Name _____ Chemistry ___/___/___

Equilibrium & Acid – Base Test

Part I: Mass Action Expressions: Write mass action expressions for the following reactions.

1. $2HBr(g) \rightleftharpoons H_2(g) + Br_2(g)$ _____

2. $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$ _____

3. $PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$ _____

4. $Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$ _____

Part II: Calculating Equilibrium: Solve each of the following.

1. Calculate the equilibrium constant for the following reaction $4NH_3(g) + 5O_2(g) \rightleftharpoons 6H_2O(g) + 4NO(g)$ given the following concentrations $[NH_3] = 1.1$ M, $[O_2] = 0.6$ M, $[H_2O] = 0.02$ M and $[NO] = 0.012$ M.

K_{eq} = _____

2. Calculate the concentration of OH^- if the equilibrium concentration of NH_2OH in water is 2.55 M.
$[OH^-] = [NH_3OH^+]$ $K_{eq} = 1.1 \times 10^{-8}$ $NH_2OH\ (aq) + H_2O\ (l) \rightleftharpoons NH_3OH^+\ (aq) + OH^-\ (aq)$

$[OH^-]$ = _____

3. What is the concentration of Ca^{2+} in a saturated solution of CaF_2 if $[F^-]$ is 2.2×10^{-3}? $K_{sp} = 5.3 \times 10^{-9}$
$CaF_2\ (s) \rightleftharpoons Ca^{2+}\ (aq) + 2F^-\ (aq)$

$[Ca^{2+}]$ = _____

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.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + 92.0$ kJ

Stress	Equilibrium Shift	$[N_2]$	$[H_2]$	$[NH_3]$	K
1. Add N_2		-----			
2. Add NH_3				-----	
3. Remove H_2			-----		
4. Increase Temperature					
5. Decrease Pressure					

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

1. HI _____ _____

2. H_2SO_3 _____ _____

3. H_3PO_4 _____ _____

4. $HClO_3$ _____ _____

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. $NH_3 + H_2O \rightleftharpoons NH_4^{1+} + OH^{1-}$

2. $HCl + H_2O \rightleftharpoons H_3O^{1+} + Cl^{1-}$

3. $H_2SO_4 + H_2O \rightleftharpoons H_3O^{1+} + HSO_4^{1-}$

4. $HNO_3 + H_2O \rightleftharpoons H_3O^{1+} + NO_3^{1-}$

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 H_2SO_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 $[H^+]$ of 3.7×10^{-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 PbF_2 at 25°C to reduce the $[Pb^{2+}]$ to 1 x 10^{-6} molar? (K_{sp} of PbF_2 at 25°C = 4.0 x 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 $C_5H_5N_5$ (K_b = 1.7 x 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. _____ $HSO_4^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$
In the equilibrium represented above, the species that act as bases include which of the following?
I. H_2O II. HSO_4^- III. 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) H_2SO_4 and HSO_4^- (B) HCl and Cl^- (C) NH_3 and NH_2^-
(D) $H_2PO_4^-$ and PO_4^{3-} (E) H_2S and HS^-

6. _____ What is the H^+ (aq) concentration in 0.05 M HCN (aq)? (The K_a for HCN is 5.0 x 10^{-10})
(A) 2.5 x 10^{-11} (B) 2.5 x 10^{-10} (C) 5.0 x 10^{-10} (D) 5.0 x 10^{-6} (E) 5.0 x 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 x 10^{-7} (B) 2.0 x 10^{-7} (C) 5.0 x 10^{-6} (D) 5.0 x 10^{-3} (E) 2.0 x 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 HClO is 3.0 x 10^{-8}. What is the hydrogen ion concentration in 0.12 M solution of HClO?
(A) 3.6 x 10^{-9} M (B) 3.6 x 10^{-8} M (C) 6.0 x 10^{-8} M (D) 2.0 x 10^{-5} M (E) 6.0 x 10^{-5} M

10. _____ Which of the following can function as both a Brønsted-Lowry acid and Brønsted-Lowry base?
(A) HCl (B) H_2SO_4 (C) HSO_3^- (D) SO_4^{2-} (E) H^+

11. _____ The solubility product, K_{sp}, of CaF_2 is 4 x 10^{-11}. Which of the following expressions is equal to the solubility of CaF_2?
(A) $\sqrt{4x10^{-11}}$ M (B) $\sqrt{2x10^{-11}}$ M (C) $\sqrt[3]{4x10^{-11}}$ M
(D) $\sqrt[3]{2x10^{-11}}$ M (E) $\sqrt[3]{1x10^{-11}}$ M

12. _____ How many moles of calcium fluoride, CaF_2, must be dissolved in 2.0 L of water at 25°C to form a saturated solution? CaF_2 1.6 x 10^{-10} K_{sp} at 25 °C
(A) 2.6 x 10^{-2} mol (B) 1.3 x 10^{-3} mol (C) 6.8 x 10^{-4} mol
(D) 3.4 x 10^{-4} mol (E) 1.6 x 10^{-10} mol

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

$C_6H_5COOH(aq) \rightleftharpoons H^+(aq) + C_6H_5COO^-(aq)$

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

(A) 7.7×10^{-5} (B) 6.7×10^{-5} (C) 3.8×10^{-2}

(D) 8.4×10^{-1} (E) 2.9×10^{-6}

14. _____ $C_6H_5OH(aq) + CN^-(aq) \rightleftharpoons HCN(aq) + C_6H_5O^-(aq)$

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

(A) $C_6H_5OH(aq)$ (B) $CN^-(aq)$ (C) $HCN(aq)$

(D) $C_6H_5O^-(aq)$ (E) all bases are equal in strength

15. _____What is the conjugate base of $H_2PO_4^-$?

(A) $HPO_4^{2-}(aq)$ (B) $H_2O(l)$ (C) $HPO_4^-(aq)$

(D) $H_3PO_4(aq)$ (E) HPO_4

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

1. $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

In aqueous solution, ammonia reacts as represented above. In 0.0180 *M* $NH_3(aq)$ at 25°C, the hydroxide ion concentration, $[OH^-]$, is 5.60×10^{-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* $NH_3(aq)$.

(c) Determine the value of the base ionization constant, K_b, for $NH_3(aq)$.

2. Answer the following questions regarding the decomposition of arsenic pentafluoride, $AsF_5(g)$.

(a) A 55.8 g sample of $AsF_5(g)$ is introduced into an evacuated 10.5 L container at 105°C. What is the initial molar concentration of $AsF_5(g)$ in the container?

At 105°C, $AsF_5(g)$ decomposes into $AsF_3(g)$ and $F_2(g)$ according to the following chemical equation.

$AsF_5(g) \rightleftharpoons AsF_3(g) + F_2(g)$

(b) In terms of molar concentrations, write the equilibrium-constant expression for the decomposition of $AsF_5(g)$.

(c) When equilibrium is established, 27.7 percent of the original number of moles of $AsF_5(g)$ has decomposed.

(i) Calculate the molar concentration of $AsF_5(g)$ at equilibrium.

(ii) Using molar concentrations, calculate the value of the equilibrium constant, K_{eq}, at 105°C.