Module 4 Lesson 8 Exercises Answer Key

1. a)

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

$$K_{sp} = [Ag^+][I^-]$$
$$8.5 \times 10^{-17} = x^2$$
$$\sqrt{8.5 x 10^{-17}} = \sqrt{x^2}$$
$$9.2 \times 10^{-9} = x$$

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

b) $[I^-]$ = 0.010 mol/L

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

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

$$K_{sp} = [Ag^+][I^-]$$
$$8.5 \times 10^{-17} = x(0.010 + x)$$
$$\frac{8.5 \times 10^{-17}}{0.010} = \frac{0.010x}{0.010}$$
$$8.5 \times 10^{-15} = x$$

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

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

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

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

$$\begin{aligned} K_{sp} &= [Ag^+][I^-] \\ 8.5 \times 10^{-17} &= x(0.020 + x) \\ \frac{8.5 \times 10^{-17}}{0.020} &= \frac{0.020x}{0.020} \\ 4.25 \times 10^{-15} &= x \end{aligned}$$

The solubility of AgI in 0.010 mol/L MgI_2 is 4.25 x 10^{-15} mol/L.

d) $[Ag^+]$ = 0.010 mol/L from $AgNO_3$

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

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

$$\begin{aligned} K_{sp} &= [Ag^+][I^-] \\ 8.5 \times 10^{-17} &= (0.010 + x)x \\ \frac{8.5 \times 10^{-17}}{0.010} &= \frac{0.010x}{0.010} \\ 8.5 \times 10^{-15} &= x \end{aligned}$$

The solubility of AgI in 0.010 mol/L $AgNO_3$ is 8.5 x 10^{-15} mol/L.

2. a)

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

$$\begin{aligned} K_{sp} &= [Mg^{2+}][F^-]^2 \\ 8.0\times10^{-8} &= x(2x)^2 \\ \frac{8.0\times10^{-8}}{4} &= \frac{4x^3}{4} \\ \sqrt[3]{2.0\times10^{-8}} &= \sqrt[3]{x^3} \\ 2.7\times10^{-3} &= x \end{aligned}$$

The solubility of MgF_2 in pure water is 2.7 x 10^{-3} mol/L.

b) $[F^-]$ = 0.50 mol/L from the NaF

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

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

$$\begin{aligned} K_{sp} &= [Mg^{2+}][F^-]^2 \\ 8.0\times10^{-8} &= x(0.50+2x)^2 \\ 8.0\times10^{-8} &\approx x(0.50)^2 \\ \frac{8.0\times10^{-8}}{0.25} &\approx \frac{x(0.25)}{0.25} \\ 3.2\times10^{-7} &\approx x \end{aligned}$$

The solubility of MgF_2 in 0.50 mol/L NaF is 3.2 x 10^{-7} mol/L.

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

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

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

$$K_{sp} = [Mg^{2+}][F^-]^2$$
$$8.0 \times 10^{-8} = (0.5 + x)(2x)^2$$
$$8.0 \times 10^{-8} \approx (0.50)\left(4x^2\right)$$
$$\frac{8.0 \times 10^{-8}}{2} \approx \frac{2x^2}{2}$$
$$\sqrt{4.0 \times 10^{-8}} \approx x$$
$$2.0 \times 10^{-4} \approx x$$

The solubility of MgF_2 in 0.50 mol/L $MgCl_2$ is 2.0 x 10^{-4} mol/L.

3. a)

	$AuCl_3(s) \rightleftharpoons$	$Au^{3+}(aq)$ +	$3 Cl^-(aq)$
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 x 10^{-7} mol/L.

3. b) $[Cl^-]$ = 0.20 mol/L from HCl

	$AuCl_3(s) \rightleftharpoons$	$Au^{3+}(aq)$ +	$3\ Cl^-(aq)$
I		0	0.20
C		+ x	+ $3x$
E		x	$0.20 + 3x$

Since K_{sp} is very small, assume $3x$ is negligible.

$$K_{sp} = [Au^{3+}][Cl^-]^3$$
$$3.2 \times 10^{-25} = x(0.20 + 3x)^3$$
$$3.2 \times 10^{-25} \approx x(0.20)^3$$
$$\frac{3.2 \times 10^{-25}}{0.0080} \approx \frac{(0.0080)x}{0.0080}$$
$$4.0 \times 10^{-23} \approx x$$

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

c) $[Cl^-]$ = 2 x 0.20 mol/L = 0.40 mol/L from $MgCl_2$

	$AuCl_3(s) \rightleftharpoons$	$Au^{3+}(aq)$ +	$3\ Cl^-(aq)$
I		0	0.40
C		+ x	+ $3x$
E		x	$0.40 + 3x$

Since K_{sp} is very small, assume $3x$ is negligble.

$$K_{sp} = [Au^{3+}][Cl^-]^3$$
$$3.2 \times 10^{-25} = x(0.40 + 3x)^3$$
$$3.2 \times 10^{-25} \approx x(0.40)^3$$
$$\frac{3.2 \times 10^{-25}}{0.064} \approx \frac{(0.064)x}{0.064}$$
$$5.0 \times 10^{-24} \approx x$$

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

3. d) $[Au^{3+}]$ = 0.20 mol/L $Au(NO_3)_3$

	$AuCl_3(s) \rightleftharpoons$	$Au^{3+}(aq)$ +	$3\ Cl^-(aq)$
I		0	0.20
C		+ x	+ $3x$
E		$0.20 + x$	$3x$

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

$$
\begin{aligned}
K_{sp} &= [Au^{3+}][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\left(27x^3\right) \\
\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
\end{aligned}
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The solubility of $AuCl_3$ in 0.20 mol/L $Au(NO_3)_3$ is 3.9×10^{-9} mol/L.