cancel{x})^2$

$x = 4.25 \times 10^{-4}\ \frac{mol}{L}$ ✓

4. What amount of $PbCl_2(s)$ in grams, can dissolve in 1.00L of a 0.500 mol/L solution of LiCl(aq)? K_{sp} for $PbCl_2$ is 1.7×10^{-5} at 25°C. **[5 marks]**

$LiCl(aq) \rightarrow Li^+ + Cl^-$

0.500 M 0.500 M ✓

$PbCl_2(s) \rightleftharpoons Pb^{2+} + 2Cl^-$

I	0	0.500
C	+x	+2x
E	x	0.500 + 2x ✓

$K_{sp} = [Pb^{2+}][Cl^-]^2$ ✓

$1.7 \times 10^{-5} = (x)(0.500 + 2x)^2$

$x = 6.8 \times 10^{-5}$ mol/L (molar solubility). ✓

$6.8 \times 10^{-5} \frac{mol}{L} \times 278.1 \frac{g}{mol}$

$= \boxed{1.9 \times 10^{-2} \text{ g/1L}}$ ✓

5. Calculate the molar solubility of $Zn(OH)_2$ (s), if the K_{sp} is 3×10^{-17} at 25°C. **[3 marks]**

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

x 2x ✓

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

$3 \times 10^{-17} = (x)(2x)^2$

$3 \times 10^{-17} = 4x^3$ ✓

$x = \sqrt[3]{\frac{3 \times 10^{-17}}{4}}$

$= 2 \times 10^{-6}$ mol/L ✓

6. A solution contains 0.15 mol/L of NaCl and 0.0034 mol/L $Pb(NO_3)_2$. Does a precipitate form? Include a balanced chemical equation for the formation of the possible precipitate. K_{sp} for $PbCl_2$ is 1.7×10^{-5} at 25°C. **[4 marks]**

$2NaCl + Pb(NO_3)_2 \rightarrow 2NaNO_3(aq) + PbCl_2(s)$.

NaCl contributes $[Cl^-]$

$NaCl \rightarrow Na^+ + Cl^-$

0.15 M 0.15 M ✓

$Pb(NO_3)_2$ contributes $[Pb^{2+}]$

$Pb(NO_3)_2 \rightarrow Pb^{2+} + 2NO_3^-$

0.0034 M 0.0034 M ✓

$Q_{sp} = [Pb^{2+}][Cl^-]^2$

$= (0.0034)(0.15)^2$

$= 7.65 \times 10^{-5} \rightarrow 7.7 \times 10^{-5}$ ✓

$Q_{sp} > K_{sp}$ ∴ ppt will form. ✓

7. One drop (0.050ml) of 1.5 mol/L potassium chromate, K_2CrO_4 is added to 250 mL of 0.10 mol/L $AgNO_3$. Does a precipitate form? Include a balanced chemical equation for the formation of the possible precipitate. K_{sp} for Ag_2CrO_4 is 1.12×10^{-12} at 25°. **[6 marks]**

$K_2CrO_4 + 2AgNO_3 \longrightarrow 2KNO_3(aq) + Ag_2CrO_4(s)$

insignificant volume: $C = 1.5\ M$, $V = 5.0 \times 10^{-5}\ L$ ~~$\times 10^{-5}$~~ ; $C = 0.10\ M$, $V = 0.250\ L$

$Ag_2CrO_4 \rightleftharpoons 2Ag^+ + CrO_4^{2-}$ ✓

$AgNO_3$ contributes $[Ag^+]$

$AgNO_3 \longrightarrow Ag^+ + NO_3^-$

$[Ag^+] = \dfrac{0.10\ M \times 0.250\ L}{0.250\ L}$

$= 0.10\ M$. ✓

K_2CrO_4 contributes $[CrO_4^{2-}]$

$K_2CrO_4 \longrightarrow 2K^+ + CrO_4^{2-}$

$[CrO_4^{2-}] = \dfrac{1.5 \times 5.0 \times 10^{-5}}{0.250}$

$= 3.0 \times 10^{-4}\ M$. ✓

$Q_{sp} = [Ag^+]^2[CrO_4^{2-}]$ ✓

$= (0.10)^2(3.0 \times 10^{-4})$

$= 3.0 \times 10^{-6}$ ✓

$Q_{sp} > K_{sp}$ ∴ ppt will form ✓

8. A chemist adds 0.010 g of $CaCl_2$ to 5.0×10^2 mL of 0.0015 mol/L sodium carbonate, Na_2CO_3. Does a precipitate of calcium carbonate form? Include a balanced chemical equation for the formation of the possible precipitate. K_{sp} for $CaCO_3$ is 3.36×10^{-9}. **[6 marks]**

$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3(s) + 2NaCl(aq)$

$m = 0.010\ g$

$M = 110.984\ g/mol$

$n = 9.01 \times 10^{-5}$ ~~mol~~ ✓

$C = 0.0015\ M$

$V = 0.150\ L$.

$CaCO_3 \longrightarrow Ca^{2+} + CO_3^{2-}$

$CaCl_2$ contributes $[Ca^{2+}]$.

$[Ca^{2+}] = \dfrac{9.01 \times 10^{-5}\ mol}{0.50\ L}$

$= 1.8 \times 10^{-4}\ M$ ✓

Na_2CO_3 contributes $[CO_3^{2-}]$

$[CO_3^{2-}] = \dfrac{0.0015 \times 0.50}{0.50}$

$= 0.0015\ M$ ✓

$Q_{sp} = [Ca^{2+}][CO_3^{2-}]$ ✓

$= (1.8 \times 10^{-4})(0.0015)$

$= 2.7 \times 10^{-7}$ ✓

$Q_{sp} > K_{sp}$ ∴ ppt will form. ✓

9. 230ml of 0.0015M $AgNO_3$ is added to 130ml of 0.010M calcium acetate, $Ca(CH_3COO)_2$. Does a precipitate form? Include a balanced chemical equation for the formation of the possible precipitate. K_{sp} for $AgCH_3COO$ is 2.0×10^{-3}. **[6 marks]**

$2AgNO_3 + Ca(CH_3COO)_2 \rightarrow 2AgCH_3COO_{(s)} + Ca(NO_3)_{2(aq)}$.

$V = 0.230\,L$ $V = 0.130\,L$

$C = 0.0015\,M$ $C = 0.010$

$AgNO_3$ contributes $[Ag^+]$ $Ca(CH_3COO)_2$ contributes $2[CH_3COO^-]$

$[Ag^+] = \frac{0.0015 \times 0.230}{0.230 + 0.130}$ $[CH_3COO^-] = \frac{0.130 \times 0.010}{0.360} \times 2$ ✓

$= 9.58 \times 10^{-4}\,M$ ✓ $= 7.22 \times 10^{-3}\,M$ ✓

$Q_{sp} = [Ag^+][CH_3COO^-]$ ✓

$= (9.58 \times 10^{-4})(7.22 \times 10^{-3})$

$= 6.92 \times 10^{-6}$ ✓

$Q_{sp} < K_{sp}$ ∴ no ppt forms ✓

10. 250ml of 0.0011 mol/L $Al_2(SO_4)_3$ is added to 50ml of 0.022M $BaCl_2$. Does a precipitate form? Include a balanced chemical equation for the formation of the possible precipitate. K_{sp} for $BaSO_4$ is 1.08×10^{-10}. **[6 marks]**

$Al_2(SO_4)_3 + 3BaCl_2 \rightarrow 2AlCl_{3(aq)} + 3BaSO_{4(s)}$.

$V = 0.250\,L$ $V = 0.050\,L$

$C = 0.0011\,M$ $C = 0.022\,M$

$Al_2(SO_4)_3$ contributes $3[SO_4^{2-}]$ $BaCl_2$ contributes $[Ba^{2+}]$

$[SO_4^{2-}] = \frac{0.250 \times 0.0011}{0.300} \times 3$ ✓ $[Ba^{2+}] = \frac{0.050 \times 0.022}{0.300}$

$= 2.75 \times 10^{-3}\,M$ ✓ $= 3.67 \times 10^{-3}\,M$ ✓

$Q_{sp} = [Ba^{2+}][SO_4^{2-}]$ ✓

$= (3.67 \times 10^{-3})(2.75 \times 10^{-3})$

$= 1.01 \times 10^{-5}$ ✓

$Q_{sp} > K_{sp}$ ∴ ppt will form ✓