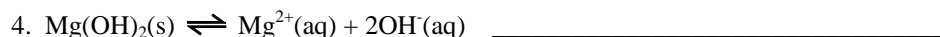
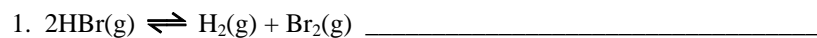
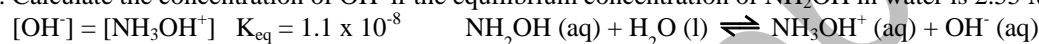
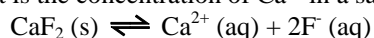


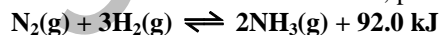
Name \_\_\_\_\_

Chemistry

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**Equilibrium & Acid – Base Test****Part I: Mass Action Expressions: Write mass action expressions for the following reactions.****Part II: Calculating Equilibrium: Solve each of the following.**1. Calculate the equilibrium constant for the following reaction  $4\text{NH}_3\text{(g)} + 5\text{O}_2\text{(g)} \rightleftharpoons 6\text{H}_2\text{O(g)} + 4\text{NO(g)}$  given the following concentrations  $[\text{NH}_3] = 1.1 \text{ M}$ ,  $[\text{O}_2] = 0.6 \text{ M}$ ,  $[\text{H}_2\text{O}] = 0.02 \text{ M}$  and  $[\text{NO}] = 0.012 \text{ M}$ . $K_{\text{eq}} =$  \_\_\_\_\_2. Calculate the concentration of  $\text{OH}^-$  if the equilibrium concentration of  $\text{NH}_2\text{OH}$  in water is 2.55 M. $[\text{OH}^-] =$  \_\_\_\_\_3. What is the concentration of  $\text{Ca}^{2+}$  in a saturated solution of  $\text{CaF}_2$  if  $[\text{F}^-]$  is  $2.2 \times 10^{-3}$ ?  $K_{\text{sp}} = 5.3 \times 10^{-9}$  $[\text{Ca}^{2+}] =$  \_\_\_\_\_**Part III: Le Chatelier's Principle**

Complete the following chart by writing LEFT, RIGHT or NONE for the equilibrium shift and INCREASES, DECREASES or STAYS THE SAME for the concentrations of the reactants, products and for the value of K.



Stress	Equilibrium Shift	$[\text{N}_2]$	$[\text{H}_2]$	$[\text{NH}_3]$	K
1. Add $\text{N}_2$		-----			
2. Add $\text{NH}_3$				-----	
3. Remove $\text{H}_2$			-----		
4. Increase Temperature					
5. Decrease Pressure					

**Part IV: Name the following acids and identify them as binary or ternary.**

1. HI \_\_\_\_\_

2.  $\text{H}_2\text{SO}_3$  \_\_\_\_\_3.  $\text{H}_3\text{PO}_4$  \_\_\_\_\_4.  $\text{HClO}_3$  \_\_\_\_\_

**Part V: Write the formula for each of the following and identify it as monoprotic, diprotic or triprotic.**

1. sulfuric acid \_\_\_\_\_
2. hydroiodic acid \_\_\_\_\_
3. phosphorous acid \_\_\_\_\_
4. hydrochloric acid \_\_\_\_\_

**Part VI: Identify the ACID (A), BASE (B), CONJUGATE ACID (CA) and CONJUGATE BASE (CB) in each of the following equations.**

1.  $\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^{1+} + \text{OH}^{1-}$
2.  $\text{HCl} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^{1+} + \text{Cl}^{1-}$
3.  $\text{H}_2\text{SO}_4 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^{1+} + \text{HSO}_4^{1-}$
4.  $\text{HNO}_3 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^{1+} + \text{NO}_3^{1-}$

**Part VII: Calculating the pH/pOH of a strong acid/base.**

1. Calculate the pH & pOH of a 0.035 M NaOH solution.

pH = \_\_\_\_\_ pOH = \_\_\_\_\_

2. Calculate the pH & pOH of a 0.15 M  $\text{H}_2\text{SO}_4$  solution.

pH = \_\_\_\_\_ pOH = \_\_\_\_\_

**Part VIII: Calculating pH/pOH,  $K_a/K_b$ , of a Weak Acid/Weak Base**

1. Calculate the pH & pOH of a 0.010 M hydrofluoric acid solution.  $K_a = 6.8 \times 10^{-4}$

pH = \_\_\_\_\_ pOH = \_\_\_\_\_

2. A 0.30M solution of weak acid has a pH of 4.3. Calculate the  $K_a$  of this acid.

$K_a =$  \_\_\_\_\_

3. Calculate the pH & pOH of a 0.30 M ammonia solution.  $K_b = 1.80 \times 10^{-5}$

pH = \_\_\_\_\_ pOH = \_\_\_\_\_

4. A 0.040 M weak acid has a  $[\text{H}^+]$  of  $3.7 \times 10^{-3}$ . Calculate the  $K_a$  of this acid.

$K_a =$  \_\_\_\_\_

5. A 0.15M solution of weak base has a pH of 9.6. Calculate the  $K_b$  of this base.

$K_b =$  \_\_\_\_\_

**Part IX: Multiple Choice: Choose the best answer for each of the following.**

1. \_\_\_\_\_ Which of the following will occur when a solution of a weak acid is diluted?  
I. The pH of the solution will increase  
II. The equilibrium constant for the acid will decrease  
III. The dissociation of the acid will increase  
(A) I only (B) III only (C) I, II, and III (D) II and III only (E) I and III only
2. \_\_\_\_\_ How many moles of NaF must be dissolved in 1.00 liter of a saturated solution of  $\text{PbF}_2$  at  $25^\circ\text{C}$  to reduce the  $[\text{Pb}^{2+}]$  to  $1 \times 10^{-6}$  molar? ( $K_{\text{sp}}$  of  $\text{PbF}_2$  at  $25^\circ\text{C} = 4.0 \times 10^{-8}$ )  
(A) 0.020 mole (B) 0.040 mole (C) 0.10 mole (D) 0.20 mole (E) 0.40 mole
3. \_\_\_\_\_ Which of the following best describes the pH of a 0.01 molar solution of  $\text{C}_5\text{H}_5\text{N}_5$  ( $K_b = 1.7 \times 10^{-9}$ )?  
(A) Less than or equal to 2.0 (B) Between 2 and 7 (C) 7  
(D) Between 7 and 11 (E) Greater than or equal to 11
4. \_\_\_\_\_  $\text{HSO}_4^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{SO}_4^{2-}$   
In the equilibrium represented above, the species that act as bases include which of the following?  
I.  $\text{H}_2\text{O}$  II.  $\text{HSO}_4^-$  III.  $\text{SO}_4^{2-}$   
(A) II only (B) III only (C) I and II (D) I and III (E) II and III
5. \_\_\_\_\_ Which of the following is not a conjugate acid-base pair?  
(A)  $\text{H}_2\text{SO}_4$  and  $\text{HSO}_4^-$  (B)  $\text{HCl}$  and  $\text{Cl}^-$  (C)  $\text{NH}_3$  and  $\text{NH}_2^-$   
(D)  $\text{H}_2\text{PO}_4^-$  and  $\text{PO}_4^{3-}$  (E)  $\text{H}_2\text{S}$  and  $\text{HS}^-$
6. \_\_\_\_\_ What is the  $\text{H}^+$  (aq) concentration in 0.05 M  $\text{HCN}$  (aq)? (The  $K_a$  for  $\text{HCN}$  is  $5.0 \times 10^{-10}$ )  
(A)  $2.5 \times 10^{-11}$  (B)  $2.5 \times 10^{-10}$  (C)  $5.0 \times 10^{-10}$  (D)  $5.0 \times 10^{-6}$  (E)  $5.0 \times 10^{-4}$
7. \_\_\_\_\_ A 0.20-molar solution of a weak monoprotic acid, HA, has a pH of 3.00. The ionization constant ( $K_a$ ) of this acid is:  
(A)  $5.0 \times 10^{-7}$  (B)  $2.0 \times 10^{-7}$  (C)  $5.0 \times 10^{-6}$  (D)  $5.0 \times 10^{-3}$  (E)  $2.0 \times 10^{-3}$
8. \_\_\_\_\_ A molecule or an ion is classified as a Lewis acid if it  
(A) accepts a proton from water (B) accepts a pair of electrons to form a bond  
(C) donates a pair of electrons to form a bond (D) donates a proton to water  
(E) has resonance Lewis electron-dot structures
9. \_\_\_\_\_ The acid dissociation constant for  $\text{HClO}$  is  $3.0 \times 10^{-8}$ . What is the hydrogen ion concentration in 0.12 M solution of  $\text{HClO}$ ?  
(A)  $3.6 \times 10^{-9}$  M (B)  $3.6 \times 10^{-8}$  M (C)  $6.0 \times 10^{-8}$  M (D)  $2.0 \times 10^{-5}$  M (E)  $6.0 \times 10^{-5}$  M
10. \_\_\_\_\_ Which of the following can function as both a Brønsted-Lowry acid and Brønsted-Lowry base?  
(A)  $\text{HCl}$  (B)  $\text{H}_2\text{SO}_4$  (C)  $\text{HSO}_3^-$  (D)  $\text{SO}_4^{2-}$  (E)  $\text{H}^+$
11. \_\_\_\_\_ The solubility product,  $K_{\text{sp}}$ , of  $\text{CaF}_2$  is  $4 \times 10^{-11}$ . Which of the following expressions is equal to the solubility of  $\text{CaF}_2$ ?  
(A)  $\sqrt{4 \times 10^{-11}}$  M (B)  $\sqrt{2 \times 10^{-11}}$  M (C)  $\sqrt[3]{4 \times 10^{-11}}$  M  
(D)  $\sqrt[3]{2 \times 10^{-11}}$  M (E)  $\sqrt[3]{1 \times 10^{-11}}$  M
12. \_\_\_\_\_ How many moles of calcium fluoride,  $\text{CaF}_2$ , must be dissolved in 2.0 L of water at  $25^\circ\text{C}$  to form a saturated solution?  $\text{CaF}_2$   $1.6 \times 10^{-10}$   $K_{\text{sp}}$  at  $25^\circ\text{C}$   
(A)  $2.6 \times 10^{-2}$  mol (B)  $1.3 \times 10^{-3}$  mol (C)  $6.8 \times 10^{-4}$  mol  
(D)  $3.4 \times 10^{-4}$  mol (E)  $1.6 \times 10^{-10}$  mol

13. \_\_\_\_\_ The ionization of benzoic acid is represented by this equation.



If a 0.045 M solution of benzoic acid has an  $[\text{H}^+] = 1.7 \times 10^{-3}$ , what is the  $K_a$  of benzoic acid?

- (A)  $7.7 \times 10^{-5}$  (D)  $8.4 \times 10^{-1}$  (E)  $2.9 \times 10^{-6}$   
(B)  $6.7 \times 10^{-5}$  (C)  $3.8 \times 10^{-2}$

14. \_\_\_\_\_  $\text{C}_6\text{H}_5\text{OH}(\text{aq}) + \text{CN}^-(\text{aq}) \rightleftharpoons \text{HCN}(\text{aq}) + \text{C}_6\text{H}_5\text{O}^-(\text{aq})$

The equilibrium constant for this reaction is less than 1. What is the strongest base in this system?

- (A)  $\text{C}_6\text{H}_5\text{OH}(\text{aq})$  (B)  $\text{CN}^-(\text{aq})$  (C)  $\text{HCN}(\text{aq})$   
(D)  $\text{C}_6\text{H}_5\text{O}^-(\text{aq})$  (E) all bases are equal in strength

15. \_\_\_\_\_ What is the conjugate base of  $\text{H}_2\text{PO}_4^-$ ?

- (A)  $\text{HPO}_4^{2-}(\text{aq})$  (B)  $\text{H}_2\text{O}(\text{l})$  (C)  $\text{HPO}_4^-(\text{aq})$   
(D)  $\text{H}_3\text{PO}_4(\text{aq})$  (E)  $\text{HPO}_4$

**Part X: Free Response: Solve each of the following.**

1.  $\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$

In aqueous solution, ammonia reacts as represented above. In 0.0180 M  $\text{NH}_3(\text{aq})$  at 25°C, the hydroxide ion concentration,  $[\text{OH}^-]$ , is  $5.60 \times 10^{-4}$  M. In answering the following, assume that temperature is constant at 25°C and that volumes are additive.

- (a) Write the equilibrium-constant expression for the reaction represented above.  
(b) Determine the pH of 0.0180 M  $\text{NH}_3(\text{aq})$ .  
(c) Determine the value of the base ionization constant,  $K_b$ , for  $\text{NH}_3(\text{aq})$ .

2. Answer the following questions regarding the decomposition of arsenic pentafluoride,  $\text{AsF}_5(\text{g})$ .

(a) A 55.8 g sample of  $\text{AsF}_5(\text{g})$  is introduced into an evacuated 10.5 L container at 105°C. What is the initial molar concentration of  $\text{AsF}_5(\text{g})$  in the container?

At 105°C,  $\text{AsF}_5(\text{g})$  decomposes into  $\text{AsF}_3(\text{g})$  and  $\text{F}_2(\text{g})$  according to the following chemical equation.



(b) In terms of molar concentrations, write the equilibrium-constant expression for the decomposition of  $\text{AsF}_5(\text{g})$ .

(c) When equilibrium is established, 27.7 percent of the original number of moles of  $\text{AsF}_5(\text{g})$  has decomposed.

- (i) Calculate the molar concentration of  $\text{AsF}_5(\text{g})$  at equilibrium.  
(ii) Using molar concentrations, calculate the value of the equilibrium constant,  $K_{\text{eq}}$ , at 105°C.