

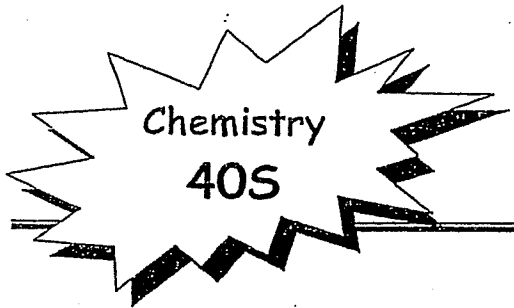
Science Notebook



40S

Chemistry

Solutions and Solubility Equilibrium



Solubility

K_{sp} - Assignment #1

Answer the following questions in the spaces provided.

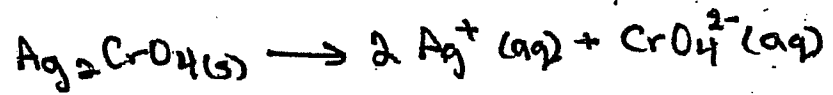
1. Write the equation for the dissolving of calcium sulfate, CaSO₄.

Write the solubility product expression. $K_{sp} = 2.4 \times 10^{-5}$.



$$K_{sp} = [Ca^{2+}][SO_4^{2-}] = 2.4 \times 10^{-5}$$

2. Write the equation for the dissociation of silver chromate, Ag₂CrO₄. Write the solubility product expression. Silver chromate dissolves to give Ag⁺ and CrO₄²⁻ ions.



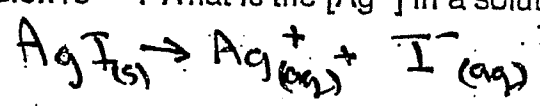
$$K_{sp} = [Ag^+]^2 [CrO_4^{2-}]$$

3. Compare the K_{sp} values for AgCl ($K_{sp} = 1.7 \times 10^{-10}$), AgBr ($K_{sp} = 5.0 \times 10^{-13}$), and AgI ($K_{sp} = 8.5 \times 10^{-17}$). Which of these compounds is most soluble in water? Which are least soluble?

AgCl - most soluble → highest K_{sp}

AgI - least soluble → lowest K_{sp}

4. The solubility product constant of silver iodide, AgI is 8.5×10^{-17} . What is the [Ag⁺] in a solution at equilibrium?



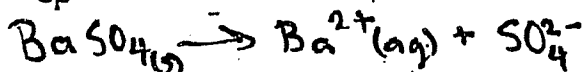
$$K_{sp} = [Ag^+][I^-] \quad [Ag^+] = [I^-]$$

$$[Ag^+][I^-] = [Ag^+]^2 = 8.5 \times 10^{-17} \quad [Ag^+] = 9.2 \times 10^{-9} \text{ mol/L}$$

Calculate the concentration of the ion indicated in a saturated solution of each of the following salts. Show all work.

5. $[Ba^{2+}(aq)]$ in a saturated solution of $BaSO_4(aq)$.

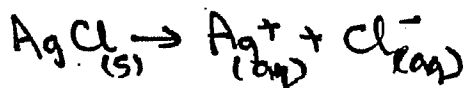
$$K_{sp} = 1.0 \times 10^{-10}$$



$$K_{sp} = [Ba^{2+}][SO_4^{2-}] = [Ba^{2+}]^2 = 1.0 \times 10^{-10}$$

$$[Ba^{2+}] = 1.0 \times 10^{-5} \text{ mol/L}$$

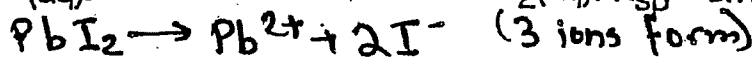
6. $[Cl^-(aq)]$ in a saturated solution of $AgCl(aq)$. $K_{sp} = 1.7 \times 10^{-10}$.



$$K_{sp} = [Ag^+][Cl^-] = [Cl^-]^2 = 1.7 \times 10^{-10}$$

$$[Cl^-] = 1.3 \times 10^{-5} \text{ mol/L}$$

7. $[I^-(aq)]$ in a saturated solution of $PbI_2(aq)$. $K_{sp} = 8.7 \times 10^{-9}$.



$$\text{Let } x = [Pb^{2+}] \therefore [I^-] = 2x$$

$$K_{sp} = [Pb^{2+}][I^-]^2$$

$$K_{sp} = (x)(2x)^2 = 4x^3 = 8.7 \times 10^{-9}$$

$$x^3 = 2.2 \times 10^{-9}$$

$$x = 1.3 \times 10^{-3}$$

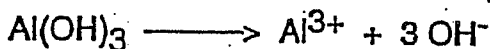
$$x = [Pb^{2+}] = 1.3 \times 10^{-3} \text{ mol/L}$$

$$[I^-] = 2x = 2.6 \times 10^{-3} \text{ mol/L}$$

8. $[Al^{3+}(aq)]$ in a saturated solution of $Al(OH)_3(aq)$.

$$K_{sp} = 3.7 \times 10^{-15}$$

In this dissociation four ions form;



Let $x = [Al^{3+}]$; therefore, $[OH^-] = 3x$

$$\text{but } K_{sp} = [Al^{3+}][OH^-]^3$$

$$\text{and } K_{sp} = (x)(3x)^3 = 27x^4 = 3.7 \times 10^{-15}$$

$$x^4 = 4.1 \times 10^{-16} \quad 1.4 \times 10^{-4}$$

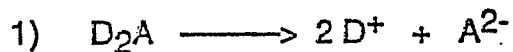
$$x = 1.6 \times 10^{-4} \quad 1.1 \times 10^{-4}$$

$$x = [Al^{3+}] = 7.4 \times 10^{-6} \text{ mol/L}$$

$$\text{and } [OH^-] = 3x = 2.2 \times 10^{-5} \text{ mol/L}$$

$$3.3 \times 10^{-4}$$

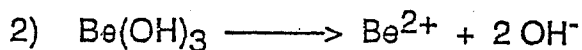
Lesson 3 - K_{sp} ASSIGNMENT #2



If $[D^+] = 2.00 \times 10^{-5} \text{ mol/L}$, then $[A^{2-}] = 1.00 \times 10^{-5} \text{ mol/L}$

$$K_{sp} = [D^+]^2 [A^{2-}] = (2.00 \times 10^{-5})^2 (1.00 \times 10^{-5})$$

$$K_{sp} = 4.00 \times 10^{-15}$$



Let $x = [Be^{2+}]$; therefore, $[OH^-] = 2x$

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

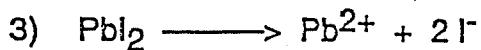
$$\text{and } K_{sp} = (x) (2x)^2 = 4x^3 = 1.60 \times 10^{-22}$$

$$x^3 = 4.00 \times 10^{-23}$$

$$x = 3.42 \times 10^{-8}$$

$$x = [Be^{2+}] = 3.42 \times 10^{-8} \text{ mol/L}$$

$$\text{and } [OH^-] = 2x = 6.84 \times 10^{-8} \text{ mol/L}$$



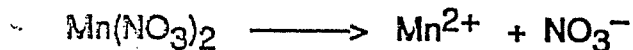
If $[Pb^{2+}] = 1.21 \times 10^{-3}$ then $[I^-] = 2.42 \times 10^{-3} \text{ mol/L}$

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

$$= (1.21 \times 10^{-3}) (2.42 \times 10^{-3})^2$$

$$K_{sp} = 7.09 \times 10^{-9}$$

4) Consider the $Mn(NO_3)_2$ as completely dissociated into ions;



Ion concentrations; 0.100 0.100

Now consider the partial dissociation of MnS ;



$$\text{Its } K_{sp} = [Mn^{2+}] [S^{2-}] = 1.40 \times 10^{-15}$$

Substitute conc. of Mn^{2+} from the first dissociation and solve;

$$K_{sp} = (0.100) [S^{2-}] = 1.40 \times 10^{-15}$$

$$[S^{2-}] = 1.40 \times 10^{-14} \text{ mol/L}$$

EQUILIBRIUM Constant QUESTION SHEET # 2

KEY

$$1. a) K_{eq} = \frac{[NO]^2}{[N_2][O_2]}$$

$$b) K_{eq} = \frac{[CO_2]}{[CO]}$$

$$c) K_{eq} = \frac{[HCl]^4 [O_2]}{[Cl_2]^2 [H_2O]^2}$$

$$d) K_{eq} = \frac{[H_2O]}{[H_2]}$$

$$e) K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$2. C_{P_4} = \frac{n}{V} = \frac{10 \text{ mol}}{5 \text{ L}} = 2 \text{ mol/L}$$

$$C_{H_2} = \frac{n}{V} = \frac{25 \text{ mol}}{5 \text{ L}} = 5 \text{ mol/L}$$

$$C_{PH_3} = \frac{n}{V} = \frac{5 \text{ mol}}{5 \text{ L}} = 1 \text{ mol/L}$$

$$K_c = \frac{[PH_3]^4}{[P_4][H_2]^6}$$

$$K_c = \frac{(1)^4}{(2)(5)^6}$$

$$K_c = 3.2 \times 10^{-5}$$

$$3. C_{CO} = \frac{n}{V} = \frac{3 \text{ mol}}{0.5 \text{ L}} = 6 \text{ mol/L}$$

$$C_{Zn} = \frac{n}{V} = \frac{4 \text{ mol}}{0.5 \text{ L}} = 8 \text{ mol/L}$$

$$C_{CO_2} = \frac{n}{V} = \frac{4 \text{ mol}}{0.5 \text{ L}} = 8 \text{ mol/L}$$

$$K_{eq} = \frac{[Zn][CO_2]}{[CO]}$$

$$K_{eq} = \frac{(8)(8)}{(6)}$$

$$K_{eq} = 10.6 = 10$$

$$4. [H_2] = 1.5 \text{ M}$$

$$[H_2S] = 2.5 \text{ M}$$

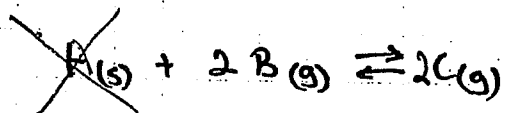
$$K_{eq} = \frac{[H_2S]}{[H_2]}$$

$$K_{eq} = \frac{(2.5)}{(1.5)}$$

$$K_{eq} = \frac{1.666}{1.7}$$

-3-

7. $K_c = 2.0$



$$[B] = \frac{n}{V} = \frac{3 \text{ mol}}{0.250 \text{ L}} = 12 \text{ mol/L}$$

$$K_c = \frac{[C]^2}{[B]^2}$$

$$[C] = \sqrt{K_c [B]^2}$$

$$[C] = \sqrt{2.0 (12)^2}$$

$$[C] = \sqrt{288}$$

$$[C] = 16.97 \approx 17 \text{ mol/L}$$

8. $K = 10.$

$$[H_2] = 2.0 \text{ M}$$

$$[N_2] = 5.0 \text{ M}$$

$$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$[NH_3]^2 = K_c [N_2][H_2]^3$$

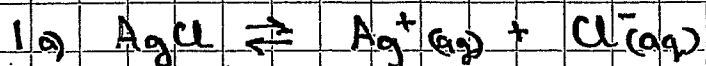
$$\sqrt{[NH_3]^2} = \sqrt{K_c [N_2][H_2]^3}$$

$$[NH_3] = \sqrt{10. (5.0)(2.0)^3}$$

$$[NH_3] = 20. \text{ mol/L}$$

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Solubility: K_{SP}-Assignment #3

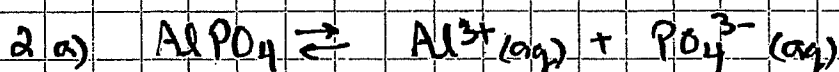


b) $K_{SP} = [\text{Ag}^+][\text{Cl}^-]$

c) $[\text{Ag}^+] = [\text{Cl}^-] \quad K_{SP} = [\text{Ag}^+]^2$
 $1.77 \times 10^{-10} = [\text{Ag}^+]^2$
 $= 1.33 \times 10^{-5} \text{ mol/L}$

d) $[\text{Ag}^+] = 1.33 \times 10^{-5} \text{ mol/L}$

$[\text{Cl}^-] = 1.33 \times 10^{-5} \text{ mol/L}$



b) $K_{SP} = [\text{Al}^{3+}][\text{PO}_4^{3-}]$

c) $[\text{Al}^{3+}] = [\text{PO}_4^{3-}] \quad K_{SP} = [\text{Al}^{3+}][\text{PO}_4^{3-}] = 9.83 \times 10^{-21}$
 $[\text{Al}^{3+}]^2 = 9.83 \times 10^{-21}$
 $[\text{Al}^{3+}] = 9.91 \times 10^{-11} \text{ mol/L}$

d) $[\text{Al}^{3+}] = 9.91 \times 10^{-11} \text{ mol/L}$

$[\text{PO}_4^{3-}] = 9.91 \times 10^{-11} \text{ mol/L}$



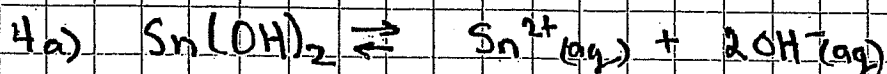
b) $K_{SP} = [\text{Ba}^{2+}][\text{SO}_4^{2-}]$

c) $[\text{Ba}^{2+}] = [\text{SO}_4^{2-}] \quad K_{SP} = [\text{Ba}^{2+}][\text{SO}_4^{2-}] = 1.07 \times 10^{-10}$
 $[\text{Ba}^{2+}]^2 = 1.07 \times 10^{-10}$
 $[\text{Ba}^{2+}] = 1.03 \times 10^{-5} \text{ mol/L}$

d) $[\text{Ba}^{2+}] = 1.03 \times 10^{-5} \text{ mol/L}$

$[\text{SO}_4^{2-}] = 1.03 \times 10^{-5} \text{ mol/L}$

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b) $K_{sp} = [\text{Sn}^{2+}][\text{OH}^{-}]^2$

c) $K_{sp} = [\text{Sn}^{2+}][\text{OH}^{-}]^2 = 5.45 \times 10^{-27}$

Let $x = [\text{Sn}^{2+}]$, $[\text{OH}^{-}] = 2x$

$$(x)(2x)^2 = 5.45 \times 10^{-27}$$

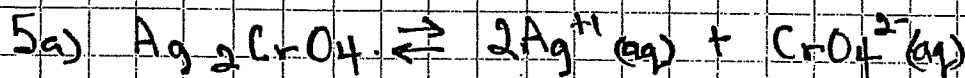
$$4x^3 = 5.45 \times 10^{-27}$$

$$x^3 = 1.36 \times 10^{-27}$$

$$x = 1.11 \times 10^{-9} \text{ mol/L}$$

d) $x = [\text{Sn}^{2+}] = 1.11 \times 10^{-9} \text{ mol/L}$

$$2x = [\text{OH}^{-}] = 2.22 \times 10^{-9} \text{ mol/L}$$



b) $K_{sp} = [\text{Ag}^{+}]^2[\text{CrO}_4^{2-}]$

c) $K_{sp} = [\text{Ag}^{+}]^2[\text{CrO}_4^{2-}] = 1.12 \times 10^{-12}$

Let $x = [\text{CrO}_4^{2-}]$, $[\text{Ag}^{+}] = 2x$

$$(2x)^2(x) = 1.12 \times 10^{-12}$$

$$4x^3 = 1.12 \times 10^{-12}$$

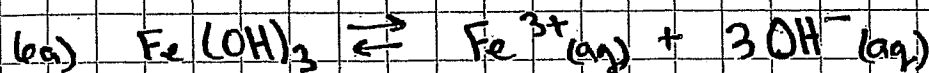
$$x^3 = 2.80 \times 10^{-13}$$

$$x = 6.54 \times 10^{-5} \text{ mol/L}$$

d) $x = [\text{CrO}_4^{2-}] = 6.54 \times 10^{-5} \text{ mol/L}$

$$2x = [\text{Ag}^{+}] = 1.31 \times 10^{-4} \text{ mol/L}$$

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b) $K_{sp} = [\text{Fe}^{3+}][\text{OH}^{-}]^3$

c) $K_{sp} = [\text{Fe}^{3+}][\text{OH}^{-}]^3 = 2.64 \times 10^{-39}$

Calculator:

4 then MATH 5.

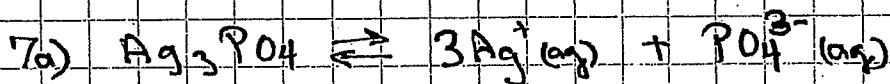
Let $x = [\text{Fe}^{3+}]$, $[\text{OH}^{-}] = 3x$

$$(x)(3x)^3 = 2.64 \times 10^{-39}$$

$$27x^4 = 2.64 \times 10^{-39}$$

$$[\text{Fe}^{3+}] = x = 9.94 \times 10^{-11} \text{ mol/L} \quad x^4 = 9.77 \times 10^{-41}$$

$$[\text{OH}^{-}] = 3x = 2.98 \times 10^{-10} \text{ mol/L} \quad x = 9.94 \times 10^{-11} \text{ mol/L}$$



b) $K_{sp} = [\text{Ag}^{+}]^3 [\text{PO}_4^{3-}]$

c) $K_{sp} = [\text{Ag}^{+}]^3 [\text{PO}_4^{3-}] = 8.88 \times 10^{-17}$

Let $x = [\text{PO}_4^{3-}]$, $[\text{Ag}^{+}] = 3x$

$$(x)(3x)^3 = 8.88 \times 10^{-17}$$

$$27x^4 = 8.88 \times 10^{-17}$$

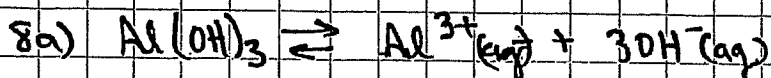
$$x^4 = 3.29 \times 10^{-18}$$

$$x = 4.26 \times 10^{-5} \text{ mol/L}$$

$$x = [\text{PO}_4^{3-}] = 4.26 \times 10^{-5} \text{ mol/L}$$

$$3x = [\text{Ag}^{+}] = 1.28 \times 10^{-4} \text{ mol/L}$$

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b) $K_{sp} = [\text{Al}^{3+}][\text{OH}^-]^3$

c) $K_{sp} = [\text{Al}^{3+}][\text{OH}^-]^3 = 3.50 \times 10^{-24}$

Let $x = [\text{Al}^{3+}]$, $[\text{OH}^-] = 3x$

$$(x)(3x)^3 = 3.50 \times 10^{-24}$$

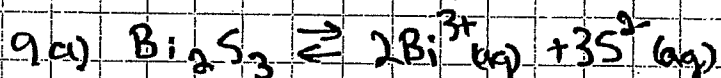
$$27x^4 = 3.50 \times 10^{-24}$$

$$x^4 = 1.30 \times 10^{-25}$$

$$x = 6.00 \times 10^{-7} \text{ mol/L}$$

$$x = [\text{Al}^{3+}] = 6.00 \times 10^{-7} \text{ mol/L}$$

$$3x = [\text{OH}^-] = 1.80 \times 10^{-6} \text{ mol/L}$$



b) $K_{sp} = [\text{Bi}^{3+}]^2[\text{S}^{2-}]^3$

c) $K_{sp} = [\text{Bi}^{3+}]^2[\text{S}^{2-}]^3 = 1.82 \times 10^{-15}$

Let $x = \text{molar solubility}$, $[\text{Bi}^{3+}] = 2x$, $[\text{S}^{2-}] = 3x$

$$(2x)^2(3x)^3 = 1.82 \times 10^{-15}$$

$$(4x^2)(27x^3) = 1.82 \times 10^{-15}$$

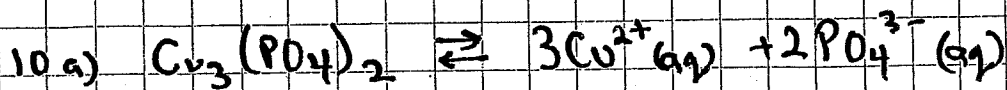
$$108x^5 = 1.82 \times 10^{-15}$$

$$[\text{Bi}^{3+}] = 2x = 8.84 \times 10^{-4} \text{ mol/L} \quad x^5 = 1.69 \times 10^{-17}$$

$$[\text{S}^{2-}] = 3x = 1.33 \times 10^{-3} \text{ mol/L}$$

$$x = 4.42 \times 10^{-4} \text{ mol/L}$$

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b) $K_{sp} = [\text{Cu}^{2+}]^3 [\text{PO}_4^{3-}]^2$

c) $K_{sp} = [\text{Cu}^{2+}]^3 [\text{PO}_4^{3-}]^2 = 1.93 \times 10^{-37}$

Let $x = \text{molar solubility} \Rightarrow [\text{Cu}^{2+}] = 3x, [\text{PO}_4^{3-}] = 2x$

$$(3x)^3 (2x)^2 = 1.93 \times 10^{-37}$$

$$(27x^3)(4x^2) = 1.93 \times 10^{-37}$$

$$108x^5 = 1.93 \times 10^{-37}$$

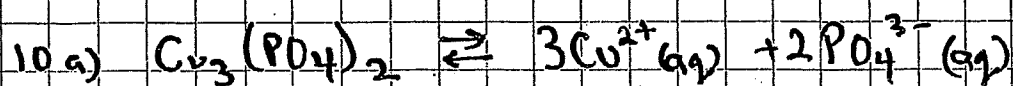
$$x^5 = 1.78 \times 10^{-39}$$

$$x = 1.78 \times 10^{-8} \text{ mol/L}$$

$$3x = [\text{Cu}^{2+}] = 5.33 \times 10^{-8} \text{ mol/L}$$

$$2x = [\text{PO}_4^{3-}] = 3.56 \times 10^{-8} \text{ mol/L}$$

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b) $K_{sp} = [\text{Cu}^{2+}]^3 [\text{PO}_4^{3-}]^2$

c) $K_{sp} = [\text{Cu}^{2+}]^3 [\text{PO}_4^{3-}]^2 = 1.93 \times 10^{-37}$

Let $x = \text{molar solubility} \rightarrow [\text{Cu}^{2+}] = 3x, [\text{PO}_4^{3-}] = 2x$

$$(3x)^3 (2x)^2 = 1.93 \times 10^{-37}$$

$$(27x^3)(4x^2) = 1.93 \times 10^{-37}$$

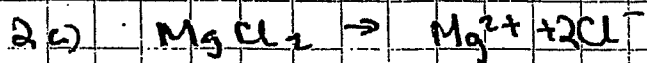
$$108x^5 = 1.93 \times 10^{-37}$$

$$x^5 = 1.78 \times 10^{-39}$$

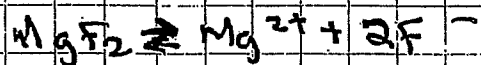
$$x = 1.78 \times 10^{-8} \text{ mol/L}$$

$$3x = [\text{Cu}^{2+}] = 5.33 \times 10^{-8} \text{ mol/L}$$

$$2x = [\text{PO}_4^{3-}] = 3.56 \times 10^{-8} \text{ mol/L}$$



$$[\text{MgCl}_2] = [\text{Mg}^{2+}] = 0.50 \text{ mol/L}$$



$$[\text{Mg}^{2+}] = x + 0.50 \quad [\text{F}^-] = 2[\text{Mg}^{2+}] = 2x$$

$$K_{sp} = [\text{Mg}^{2+}][\text{F}^-]^2 = 8.0 \times 10^{-8}$$

K_{sp} is small.

x is negligible

$$\cancel{(x+0.50)}(2x)^2 = 8.0 \times 10^{-8}$$

$$(0.50)(4x^2) = 8.0 \times 10^{-8}$$

$$2x^2 = 8.0 \times 10^{-8}$$

$$x^2 = 4.0 \times 10^{-8}$$

$$x = 2.0 \times 10^{-4}$$

Student Name: _____ Date: _____

Chemistry
40S

Solubility

K_{sp} - Assignment #4

1. a)

	AgI(s)	⇌	Ag ⁺ (aq)	+	I ⁻ (aq)
I			0		0
C			+x		+x
E			x		x

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

$$8.5 \times 10^{-17} = x^2$$

$$\sqrt{8.5 \times 10^{-17}} = \sqrt{x^2}$$

$$9.2 \times 10^{-9} = x$$

Solubility of AgI in pure water is 9.2×10^{-9} mol/L.

b) [I⁻] = 0.010 mol/L

	AgI(s)	⇌	Ag ⁺ (aq)	+	I ⁻ (aq)
I			0		0.010
C			+x		+x
E			x		0.010 + x

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

$$8.5 \times 10^{-17} = x(0.010 + x)$$

$$\frac{8.5 \times 10^{-17}}{0.010} = \frac{0.010x}{0.010}$$

$$8.5 \times 10^{-15} = x$$

Since K_{sp} is very small, assume x is negligible.

Solubility of AgI in 0.010 mol/L HI is 8.5×10^{-15} mol/L.

1. c) $[I^-] = 0.020 \text{ mol/L}$ from MgI_2

	$AgI(s)$	$Ag^+(aq)$	$+ I^-(aq)$
I		0	0.020
C		$+x$	$+x$
E		x	$0.020 + x$

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

$$8.5 \times 10^{-17} = x(0.020 + x)$$

$$\frac{8.5 \times 10^{-17}}{0.020} = \frac{0.020x}{0.020}$$

$$4.25 \times 10^{-15} = x$$

Since K_{sp} is very small, assume x is negligible.

The solubility of AgI in $0.010 \text{ mol/L } MgI_2$ is $4.25 \times 10^{-15} \text{ mol/L}$

- d) $[Ag^+] = 0.010 \text{ mol/L}$ from $AgNO_3$

	$AgI(s)$	$Ag^+(aq)$	$+ I^-(aq)$
I		0.010	0
C		$+x$	$+x$
E		$0.010 + x$	x

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

$$8.5 \times 10^{-17} = (0.010 + x)x$$

$$\frac{8.5 \times 10^{-17}}{0.010} = \frac{0.010x}{0.010}$$

$$8.5 \times 10^{-15} = x$$

Since K_{sp} is very small, assume x is negligible.

The solubility of AgI in $0.010 \text{ mol/L } AgNO_3$ is $8.5 \times 10^{-15} \text{ mol/L}$

2. a)

	MgF ₂ (s)	⇌	Mg ²⁺ (aq)	+ 2 F ⁻ (aq)
I			0	0
C			+x	+2x
E			x	2x

$$K_{sp} = [\text{Mg}^{2+}][\text{F}^-]^2$$

$$8.0 \times 10^{-8} = x(2x)^2$$

$$\frac{8.0 \times 10^{-8}}{4} = \frac{4x^3}{4}$$

$$\sqrt[3]{8.0 \times 10^{-8}} = \sqrt[3]{x^3}$$

$$4.3 \times 10^{-3} = x$$

The solubility of MgF₂ in pure water is 4.3×10^{-3} mol/L

2.7×10^{-3}

b) [F⁻] = 0.50 mol/L from the NaF

	MgF ₂ (s)	⇌	Mg ²⁺ (aq)	+ 2 F ⁻ (aq)
I			0	0.50
C			+x	+2x
E			x	0.50 + 2x

$$K_{sp} = [\text{Mg}^{2+}][\text{F}^-]^2$$

$$8.0 \times 10^{-8} = x(0.50 + 2x)^2$$

$$8.0 \times 10^{-8} \approx x(0.50)^2$$

Since K_{sp} is very small, assume 2x is negligible.

$$\frac{8.0 \times 10^{-8}}{0.025} \approx \frac{x(0.025)}{0.025}$$

$$3.2 \times 10^{-7} \approx x$$

The solubility of MgF₂ in 0.50 mol/L NaF is 3.2×10^{-7} mol/L

2. c) $[Mg^{2+}] = 0.50 \text{ mol/L}$ from the $MgCl_2$

	$MgF_2(s)$	$q \in Mg^{2+}(aq)$	$+ 2 F^-(aq)$
I		0	0.50
C		$+x$	$+ 2x$
E		x	$0.50 + 2x$

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

$$8.0 \times 10^{-8} = x(0.50 + 2x)^2$$

$$8.0 \times 10^{-8} \approx x(0.50)^2$$

Since K_{sp} is very small, assume $2x$ is negligible.

$$\frac{8.0 \times 10^{-8}}{0.025} \approx \frac{x(0.025)}{0.025}$$

$$3.2 \times 10^{-7} \approx x$$

The solubility of MgF_2 in 0.50 mol/L NaF is $3.2 \times 10^{-7} \text{ mol/L}$.

3. a)

	$AuCl_3(s)$	$q \in Au^{3+}(aq)$	$+ 3 Cl^-(aq)$
I		0	0
C		$+x$	$+ 3x$
E		x	$3x$

$$K_{sp} = [Au^{3+}][Cl^-]^3$$

$$3.2 \times 10^{-25} = x(3x)^3$$

$$\frac{3.2 \times 10^{-25}}{27} = \frac{27x^4}{27}$$

$$\sqrt[4]{1.185 \times 10^{-26}} = \sqrt[4]{x^4}$$

$$3.3 \times 10^{-7} = x$$

The solubility of $AuCl_3$ in pure water is $3.3 \times 10^{-7} \text{ mol/L}$.

2.0×10^{-4}

b) $[\text{Cl}^-] = 0.20 \text{ mol/L}$ from HCl

	$\text{AuCl}_3(s) \rightleftharpoons \text{Au}^{3+}(aq) + 3 \text{Cl}^-(aq)$	
I	0	0.20
C	+x	+3x
E	x	0.20 + 3x

$$K_{sp} = [\text{Au}^{3+}][\text{Cl}^-]^3$$

$$3.2 \times 10^{-25} = x(0.20 + 3x)^3$$

$$3.2 \times 10^{-25} \approx x(0.20)^3 \quad \text{Since } K_{sp} \text{ is very small, assume } 3x \text{ is negligible.}$$

$$\frac{3.2 \times 10^{-25}}{0.0080} \approx \frac{(0.0080)x}{0.0080}$$

$$4.0 \times 10^{-23} \approx x$$

The solubility of AuCl_3 in 0.20 mol/L HCl is $4.0 \times 10^{-23} \text{ mol/L}$.

c) $[\text{Cl}^-] = 0.40 \text{ mol/L}$ from MgCl_2

	$\text{AuCl}_3(s) \rightleftharpoons \text{Au}^{3+}(aq) + 3 \text{Cl}^-(aq)$	
I	0	0.40
C	+x	+3x
E	x	0.40 + 3x

$$K_{sp} = [\text{Au}^{3+}][\text{Cl}^-]^3$$

$$3.2 \times 10^{-25} = x(0.40 + 3x)^3$$

$$3.2 \times 10^{-25} \approx x(0.40)^3 \quad \text{Since } K_{sp} \text{ is very small, assume } 3x \text{ is negligible.}$$

$$\frac{3.2 \times 10^{-25}}{0.064} \approx \frac{(0.064)x}{0.064}$$

$$5.0 \times 10^{-24} \approx x$$

The solubility of AuCl_3 in 0.20 mol/L MgCl_2 is $5.0 \times 10^{-24} \text{ mol/L}$.

3. d) $[\text{Au}^{3+}] = 0.20 \text{ mol/L Au(NO}_3)_3$

	$\text{AuCl}_3(s)$	$\text{Au}^{3+}(aq)$	$+ 3 \text{Cl}^-(aq)$
I		0	0.20
C		$+x$	$+3x$
E		$0.20+x$	$3x$

$$K_{sp} = [\text{Au}^{3+}][\text{Cl}^-]^3$$

$$3.2 \times 10^{-25} = (0.20+x)(3x)^3$$

$$3.2 \times 10^{-25} \approx 0.20(3x)^3$$

$$3.2 \times 10^{-25} \approx 0.20(27x^3) \quad \text{Since } K_{sp} \text{ is very small, assume } x \text{ is negligible.}$$

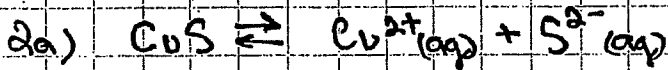
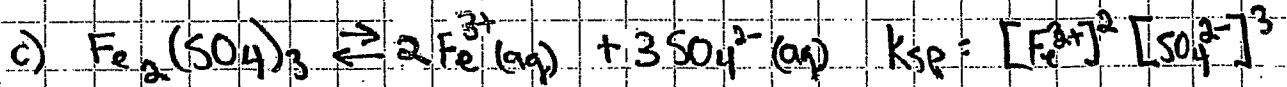
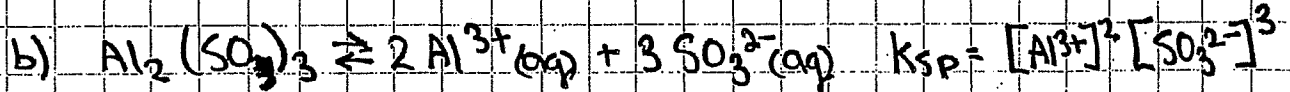
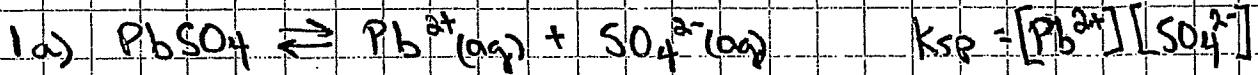
$$\frac{3.2 \times 10^{-25}}{5.4} \approx \frac{5.4x^3}{5.4}$$

$$\sqrt[3]{5.9 \times 10^{-26}} \approx \sqrt[3]{x^3}$$

$$3.9 \times 10^{-9} \approx x$$

The solubility of AuCl_3 in $0.20 \text{ mol/L Au(NO}_3)_3$ is $3.9 \times 10^{-9} \text{ mol/L}$

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K_{sp} Assignment #5

$$\text{let } x = [\text{Cu}^{2+}] = [\text{S}^{2-}]$$

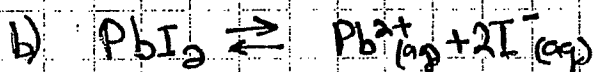
$$K_{sp} = [\text{Cu}^{2+}][\text{S}^{2-}] = 6.31 \times 10^{-33}$$

$$x^2 = 6.31 \times 10^{-33}$$

$$x = 7.94 \times 10^{-17} \text{ mol/L}$$

$$x = [\text{Cu}^{2+}] = [\text{S}^{2-}] = 7.94 \times 10^{-17} \text{ mol/L} \quad \therefore [\text{CuS}] = 7.94 \times 10^{-17} \text{ mol/L}$$

$$7.94 \times 10^{-17} \text{ mol CuS} \times \frac{1 \text{ mol CuS}}{1 \text{ mol CuS}} = \text{g/L}$$



$$\text{let } x = [\text{Pb}^{2+}], [\text{I}^{-}] = 2x$$

$$K_{sp} = [\text{Pb}^{2+}][\text{I}^{-}]^2 = 1.39 \times 10^{-8}$$

$$(x)(2x)^2 = 1.39 \times 10^{-8}$$

$$x = [\text{Pb}^{2+}] = 1.51 \times 10^{-3} \text{ mol/L} \quad 4x^3 = 1.39 \times 10^{-8}$$

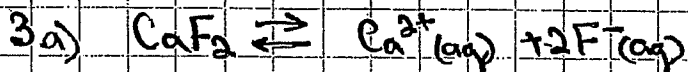
$$2x = [\text{I}^{-}] = 3.02 \times 10^{-3} \text{ mol/L}$$

$$\therefore [\text{PbI}_2] = 1.51 \times 10^{-3} \text{ mol/L} \quad x = 1.51 \times 10^{-3} \text{ mol/L}$$

$$1.51 \times 10^{-3} \text{ mol PbI}_2 \times \frac{460.99 \text{ g PbI}_2}{1 \text{ mol PbI}_2} = 6.96 \times 10^{-1} \text{ g PbI}_2$$

$$\text{PbI}_2 = 207.19 \text{ g} + 2(126.90 \text{ g}) = 460.99 \text{ g}$$

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$$\text{CaF}_2 = 40.08\text{g} + 2(19.00\text{g}) = 78.08\text{g}$$

$$1.70 \times 10^{-2} \frac{\text{g CaF}_2}{\text{g CaF}_2} \times \frac{1 \text{ mol CaF}_2}{78.08 \text{ g CaF}_2} = 2.18 \times 10^{-4} \text{ mol CaF}_2$$

$$[\text{Ca}^{2+}] = [\text{CaF}_2] = 2.18 \times 10^{-4} \text{ mol/L}$$

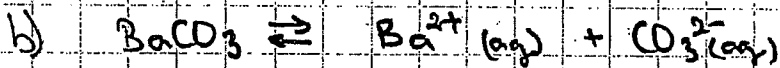
$$[\text{F}^{-}] = 2[\text{Ca}^{2+}] = 4.35 \times 10^{-4} \text{ mol/L}$$

$$K_{sp} = [\text{Ca}^{2+}][\text{F}^{-}]^2$$

$$K_{sp} = (2.18 \times 10^{-4})(4.35 \times 10^{-4})^2$$

$$K_{sp} = 4.13 \times 10^{-11}$$

$$\frac{1.70 \times 10^{-2} \text{ g}}{1 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}}$$
$$= 1.70 \times 10^{-2} \text{ g/L}$$



$$\text{BaCO}_3 = 137.33\text{g} + 12.01\text{g} + 3(16.00) = 197.34\text{g}$$

$$0.0138 \frac{\text{g BaCO}_3}{\text{g BaCO}_3} \times \frac{1 \text{ mol BaCO}_3}{197.34 \text{ g BaCO}_3} = 6.99 \times 10^{-5} \text{ mol BaCO}_3$$

$$[\text{BaCO}_3] = [\text{Ba}^{2+}] = [\text{CO}_3^{2-}] = 6.99 \times 10^{-5} \text{ mol/L}$$

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

$$K_{sp} = (6.99 \times 10^{-5})^2$$

$$K_{sp} = 4.89 \times 10^{-9}$$

K_{sp} #4

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4. $6.7 \times 10^{-5} \text{ g AgBr}$
25°C

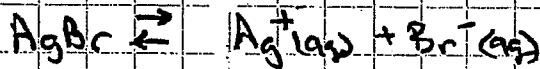
500.0 mL

$$\text{AgBr} = 107.87 \text{ g} + 79.90 \text{ g} = 187.77 \text{ g}$$

$$6.7 \times 10^{-5} \text{ g AgBr} \times \frac{1 \text{ mol AgBr}}{187.77 \text{ g AgBr}} = 3.59 \times 10^{-7} \text{ mol AgBr}$$

$$M = \frac{\text{mol}}{\text{L}} = \frac{3.59 \times 10^{-7} \text{ mol}}{0.5000 \text{ L}} = 7.19 \times 10^{-7} \text{ mol/L}$$

$$[\text{Ag}^+] = [\text{Br}^-] = 7.19 \times 10^{-7} \text{ mol/L}$$



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

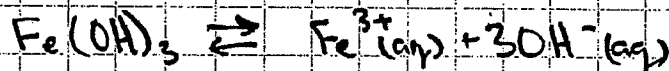
$$K_{sp} = (7.19 \times 10^{-7})^2$$

$$K_{sp} = 5.2 \times 10^{-13}$$

$$5.14 \times 10^{-13} = 5.1 \times 10^{-13}$$

5. 25°C

$$[\text{Fe}(\text{OH})_3] = 1.3 \times 10^{-13} \text{ mol/L}$$



$$[\text{OH}^-] = 3[\text{Fe}^{3+}] = 3.9 \times 10^{-13} \text{ mol/L}$$

$$K_{sp} = [\text{Fe}^{3+}][\text{OH}^-]^3$$

$$K_{sp} = (1.3 \times 10^{-13})(3.9 \times 10^{-13})^3$$

$$K_{sp} = 7.7 \times 10^{-51}$$