CHEM1128- EXAM 2 REVIEW

By Q-Center

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1. Calculate the solubility (in g/L) of CaF_2 in water from the known solubility product constant (3.4×10^{-11}).

Given, $CaF_2 (s) \rightleftharpoons Ca^{2+}(aq) + 2F^-(aq)$

	CaF_2	Ca^{2+}	$2F^-$
I	X	0	0
C		+s	+2s
E		s	2s

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

$$K_{sp} = [s][2s]^2$$

$$3.4 \times 10^{-11} = 4s^3$$

$\Rightarrow s = 2.0 \times 10^{-4}$ mol of CaF_2 in 1 L of solution.

In g/L $\Rightarrow s = 2.0 \times 10^{-4} \frac{mol}{L} \times \frac{78.07\ g}{1\ mol\ CaF_2}$

$$\boxed{s = 0.0156\ g/L}$$

2. The measured solubility of MgF_2 at 25ºC is 2.6 X 10^{-4} mol/L. Calculate the K_{sp} for MgF_2.

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

2.6×10^{-4} mol of MgF_2 dissolves.

1 mol MgF_2 splits to give 1 mol Mg^{2+} and 2 mol F^-.

Equilibrium concentration, $[Mg^{2+}] = 2.6 \times 10^{-4}$ M

$[F^-] = 2 \times (2.6 \times 10^{-4})$

$= 5.2 \times 10^{-4}$ M

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

$= [2.6 \times 10^{-4}][5.2 \times 10^{-4}]^2 = \boxed{7.0 \times 10^{-11}}$

3. How many grams of Silver Chromate can you dissolve in water to make one liter of solution? (K_{sp} = 1 X 10^{-12})

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

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

If solubility of $Ag_2CrO_4 = s$, then it forms 2s moles of Ag^+ and s moles of CrO_4^{2-}.

$$K_{sp} = [2s]^2 [s]$$
$$1 \times 10^{-12} = 4s^3$$
$$\boxed{6 \times 10^{-5} M = s}$$

This means that 6×10^{-5} moles of Ag_2CrO_4 can be dissolved in enough water to make one liter of solution.

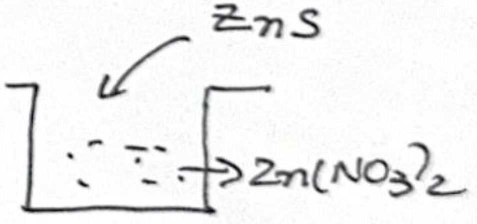
$$\frac{6 \times 10^{-5} mol}{1L} \times \frac{331.7 g\ Ag_2CrO_4}{1 mol\ Ag_2CrO_4} = \frac{2 \times 10^{-2} g\ Ag_2CrO_4}{1L}$$

4. What mass of ZnS (K_{sp} = 2.5 X 10^{-22}) will dissolve in 300mL of 0.050M $Zn(NO_3)_2$?

Solu:

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

	$Zn(NO_3)_2$	$Zn^{2+}(aq)$	$2NO_3^-(aq)$
Initial:	0.05M	0	0
final:	0	0.05M	0.05 x 2 = 0.10M



$$ZnS(s) \rightleftharpoons Zn^{2+}(aq) + S^{2-}(aq)$$

		$Zn^{2+}(aq)$	$S^{2-}(aq)$
(I)		0.05M	0
(C)		s	s
(E)		0.05+s	s

$$K_{sp} = [Zn^{2+}][S^{2-}] = (0.05+\cancel{s})(s) = 2.5 \times 10^{-22} \text{ mol/L}$$

5. A solution containing 0.020M Fluoride ions is added to a solution in which the original concentration of Barium ions is 1.0×10^{-4} M.

a) Will a precipitate form?

Solu^n: (a)

$$BaF_{2(s)} \rightleftharpoons Ba^{2+}(aq) + 2F^{-}(aq)$$

$$Q = [Ba^{2+}][F^{-}]^2$$

$$Q = [1 \times 10^{-4}][2 \times 10^{-2}]^2 = 4.0 \times 10^{-8}$$

$$K_{sp} = 1.8 \times 10^{-7}$$

Since, $K_{sp} > Q \Rightarrow$ **No precipitation.**

5. A solution containing 0.020M Fluoride ions is added to a solution in which the original concentration of Barium ions is 1.0×10^{-4} M.

b)What concentration of Fluoride ion is needed to get the saturated solution?

Solu^{n}: Saturated solution ⇒ $Q = K_{sp}$

We calculate $[F^-]$ in the Ksp expression by substituting values for the Ksp of BaF_2 and writing in the original $[Ba^{2+}]$ as equilibrium concentration.

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

$$1.8 \times 10^{-7} = (1.0 \times 10^{-4})[F^-]^2$$

$$[F^-]^2 = 1.8 \times 10^{-7} / 1.0 \times 10^{-4})$$

$$[F^-] = 4.2 \times 10^{-2} M$$

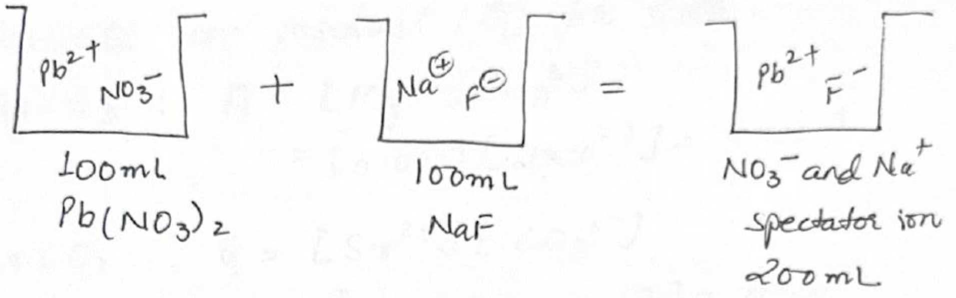
If the initial $[F^-] = 4.2 \times 10^{-2}$ and initial $[Ba^{2+}] = 1.0 \times 10^{-4}$ we get the saturated solution.

5. A solution containing 0.020M Fluoride ions is added to a solution in which the original concentration of Barium ions is 1.0×10^{-4} M.

c)What concentration of Fluoride ion gives a precipitate?

Sol^{n}: Any solution with $[F^-] > 4.2 \times 10^{-2}$ M gives ppt.
Because then $Q > K_{sp}$.

6. A solution is prepared by mixing 100mL of 1.0 X 10^{-2}M $Pb(NO_3)_2$ and 100mL of 1.0 X 10^{-3}M NaF. Will PbF_2 (s) precipitate (K_{sp} = 4 X 10^{-8})?



$$PbF_2(s) \rightleftharpoons Pb^{2+}(aq) + 2F^-(aq)$$

Initial Concentration

$$[F^-] = 0.100\,L \times \frac{1.0\times10^{-3}\,mol}{1\,L} \times \frac{1}{0.200\,L} = 5.0\times10^{-4}\,M$$

(final volume)

$$[Pb^{2+}] = 0.100\,L \times \frac{1.0\times10^{-2}\,mol}{1\,L} \times \frac{1}{0.200\,L} = 5.0\times10^{-3}\,M$$

$$Q = [Pb^{2+}][F^-]^2$$

$$= [5.0\times10^{-3}][5.0\times10^{-4}]^2$$

$$Q = 1.3\times10^{-9}$$

$$K_{sp} = 4\times10^{-8}$$

$\because K_{sp} > Q \Rightarrow$ NO precipitate.

7. A solution contains 0.02M Mg^{2+} and 0.02 M Sr^{2+}. Sufficient carbonate is added so that the carbonate ion concentration is 2 X 10^{-7}M. Will a precipitate form and so, what is it?

Solu^n^: Calculate ion product (Q) for both.

$MgCO_3$: $Q = [Mg^{2+}][CO_3^{2-}]$

$= [0.02][2\times10^{-7}] = 4\times10^{-9}$

$SrCO_3$: $Q = [Sr^{2+}][CO_3^{2-}]$

$= [0.02][2\times10^{-7}] = 4\times10^{-9}$

$K_{sp}(MgCO_3) = 6.8\times10^{-6} > Q_{(MgCO_3)} = 4\times10^{-9}$

NO PPT

$K_{sp}(SrCO_3) = 5.6\times10^{-10} < Q(SrCO_3) = 4\times10^{-9}$

PPT

8. A solution consists of 0.10 M $MgCl_2$ and 0.10 M $ZnCl_2$. To separate the two cations from each other, solid NaOH is added. The volume of the solution does not change. Which salt will precipitate?

Solnⁿ:

$Mg(OH)_2 = Mg^{2+} + 2OH^-$

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

$6 \times 10^{-12} = [0.10][OH^-]^2$

$8 \times 10^{-6} = [OH^-]$

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

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

$4 \times 10^{-17} = [0.1][OH^-]^2$

$[OH^-] = 2 \times 10^{-8}$

Small amount of NaOH is required to precipitate Zn^{2+}.

So, $Zn(OH)_2$ precipitates first.

9. Write the overall equation equation and calculate K for the reaction in which $Ca(OH)_2$. is dissolved in HNO_3. $K_{sp} = 4 \times 10^{-6}$ and $K_w = 1 \times 10^{-14}$.

Solution:

① — $Ca(OH)_2 (s) \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$ $K_{sp} = K_1$

② – flip and double it (multiply by 2)

$2H^+(aq) + 2OH^-(aq) \rightleftharpoons 2H_2O(l)$ $\left(\frac{1}{K_w}\right)^2 = K_2$

Add ① and ②,

$Ca(OH)_2 (s) + 2H^+(aq) \rightleftharpoons 2H_2O + Ca^{2+}(aq)$

$K = K_1 * K_2$

$= K_{sp} * \left(\frac{1}{K_w}\right)^2$

$= (4 \times 10^{-6}) \left(\frac{1}{1 \times 10^{-14}}\right)^2$

$K = 4.0 \times 10^{22}$

10. Cadmium(II) oxalate, CdC_2O_4 has a K_{sp} = 1.5 X 10^{-8}. Cadmium ions readily combine with ammonia to form the complex ion $Cd(NH_3)^{2+}$ (K_f = 2.8 X 10^7). Calculate the molar solubility of CdC_2O_4 in 0.010 M NH_3.

Solution:

$$CdC_2O_4(s) \rightleftharpoons Cd^{2+}(aq) + C_2O_4^{2-}(aq)$$

$$Cd^{2+}(aq) + 4NH_3(aq) \rightleftharpoons Cd(NH_3)_4^{2+}(aq)$$

$$CdC_2O_4(s) + 4NH_3(aq) \rightleftharpoons Cd(NH_3)_4^{2+}(aq) + C_2O_4^{2-}(aq)$$

$$K = \frac{[Cd(NH_3)_4^{2+}][C_2O_4^{2-}]}{[NH_3]^4}$$

$$K = K_f * K_{sp} = (2.8\times10^{7})(1.5\times10^{-8})$$

$$\boxed{K = 0.42}$$

For 1 mol CdC_2O_4 ≡ 1 mol $C_2O_4^{2-}$ ≡ 1 mol of $Cd(NH_3)_4^{2+}$ are formed.

$$s = [C_2O_4^{2-}] = [Cd(NH_3)_4^{2+}]$$

$$0.42 = \frac{(s)(s)}{(0.010)^4}$$

$$s = 6.5\times10^{-5}\,M$$

1. Calculate the $[H^+]$ and the pH of a 0.25M solution of HNO_3.

$$HNO_3 \longrightarrow H^+_{(aq)} + NO_3^-{}_{(aq)}$$

(strong acid)

0·25M   0·25M   0·25M

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

$$= -\log[0{\cdot}25] = \boxed{0{\cdot}602}$$

2. Calculate the pH of a solution prepared by dissolving 2.08g KOH in enough water to make 500mL solution.

$$\text{Molarity of KOH} = \frac{2.08\,g\ KOH}{0.5000\,L} \times \frac{1\,mol\ KOH}{56.1\,g\ KOH} = 0.0742\,M$$

$$\underset{0.0742M}{KOH}\ (\text{strong base}) \longrightarrow \underset{0.0742M}{K^+} + \underset{0.0742M}{OH^-}$$

$$pOH = -\log[OH^-] = -\log(0.0742) = 1.130$$

$$pH = 14.000 - 1.130 = \boxed{12.870}$$

3. A solution of $HClO_2$ is prepared by dissolving 1.369g $HClO_2$ in enough water to make 100mL of solution. The pH of the resulting solution is 1.36.

a) Write the reaction for ionization of $HClO_2$.

$$HClO_2(aq) \rightleftharpoons H^+(aq) + ClO_2^-(aq)$$

b) Write the expression for K_a.

$$K_a = \frac{[H^+][ClO_2^-]}{[HClO_2]}$$

3. A solution of $HClO_2$ is prepared by dissolving 1.369g $HClO_2$ in enough water to make 100mL of solution. The pH of the resulting solution is 1.36.

c) Calculate K_a.

Solu^n: Molar mass of $HClO_2$ = 68.46 g/mol

mass of $HClO_2$ = ~~68.46g~~ 1.369g

moles = $1.369\,g \times \frac{1\,mol}{68.46\,g/mol}$ = 0.02000 mol

Concentration (mol/L) = $\frac{0.02000}{0.1000}$ = 0.2000M

$[HClO_2]_0$ = 0.2000M

$pH = -\log[H^+] \Rightarrow [H^+]_{eq} = 10^{-1.36} = 0.044M$

	$HClO_2$ ⇌	H^+ +	ClO_2^-
$[\,]_0$	0.2000	0	0
Change	−0.044	+0.044	+0.044
$[\,]_{eq}$	0.156	0.044	0.044

$$K_a = \frac{[H^+][ClO_2^-]}{[HClO_2]} = \frac{[0.044][0.044]}{0.156}$$

$$\boxed{K_a = 0.012}$$

4. A 0.300M aqueous solution of Benzoic acid ($HC_7H_5O_2$) is 1.47% ionized.

a) Write the equation for the ionization.

$$HC_7H_5O_2\,(aq) \rightleftharpoons H^+(aq) + C_7H_5O_2^-\,(aq)$$

b) K_a expression for the ionization.

$$K_a = \frac{[H^+][C_7H_5O_2^-]}{[HC_7H_5O_2]}$$

4. A 0.300M aqueous solution of Benzoic acid ($HC_7H_5O_2$) is 1.47% ionized.
c) Calculate K_a for the ionization.

Soln: 1.47% ionization ⇒ 1.47% of $HC_7H_5O_2$ has been ionized.

1.47% of 0.300M = $0.3 \times 1.47/100$ = 0.00441M

1 mol Benzoic acid ≡ 1 mol H^+ ≡ 1 mol benzoate ion

$\Delta[HC_7H_5O_2] = \Delta[H^+] = \Delta[C_7H_5O_2^-] = 0.0044M$

Table:

	$HC_7H_5O_2$ ⇌	H^+	+ $C_7H_5O_2^-$
$[\ ]_0$	0.3000	0	0
Change	−0.00441	+0.00441	+0.00441
$[\ ]_{eq}$	0.2956	0.00441	0.00441

$$K_a = \frac{(0.00441)(0.00441)}{0.2956} = \boxed{6.58 \times 10^{-5}}$$

5. Hydroxylamine ionizes in water according to the rxn.

$HONH_2(aq) + H_2O \longleftrightarrow OH^-(aq) + HONH_3^+(aq)$ $K_b = 9.1 \times 10^{-9}$

Calculate the [OH-] and pH of one-liter solution containing 0.20M Hydroxylamine.

Soln:

	$HONH_2$ + H_2O ⇌	OH^-	+ $HONH_3^+$
$[\ ]_0$	0.2	0	0
Change	$-x$	$+x$	$+x$
$[\ ]_{eq}$	$0.2-x$	x	x

$$K_b = \frac{[OH^-][HONH_3^+]}{[HONH_2]}$$

$$9.1 \times 10^{-9} = \frac{(x)(x)}{0.20-x}$$ Ignore $-x$

$$9.1 \times 10^{-9} = \frac{x^2}{0.2}$$

$$x = 4.3 \times 10^{-5} = [OH^-]$$

$$pOH = -\log[OH^-] = -\log[4.3 \times 10^{-5}] = 4.37$$

$$pH = 14 - pOH = 14 - 4.37 = \boxed{9.63}$$

6. Consider Sodium hypochlorite (NaOCl), household bleach. The OCl^- has $K_b = 3.6 \times 10^{-7}$. A solution is prepared by dissolving 12.0g of NaOCl (m.m= 74.45g/mol) is enough water to make 835mL of solution.

a) What is the pH of the solution?

Solu^n (a) $[\ ]_0$ NaOCl $= \frac{12.0g}{0.835L} \times \frac{1 mol}{74.45g} = 0.193M$

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

	OCl^-	$HOCl$	OH^-
Initial	0.193	0	0
Change	$-x$	$+x$	$+x$
final	$0.193-x$	x	x

$K_b = \frac{[OH^-][HOCl]}{[OCl^-]} \Rightarrow 3.6 \times 10^{-7} = \frac{(x)(x)}{0.193-x}$

Ignore $(-x)$, so, $x = 2.6 \times 10^{-4} M = [OH^-]$

$[H^+] = \frac{1 \times 10^{-14}}{2.6 \times 10^{-4}} = 3.9 \times 10^{-11}$

pH = 10.41

6. Consider Sodium hypochlorite (NaOCl), household bleach. The OCl^- has $K_b = 3.6 \times 10^{-7}$. A solution is prepared by dissolving 12.0g of NaOCl (m.m= 74.45g/mol) is enough water to make 835mL of solution.

b) Household bleach is 5.25% NaOCl by mass. Assuming that its density is 1.00g/mL is household bleach more alkaline than the prepared solution?

(b) Assuming 100g of bleach; we have 5.25g NaOCl in ~~100g~~

100 mL solution.

$$[NaOCl] = [OCl^-] = \frac{5.25g}{0.100L} \times \frac{1\,mol}{74.45g} = 0.705M$$

$$K_b = \frac{[HOCl][OH^-]}{[OCl^-]} \Rightarrow x = 5.0 \times 10^{-4}$$

~~% ionization~~ $[H^+] = \frac{1 \times 10^{-14}}{5 \times 10^{-4}} = 2.0 \times 10^{-11} \Rightarrow$ $\boxed{pH = 10.70}$

BLEACH IS MORE ALKALINE

7. Suppose that you want to prepare an $H_2PO_4^-$ - HPO_4^{2-} buffer with a pH of 7. Taking the K_a of $H_2PO_4^-$ to be $6.2X10^{-8}$, how many grams of NaH_2PO_4 and Na_2HPO_4 should you add to water to make this buffer?

Solⁿ: $[H^+] = 10^{-7} = 1.0 \times 10^{-7}$ M

$H_2PO_4^- \rightleftharpoons H^+(aq) + HPO_4^{2-}(aq)$

$$K_a = \frac{[H^+][HPO_4^{2-}]}{[H_2PO_4^-]}$$

$$\frac{[H_2PO_4^-]}{[HPO_4^{2-}]} = \frac{[H^+]}{K_a} = \frac{1.0\times10^{-7}}{6.2\times10^{-8}} = 1.6$$

for every mole of weak base (HPO_4^{2-}), we need 1.6 mol of weak acid ($H_2PO_4^-$)

mass of Na_2HPO_4 = 1 mol × $\frac{142 g}{1 mol}$ = 1.4×10^2 g

∵ We need 1.6 mol weak acid, ~~so~~ we also need 1.6 mol NaH_2PO_4.

mass NaH_2PO_4 = 1.6 mol × $\frac{120 g}{1 mol}$ = 1.9×10^2 g

For buffer of pH = 7 ⇒ Dissolve 1.4×10^2 g Na_2HPO_4 and 1.9×10^2 g of NaH_2PO_4.

Dosen't matter how much water you use.