Exam 1

# Part 1: Multiple Choice (2 points each)

## Directions: Please circle the *best* answer for each of the following questions.

1. The rate of a chemical reaction depends on
   1. the concentration of products.
   2. the concentration of reactants.
   3. the densities of reactants.
   4. the densities of products.
   5. all of the above
2. The reaction CHCl3 (g) + Cl2 (g) CCl4 (g) + HCl (g) has the rate law: rate = k[CHCl3][Cl2]. If the concentration of CHCl3 is increased by a factor of five while the concentration of Cl2 is kept the same, the rate will
   1. double.
   2. triple.
   3. stay the same.
   4. increase by a factor of five.
   5. none of the above
3. The difference between an average rate and an instantaneous rate is
   1. the average rate is taken over a larger time period.
   2. the instantaneous rate is taken from the slope of the curve at a specific time.
   3. they are not different if the time interval chosen is small enough.
   4. none of the above
   5. all of the above
4. The equilibrium constant for the formation of calcium carbonate from the ions in solution is 2.2 × 108 according to the reaction: Ca2+ (aq) + CO32- (aq) CaCO3 (s). What is the value of the equilibrium constant for the reverse of this reaction?
   1. The same, 2.2 × 108
   2. -2.2 × 108
   3. 2.2 × 10-8
   4. 4.5 × 10-9
   5. 1
5. The equilibrium constant for the acid ionization of mercaptoethanol is 1.91 × 10-10:

HSCH2CH2OH (aq) H+ (aq) + SCH2CH2OH- (aq)

A solution of mercaptoethanol in water

* 1. is almost entirely ionized.
  2. is almost entirely unionized.
  3. is about one-half ionized.
  4. is a strong acid.
  5. is completely dissociated.

1. Since a catalyst promotes both the forward and reverse reactions in equilibrium, what may be done to promote creation of products?
   1. The removal of any reactants that are formed by the equilibrium.
   2. The lowering of the temperature to limit the reverse reaction progress.
   3. The removal of products as they are made.
   4. all of the above
   5. none of the above
2. pH indicators
   1. are weak acids.
   2. have characteristic colors in their various protonated and deprotonated forms.
   3. have characteristic pKHIn values.
   4. all of the above
   5. none of the above
3. Phosphoric acid is a triprotic acid, which ionizes in sequential steps:

H3PO4 (aq) + H2O (l) H2PO4- (aq) + H3O+ (aq) Ka1

H2PO4- (aq) + H2O (l) HPO42- (aq) + H3O+ (aq) Ka2

HPO42- (aq) + H2O (l) PO43- (aq) + H3O+ (aq) Ka3

Which equilibrium is most important in determining the pH of a solution of sodium phosphate?

* 1. H3PO4 (aq) + H2O (l) H2PO4- (aq) + H3O+ (aq)
  2. H2PO4- (aq) + H2O (l) HPO42- (aq) + H3O+ (aq)
  3. HPO42- (aq) + H2O (l) PO43- (aq) + H3O+ (aq)
  4. PO43- (aq) + H2O (l) HPO42- (aq) + OH- (aq)
  5. H2PO4- (aq) + H2O (l) H3PO4 (aq) + OH- (aq)

1. In order to avoid exposure to your eyes in a chemistry lab you should wear eye protection
   1. only when working with corrosive chemicals.
   2. only when your instructor requires it.
   3. only when there are other students working nearby who might do something stupid.
   4. never, they are not necessary.
   5. whenever anyone is working with chemicals or flames.
2. What is the most effective method for avoiding exposure by ingestion?
   1. Taste only chemicals that your instructor gives you permission to taste.
   2. Taste only chemicals that you know are nontoxic.
   3. Never eat or drink anything while in a chemistry lab.
   4. Only eat food in the lab when you know that it cannot be contaminated with toxic chemicals.
   5. all of the above

# Part 2: Short Answer

## Directions: Answer each of the following questions. Be sure to use complete sentences where appropriate. For full credit be sure to show all of your work.

1. If a 0.500 L flask containing 1.25 × 10-4 mol hydrogen sulfide gas is heated to 800 °C,

2 H2S (g) 2 H2 (g) + S2 (g) Kc = 1.67 × 10-7 M (15 points)

* 1. find the equilibrium concentrations.
  2. determine Kp .

1. Consider this equilibrium system (4 points):

CO (g) + Fe3O4 (s) CO2 (g) + 3 FeO (s)

How does the equilibrium position shift as a result of each of the following disturbances?

* 1. CO is added. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  2. CO2 is removed by adding solid NaOH. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  3. Additional Fe3O4 (s) is added to the system. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  4. Dry ice is added at constant temperature. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Is the rate of an overall reaction lower, higher, or equal to the average rate of the individual steps? Explain (3 points).
2. The decomposition of ethanol (C2H5OH) on an alumina (Al2O3) surface

C2H5OH (aq) → C2H4 (g) + H2O (g)

was studied at 600 K. Concentration versus time data were collected for this reaction, and a plot of [A] versus time resulted in a straight line with a slope of -4.00 × 10-5 mol/L∙s (8 points).

1. Determine the rate law, the integrated rate law, and the value of the rate constant for this reaction.
2. If the initial concentration of C2H5OH was 1.25 × 10-2 M, calculate the half-life for this reaction.
3. How much time is required for all the 1.25 × 10-2 M C2H5OH to decompose?

1. Although the depletion of stratospheric ozone threatens life on Earth today, its accumulation was one of the crucial processes that allowed life to develop in prehistoric times. Reaction rate is expressed in terms of changes in concentration of reactants and products (5 points).
   1. Write a balanced equation for:
   2. At a given instant, the reaction rate in terms of [O2] is 2.17 × 10-5 mol/L∙s. What is it in terms of [O3]?
2. The following statements relate to the reaction for the formation of HI:

H2 (g) + I2 (g) →2 HI (g) rate = k[H2][I2]

Determine which of the following statements are true. If a statement is false, indicate why it is incorrect (10 points).

* 1. The reaction must occur in a single step.
  2. This is a second-order reaction overall.

* 1. Raising the temperature will cause the value of k to decrease.
  2. Raising the temperature lowers the activation energy for this reaction.
  3. If the concentration of both reactants are doubled, the rate will double.

* 1. Adding a catalyst in the reaction will cause the initial rate to increase.

1. The interhalogen compound ClF3 is prepared in a two-step fluorination of chlorine gas (5 points):
   * 1. Cl2 (g) + F2 (g) ClF (g)
     2. ClF (g) + F2 (g) ClF3 (g)
2. Balance each step and write the overall equation.
3. Show that the overall Qc equals the products of the Qc’s for the individual steps.
4. Predict whether aqueous solutions of the following salts are acidic, basic, or neutral, and write an equation for the reaction of any ion with water (6 points):
   1. Potassium perchlorate, KClO4
   2. Sodium benzoate, C6H5COONa
   3. Chromium(III) nitrate, Cr(NO3)­3
5. What is the key structural feature of all Brønsted-Lowry bases? How does this feature function in an acid-base reaction (3 points)?
6. How many moles of H3O+ or OH- must you add to 5.6 L of HA solution to adjust its pH from 4.52 to 5.25? Assume a negligible volume change (6 points).
7. Sodium hypochlorite solution, sold as chlorine bleach, is potentially dangerous because of the basicity of ClO-, the active bleaching ingredient. Assume d = 1.0 g/mL and Ka of HClO4 = 2.9 × 10-8 M (15 points).
   1. What is Kb for the solution?
   2. What is the [OH-] in an aqueous solution that is 6.5% NaClO by mass?
   3. What is the pH of the solution?