

SIC 102  
Exam II

1. A solution of sulfuric acid of unknown concentration is titrated with a standard solution of sodium hydroxide.

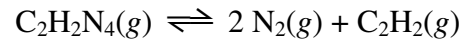
a) Write a balanced equation for this reaction. Under the equation, identify which species reacts as an acid, which species reacts as a base, which species is the conjugate acid, and which species is the conjugate base.

b) A 25.00 mL sample of sulfuric acid reacts completely with 27.22 mL of 0.1078 M sodium hydroxide. What is the concentration of the sulfuric acid solution?

c) Suppose that during the titration a small quantity of sulfuric acid is spilled. These spills are normally neutralized with sodium hydrogen carbonate (sodium bicarbonate). Write a balanced chemical equation for the reaction of sulfuric acid with sodium bicarbonate.

d) What physical phenomenon would you observe as the sulfuric acid reacts with sodium bicarbonate?

2. Tetrazine is in equilibrium with nitrogen and acetylene in the gas phase:



a) Write an equilibrium expression for this reaction relating concentrations of all species to the equilibrium constant.

b) If this reaction is exothermic, what effect will heating the reaction mixture have on the equilibrium position?

c) If nitrogen gas is added to the reaction mixture, what will the effect on the equilibrium position be?

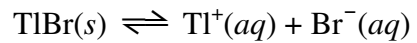
d) If the pressure of the reaction vessel is increased, what will the effect on the equilibrium position be?

e) At a particular temperature, the value of the equilibrium constant is  $2.8 \times 10^5$ . To what side does the equilibrium position lie? Explain.

f) If the concentration of tetrazine is  $2.7 \times 10^{-9}$  M and the concentration of nitrogen is 0.13 M, what is the concentration of acetylene?

3. Suppose you come into the lab and notice two reagent bottles whose labels have fallen off. You pick the labels up off the floor and one label reads 0.001 M HCl while the other label reads pH 3 buffer. Describe a simple test that you could perform to determine which bottle is which. You have at your disposal solutions of 0.1 M KOH, 0.1 M HCl, water, a pH meter, and any glassware you may need. Briefly explain why your test works.

4. Thallium (I) bromide is a sparingly soluble salt which dissolves in water to form thallium (I) ions and bromide ions:



a) Write an equilibrium expression for this reaction.

b) If  $K_{\text{sp}} = 3.4 \times 10^{-6}$ , what is the molar solubility of thallium (I) bromide?

c) Suppose you have a saturated solution of TlBr and you add some potassium bromide to it. What would the effect on the concentration of  $\text{Tl}^+(aq)$  be? Explain.

5. Ammonia is a weak base. Suppose you have a solution of 0.10 M ammonia.

a) When dissolved in water, ammonia reacts with water in an acid-base reaction. Write a balanced chemical equation for this reaction. Under the equation, identify which species reacts as an acid, which species reacts as a base, which species is the conjugate acid, and which species is the conjugate base.

b) Write an equilibrium expression for this reaction relating concentrations to the equilibrium constant.

c) The equilibrium constant for this reaction is  $K_{\text{eq}} = 1.74 \times 10^{-5}$ . What does this tell you about the position of the equilibrium?

d) At equilibrium, the concentration of  $[\text{NH}_4^+] = 0.0013 \text{ M}$  and  $[\text{NH}_3] = 0.0987 \text{ M}$ . What is the concentration of hydroxide ions in this solution?

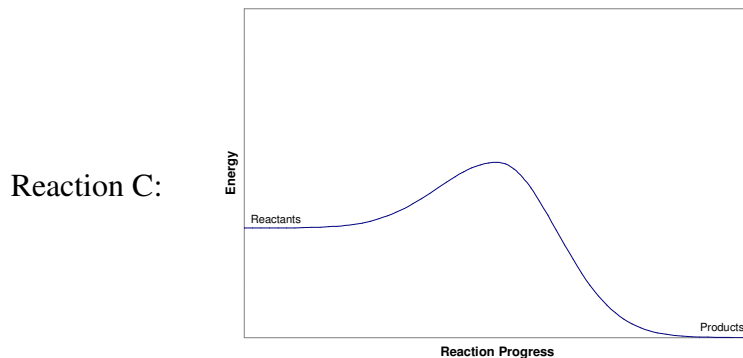
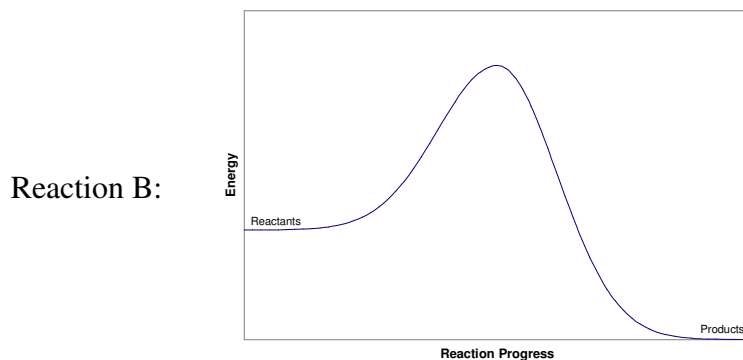
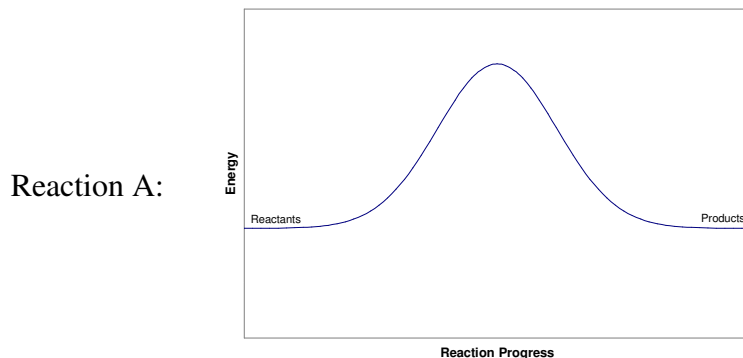
e) What is the concentration of  $[\text{H}^+]$  in this solution?

f) What is the pH of this solution?

g) How does this compare with the pH of a  $0.10 \text{ M}$  NaOH solution? Why are the values different?

For questions 6-9, circle the letter that corresponds to the best answer.

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

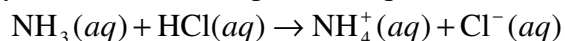


Which of the following is *true*?

- I. Reaction B and reaction C have the same activation energy.
- II. Reaction C will react faster than reaction A or reaction B.
- 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.

- (A) II only
- (B) I and III
- (C) I and IV
- (D) II and IV
- (E) all of the above

7. Ammonia reacts with hydrochloric acid to produce aqueous ammonium chloride:



Which of the following is *false*?

- (A) The chloride ion is the conjugate base of HCl.
- (B) In this reaction, ammonia reacts as a Brønsted-Lowry base.
- (C) In this reaction, ammonia reacts as an Arrhenius base.
- (D) HCl donates a proton to ammonia.
- (E) The ammonium ion is acidic.

8. Solution A has a pH of 3.00 and solution B has a pH of 4.00. Which of the following is *true*?

- I.** Solution B has ten times as many  $\text{OH}^-$  ions as solution A.
- II.** Solution B has ten times as many  $\text{H}_3\text{O}^+$  ions as solution A.
- III.** Solution A has ten times as many  $\text{H}_3\text{O}^+$  ions as solution B.
- IV.** There are no  $\text{OH}^-$  ions in either solution because they are both acidic.

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

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

- I.**  $\text{HNO}_3$  and  $\text{NO}_3^-$
- II.**  $\text{H}^+$  and  $\text{OH}^-$
- III.**  $\text{H}_2\text{PO}_4^-$  and  $\text{HPO}_4^{2-}$
- IV.**  $\text{C}_5\text{H}_5\text{N}$  and  $\text{C}_5\text{H}_5\text{NH}^+$

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