Ksp and Le Chatelier Station Review

Station #1

Calculate the K_{sp} for $CaCl_2$ if 2.00g of $CaCl_2$ is required to saturate 100.0 mL of solution.

$CaCl_{2\,(s)} \rightleftharpoons Ca^{2+}_{(aq)} + 2Cl^-_{(aq)}$

$M_{CaCl_2} = 110.984\ g/mol$

$C = 2.00g\ CaCl_2 \times \frac{1\ mol}{110.984\ g} \times \frac{}{0.1\ L}$

$= 0.1802\ mol/L$

$[Ca^{2+}] = 0.1802\ mol/L$

$[Cl^-] = 2(0.180\ mol/L)$

$= 0.3604\ mol/L$

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

$= (0.1802)(0.3604)^2$

$= 0.0234$ OR 2.34×10^{-2}

∴ the Ksp is 2.34×10^{-2}

Station #2

The solubility of SF_2 is 2.83×10^{-5} M. Calculate the K_{sp}.

$SF_{2\,(s)} \rightleftharpoons S^{2+}_{(aq)} + 2F^-_{(aq)}$

$2.83 \times 10^{-5}\ mol/L$ $\quad 2.83 \times 10^{-5}\ mol/L$ $\quad 2(2.83 \times 10^{-5}\ mol/L)$

$= 5.66 \times 10^{-5}\ mol/L$

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

$= (2.83 \times 10^{-5})(5.66 \times 10^{-5})^2$

$= 9.07 \times 10^{-14}$

∴ the Ksp is 9.07×10^{-14}

Station #3

Calculate the concentration of lithium and carbonate ions in a saturated solution of lithium carbonate given $K_{sp} = 1.7 \times 10^{-3}$

$$Li_2CO_3(s) \rightleftharpoons 2Li^+(aq) + CO_3^{2-}(aq)$$

I			
C	$-x$	$+2x$	$+x$
E	$-x$	$+2x$	$+x$

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

$$1.7 \times 10^{-3} = (2x)^2 (x)$$

$$1.7 \times 10^{-3} = 4x^3$$

$$x = 0.07518$$

$$[Li^+] = 2x$$
$$= 2(0.07518)$$
$$= 0.15 \text{ mol/L}$$

$$[CO_3^{2-}] = 0.075 \text{ mol/L}$$

∴ the concentration of Li ions is 0.15 mol/L and the concentration of carbonate ions is 0.075 mol/L

Station #4

a) **Write the dissociation equation for silver chloride** $K_{sp} = 1.77 \times 10^{-10}$

b) **Predict what will happen if sodium chloride is added to the solution (direction of shift, and concentration of silver ions)**

c) **What is the molar solubility of silver chloride in**
Water **and** **0.15 M solution of NaCl**

a) $AgCl_{(s)} \rightleftharpoons Ag^+_{(aq)} + Cl^-_{(aq)}$

b) • If $Na^+ Cl^-$ is added it will make it shift to the left since Cl^- is on the right side
• the concentration of silver ions will decrease.

c)

	$AgCl_{(s)}$	Ag^+	Cl^-	in water
I				
C	$-x$	$+x$	$+x$	
E				

Water

$K_{sp} = [Ag^+][Cl^-]$

$1.77 \times 10^{-10} = (x)(x)$

$1.77 \times 10^{-10} = x^2$

$x = 1.33 \times 10^{-5}$

∴ the molar solubility is 1.33×10^{-5} mol/L

$NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

$0.15 \frac{mol}{L}$ $0.15 \frac{mol}{L}$ $0.15 \frac{mol}{L}$

$K_{sp} = [Ag^+][Cl^-]$

$1.77 \times 10^{-10} = (x)(0.15 + x)$

check $\frac{0.15}{1.77 \times 10^{-10}} \geq 1000$

x is small wrt 0.15.

	$AgCl_{(s)}$	Ag^+	Cl^-
			0.15
I			
C	$-x$	$+x$	$+x$
E		x	$0.15 + x$

$1.77 \times 10^{-10} = 0.15\,x$

$x = 1.2 \times 10^{-9}$ mol/L

∴ the molar solubility in NaCl is 1.2×10^{-9}

Station #5

$AgCl_{(s)} \rightleftharpoons Ag^+_{(aq)} + Cl^-_{(aq)}$

Determine if silver chloride will form a precipitate if 0.05 mL of 6.0M of silver nitrate is added to 1.0 L of 0.1M of sodium chloride. $K_{sp} = 1.77 \times 10^{-10}$

$AgNO_{3(s)} \rightleftharpoons Ag^+_{(aq)} + NO_3^-{}_{(aq)}$

$V = 0.00005\ L$

$C = 6.0\ mol/L$

total volume $= 0.00005\ L + 1.0\ L$
$= 1.00005\ L$

$n = 0.00005\ L \times \frac{6.0\ mol}{L}$

$= 0.0003\ mol$

$[Ag^+] = \frac{0.0003\ mol}{1.00005\ L} = 0.000299985\ \frac{mol}{L}$

$NaCl_{(s)} \rightleftharpoons Na^+_{(aq)} + Cl^-_{(aq)}$

$V = 1.0\ L$

$C = 0.1\ mol/L$

$n = 1.0\ L \times \frac{0.1\ mol}{L}$

$= 0.1\ mol$

$[Cl^-] = \frac{0.1\ mol}{1.00005\ L} = 0.099995\ \frac{mol}{L}$

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

$= (0.000299985)(0.099995)$

$= 3 \times 10^{-5} \quad > K_{sp}$

$\therefore$ a precipitate will form.

Station #6

In the following reaction $2H_2S_{(g)} + O_{2(g)} \rightleftarrows 2S_{(s)} + 2H_2O_{(g)}$

What happens to

a) **$[H_2O]$ if O_2 is added** proceeds right $[H_2O] \uparrow$

b) **$[H_2S]$ if O_2 is added** proceeds right $[H_2S] \downarrow$

c) **$[O_2]$ if H_2S is removed** proceeds left $[O_2] \uparrow$

d) **$[H_2S]$ if S is added** no effect ∴ S is a solid. it wouldn't be in the equilibrium equation.

Station #7

How would you change the volume of each of the following reactions to increase the yield of the products?

a) $\overset{0}{CaCO_{3(s)}} \rightleftarrows \overset{0}{CaO_{(s)}} + \overset{1}{CO_{2(g)}}$ $\uparrow V (\downarrow P)$

b) $\overset{3}{S_{(s)}} + \overset{1}{3F_{2(g)}} \rightleftarrows \overset{1}{SF_{6(g)}}$ $\downarrow V (\uparrow P)$

c) $\overset{1}{Cl_{2(g)}} + \overset{1}{I_{2(g)}} \rightleftarrows \overset{2}{2ICl_{(g)}}$ changing V ↕P has no effect same # of molecules on each side.

Station #8

Which direction would the following equations shift to if the temperature was increased?

a) $CaO_{(s)} + H_2O_{(l)} \rightleftarrows Ca(OH)_{2(aq)} \quad \overset{+\text{heat}}{\Delta H = -82kJ}$ exothermic shift left

b) $CaCO_{3(s)} \rightleftarrows CaO_{(s)} + CO_{2(g)} \quad \Delta H = 178kJ$ endothermic shift right.

heat