CHM 1046 - JOENS WORKSHEET #10 Due date: M,W,F Wednesday, November 2
T,R Thursday, November 3

* While I prefer you turn in a hard copy of the worksheet, I will accept scanned copies sent to my email address, joensj@fiu.edu

Section: (circle one) M,W,F Tu,Tr

For problems involving calculations you must show your work for credit. Unless otherwise stated, you may assume T = 25.0 °C.

1) A chemist has the following two solutions

Solution A 0.0428 M HCl (a strong acid)
Solution B 0.1425 M KOH (a strong soluble base)

a) What are the values for pH for solution A and solution B?

The reactions are $HCl(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + Cl^-(aq)$

$KOH(s) \rightarrow K^+(aq) + OH^-(aq)$

For solution A $[H_3O^+] = [HCl] = 0.0428$ M $pH = -\log_{10}(0.0428) = 1.37$

For solution B $[OH^-] = [KOH] = 0.1425$ M $pOH = -\log_{10}(0.1425) = 0.85$

$pH = 14.00 - pOH = 14.00 - 0.85 = 13.15$

b) A new solution, solution C, is formed by combining 10.00 mL of solution A with 15.00 mL of solution B. What is the pH for solution C?

The reaction taking place when we add solutions A and B together is

$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(\ell)$

$$\text{moles HCl} = 0.01000 \text{ L soln } \frac{0.0428 \text{ mol HCl}}{\text{L}} = 4.28 \times 10^{-4} \text{ mol HCl}$$

$$\text{moles KOH} = 0.01500 \text{ L soln } \frac{0.1425 \text{ mol KOH}}{\text{L}} = 2.138 \times 10^{-3} \text{ mol KOH}$$

Based on the number of moles and the reaction, HCl is the limiting reactant, and KOH is in excess. The number of moles of excess KOH is

moles excess KOH = 2.138×10^{-3} mol – 4.28×10^{-4} mol = 1.71×10^{-3} mol KOH in excess

The volume of the solution is V = 10.00 mL + 15.00 mL = 25.00 mL = 0.02500 L

$$\text{So } [KOH]_{excess} = \frac{1.71 \times 10^{-3} \text{ mol KOH}}{0.02500 \text{ L}} = 0.0684 \text{ M KOH}$$

$pOH = -\log_{10}(0.0684) = 1.16$ $pH = 14.00 - 1.16 = 12.84$

2) Give the correct expressions for K_{sp} for the following slightly soluble ionic compounds in water.

a) CaF_2 (calcium fluoride) $K_{sp} = [Ca^{2+}] [F^-]^2$

$CaF_2(s) \rightarrow Ca^{2+}(aq) + 2 F^-(aq)$

b) Ag_2SO_4 (silver sulfate) $K_{sp} = [Ag^+]^2 [SO_4^{2-}]$

$Ag_2SO_4(s) \rightarrow 2 Ag^+(aq) + SO_4^{2-}(aq)$

3) The solubility product for lead II bromide ($PbBr_2$, MW = 367.0 g/mol) is $K_{sp} = 4.6 \times 10^{-6}$ at T = 25.0 °C.

a) Give the reaction corresponding to $PbBr_2$ dissolving in water, and the corresponding expression for K_{sp}.

$PbBr_2(s) \leftrightarrows Pb^{2+}(aq) + 2 Br^-(aq)$ K_{sp} $[Pb^{2+}] [Br^-]^2$

b) What are the molar solubility and solubility by mass for lead II bromide in pure water?

	Initial	Change	Equiibrium
Pb^{2+}	0	x	x
Br^-	0	2x	2x

$(x) (2x)^2 = 4x^3 = 4.6 \times 10^{-6}$ $x^3 = (4.6 \times 10^{-6})/4 = 1.15 \times 10^{-6}$

$x = (1.15 \times 10{-}6)^{1/3} = 1.05 \times 10^{-2}$

molar solubility = $x = 1.05 \times 10^{-2}$ M

solubility by mass = $1.05 \times 10^{-2} \ \frac{\text{mol}}{\text{L}} \ \frac{367.0 \text{ g}}{\text{mol}} = 3.85$ g/L

c) What are the molar solubility and the solubility by mass for lead II bromide when added to a 0.088 M solution of sodium bromide (NaBr, MW = 102.9 g/mol), a soluble ionic compound?

NaBr is a soluble ionic compound. When added to water it dissociates by the process

$NaBr(s) \rightarrow Na^+(aq) + Br^-(aq)$

Because the solution has [NaBr] = 0.088 M, there is an initial concentration of Br^- ion, $[Br^-]$ = 0.088 M. Other than that, the problem is the same as in part b.

	Initial	Change	Equiibrium
Pb^{2+}	0	x	x
Br^-	0.088	2x	0.088 + 2x

$(x) (0.088 + 2x)^2 = 4.6 \times 10^{-6}$ Assume x << 0.088, then

$x (0.088)^2 = 4.6 \times 10^{-6}$ $x = (4.6 \times 10^{-6})/(0.088)^2 = 5.9 \times 10^{-4}$ The assumption that x << 0.088 was good.

molar solubility = $x = 5.9 \times 10^{-4}$ M

solubility by mass = $5.9 \times 10^{-4} \ \frac{\text{mol}}{\text{L}} \ \frac{367.0 \text{ g}}{\text{mol}} = 0.22$ g/L

4) What is the molar solubility for cadmium hydroxide ($Cd(OH)_2$, MW = 146.4 g/mol) in a pH = 10.00 buffer solution? The solubility product for cadmium hydroxide is $K_{sp} = 2.0 \times 10^{-14}$

The solubility reaction is

$Cd(OH)_2(s) \leftrightarrows Cd^{2+}(aq) + 2\ OH^{-}(aq)$ $\quad K_{sp} = [Cd^{2+}]\,[OH^{-}]^2 = 2.0 \times 10^{-14}$

Normally we would at this point make an ICE table, but since the solution is a buffer solution we can assume the pH is constant.

pH = 10.00 $\quad$ pOH = 14.00 – 10.00 = 4.00 $\quad$ $[OH^{-}] = 10^{-pOH} = 10^{-4.00} = 1.0 \times 10^{-4}$ M

$[Cd^{2+}]\,[OH^{-}]^2 = 2.0 \times 10^{-14}$ $\quad$ $[Cd^{2+}] = \dfrac{2.0 \times 10^{-14}}{[OH^{-}]^2} = \dfrac{2.0 \times 10^{-14}}{(1.0 \times 10^{-4})^2} = 2.0 \times 10^{-6}$ M

Since for every Cd^{2+} ion that forms a $Cd(OH)_2$ must dissociate, the molar solubility is

molar solubility = x = 2.0×10^{-6} M