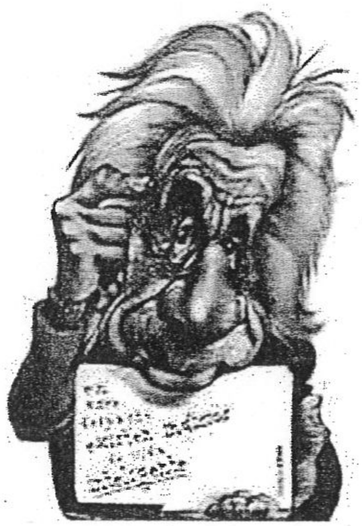
AP Chemistry Review Packet

"Equilibrium Problems"

**This packet contains various types of "Equilibrium" problems from previous AP Chemistry tests. There is always one of the Free-Response questions that will be very similar to the ones in this packet. Put in the time and effort into this packet and reap the benefits on the test.

1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010



Solutions and Answers

1990 CH. 17 Solubility Equilibrium (Ksp)

(a) $Fe(OH)_2$ 1.43×10^{-3} gr/1L → convert to moles then calculate Molarity (molar solubility)

89.85 $g\,mol^{-1}$

$$\frac{1.43 \times 10^{-3}\ gr}{} \Big| \frac{1\ mole}{89.85\ gr} = 1.65 \times 10^{-5}\ moles\ /\ 1L$$

* 1.65×10^{-5} M

(b) $K_{sp} = [Fe^{+2}]^1[OH^{-1}]^2$

$K_{sp} = (1.65 \times 10^{-5})(3.30 \times 10^{-5})^2$

$K_{sp} = 1.8 \times 10^{-14}$

(c) $Fe(OH)_2(s) \rightleftharpoons Fe^{+2}(aq) + 2OH^-(aq)$

	$Fe(OH)_2(s)$	$Fe^{+2}(aq)$	$2OH^-(aq)$
[ ]i	* 1.65×10^{-5} M	0	0
[ ]f	0	↓	↓
[ ]equ		1.65×10^{-5}	$2(1.65 \times 10^{-5})$

(1:1:2 ratio)

3.30×10^{-5} M = $[OH^-]$

pOH = 4.49

pH = 9.51

$\begin{cases} pOH = -\log[OH^-] \\ pH + pOH = 14 \end{cases}$

(d) $\overset{+2}{Fe}\ \cancel{\overset{-2}{SO_4}}$ | $\cancel{\overset{+1}{Na}}\overset{-1}{OH}$

3×10^{-3} M | 4×10^{-6} M

× (50mL) .050L | × .050L 50mL

1.5×10^{-4} mol Fe^{+2} | 2×10^{-7} mol OH^{-1}

To Molarity

$$\frac{1.5 \times 10^{-4}\ mol\ Fe^{+2}}{(.050 + .050)\ L} \qquad \frac{2 \times 10^{-7}\ mol\ OH^-}{(.050 + .050)\ L}$$

$[Fe^{+2}] = 1.5 \times 10^{-3}$ $\qquad$ $[OH^-] = 2 \times 10^{-6}$ M

Ksp (part "b") 1.8×10^{-14} $\Big\{$ $Q_{sp} = [Fe^{+2}]^1[OH^-]^2$

$= (1.5 \times 10^{-3})(2 \times 10^{-6})^2$

$K_{sp} > Q_{sp} = 6 \times 10^{-15}$ $\boxed{\text{No ppt}}$

$\boxed{1991}$ weak acid (Ka) ch. 16 Buffer ch. 17.

(a) $C_2H_5COOH + H_2O \rightleftharpoons H_3O^+ + C_2H_5COO^-$ $Ka = \frac{[H_3O^+][C_2H_5COO^-]}{[C_2H_5COOH]}$

	C_2H_5COOH	H_3O^+	$C_2H_5COO^-$
I	.2 M	0	0
C	− x	+ x	+ x
E	.2 − x (5%)	x	x
	.2		

$1.3 \times 10^{-5} = \frac{(x)(x)}{.2}$

$x = [H_3O^+] = 1.6 \times 10^{-3}\,M$

(b) $\alpha_i = \frac{[H_3O^+]_{equ}}{[C_2H_5COOH]_i} \times 100$ $\alpha_i = \frac{1.6 \times 10^{-3}}{.2} \times 10^2 = 0.81\%$

(c) $Ka = \frac{[H_3O^+][C_2H_5COO^-]}{[C_2H_5COOH]}$

pH = 5.20
$[H_3O^+] = 10^{-5.2} = 6.3 \times 10^{-6}\,M$
$Ka = 1.3 \times 10^{-5}$

$\frac{Ka}{[H_3O^+]} = \frac{[C_2H_5COO^-]}{[C_2H_5COOH]}$

$\frac{Ka}{[H_3O^+]} = \frac{1.3 \times 10^{-5}}{6.3 \times 10^{-6}} = 2.1 \rightarrow$ $C_2H_5COO^-$: C_2H_5COOH = 2.1 : 1 mole ratio

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(d) Buffer stressed

$C_2H_5COOH + H_2O \rightleftharpoons C_2H_5COO^- + H_3O^+$ | $\cancel{Na}C_2H_5COO^{-1}$ (+1) .5M

	C_2H_5COOH	$C_2H_5COO^-$	H_3O^+
I	.35	0	0
C	− x		+ x
E	.35 − x	x + .5	$\cancel{x}$
	.35 M (5%)	.50 M	

will   could

$\boxed{.004M\ [OH^-]}$

strong Base stress
NaOH
.004 mol
.1 L of Buffer (100 ml)
$\frac{.004\text{ mol } OH^-}{1L}$
$.004M = [OH^-]$

$C_2H_5COOH + OH^- \longrightarrow C_2H_5COO^- + H_2O$

.35 − .04 = .31 M   .5 + .04 = .54 M   x'

$Ka = \frac{[C_2H_5COO^-][H_3O^+]}{[C_2H_5COOH]}$ $1.3 \times 10^{-5} = \frac{(.54)(x')}{(.31)}$

$x' = [H_3O^+] = 7.46 \times 10^{-6}\,M$
pH = 5.12

1992 $2NaHCO_3 (s) \rightleftharpoons Na_2CO_3 (s) + \underbrace{H_2O (g) + CO_2 (g)}_{P_T = 7.76 \text{ atm}}$

$V = 5.0 L$ $T = 433 K$

$R = 0.082 \frac{atm \cdot L}{mol \cdot K}$

(a) $PV = nRT$ $P_T = \frac{n_T RT}{V}$ $7.76 atm = n_T \left(.082 \frac{atm \cdot L}{mol \cdot K}\right) 433 K$

$n_T = 1.09$ mol of H_2O and CO_2

$H_2O : CO_2$ 1:1 mole ratio from equation

0.546 mol H_2O $\leftarrow$ $\frac{1.09 mol}{2} = 0.546$ mol H_2O 0.546 mol CO_2

b) $NaHCO_3 : H_2O$
2 : 1 mole ratio from equation

Therefore $0.546 \times 2 = 1.09$ mol $NaHCO_3$ needed

$\frac{100g \; NaHCO_3 \text{ (with excess)}}{84 g \; mol^{-1}} = 1.19$ mol

1.19 mol
− 1.09 mol
0.098 mol Excess $NaHCO_3$

$0.098 mol \left| \frac{84 g}{1 mol} \right.$ $\leftarrow$

8.23 g excess of $NaHCO_3$

c) $Kp = (P_{H_2O}) P_{CO_2}$

$(3.87)(3.87)$

$Kp = 14.97$

$PV = nRT$

$P = \frac{nRT}{V} = \frac{(.546 mol)(.082)(433 K)}{5 L}$

$\leftarrow P = 3.87$ atm same for CO_2 and H_2O b/c same moles

d) $NaHCO_3$ is already in excess so adding more will not charge the total pressure.

I

1993 weak Base(K_b) - Ch.16 Base Buffer (CH.17)

ⓐ $CH_3\ddot{N}H_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$ $K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]}$

[ ]$_i$ .225M 0 0

[ ]equ .225 − x 5% x x $\Longrightarrow$ $5.25 \times 10^{-4} = \frac{(x)(x)}{.225}$

.225

$x = [OH^-] = 1.09 \times 10^{-2}$ M

ⓑ $CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$ | $CH_3NH_3^+ \cancel{NO_3^-}$ ionic salt

[ ]$_i$ .225M 0 0 | .01 mol

120 mL .12 L

.225 − x x x + .083 | $[CH_3NH_3^+] = \frac{.01\,mol}{.12\,L} = .08$ M

5%

.225 x .083

common ion effect

$\boxed{\text{Henderson Hasselbach}}$ $pOH = pK_b + \log \frac{[\text{conj acid}]}{[\text{weak base}]}$

$pOH = (-\log 5.25 \times 10^{-4}) + \log\left(\frac{.083}{.225}\right)$

$pOH = 3.28 + -.44$

$pOH = 2.84$ $pH = 11.16$

— OR —

$K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]}$

$5.25 \times 10^{-4} = \frac{(.083)[OH^-]}{(.225)}$ $[OH^-] = 1.42 \times 10^{-3}$ M

$pOH = 2.84$ $pH = 11.16.$

1993

(c) Desired pH $= 11$ $[H_3O^+] = 10^{-pH} = 10^{-11} = 1 \times 10^{-11}\,M$

$[OH^-] = 1 \times 10^{-3}\,M$

$K_b = 5.25 \times 10^{-4}$

$$K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3CN_2]} \longrightarrow \frac{K_b}{[OH^-]} = \frac{[CH_3NH_3^+]}{[CH_3NH_2]}$$

$$\frac{5.25 \times 10^{-4}}{1 \times 10^{-3}} = .525$$

$$\frac{5.25 \times 10^{-4}}{1.42 \times 10^{-3}} = .370 \leftarrow \text{(part "b")}$$

$.525 - .370 = .155\,M$

$.155\,M$ HCl $\times$ $.120\,L$ $=$ $.0186$ mol HCl must be added.

(d) pH will not change, because components of Buffer CH_3NH_2 (weak base) and $CH_3NH_3^+$ (conj acid) amounts are not altered, no matter how much water is added (or removed)

$\boxed{1994}$ Solubility Equilibrium (CH.17) Ksp

$$MgF_2(s) \rightleftharpoons Mg^{+2}(aq) + 2F^-(aq) \quad @\ 18°C$$

1.21×10^{-3} M

ⓐ $Ksp = [Mg^{+2}][F^-]^2$

ⓑ $MgF_2 \rightleftharpoons Mg^{+2} + 2F^-$ $\Longrightarrow$ $Ksp = [Mg^{+2}][F^-]^2$

1.21×10^{-3} M $\quad$ 2.42×10^{-3} M $\quad$ $Ksp = (1.21 \times 10^{-3})(2.42 \times 10^{-3})^2$

1:2 ratio $\quad$ $Ksp = 7.08 \times 10^{-9}$

1st Find the Ksp value

	MgF_2	$\rightleftharpoons$	Mg^{+2}	$+ 2F^-$
[ ]i	x		0	0
[ ]f	0			
[ ]equ			x	2x + .1
			5%	.1

	KF $\rightarrow$	$\cancel{K^+}$	$+ F^-$
ni	.1mol	0	0
nf	0	.1mol	.1mol

into 1L

$\frac{.1 mol}{1L} = .1M = [F^-]$

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

$7.08 \times 10^{-9} = [Mg^{+2}][.1]^2 \quad [Mg^{+2}] = 7.09 \times 10^{-7}$ M

ⓒ $Mg^{+2}\cancel{(NO_3^{-1})_2}$

$.003$ M
(100mL) $\times$ .1L
3×10^{-4} mol Mg^{+2}

convert to M $\quad \frac{3 \times 10^{-4} mol}{(.1 + .2) L}$

$[Mg^{+2}] = 1 \times 10^{-3}$ M

$Na^{+1}F^{-1}$

2×10^{-3} M
$\times$ .2L (200mL)
4×10^{-4} mol F^-

$\frac{4 \times 10^{-4} mol}{.1 + .2 L}$

$[F^-] = 1.33 \times 10^{-3}$ M

$Ksp = 7.09 \times 10^{-9}$

$Qsp = [Mg^{+2}][F^-]^2$
$= (1 \times 10^{-3})(1.33 \times 10^{-3})^2$

Ksp > Qsp

No ppt

1994 (d) $MgF_2(s) \rightleftharpoons Mg^{+2}(aq) + 2F^-(aq)$

$\downarrow$

27°C $[Mg^{+2}] = 1.17 \times 10^{-3}$ M

18°C $[Mg^{+2}] = 1.21 \times 10^{-3}$ M

T ↑ M ↓ dissolving is Exothermic.

$\boxed{1995}$ GAS EQUILIBRIUM (CH. 15)

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$
$$.2\ mol/L \quad .3\ mol/L \quad .55\ mol/L \quad .55\ mol/L$$

(a) $$\chi_{CO} = \frac{n_{CO}}{n_T} = \frac{.55\ mol}{.2 + .3 + .55 + .55} = 0.33$$

(b) $$K_c = \frac{[H_2O][CO]}{[H_2][CO_2]} = \frac{(.55M)(.55M)}{(.2M)(.3M)} = 4.3$$

(c) $$K_p = K_c(RT)^{\Delta n} \qquad \Delta n = n_p - n_r$$
$$\Delta n = (1+1) - (1+1) = 0$$
$$K_p = K_c(RT)^0$$
$$K_p = K_c = 4.3$$

(d) $$H_2 + CO_2 \rightleftharpoons H_2O + CO$$
$$.30(.55) = .165M$$
$$.2 + .165 \quad .3 + .165 \quad .55 - .165 \quad .55 - .165$$
$$.385 \quad .495 \quad .385 \quad .385$$
$$K_c = \frac{[H_2O][CO]}{[H_2][CO_2]}$$
$$K_c = \frac{(.385)(.385)}{(.385)(.495)}$$

@ 2000K $K_c = .87$

(e) $$H_2 + CO_2 \rightleftharpoons H_2O + CO \qquad K_c = .87\ (2000K)$$
$$\frac{.5\ mol}{3L} \quad \frac{.5\ mol}{3L}$$
$$[\ ]_i \quad .167M \quad .167M \quad 0 \quad 0$$
$$.167 - x \quad .167 - x \quad x \quad x$$

NO 5% Rule

$\boxed{BUT}$

$$K_c = \frac{[H_2O][CO]}{[H_2][CO_2]} \qquad .87 = \frac{(x)(x)}{(.167-x)(.167-x)}$$

SQUARE root both sides and solve for x

$$\sqrt{.87} = \frac{x}{.167 - x} \qquad x = .11$$

$$X = .11\ mol/L = [CO]$$

1996 CH. 16 Weak acid (Ka) Ch. 17 Hydrolysis (conj base) $K_b = \frac{K_w}{K_a}$

CH. 17 titration weak acid / strong Base.

(a) $HOCl + H_2O \rightleftharpoons H_3O^+ + OCl^{-1}$ $K_a = 3.2 \times 10^{-8}$

	$HOCl$		H_3O^+	OCl^{-1}
$[\,]_i$	.14 M		0	0
$[\,]_{equ}$	.14 − x		x	x
	.14	5%		

$$K_a = \frac{[H_3O^+][OCl^-]}{[HOCl]}$$

$$3.2 \times 10^{-8} = \frac{(x)(x)}{.14} \qquad x = [H_3O^+] = 6.7 \times 10^{-5}\,M$$

(b) $NaOCl \xrightarrow{H_2O} \cancel{Na^+} + OCl^{-1}$

Hydrolysis of conj base of a weak acid

$OCl^{-1} + H_2O \rightleftharpoons HOCl + OH^-$

K_b base H^+

$K_w = K_a \times K_b$

$$K_b = \frac{K_w}{K_a} = \frac{1 \times 10^{-14}}{3.2 \times 10^{-8}} = 3.1 \times 10^{-7}$$

(c)

$HOCl$	$\cancel{Na}^+OH^-$
.14 M	.56 M
× 40 mL	× 10 mL
5.6 mmol HOCl	5.6 mmol H+

$HOCl + OH^- \rightarrow H_2O + OCl^-$

$HOCl$	OH^-	H_2O	OCl^-
5.6 mmol	5.6 mmol	0	0
0	0	—	5.6 mmol

NO EXCESS / NO LR

Hydrolysis.

$OCl^{-1} + H_2O \rightleftharpoons HOCl + OH^-$

	OCl^{-1}		$HOCl$	OH^-
	$\frac{5.6\ mmol}{(40+10)\ mL}$		0	0
$[\,]_i$	.112 M			
$[\,]_{equ}$	.112 − x	5%	x	x
	.112			

$$K_a = \frac{[HOCl][OH^-]}{[OCl^-]}$$

$$3.1 \times 10^{-7} = \frac{(x)(x)}{.112}$$

$x = 1.87 \times 10^{-4} = [OH^-]$

$x = [OH^-] = 1.87 \times 10^{-4}$

$pOH = 3.73$

$pH = 10.21$

$\boxed{1996}$ (d) HOCl $\quad$ NaOH $\qquad$ $K_a = [H_3O^+]$ coincidence

$K_a = 3.2 \times 10^{-8}$ $\quad$ .20M $\quad$ 50mL $\quad \leftarrow$? mmol

desired $\rightarrow$ $\begin{cases} pH = 7.49 ? \\ [H_3O^+] = 10^{-pH} = 10^{-7.49} = 3.2 \times 10^{-8} M \end{cases}$

$HOCl + H_2O \rightleftharpoons H_3O^+ + OCl^{-1}$

$K_a = \frac{[H_3O^+][OCl^-]}{[HOCl]} \rightarrow [OCl^-] = \frac{K_a [HOCl]}{[H_3O^+]} = \frac{(3.2 \times 10^{-8})(.2M)}{[3.2 \times 10^{-8}]}$

$[OCl^-] = .2M \times 50mL = 10 \text{ mmol } OCl^-$

$[HOCl] = [OCl^-]$

$\underset{10 mmol}{n_{HOCl}} = \underset{10 mmol}{n_{OCl^-}}$ $\longrightarrow$ moles NaOH

$n_{HOCl} = \underset{10 mmol}{n_{OH^-}}$

10 mmol NaOH $\longleftarrow$

(e) $Cl_2 + H_2O \longrightarrow H^+ + Cl^- + HOCl$

H^+: .065M $\quad$ HOCl: .065M

$HOCl + H_2O \rightleftharpoons H_3O^+ + OCl^-$

larger amount than small amt

use this [ ] to find pH

$pH = -\log [H_3O^+]$

$pH = -\log(.065)$

$pH = 1.19$

$\boxed{1997}$ ch. 16 weak acid (diprotic) $K_a = K_{a_1} \times K_{a_2}$
ch. 17 Titration
ch 17 Hydrolysis

$$H_2C_2O_4 \rightleftharpoons 2H^+ + C_2O_4^{-2} \qquad K_a = 3.78 \times 10^{-6}$$

(a) $H_2C_2O_4$ | $\overset{+}{Na}\overset{-}{OH}$
5×10^{-3} mol | .4 M
$2(5\times10^{-3}$ mol$)$ | ? L (mL)
1×10^{-2} mol H^+ | 1×10^{-2} mol OH^-

$\boxed{H^+ : OH^-}$ 1 : 1

$M = \frac{n}{L}$

$L = \frac{n}{M} = \frac{1\times10^{-2}\text{ mol}}{.4\text{ M}}$

$L = .025L$ (25mL)

(b) $K_a = K_{a_1} \times K_{a_2}$ $\qquad K_{a_1} = \frac{K_a}{K_{a_2}} = \frac{3.78\times10^{-6}}{6.4\times10^{-5}} = .059$

(c) $H_2C_2O_4$ .015 M $\leftarrow$ strong acid added until pH = .5 $\qquad [C_2O_4^{-2}] = ?$

$$H_2C_2O_4 + 2H_2O \rightleftharpoons 2H_3O^+ + C_2O_4^{-2}$$

pH = .5
$[H_3O^+] = 10^{-pH} = 10^{-.5} = .316M$

$$K_a = \frac{[H_3O^+]^2[C_2O_4^{-2}]}{[H_2C_2O_4]} \qquad 3.78\times10^{-6} = \frac{(.316)^2[C_2O_4^{-2}]}{(.015)}$$

$[C_2O_4^{-2}] = 5.67\times10^{-7}$ M

(d) $Na_2C_2O_4 \rightarrow 2Na^+ + C_2O_4^{-2}$

$C_2O_4^{-2} + 2H_2O \rightleftharpoons H_2C_2O_4 + 2OH^-$

$K_w = K_{a_2} \times K_b \leftarrow$ base $\quad$ 2H+

$$K_b = \frac{K_w}{K_{a_2}} = \frac{1\times10^{-14}}{6.4\times10^{-5}} = 1.56\times10^{-10}$$

1998 Ch. 17 Solubility Equilibrium (Ksp)

a) i) $Cu(OH)_2 (s) \rightleftharpoons Cu^{+2} (aq) + 2OH^{-1} (aq)$

ii) 1 mole = 96.7 gr.

$\frac{1.72 \times 10^{-6} g \mid 1 mol}{\mid 96.7 g} = 1.78 \times 10^{-8}$ mol

100 mL (.1 L)

Molar solubility $Cu(OH)_2$ $\frac{1.78 \times 10^{-8} mol}{.1 L} = 1.78 \times 10^{-7}$ M

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

	$Cu(OH)_2$	Cu^{+2}	$2OH^-$
[ ]i	1.78×10^{-7} M	0	0
[ ]f	0		
[ ]equ		1.78×10^{-7}	$2(1.78 \times 10^{-7})$ 3.52×10^{-7}

1:1:2 ratio

$Ksp = [Cu^{+2}][OH^-]^2$
$= (1.78 \times 10^{-7})(3.52 \times 10^{-7})^2$

$Ksp = 2.2 \times 10^{-20}$

b) $Zn(OH)_2$ $Ksp = 7.7 \times 10^{-17}$

i) pH = 9.35 pOH = 4.65 $[OH^-] = 10^{-pOH} = 10^{-4.65} = 2.24 \times 10^{-5}$ M

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

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

$2.24 \times 10^{-5} = [Zn^{+2}][2.24 \times 10^{-5}]^2$

$[Zn^{+2}] = 1.54 \times 10^{-7}$ M

$[Zn^{+2}] = Zn\,SO_4$ molar solubility

$[Zn(OH)_2]$ 1.54×10^{-7} M

$\boxed{1998}$

(b) $\boxed{ii}$

$Zn^{+2}\cancel{(NO_3)_2}(aq)$

$.1 M$

$\times$ (50 mL) $.050 L$

5×10^{-3} mol

$\cancel{Na^+}OH^-$

$.3 M$

$\times$ $.050 L$ (50 mL)

1.5×10^{-2} mol

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

.005 mol .015 mol —

(1:2 ratio)

L.R Excess

0 .015 − 2(.005 mol) .005 mol

.005 mol OH^- excess $\longrightarrow$ $\dfrac{.005 \text{ mol } OH^-}{(.050 + .050)\,L}$

$[OH^-] = .05 M$

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

$7.7 \times 10^{-17} = [Zn^{+2}][.05]^2$

$[Zn^{+2}] = 3.08 \times 10^{-14} M$

1999 CH. 16 (weak Base, K_b) : Ch. 17 (Titration - weak base, strong Acid)

a) $\frac{[NH_4^+][OH^-]}{[NH_3]}$

b) Given: $[OH^-] = 5.6\times10^{-4}$ M

pOH = $-\log[OH^-]$
pOH = $-\log(5.6\times10^{-4})$
pOH = 3.252

pH + pOH = 14
pH + 3.252 = 14   pH = 10.748

c) $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

	NH_3	NH_4^+	OH^-
[ ]i	.018	0	0
]equ	$.018 - 5.6\times10^{-4}$	5.6×10^{-4}	5.6×10^{-4}
	.018 (5% Rule)		

$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$

$K_b = \frac{(5.6\times10^{-4})(5.6\times10^{-4})}{.018}$

$K_b = 1.74\times10^{-5}$

d) $\alpha_i = \frac{[OH^-]_{equ}}{[NH_3]_i}\times10^2$ $\alpha_i = \frac{5.6\times10^{-4}\,M}{.018\,M}\times10^2 = 3.11\%$

e) i

NH_3	HCl
20 mL	? mL
.018 M	.012 M

At EQUI. PT. $n_A = n_B$ $M = \frac{n}{V}$ $n = M\times V$

$M_AV_A = M_BV_B$
$(.012M)V_A = (.018M)\,20\,mL$
$V_A = 30$ mL

ii

NH_3	$\overset{+}{H}\cancel{\overset{-}{Cl}}$
20 mL	15 mL
x .018 M	x .012 M
.36 mmol	.18 mmol

1:1

NH_3	$+ H^+$	$\longrightarrow NH_4^+$
.36 mmol	.18 mmol	0
EXCESS	LR	
.18 mmol	0	.18 mmol

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

$\frac{.18\,mmol}{(20+15)\,mL}$ $\frac{.18\,mmol}{(20+15)\,mL}$

.0051 M   .0051 M

$K_b = \frac{[\cancel{NH_4^+}][OH^-]}{[\cancel{NH_3}]}$

$K_b = [OH^-] = 1.74\times10^{-5}$ M
pOH = $-\log K_b$
pOH = 4.745   pH = 9.225

(could have used moles and Liters instead of mmol and mL)

1999

e iii

NH_3	$\overset{+}{H}\overset{-}{Cl}$
.018 M	.012 M
× 20 mL	× 40 mL
.36 mmol	.48 mmol

1:1

NH_3	+ H^+	$\rightarrow$ NH_4^+
.36 mmol	.48 mmol	0
LR	Excess	
0	.18 mmol	.36 mmol

larger amount
use to find pH

$$\frac{.18 \text{ mmol } H^+}{(20 + 40) \text{ mL}}$$

$[H^+] = 3 \times 10^{-3}$ M

pH = $-\log(3 \times 10^{-3}$ M)

pH = 2.70

Hydrolysis

$NH_4^+ + H_2O \rightleftharpoons H_3O^+ + NH_3$

small amt

$\boxed{2000}$ CH. 15 (GAS EQU. Keq, PV = nRT)

(a) $\dfrac{[H_2]^2[S_2]^1}{[H_2S]^2}$

(b) $M = \dfrac{\text{moles}}{L}$

$\boxed{i}$ $H_2 : S_2$

$2 : 1$ mole ratio

$\boxed{7.44\times10^{-2}\,mol} : 3.72\times10^{-2}$ mol given

$\dfrac{3.72\times10^{-2}\,mol}{1.25\,L} = .0298\,M$

$[H_2] = \dfrac{7.44\times10^{-2}\,mol}{1.25\,L} = .059\,M$

$\boxed{ii}$ $\dfrac{3.40\,gr\,H_2S}{34\,g/mol} = .100$ mol H_2S initially

$2H_2S \rightleftharpoons 2H_2 + S_2$

$[\,]_i$ .1 mol 0 0

$[\,]_{equ.}$ $.1 - 7.44\times10^{-2}$ mol $\quad 7.44\times10^{-2}$ mol $\quad 3.72\times10^{-2}$ mol

remain $\quad [H_2S]$

$\dfrac{.0256\,mol\,H_2S}{1.25\,L} = .0205\,M$

(c) $K_c = \dfrac{[H_2]^2[S_2]^1}{[H_2S]^2} = \dfrac{(.059\,M)^2(.0298\,M)}{(.0205\,M)^2} = 0.251$

(d) $P_{S_2} = ?$ $\quad PV = nRT \quad P = \dfrac{nRT}{V} = \dfrac{(3.72\times10^{-2}\,mol)(.082\,\frac{atm\cdot L}{mol\cdot K})(483)}{1.25\,L}$

$P_{S_2} = 1.18$ atm

(e) $H_2 + \frac{1}{2}S_2 \rightleftharpoons H_2S \qquad K_c' = \dfrac{1}{\sqrt{K}} = \dfrac{1}{\sqrt{.251}} = 2.00$

Reverse & 1/2 $\longrightarrow$

$\boxed{2001}$ CH. 17 (Solubility EQU: Ksp, common ion effect, ppt)

(a) 10°C 8.9×10^{-5} grams AgCl in 100 mL (.1L) H_2O will dissolve.

$\boxed{i}$ $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

$\boxed{ii}$ $AgCl\ (143\ g\ mol^{-1})$ $\frac{8.9 \times 10^{-5}\ gr}{143\ g\ mol^{-1}} = \frac{6.2 \times 10^{-7}\ mol}{.1L} = 6.2 \times 10^{-6}\ M$ (molar solubility)

$\boxed{iii}$

	$AgCl$	$\rightleftharpoons$	Ag^+	+	Cl^-
[ ]i	6.2×10^{-6}		0		0
[ ]f	0				
[ ]equ			6.2×10^{-6} M		6.2×10^{-6} M

$Ksp = [Ag^+][Cl^-]$

$Ksp = (6.2 \times 10^{-6})(6.2 \times 10^{-6})$

$Ksp = 3.85 \times 10^{-11}$

(b)

$\boxed{i}$ $\cancel{Na}^{+1}Cl^{-1}$

.04M
(60 mL) × .060L
Cl^- .0024 mol

$Pb^{+2}\cancel{(NO_3)}_2^{-1}$

.03M
× .060L (60mL)
.0018 mol Pb^{+2}

$[Cl^-] = \frac{.0024\ mol}{(.06+.06)\ L}$

$[Cl^-] = .02M$

$[Pb^{+2}] = \frac{.0018\ mol}{(.06+.06)\ L}$

$[Pb^{+2}] = .015M$

$PbCl_2 \rightleftharpoons Pb^{+2} + 2Cl^{-1}$

$Ksp = [Pb^{+2}][Cl^{-1}]^2$

$Ksp = 1.6 \times 10^{-5}$ $Qsp = (.015)(.02)^2$

$Ksp > Qsp = 6 \times 10^{-6}$

(No ppt) - unsaturated solution

$\boxed{ii}$ $[Pb^{+2}] = x$

$PbCl_2 \rightleftharpoons Pb^{+2} + 2Cl^{-1}$
x

$\cancel{Na}Cl$
.25 mol
$\frac{.25\ mol}{1L}$
$[Cl^-] = .25$

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

$1.6 \times 10^{-5} = [Pb^{+2}][.25]^2$

$[Pb^{+2}] = 2.56 \times 10^{-4}\ M$

2001

(b) $\boxed{iii}$

$\cancel{\overset{+1}{Na}\overset{-1}{Cl}}$

.1 M

$[Cl^{-1}] = .1\,M$

$\cancel{\overset{+}{Ag}\,\overset{-}{NO_3}}$ $K_{sp} = [Ag^+][Cl^-]$ $[Cl^-] = 1.5 \times 10^{-9}\,M$

.120 M $1.8 \times 10^{-10} = (.120)[Cl^-]$ needed to ppt $AgCl(s)$

$\overset{+2}{Pb}(\overset{-1}{NO_3})_2$ $K_{sp} = [Pb^{+2}][Cl^{-1}]^2$ $[Cl^-] = 1 \times 10^{-2}\,M$

.150 M $1.6 \times 10^{-5} = (.150)[Cl^{-1}]^2$ needed to ppt $PbCl_2(s)$

less amt of Cl^- needed to ppt AgCl ∴ AgCl will ppt 1ST.

2002 CH 16 (weak acid, Ka) CH. 17 (Titration: strong acid / weak base) (Hydrolysis $K_w = K_a \times K_b$)

$$HOBr \rightleftharpoons H^+ + OBr^- \qquad K_a = 2.3 \times 10^{-9}$$

1

(a) $pH = 4.95 \qquad [H^+] = 10^{-pH} = 10^{-4.95} = 1.12 \times 10^{-5}\ M$

(b) $K_a = \dfrac{[H^+][OBr^-]}{[HOBr]} \qquad [H^+] = [OBr^{-1}]$

$$2.3 \times 10^{-9} = \frac{(1.12 \times 10^{-5})(1.12 \times 10^{-5})}{[HOBr]}$$

$[HOBr] = 0.0536\ M$

(c)

i

$Ba(OH)_2$	$HOBr$
.115 M	.146 M
? mL	65 mL

$x = 2$ $(OH)_2$ $\qquad y = 1$ (H)

$x M_A V_A = y M_B V_B$

$(1)(.146M)(65mL) = (2)(.115M) V_B$

$V_B = 41.26$ mL

ii

pH > 7 b/c at equivalence point there will be Hydrolysis of OBr^- to produce OH^-

(strong conj base) $\qquad OBr^- + H_2O \rightleftharpoons HOBr + OH^-$

2002

(d) HOBr $K_a = 2.3 \times 10^{-9}$

.160 M

.125 L (125 mL)

NaOBr ? moles

so that the

* $[H^+] = 5 \times 10^{-9}$ M

$Br + H_2O \rightleftharpoons OBr^- + H_3O^+$

mostly from ionic salt

$$K_a = \frac{[H_3O^+][OBr^-]}{HOBr}$$

$$2.3 \times 10^{-9} = \frac{{}^{*}(5 \times 10^{-9} M)[OBr^{-1}]}{(.160 M)}$$

$$[OBr^{-1}] = 0.074 M$$

$$.074 M \text{ NaOBr} \times .125 L = 9.2 \times 10^{-3} \text{ mole } Na^+OBr^-$$

(e) $\overset{+1}{H}\overset{-2}{O}\overset{+1}{Br}$ $\quad$ $\overset{+1}{H}\overset{+5}{Br}\overset{-2,-2,-2}{O_3}$

weaker bond

Stronger Bond

more O atoms causes more polarity polling H electron away making it easier to ionize $H \rightarrow H^+$

$H \rightarrow Br \rightarrow O$

$$\begin{array}{ccccc} & & O & & \\ & & \uparrow & & \\ H & \rightarrow & Br & \rightarrow & O \\ & & \downarrow & & \\ & & O & & \end{array}$$

2003

(d)

$C_6H_5NH_2$	H^+
.1 M	.1 M
25 mL	25 mL
×	×
2.5 mmol $C_6H_5NH_2$	2.5 mmol H^+

$M_A V_A = M_B V_B$

$(.1 M)(V_A) = (.1 M)(25 mL)$

$$C_6H_5NH_2 + H^+ \longrightarrow C_6H_5NH_3^+$$

$C_6H_5NH_2$	H^+	$C_6H_5NH_3^+$
2.5 mmol	2.5 mmol	0
0	0	2.5 mmol

NO EXCESS
NO LR

$$[C_6H_5NH_3^+] = \frac{2.5\ mmol}{(25 + 25)\ mL} = .05 M$$

Hydrolysis conj acid of a weak base

$$C_6H_5NH_3^+ + H_2O \xrightarrow{} H_3O^+ + C_6H_5NH_2$$

H+

$C_6H_5NH_3^+$	H_3O^+	$C_6H_5NH_2$
.05 M	0	0
.05 − x	x	x
.05		

5% Rule

ACID (Ka)

$K_w = K_a \times K_b$

$$K_a = \frac{K_w}{K_b} = \frac{[H_3O^+][C_6H_5NH_2]}{[C_6H_5NH_3^+]}$$

$$\frac{1 \times 10^{-14}}{4.3 \times 10^{-10}} = \frac{(x)(x)}{.05}$$

$x = [H_3O^+] = 1.16 \times 10^{-6}\ M \rightarrow pH = -\log[H_3O^+]$

$pH = 5.93$

(e) Erythosine (pH < 7)

2003 CH.16 (weak base EQU - K_b) CH.17 (Titration strong acid / weak base ; Hydrolysis $K_w = K_a \times K_b$

$$C_6H_5\ddot{N}H_2 + H_2O \rightleftharpoons C_6H_5NH_3^+ + OH^- \qquad K_b = ?$$

(a) $$K_b = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]}$$

(b) $[C_6H_5NH_2] = .1M$

$pH = 8.85 \rightarrow pOH = 5.18$

$[OH^-] = 10^{-pOH} = 10^{-5.18} = 6.6\times10^{-6}\,M$

$.1M - 6.6\times10^{-6}\,M \approx .1M$

$[OH^-] = [C_6H_5NH_3^+] = 6.6\times10^{-6}\,M$

1:1 mol ratio in equation

$$K_b = \frac{(6.6\times10^{-6})(6.6\times10^{-6})}{(.1)} = 4.3\times10^{-10}$$

(c)

$C_6H_5NH_2$	$+ H\cancel{Cl}$
25 mL	5 mL
$\times$ .1M	.1M
2.5 mmol $C_6H_5NH_2$	.5 mmol H^+

$C_6H_5NH_2 + H^+ \longrightarrow C_6H_5NH_3^+$

$C_6H_5NH_2$	H^+	$C_6H_5NH_3^+$
2.5 mmol	.5 mmol	
~~LR~~ Excess	~~excess~~ LR	
2.0 mmol	.5 mmol	.5 mmol

$C_6H_6NH_2$ $\dfrac{2\text{ mmol}}{(25+5)\text{mL}} = 0.067\,M$

$C_6H_5NH_3^+$ $\dfrac{.5\text{ mmol}}{(25+5)\text{mL}} = 0.0167\,M$

$pH = 5.24$

$pH + pOH = 14$

↑

$pOH = 8.76$

$pOH = -\log[OH^-]$

↑

$C_6H_5NH_2 + H_2O \rightleftharpoons C_6H_5NH_3^+ + OH^-$

0.067 M 0.0167 M x

$$K_h = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]}$$

$$4.3\times10^{-10} = \frac{(.0167)[OH^-]}{[0.67]} \rightarrow [OH^-] = 1.725\times10^{-9}\,M$$

(part "b")

2004

(e) $Ag_3PO_4(s) \rightleftharpoons 3Ag^+(aq) + PO_4^{-3}(aq)$

(f) $[Ag^+] = 5.3 \times 10^{-5}$ M

$[Ag^+]$ to $[PO_4^{-3}]$

3 : 1

$$[PO_4^{-3}] = \frac{5.3 \times 10^{-5} M}{3}$$

$$[PO_4^{-3}] = 1.77 \times 10^{-5} M$$

$$Ksp = [Ag^+]^3[PO_4^{-3}]$$

$$Ksp = (5.3 \times 10^{-5})^3(1.77 \times 10^{-5}) = 2.64 \times 10^{-20}$$

(g) $[\ ] = \frac{\text{moles}}{L}$ if water evaporates there will be less liters of solution thus the $[Ag^+]$ will be greater even though the number of Ag^+ ions does not change.

$\boxed{2004}$

(a) $K_{sp} = [Ag^+]^2[CrO_4^{-2}]^1$

(b) $Ag_2CrO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{-2}(aq)$

	$Ag_2CrO_4(s)$	$2Ag^+(aq)$	$CrO_4^{-2}(aq)$
I	x	0	0
F	0	–	–
E		2x	x

$K_{sp} = (2x)^2(x)$ $\quad 2.6 \times 10^{-12} = 4x^3$

$x = 9.51 \times 10^{-5}$

$[Ag^{+2}] = 2x = 2(9.5 \times 10^{-5}) = 1.90 \times 10^{-4}$ mol L^{-1}

(c) $\boxed{Ag_2CrO_4} = x = 9.51 \times 10^{-5} \frac{mol}{L}$

$\downarrow$

332 g mol^{-1}

(100mL)

$9.51 \times 10^{-5} \frac{mol}{L} \times .1L = 1.90 \times 10^{-5}$ mol

1.90×10^{-5} mol $\times$ 332 g mol^{-1} = 6.3×10^{-3} g $Ag_2CrO_4(s)$

(d)

$Ag_2CrO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{-2}(aq)$

$\overset{+}{Ag}\overset{-}{NO_3} \longrightarrow Ag^+$

Le Chatelier said if something is added to a system that is already in the system the system will shift away to remove what has been added

$\longleftarrow$

thus $[CrO_4^{-2}]$ will decrease.

$\boxed{2005}$ (d) $Na^+ HCO_2^-$

$$\underset{\text{base}}{HCO_2^-} + \underset{\text{acid}}{H_2O} \rightleftharpoons \underset{\text{conj acid}}{HCO_2H} + \underset{\text{conj base}}{OH^-}$$

H^+

I 0.309M

C 1 : 1

(i) E $0.309 - 4.18 \times 10^{-6}$ $\boxed{4.18 \times 10^{-6}}$ (5%) 4.18×10^{-6} M

0.309

$$K_b = \frac{[HCO_2H][OH^-]}{[HCO_2^-]} = \frac{(4.18 \times 10^{-6})(4.18 \times 10^{-6})}{0.309} = 5.65 \times 10^{-11}$$

(ii) $K_w = K_a \times K_b$ $K_a = \frac{K_w}{K_b} = \frac{1 \times 10^{-14}}{5.65 \times 10^{-11}} = 1.77 \times 10^{-4}$

(e) ~~CH_3COOH~~ $HCOOH$ methanoic acid

(see pg. 705) C_2H_5COOH propanoic acid

stronger: easier to oxidize. the H. due to it being alone whereas C_2H_5 would

2005

a) $K_a = \frac{[C_3H_5O_2^-][H^+]}{[HC_3H_5O_2]}$

(b) $HC_3H_5O_2 + H_2O \rightleftharpoons H_3O^+ + C_3H_5O_2^-$

	$HC_3H_5O_2$		H_3O^+	$C_3H_5O_2^-$
I	0.265 M	$\rightarrow$	0	0
C	$-x$		$+x$	$+x$
E	$.265 - x$ (5%)		x	x
	0.265			

$1.34 \times 10^{-5} = \frac{(x)(x)}{2.65 \times 10^{-1}}$

$x = [H_3O^+] = 1.88 \times 10^{-3}$ M

pH $= -\log[H_3O^+]$

pH $= 2.73$

(c) $HC_3H_5O_2 + H_2O \rightleftharpoons H_3O^+ + C_3H_5O_2^-$

	$HC_3H_5O_2$	H_3O^+	$C_3H_5O_2^-$
I	.265	0	0
C	$-x$	$+x$	$+x$
E	$.265 - x$	x	$x + .103$
	.265 M (5%)	x' (5%)	.103 M

$NaC_3H_5O_2 \rightarrow \cancel{Na^+} + C_3H_5O_2^-$

$\frac{.496\text{ g}}{96\text{ g/mol}}$

$\frac{5.17 \times 10^{-3}\text{ mol}}{.050\text{ L}} =$

$.103$ M $[C_3H_5O_2^{-1}]$

[i] x is so small ∴ $[C_3H_5O_2^{-1}] = 0.103$ M

(ii) $1.34 \times 10^{-5} = \frac{(x')(.103)}{(.265)}$

$x' = [H_3O^+] = 3.44 \times 10^{-5}$ M

pH $= -\log[H_3O^+]$

pH $= 4.46$.

2006

1a (i) $\boxed{Ksp = [Pb^{+2}][I^-]^2}$

(ii) $PbI_2(s) \rightleftharpoons Pb^{+2} + 2I^-$ $[Pb^{+2}]$ to $[I^-]$ 1 : 2

I

F

E $1.3 \times 10^{-3} M$?

$[I^-] = 2(1.3 \times 10^{-3})$

$\boxed{[I^-] = 2.6 \times 10^{-3} M}$

(iii) $Ksp = (1.3 \times 10^{-3})(2.6 \times 10^{-3})^2$

$\boxed{Ksp = 8.79 \times 10^{-9}}$

(b) In part "a" 1 Liter of solution was made. In this part 2 Liters of solution is made. There maybe more ions (Pb^{+2} and I^-) but its in 2.0L. The molar concentrations will not change from that in a 1.0 Liter solution.

(c) $PbI_2(s) \rightleftharpoons Pb^{+2}(aq) + 2I^-(aq)$ | Adding $\cancel{Na^+}I^-$

$\leftarrow$ I^-

The Qsp value will be larger than the Ksp value. According to leChatelier, a system will shift in a direction to remove as much as possible what was added. system ~~so~~ shifts left thus decreasing $[Pb^{+2}]$.

(d) Comparing Ksp to Qsp

$BaSO_4(s)$ $Ksp = 1.2 \times 10^{-10}$

$Ksp = [Ba^{+2}][CrO_4^{-2}] = Qsp$

$Ba^{+2}(\cancel{NO_3})_2$ $\cancel{Na_2}CrO_4^{-2}$

$8.2 \times 10^{-6} M$ $8.2 \times 10^{-6} M$

$\times$ .500L $\times$ .500L

4.1×10^{-6} mol Ba^{+2} 4.1×10^{-6} mol CrO_4^{-2}

— convert back to Molarity —

$(4.1 \times 10^{-6})(4.1 \times 10^{-6}) = Qsp$

1.68×10^{-11} Qsp

$Ksp > Qsp$ (No ppt)

$\frac{4.1 \times 10^{-6} \text{ mol}}{(.5 + .5)L}$ $\frac{4.1 \times 10^{-6} \text{ mol}}{(.5 + .5)L}$

$[Ba^{+2}] = 4.1 \times 10^{-6} M$ $[CrO_4^{-2}] = 4.1 \times 10^{-6} M$

$\boxed{2006}$

1a (i) $\boxed{K_{sp} = [Pb^{+2}][I^-]^2}$

(ii) $PbI_2(s) \rightleftharpoons Pb^{+2} + 2I^-$ $[Pb^{+2}]$ to $[I^-]$

1 : 2

I

F

E $1.3 \times 10^{-3} M$?

$[I^-] = 2(1.3 \times 10^{-3})$

$\boxed{[I^-] = 2.6 \times 10^{-3} M}$

(iii) $K_{sp} = (1.3 \times 10^{-3})(2.6 \times 10^{-3})^2$

$\boxed{K_{sp} = 8.79 \times 10^{-9}}$

(b) In part "a" 1 Liter of solution was made. In this part 2 Liters of solution is made. There maybe more ions (Pb^{+2} and I^-) but its in 2.0L. The molar concentrations will not change from that in a 1.0 Liter solution.

(c) $PbI_2(s) \rightleftharpoons Pb^{+2}(aq) + 2I^-(aq)$ | Adding $\cancel{Na^+}I^-$

$\leftarrow$ I^-

The Qsp value will be larger than the Ksp value. According to leChatelier, a system will shift in a direction to remove as much as possible what was added. System ~~so~~ shifts left thus decreasing $[Pb^{+2}]$.

2007

(a) $K_a = \frac{[H_3O^+][F^-]}{[HF]}$ $K_a = 7.2 \times 10^{-4}$

(b)

	$HF + H_2O \rightleftharpoons$	H_3O^+	$+ F^-$
I	.40 M $\rightarrow$	0	0
C	$-x$	$+x$	$+x$
E	$.40 - x$ (5%)	x	x
	.40		

$7.2 \times 10^{-4} = \frac{(x)(x)}{4 \times 10^{-1}}$

$x = 1.70 \times 10^{-2}$

$[H_3O^+] = 1.70 \times 10^{-2}$ M

(c)

HF	$Na^+ OH^-$
0.40M	0.40M
~~25 mL~~	~~15 mL~~
× 0.025 L	× 0.015 L
0.01 mol HF	0.006 mol OH^-

Excess Limiting

	HF	$+ OH^- \longrightarrow$	$H_2O + F^-$
I	.01 mol	.006 mol	
F	.004 mol	0	.006 mol

0.004 mol HF remain (Excess)

(d) $[F^-] = \frac{.006 \text{ mol}}{(.025 + .015) L} = 0.15M$

e) weak base $\overset{H^+}{\curvearrowleft}$

	$F^- + H_2O \rightleftharpoons$	HF	$+ OH^-$
I	0.15M	0	0
C	$-x$	$+x$	$+x$
E	$0.15 - x$ (5%)	x	x
	0.15		

$K_b = K_h = \frac{K_w}{K_a} = \frac{[HF][OH^-]}{[F^-]}$

$\frac{1 \times 10^{-14}}{7.2 \times 10^{-4}} = \frac{(x)(x)}{1.5 \times 10^{-1}}$

$x = 1.45 \times 10 - 6$

$x = [OH^-] = 1.45 \times 10^{-6}$ M

pOH = 5.83

pH = 8.16.

2008 $C(s) + CO_2(g) \rightleftharpoons 2\,CO(g)$ 1160K 2.0L

$C(s)$ excess $CO_2(g)$ limiting

a) $$K_p = \frac{(P_{CO})^2}{P_{CO_2}}$$

b) $pV = nRT$ $t = 0$

$$n = \frac{pV}{RT} = \frac{(5)(2)}{(.082)(1160)}$$

$P = 5$ atm $V = 2$ L
$R = .082$ atm$\cdot$L mol^{-1} K^{-1}
$T = 1160$ K

$n_{CO_2} = 0.105$ mol $CO_2(g)$

$CO_2 : CO$ 1:2 mol ratio

$n_{CO} = 2(.105)$
0.210 mol

c) $$P_{CO_2} = \frac{n_{CO_2}}{n_{CO_2} + n_{CO}} P_T$$

(i) $$\boxed{1.63 \text{ atm} = \frac{.105}{.105 + .210} P_T}$$

.315

.33

use mole fraction to find total pressure

$P_T = 4.93$ atm

Dalton's formula $\boxed{P_T = P_{CO_2} + P_{CO}}$

4.93 atm = 1.63 atm + P_{CO}

$P_{CO} = 3.31$ atm.

(ii) $$K_p = \frac{(P_{CO})^2}{P_{CO_2}} = \frac{(3.31)^2}{1.63} = 6.72$$

2009

HOCl ($Ka = 2.9 \times 10^{-8}$) HOBr ($Ka = 2.4 \times 10^{-9}$)

(a) (i) HOCl is the stronger acid, it's Ka value is larger indicating a larger numerator in it's equilibrium expression of which $[H_3O^+]$ is located indicating a higher concentration of H_3O^+ than for HOBr.

(ii) $\boxed{HOCl}$ $H - \ddot{\underset{..}{O}} - \ddot{\underset{..}{Cl}}:$

I VI VII

14ē

(iii) HOI would be weaker. The trend from the given ka values and "I" being below "Br" on the periodic Table (Group VII) would indicate HOI Ka < 2.4×10^{-9}.

(b) $HOCl(aq) + H_2O(l) \rightleftharpoons H_3O^+ + OCl^-(aq)$

(c) (i) $OCl^{-1}(aq) + H_2O(l) \rightleftharpoons HOCl(aq) + OCl^{-1}(aq)$

(ii) $K_h = K_b = \frac{Kw}{Ka} = \frac{1 \times 10^{-14}}{2.9 \times 10^{-8}} = 3.45 \times 10^{-7}$

(iii)

	OCl^{-1}	+ H_2O ⇌	HOCl	+ OCl^{-1}
I	1.2M	–	0	0
C	– x		+ x	+ x
E	1.2 – x 1.2	(5% Rule)	x	x

$\frac{Kw}{Ka} = \frac{[HOCl][OCl^-]}{[OCl^-]}$

$\frac{1.0 \times 10^{-14}}{2.9 \times 10^{-8}} = \frac{(x)(x)}{1.2}$

$X = [OH^-] = 6.43 \times 10^{-4} M$

(d) NaOCl (s) HOCl (aq) $pH_{Buffer} = 6.48$

(i) $[H_3O^+] = 10^{-6.48} = 3.31 \times 10^{-7} M$

(ii) (I) $HOCl + H_2O \rightleftharpoons H_3O^+ + OCl^-$

(II) $OCl^- + H_2O \rightleftharpoons HOCl + OH^-$

Being that the pH of the Buffer is below 7 (6.48) indicates slightly more H_3O^+ than OH^-. This would indicate equation II would be more appropriate, therefore, the OCl^{-1} would have a higher concentration than HOCl.

2010

1. AgBr $K_{sp} = 5.0 \times 10^{-13}$ 298K

$AgBr(s) \rightleftharpoons Ag^+(aq) + Br^-(aq)$

	$AgBr(s)$	$Ag^+(aq)$	$Br^-(aq)$
I	x	0	0
F	0	—	—
C	—	+x	+x
E	—	x	x

a) $K_{sp} = [Ag^+][Br^-]$

b)

$$\frac{3.53 \times 10^{-8}\ mol}{0.050L}$$

$7.07 \times 10^{-7}\ M$

Molarity is the same regardless of the volume 1L (1000mL) or 0.050L (50mL)

$5.0 \times 10^{-13} = (x)(x)$

$x = 7.07 \times 10^{-7}$

$[AgBr] : [Ag^+] = 7.07 \times 10^{-7}\ M$

$$\frac{7.07 \times 10^{-7}\ mol}{1L} \times .050L$$

$[Ag^+] = 3.53 \times 10^{-8}\ mol\ Ag^+ / 50mL$

c) If more H_2O were added the more $AgBr(s)$ will be dissolved and dissociated (Not a large amount) therefore the $[Ag^+]$ would increase slightly.

d) AgBr
$187\ g\,mol^{-1}$

$$\frac{5g}{} \bigg| \frac{1mol}{187g} = 0.027\ mol\ AgBr$$

$$x\ L\ H_2O = 0.027\ mol\ AgBr \bigg| \frac{1\ L\ sol'n}{7.07 \times 10^{-7}\ mol\ AgBr}$$

$3.8 \times 10^{4}\ L$ of sol'n which is essentially all H_2O.

e) $\overset{+1}{AgNO_3}$ $\overset{-}{NaBr}$ ⇨

	$AgNO_3$	$NaBr$
	10mL	2mL
	0.010L	0.002L
	$\times\ 1.5 \times 10^{-4}\ M$	$\times\ 5 \times 10^{-4}\ M$
	$1.5 \times 10^{-6}\ mol\ Ag^+$	$1 \times 10^{-6}\ mol\ Br^{-1}$
Total vol.	$\frac{1.5 \times 10^{-6}\ mol}{.012L}$	$\frac{1 \times 10^{-6}\ mol}{0.12L}$
	$1.25 \times 10^{-4}\ M$	$8.33 \times 10^{-5}\ M$
	$[Ag^+]$	$[Br^-]$

$AgBr(s) \rightleftharpoons Ag^+(aq) + Br^-(aq)$

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

5×10^{-13} $(1.25 \times 10^{-4})8.33 \times 10^{-5} = Q_{sp}$

5×10^{-13} $1.04 \times 10^{-8} = Q_{sp}$

$Q_{sp} > K_{sp}$

ppt will occur AgBr(s)