

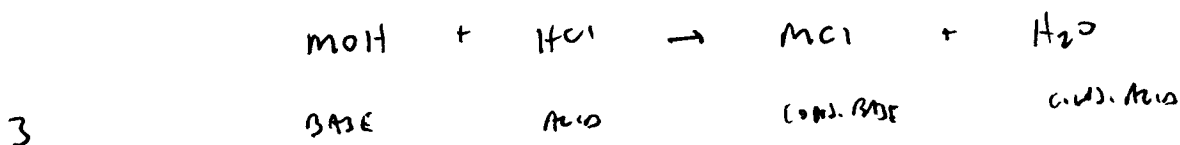
START : 8:00

STOP : 9:30

CHM 102
Exam II

1. A 0.210 g sample of an unknown alkali metal hydroxide of formula MOH is dissolved in 25.0 mL of water and titrated with 37.2 mL of standard 0.100 M HCl.

a) Write a balanced chemical equation for this reaction, representing the unknown alkali metal hydroxide with the symbol M. Under your equation, indicate which species reacts as a base, which species reacts as an acid, which species is the conjugate base, and which species is the conjugate acid.



b) How many moles of the alkali metal hydroxide are present in the sample?

4

$$0.0372 \text{ L HCl} \cdot \frac{0.100 \text{ mol HCl}}{1 \text{ L HCl}} \cdot \frac{1 \text{ mol MOH}}{1 \text{ mol HCl}} = \boxed{3.72 \times 10^{-3} \text{ mol MOH}}$$

c) What is the molar mass of the alkali metal hydroxide?

4

$$\frac{0.210 \text{ g}}{3.72 \times 10^{-3} \text{ mol}} = \boxed{56.45 \text{ g/mol}}$$

d) Which alkali metal is present in this compound?

4

$$\text{OH}^- = 17.01 \text{ g/mol}$$

$$56.45 - 17.01 \text{ g/mol} = 39.44 \text{ g/mol}$$

MEMBER IS potassium

2. Silver hydroxide is sparingly soluble in water with $K_{sp} = 2.0 \times 10^{-8}$.

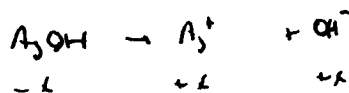
a) Write a balanced chemical equation for the dissolution of solid silver hydroxide.



b) Write an equilibrium expression relating the appropriate concentrations to the equilibrium constant.

$$K_{sp} = [Ag^+][OH^-]$$

c) What is the molar solubility of silver hydroxide?



$$2.0 \times 10^{-8} = x^2$$

$$x = \boxed{1.4 \times 10^{-4} \text{ M}}$$

d) What is the concentration of hydroxide ions in saturated silver hydroxide?

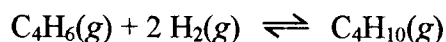
$$[OH^-] = x = \boxed{1.4 \times 10^{-4} \text{ M}}$$

e) What is the pH of saturated silver hydroxide?

$$[H^+] = \frac{K_w}{[OH^-]} = \frac{1.00 \times 10^{-14}}{1.4 \times 10^{-4}} = 7.07 \times 10^{-11} \text{ M}$$

$$pH = -\log [H^+] = \boxed{10.15}$$

3. 1,3-butadiene reacts with hydrogen to establish an equilibrium with butane:



a) Write an equilibrium expression for this reaction that relates the appropriate concentrations to the equilibrium constant.

5

$$K_{eq} = \frac{[\text{C}_4\text{H}_{10}]}{[\text{C}_4\text{H}_6][\text{H}_2]^2}$$

b) At 200 °C, the equilibrium constant for this reaction has a value of 4.76×10^3 . What does this tell you about the equilibrium position? Explain.

SINCE $K > 1$, [PRODUCTS] > [REACTANTS]

SO THE EQUILIBRIUM POSITION LIES TO THE RIGHT.

5

c) At equilibrium, the concentration of $[\text{C}_4\text{H}_6] = 0.0094 \text{ M}$ and $[\text{H}_2] = 0.0188 \text{ M}$. What is the concentration of $[\text{C}_4\text{H}_{10}]$?

$$4.76 \times 10^3 = \frac{[\text{C}_4\text{H}_{10}]}{(0.0094)(0.0188)^2}$$

$$[\text{C}_4\text{H}_{10}] = 4.76 \times 10^3 (0.0094)(0.0188)^2$$

5

$$= \boxed{0.0158 \text{ M}}$$

4. Explain the following phenomena.

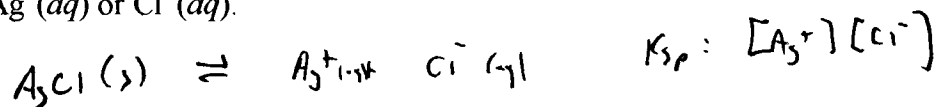
a) The pH of a solution of 0.1 M sulfurous acid (H_2SO_3) is higher than the pH of 0.1 M sulfuric acid (H_2SO_4).

5 H_2SO_4 IS A STRONG ACID THAT COMPLETELY DISSOCIATES IN WATER, WHILE H_2SO_3 IS A WEAK ACID THAT ONLY PARTIALLY DISSOCIATES IN WATER. THUS $[\text{H}^+]$ IN THE H_2SO_3 SOLUTION IS LOWER, SO H_2SO_3 MUST HAVE A HIGHER pH.

b) A solution of 1.0 M acetic acid and 1.0 M sodium acetate resists changes in pH when a little acid or base is added, but a solution of 1.0 M HCl and 1.0 M NaCl does not.

5 THE SOLUTION OF $\text{HC}_2\text{H}_3\text{O}_2$ / $\text{NaC}_2\text{H}_3\text{O}_2$ IS A MIXTURE OF A WEAK ACID AND ITS CONJUGATE, WHICH IS A BUFFER. THE SOLUTION OF HCl / NaCl IS A MIXTURE OF A STRONG ACID AND ITS CONJUGATE, WHICH IS NOT A BUFFER. THUS, ONLY THE FIRST SOLUTION RESISTS CHANGES IN pH.

c) Adding $\text{AgCl}(s)$ to a solution that is already saturated with AgCl will not increase the concentration of $\text{Ag}^+(aq)$ or $\text{Cl}^-(aq)$.



5 BECAUSE SOLUBILITY IS A HETEROGENEOUS EQUILIBRIUM.

THE EQUILIBRIUM POSITION IS INDEPENDENT OF THE AMOUNT OF THE SOLID AgCl , SINCE ITS CONCENTRATION DOES NOT CHANGE.

5. Suppose you come into the lab and find two reagent bottles whose labels have fallen off. You pick the labels up off the floor and one label reads 0.01 M HCl while the other label reads pH 2.00 buffer.

a) Describe a simple test that you could perform to determine which bottle is which. You have at your disposal solutions of 0.1 M HCl, 0.1 M NaOH, water, a pH meter, and any glassware you may need.

TAKE SAMPLES OF EACH SOLUTION AND ADD A
LITTLE 0.1M HCl, THEN MEASURE pH.

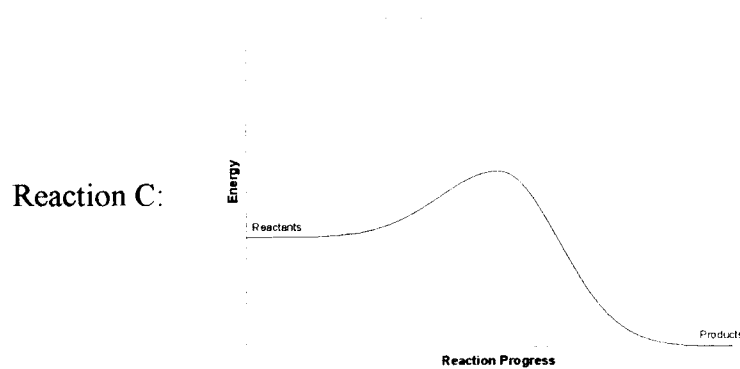
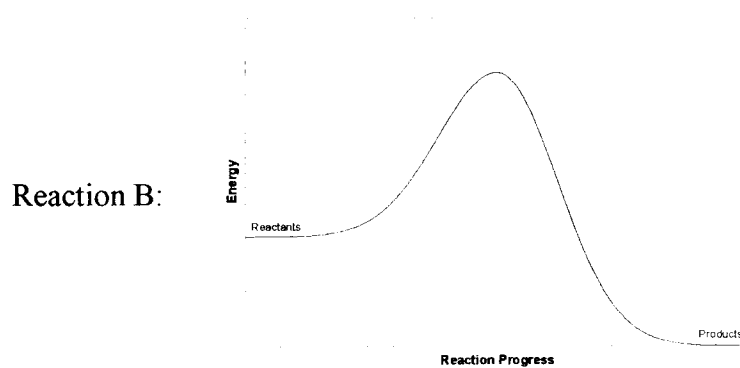
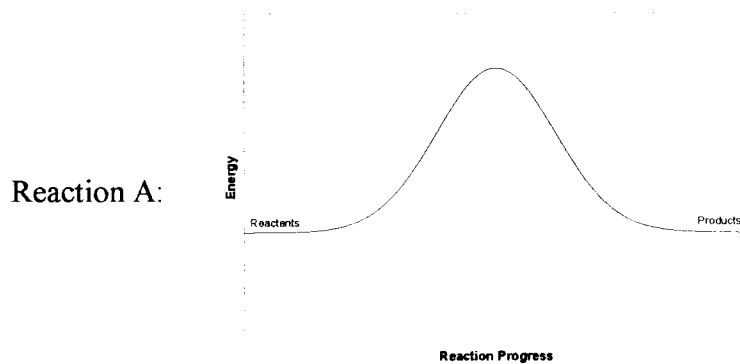
10 TAKE SAMPLES OF EACH SOLUTION AND ADD A
LITTLE 0.1M NaOH, THEN MEASURE pH.

b) Briefly explain why your test works.

BOTH SOLUTIONS HAVE A pH = 2.00. HOWEVER,
THE SOLUTION THAT RESISTS CHANGES IN
pH MUST, BY DEFINITION BE THE BUFFER
5 SOLUTION.

For the remaining problems, circle the letter that corresponds to the best answer.

6. The reaction progress diagrams for several reactions are given:



Which of the following is *true*?

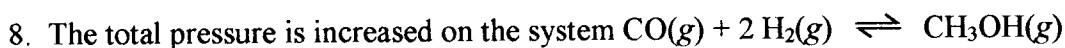
- I. ✓ Reaction A and reaction B have the same activation energy.
- II. ✗ Reaction A will react faster than reaction C.
- III. ✗ Reaction B may be the same as reaction A, but with a catalyst added.
- IV. ✓ Reaction C may be the same as reaction B, but with a catalyst added.

- 5
- (A) II only
 - (B) I and II
 - (C) I and IV
 - (D) II and III
 - (E) II and IV
- 5

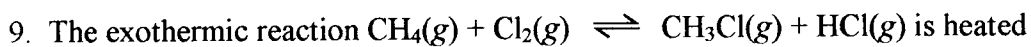
For problems 7-10, consider the following disturbances to systems at equilibrium and predict the nature of the shift in the equilibrium position.



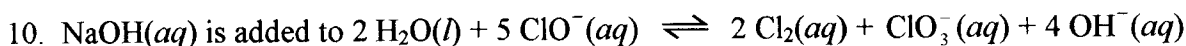
- 5
- (A) The equilibrium position will shift left.
 - (B) The equilibrium position will shift right.
 - (C) The equilibrium position will not change.



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11. Which of the following does *not* affect the rate of a chemical reaction?

- 5
- (A) temperature of the system
 - (B) catalyst
 - (C) concentration of the reactants
 - (D) activation energy
 - (E) none of the above

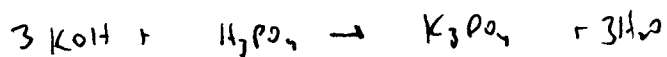
12. Which of the following are conjugate acid / base pairs?

- I. ✓ HCN and CN^-
- II. ✓ H^+ and OH^-
- III. ✓ NH_3 and NH_4^+
- IV. ✓ H_2AsO_4^- and HAsO_4^{2-}

- (A) II only
- (B) I and III
- (C) I and IV
- (D) I, II, and III
- (E) I, III, and IV

13. How many moles of potassium hydroxide are required to completely neutralize one mole of phosphoric acid?

- (A) 0.33
- (B) 0.67
- (C) 1.00
- (D) 1.50
- (E) 3.00



14. Which of the following compounds will produce a solution with $\text{pH} > 7$?

- I. ✗ $\text{SO}_2(\text{OH})_2$
- II. ✓ $\text{Ca}(\text{OH})_2$
- III. ✗ HOH
- IV. ✗ NO_2OH
- V. ✓ CsOH

- (A) I and IV
- (B) II and IV
- (C) II and V
- (D) I, III, and IV
- (E) II, III, and V

15. Solution A has a pH of 9.00 and solution B has a pH of 11.00. Which of the following statements are *true*?

- I. ✗ Solution B has twice as many OH^- ions as solution A.
- II. ✓ Solution B has one hundred times as many OH^- ions as solution A.
- III. ✗ Solution A has one hundred times as many OH^- ions as solution B.
- IV. ✓ Solution A has one hundred times as many H_3O^+ ions as solution B.
- V. ✗ There are no H_3O^+ ions in either solution because they are both basic.

- (A) I only
- (B) III only
- (C) II and III
- (D) II and IV
- (E) III and IV

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