BCIT
Winter 2016

Chem 0012

Exam #2

Name: _____

Attempt all questions in this exam. Read each question **carefully** and give a complete answer in the space provided.

Part marks given for wrong answers with partially correct reasoning/calculations.

Constants and equations are attached at the back. Data sheets and tables are provided.

Total points = 30

Section I: Multiple choice (*15 points total, 1 point each*)
Choose the **BEST** answer to the following questions.

1. In a solubility equilibrium, the
   a. Rate of dissolving equals the rate of crystallization
   b. Neither dissolving nor crystallization are occurring
   c. Concentration of solute and solvent are always equal
   d. Mass of dissolved solute is greater than the mass of solution

2. Which of the following represents the dissociation equation of a salt in water?
   a. $KCl(s) \rightarrow K^+(aq) + Cl^-(aq)$
   b. $Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$
   c. $HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(\ell)$
   d. $2Na(s) + 2H_2O(\ell) \rightarrow 2NaOH(aq) + H_2(g)$

3. There are 10.0 mL of four solutions. One solution each of 0.10 M Cl^-, 0.10 M Br^-, 0.10 M IO_3^-, and 0.10 M BrO_3^-. Equal moles of $AgNO_3$ are added to each of the four solutions. A precipitate forms in all but one solution. Which solution does not form a precipitate?
   a. 0.10 M Cl^-
   b. 0.10 M Br^-
   c. 0.10 M IO_3^-
   d. 0.10 M BrO_3^-

4. Solid NaCl is added to a saturated AgCl solution. How have $[Ag^+]$ and $[Cl^-]$ changed when equilibrium has been reestablished?

	$[Ag^+]$	$[Cl^-]$
a.	increased	increased
b.	increased	decreased
c.	decreased	increased
d.	decreased	decreased

5. Which of the following expressions represents $[Fe^{3+}]$ in a saturated $Fe(OH)_3$ solution?

   a. $[Fe^{3+}] = \frac{K_{sp}}{3[OH^-]}$

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

   c. $[Fe^{3+}] = \sqrt[3]{\frac{K_{sp}}{[OH^-]}}$

   d. $[Fe^{3+}] = K_{sp}[OH^-]^3$

6. What happens when equal volumes of 0.20 M $BaCl_2$ and 0.20 M $Pb(NO_3)_2$ are mixed?

   (a.) only $PbCl_2$ precipitates

   b. only $Ba(NO_3)_2$ precipitates

   c. both $PbCl_2$ and $Ba(NO_3)_2$ precipitate

   d. no precipitate forms

7. Which of following 1.0 M solutions will have the greatest electrical conductivity?

   (a.) HI

   b. H_2S

   c. HCN

   d. H_3PO_4

8. The relationship $\frac{[H_2P_2O_7{}^{2-}][H_3O^+]}{[H_3P_2O_7{}^-]}$ is the

   (a.) K_a for $H_3P_2O_7{}^-$

   b. K_b for $H_3P_2O_7{}^-$

   c. K_a for $H_2P_2O_7{}^{2-}$

   d. K_b for $H_2P_2O_7{}^{2-}$

9. What is produced when CH_3NH_2 acts as a base in water?

   a. CH_3NH^-

   (b.) $CH_3NH_3{}^+$

   c. $CH_3NH_2{}^+$

   d. $CH_3NH_2{}^-$

10. Which indicator below has $K_a = 1.0x10^{-6}$?

    a. methyl red

    b. phenolphthalein

    c. bromthymol blue

    (d.) chlorophenol red

11. Which of the following salt solutions is neutral?

    (a.) KBr

    b. $FeCl_3$

    c. $Li_2C_2O_4$

    d. $NaHCO_3$

12. Which of the following equations describes the predominant equilibrium that occurs at the equivalence point of a titration between $CH_3COOH(aq)$ and $NaOH(aq)$?

    a. $H^+(aq) + OH^-(aq) \rightleftharpoons H_2O(\ell)$

    (b.) $CH_3COO^-(aq) + H_2O(\ell) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$

    c. $CH_3COOH(aq) + NaOH(aq) \rightleftharpoons NaCH_3COO(aq) + H_2O(\ell)$

    d. $H^+(aq) + CH_3COO^-(aq) + Na^+(aq) + OH^-(aq) \rightleftharpoons Na^+(aq) + CH_3COO^-(aq) + H_2O(\ell)$

13. Consider the following equilibrium, where the concentrations are given below the species:

$HCN(aq)$	+	$H_2O(\ell)$	$\rightleftharpoons$	$H_3O^+(aq)$	+	$CN^-(aq)$
1.0 M				$2.2X10^{-5}$ M		$2.2x10^{-5}$ M

    Why is the above solution not considered to be a true buffer solution?

    a. excessive [HCN]

    b. excessive $[H_3O^+]$

    (c.) insufficient $[CN^-]$

    d. insufficient $[H_3O^+]$

14. What is the oxidation number of iron in magnetite, Fe_3O_4

    a. $+^4/_3$

    b. +2

    (c.) $+^8/_3$

    d. +3

15. Identify the reducing agent in the following reaction:

$$Zn + 2MnO_2 + 2H_2O \rightarrow Zn(OH)_2 + 2MnO(OH)$$

    (a.) Zn

    b. MnO_2

    c. H_2O

    d. $Zn(OH)_2$

Section II: Written problems (*15 points total*).

16. What is the maximum number of moles of Cl^- that can exist in 500.0 mL of 2.0 M $AgNO_3$? (2 points)

Must consider $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$ $\quad K_{sp} = [Ag^+][Cl^-] = 1.8x10^{-10}$

where $[Ag^+] = 2.0$ M from the $AgNO_3$

$$[Cl^-] = \frac{K_{sp}}{[Ag^+]} = \frac{1.8x10^{-10}}{2.0} = 9.0x10^{-11}\ M$$

$n_{Cl^-} = (9.0x10^{-11}\ M)(0.5000\ L) = 4.5x10^{-11}$ mol Cl^-

17. A mixture is prepared by adding 40.8 mL of 0.122 M $Mg(NO_3)_2$ and 31.6 mL of 0.343 M $Sr(OH)_2$. What mass in grams of $Mg(OH)_2$ will be formed and what will be the concentration of each of the ions after the reaction? The molar mass of $Mg(OH)_2$ is 58.3 g/mol. (5 points)

$Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s)$ $\quad K_{sp} = 5.6x10^{-12} = [Mg^{2+}][OH^-]^2$

$$[Mg(NO_3)_2]_0 = \frac{(40.8\ mL)(0.122\ M)}{40.8\ mL + 31.6\ mL} = 0.0688\ M = [Mg^{2+}]_0$$

$$\rightarrow [NO_3^-] = 2(0.0688\ M) = 0.138\ M$$

$$[Sr(OH)_2]_0 = \frac{(31.6\ mL)(0.343\ M)}{40.8\ mL + 31.6\ mL} = 0.150\ M = [Sr^{2+}]$$

$$\rightarrow [OH^-]_0 = 2(0.150\ M) = 0.300\ M$$

	$Mg(OH)_2(s) \rightleftharpoons$	$Mg^{2+}(aq)$ +	$2OH^-(aq)$
I		0.0688	0.300
R		-0.0688	-0.138
C		x	2x
E		x	0.162+2x

$$K_{sp} = 5.6x10^{-12} = [Mg^{2+}]\,[OH^-]^2 = (x)(0.162 + 2x)^2 \approx x(0.162)^2$$

$$x = \frac{5.6x10^{-12}}{(0.162)^2} = 2.1x10^{-10}$$

$$\rightarrow [Mg^{2+}] = 2.1x10^{-10}\ M, \qquad [OH^-] = 0.162 + 2(2.1x10^{-12}) = 0.162\ M$$

$$[NO_3^-] = 0.138\ M, \qquad \left[Sr^{2+}\right] = 0.150\ M$$

$$(0.0724\ L)\left(\frac{0.0688\ mol\ Mg^{2+}}{L}\right)\left(\frac{mol\ Mg(OH)_2}{mol\ Mg^{2+}}\right)\left(\frac{58.3\ g\ Mg(OH)_2}{mol}\right)$$
$$= 0.290\ g\ Mg(OH)_2\ ppt\ out$$

18. What is the pH of a 0.10 M $FeCl_3$ solution? When Fe^{3+} is in water it forms $Fe(H_2O)_6^{3+}$. (4 points)

When $FeCl_3$ is in solution it forms $Fe(H_2O)_6^{3+}$ and Cl^-. Cl^- is neither and acid or base so it will not affect the pH of a solution. But $Fe(H_2O)_6^{3+}$ is a weak acid with $K_a = 6.0x10^{-3}$.

	$Fe(H_2O)_6^{3+}(aq)$	$\rightleftharpoons$	$H^+(aq)$	+	$Fe(H_2O)_5(OH)^{2+}(aq)$
I	0.10		0		0
C	-x		x		x
E	0.10 - x		x		x

$$K_a = \frac{[H^+][Fe(H_2O)_5(OH)^{2+}]}{[Fe(H_2O)_6^{3+}]} = 6.0x10^{-3}$$

$$K_a = 6.0x10^{-3} = \frac{(x)(x)}{(0.10-x)} = \frac{x^2}{(0.10-x)}$$

$$x^2 + 6.0x10^{-3}x - 6.0x10^{-4} = 0$$

$$x = \frac{-6.0x10^{-3} \pm \sqrt{(6.0x10^{-3})^2 - 4(1)(-6.0x10^{-4})}}{2(1)} = 0.0217, -0.0277$$

$$since\ x = [H^+] > 0 \rightarrow x = [H^+] = 0.0217\ M$$

$$pH = -log[H^+] = -log(0.0217) = 1.66$$

19. Balance the following redox reaction in basic solution: (4 points)

$Sb_2S_3 + NO_3^- \rightarrow NO_2 + SO_4^{2-} + Sb_2O_5$

$$Sb_2S_3 + 17\ H_2O \rightarrow 3\ SO_4^{2-} + Sb_2O_5 + 34\ H^+ + 28\ e^-$$

$$28(2\ H^+ + NO_3^- + e^- \rightarrow NO_2 + H_2O)$$

$$Sb_2S_3 + 28\ NO_3^- + 22\ H^+ \rightarrow 3\ SO_4^{2-} + Sb_2O_5 + 28\ NO_2 + 11\ H_2O$$

$$22\ H_2O \rightarrow 22\ H^+ + 22\ OH^-$$

$$Sb_2S_3 + 28\ NO_3^- + 11\ H_2O \rightarrow 3\ SO_4^{2-} + Sb_2O_5 + 28\ NO_2 + 22\ OH^-$$

Equations and Constants

$pH = -\log[H^+]$ $\quad [H^+] = 10^{-pH}$

$pOH = -\log[OH^-]$ $\quad [OH^-] = 10^{-pOH}$

$pH + pOH = 14.00$ at 25°C

$K_w = 1.0 \times 10^{-14}$ at 25°C

$K_w = K_a K_b$

$pX = -\log(X)$ $\quad X = 10^{-pX}$

$$pH = pK_a + \log\left(\frac{[A^-]}{[HA]}\right)$$

The solution to the quadratic equation $ax^2 + bx + c = 0$ is

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$