

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.

- In a solubility equilibrium, the
 - ☒ Rate of dissolving equals the rate of crystallization
 - Neither dissolving nor crystallization are occurring
 - Concentration of solute and solvent are always equal
 - Mass of dissolved solute is greater than the mass of solution
- Which of the following represents the dissociation equation of a salt in water?
 - ☒ $\text{KCl(s)} \rightarrow \text{K}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
 - $\text{Ca}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{CaSO}_4(\text{s})$
 - $\text{HCl}(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{KCl}(\text{aq}) + \text{H}_2\text{O}(\ell)$
 - $2\text{Na(s)} + 2\text{H}_2\text{O}(\ell) \rightarrow 2\text{NaOH}(\text{aq}) + \text{H}_2(\text{g})$
- 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?
 - 0.10 M Cl^-
 - 0.10 M Br^-
 - 0.10 M IO_3^-
 - ☒ 0.10 M BrO_3^-
- Solid NaCl is added to a saturated AgCl solution. How have $[\text{Ag}^+]$ and $[\text{Cl}^-]$ changed when equilibrium has been reestablished?

	$[\text{Ag}^+]$	$[\text{Cl}^-]$
a.	increased	increased
b.	increased	decreased
<input checked="" type="radio"/> 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 $K_a = 1.0 \times 10^{-6}$?

a. methyl red

b. phenolphthalein

c. bromthymol blue

☒ d. chlorophenol red

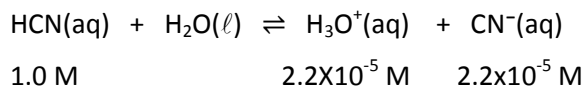
11. Which of the following salt solutions is neutral?

- ☒ a. KBr
- b. FeCl_3
- c. $\text{Li}_2\text{C}_2\text{O}_4$
- d. NaHCO_3

12. Which of the following equations describes the predominant equilibrium that occurs at the equivalence point of a titration between $\text{CH}_3\text{COOH}(\text{aq})$ and $\text{NaOH}(\text{aq})$?

- a. $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightleftharpoons \text{H}_2\text{O}(\ell)$
- ☒ b. $\text{CH}_3\text{COO}^-(\text{aq}) + \text{H}_2\text{O}(\ell) \rightleftharpoons \text{CH}_3\text{COOH}(\text{aq}) + \text{OH}^-(\text{aq})$
- c. $\text{CH}_3\text{COOH}(\text{aq}) + \text{NaOH}(\text{aq}) \rightleftharpoons \text{NaCH}_3\text{COO}(\text{aq}) + \text{H}_2\text{O}(\ell)$
- d. $\text{H}^+(\text{aq}) + \text{CH}_3\text{COO}^-(\text{aq}) + \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightleftharpoons \text{Na}^+(\text{aq}) + \text{CH}_3\text{COO}^-(\text{aq}) + \text{H}_2\text{O}(\ell)$

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



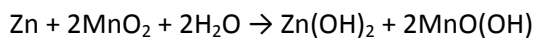
Why is the above solution not considered to be a true buffer solution?

- a. excessive $[\text{HCN}]$
- b. excessive $[\text{H}_3\text{O}^+]$
- ☒ c. insufficient $[\text{CN}^-]$
- d. insufficient $[\text{H}_3\text{O}^+]$

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

- a. $+\frac{4}{3}$
- b. +2
- ☒ c. $+\frac{8}{3}$
- d. +3

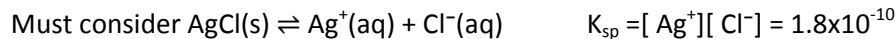
15. Identify the reducing agent in the following reaction:



- ☒ a. Zn
- b. MnO_2
- c. H_2O
- d. $\text{Zn}(\text{OH})_2$

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)

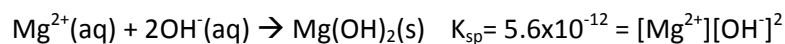


where $[\text{Ag}^+] = 2.0 \text{ M}$ from the AgNO_3

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

$$n_{\text{Cl}^-} = (9.0 \times 10^{-11} \text{ M})(0.5000 \text{ L}) = 4.5 \times 10^{-11} \text{ mol Cl}^-$$

17. A mixture is prepared by adding 40.8 mL of 0.122 M $\text{Mg}(\text{NO}_3)_2$ and 31.6 mL of 0.343 M $\text{Sr}(\text{OH})_2$. What mass in grams of $\text{Mg}(\text{OH})_2$ will be formed and what will be the concentration of each of the ions after the reaction? The molar mass of $\text{Mg}(\text{OH})_2$ is 58.3 g/mol. (5 points)

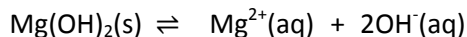


$$[\text{Mg}(\text{NO}_3)_2]_0 = \frac{(40.8 \text{ mL})(0.122 \text{ M})}{40.8 \text{ mL} + 31.6 \text{ mL}} = 0.0688 \text{ M} = [\text{Mg}^{2+}]_0$$

$$\rightarrow [\text{NO}_3^-] = 2(0.0688 \text{ M}) = 0.138 \text{ M}$$

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

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



I	0.0688	0.300
R	-0.0688	-0.138
C	x	2x
E	x	0.162+2x

$$K_{sp} = 5.6 \times 10^{-12} = [\text{Mg}^{2+}][\text{OH}^-]^2 = (x)(0.162 + 2x)^2 \approx x(0.162)^2$$

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

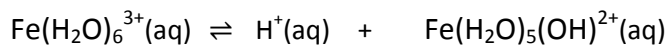
$$\rightarrow [\text{Mg}^{2+}] = 2.1 \times 10^{-10} \text{ M}, \quad [\text{OH}^-] = 0.162 + 2(2.1 \times 10^{-12}) = 0.162 \text{ M}$$

$$[\text{NO}_3^-] = 0.138 \text{ M}, \quad [\text{Sr}^{2+}] = 0.150 \text{ M}$$

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

18. What is the pH of a 0.10 M FeCl_3 solution? When Fe^{3+} is in water it forms $\text{Fe}(\text{H}_2\text{O})_6^{3+}$. (4 points)

When FeCl_3 is in solution it forms $\text{Fe}(\text{H}_2\text{O})_6^{3+}$ and Cl^- . Cl^- is neither an acid or base so it will not affect the pH of a solution. But $\text{Fe}(\text{H}_2\text{O})_6^{3+}$ is a weak acid with $K_a = 6.0 \times 10^{-3}$.



I	0.10	0	0
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C	-x	x	x
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E	0.10 - x	x	x
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$$K_a = \frac{[\text{H}^+][\text{Fe}(\text{H}_2\text{O})_5(\text{OH})^{2+}]}{[\text{Fe}(\text{H}_2\text{O})_6^{3+}]} = 6.0 \times 10^{-3}$$

$$K_a = 6.0 \times 10^{-3} = \frac{(x)(x)}{(0.10 - x)} = \frac{x^2}{(0.10 - x)}$$

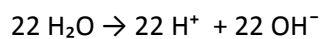
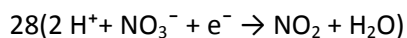
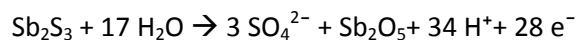
$$x^2 + 6.0 \times 10^{-3}x - 6.0 \times 10^{-4} = 0$$

$$x = \frac{-6.0 \times 10^{-3} \pm \sqrt{(6.0 \times 10^{-3})^2 - 4(1)(-6.0 \times 10^{-4})}}{2(1)} = 0.0217, -0.0277$$

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

$$\text{pH} = -\log[\text{H}^+] = -\log(0.0217) = 1.66$$

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



Equations and Constants

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

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

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

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

$$\text{pH} + \text{pOH} = 14.00 \text{ at } 25^\circ\text{C}$$

$$K_w = 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C}$$

$$K_w = K_a K_b$$

$$\text{pX} = -\log(\text{X})$$

$$\text{X} = 10^{-\text{pX}}$$

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

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

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