Name: _____

Chem 1B, Instructor: L. Yee
March 8, 2012

EXAM 1

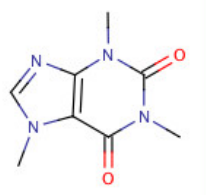
Show all work!!

Exam 1 is worth 10% of your grade. For full credit, show all work in a logical and legible sequence. Clearly underline or circle your final answer. Include units where needed. You may use your texbook, notes, and a calculator. You may ask me for a hint; however, each hint will cost you 1 point.

1. (3 units) Give a short answer to each question.

a. When you made iso-amyl acetate (the banana ester) in Lab 1, you did a liquid-liquid extraction to separate any unreacted reactants from the iso-amyl acetate. Explain how an extraction works.

b. The structure of caffeine is shown below. Circle the functional group(s) in caffeine. Write the name of the functional group next to your circle. Explain why caffeine is soluble in water.



2. (3 units) You investigated soda in Lab 2. 8 oz. (240 ml) of Pepsi Soda contains 20 mg of sodium, 28 g of sugar, and CO_2. Diet Pepsi substitutes a small amount of NutriSweet for sugar.

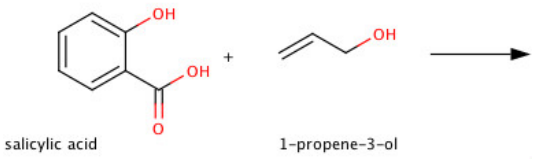
a. Is the boiling point of Pepsi greater than, less than, or the same as the boiling point of water? If your answer is greater than or less than, do a calculation to estimate the boiling point of Pepsi.

b. As Pepsi is heated, it loses mass. Explain this observation.

c. You note regular and diet soda have the same sweetness. Regular soda is placed on one side of semipermeable membrane and diet soda on other side. 30 minutes later, you taste each soda and find one soda is sweeter than the other. Which soda tastes sweeter? Give reasons.

3. (8 units) In Lab 1, you synthesized smelly esters. You are trying to come up with new smells. You mix salicylic acid with 1-propene-3-ol (see structure below). This reaction is slow and exothermic.

a. Circle the functional group(s) in salicylic acid and write the name of the functional group(s) next to your circle(s). Then, draw the structure of the product(s) of this reaction.



b. Salicylic acid and 1-propene-3-ol have carbon-carbon double bonds. You measure the IR spectrum of each compound. The C=C peak in salicylic acid is at a lower energy than the C=C peak in 1-propene-3-ol. Give reasons.

c. Show how the concentration of salicylic acid changes with time in a graph. Label each axis.

d. To make this reaction go faster, you use sulfuric acid as a catalyst. Draw a reaction energy diagram that represents the uncatalyzed and catalyzed reactions. (You want to draw two energy diagrams on the same graph.) Label each axis.

e. Your ester product from part a undergoes hydrolysis to produce salicylic acid and 1-propene-3-ol. Is this reaction faster or slower than the reaction of salicylic acid and 1-propene-3-ol to produce the ester. Give reasons.

4. (6 units) In Lab 3, you studied the rate of the iodine clock reaction:

$$IO_3^- + 3\,HSO_3^- \longrightarrow I^- + 3\,SO_4^{2-} + 3\,H^+.$$

You determined the rate law to be: rate = k $[IO_3^-][HSO_3^-]$ where k = 0.60 M^{-1} sec^{-1} at 22°C and activation energy = 14.5 kJ/mole.

a. Suppose at time t=0, one mole of IO_3^- and one mole of HSO_3^- are injected into a 1 liter container that is completely filled with water. One second later, before the reaction is complete, the contents of the container are analyzed for the number of moles of I^-. What would be the probable effect on the number of moles of I^- (increase, decrease, stay the same) if each of the following changes were made in initial conditions? You do not have to give reasons for your answer.

(i) Use a two liter container that is completely filled with water.

(ii) Lower the temperature of the reaction.

b. Which change from part a, (i) or (ii), changes the rate constant of the reaction?

c. You want the iodine clock reaction to turn blue in 45 seconds. Identify the reaction conditions ($[IO_3^-]$, $[HSO_3^-]$, temperature) that will make it turn blue in 45 seconds.
Remember that rate = $\Delta[IO_3^-]/\Delta t$ where $\Delta[IO_3^-]$ = 0.00033 M and for Solution 1, $[IO_3^-]$ = 0.02 M before mixing, $[HSO_3^-]$ = 0.002 M before mixing.

d. Which mechanism best fits the rate law? Give reasons. Identify the rate determining step in your chosen mechanism.

Mechanism A:

$IO_3^- \rightarrow IO^- + O_2$

$IO^- + HSO_3^- \rightarrow I^- + SO_4^{2-} + H^+$

$O_2 + HSO_3^- \rightarrow O + SO_4^{2-} + H^+$

$O + HSO_3^- \rightarrow SO_4^{2-} + H^+$

Mechanism B:

$IO_3^- + HSO_3^- \rightarrow IO_2^- + HSO_4^-$

$IO_2^- + HSO_3^- \rightarrow IO^- + HSO_4^-$

$IO^- + HSO_3^- \rightarrow I^- + HSO_4^-$

Mechanism C:

$IO_3^- + 2HSO_3^- \rightarrow I^- + O + 2\,SO_4^- + 2\,H^+$

$O + HSO_3^- \rightarrow SO_4^{2-} + H^+$

Name: _____

Chem 1B, Instructor: L. Yee
April 26, 2012

EXAM 2

Show all work!

Exam 2 is worth 10% of your grade. For full credit, show all work in a logical and legible sequence. Clearly underline or circle your final answer. Include units where needed. You may use your textbook, notes, and a calculator. You may ask me for a hint; however, each hint will cost you 1 point.

1. (4 units) Ammonia is used to make fertilizer. The Haber process produces ammonia, NH_3, from N_2 and H_2. This reaction has an equilibrium constant of 4.31×10^{-4} at 375°C. This reaction is exothermic.

a. N_2 and H_2 are placed in a container and heated to 375°C. Will a reaction occur? If so, do you think the % yield will be high or low? Give reasons.

b. Would you expect ΔG for this reaction to be greater than 0 or less than 0? Give reasons.

c. Does K_{eq} increase, decrease, or stay the same as temperature increases? Give reasons.

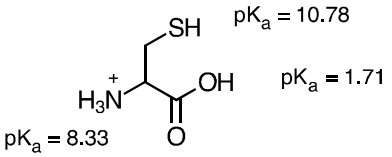
d. The Haber process uses a catalyst and product is removed during the reaction. Why is a catalyst used rather than raising the reaction temperature?

2. (5 units) You measure the heat content of a burnable food in lab. The following data pertain to a corn chip: q = -6 Cal/g (1Cal = 1 food Calorie = 1000 scientific calories = 4,180 J) and w = 100 J per gram of food burned.

a. You burn 0.5 g of a corn chip. Calculate ΔH, ΔE, ΔS, and ΔG for the burning of this chip. Assume T = 25°C.

b. Based on thermodynamics, is a corn chip a good fuel for a heat (car) engine? Give reasons based on how a heat engine works.

3. (7 units) Hair consists of proteins, which are long chains of amino acids. Curly hair is caused by disulfide bonds between S-containing amino acids. One S containing amino acid is cysteine.



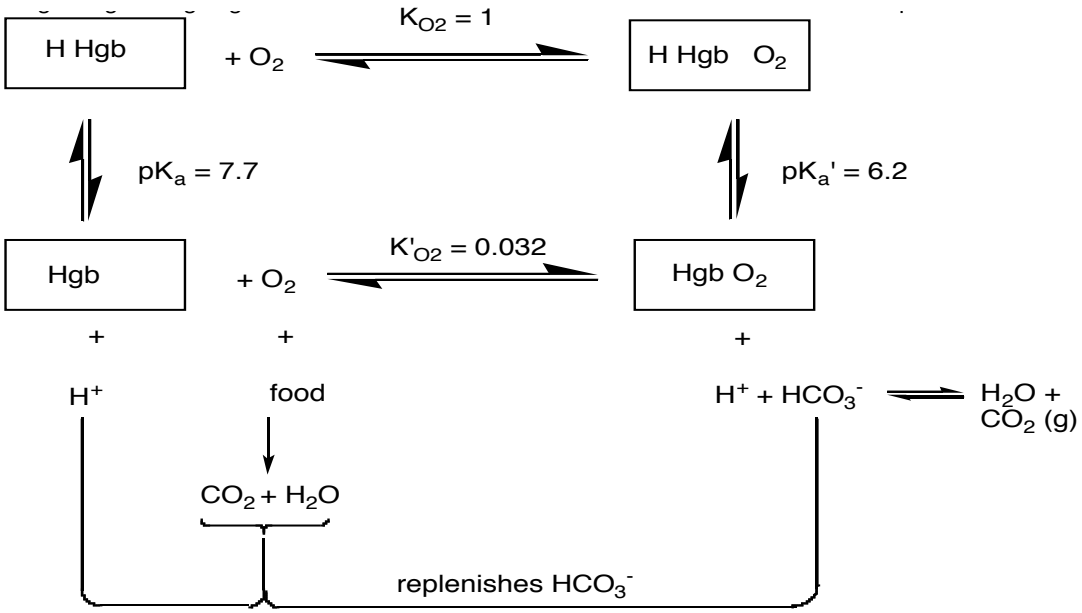
a. Draw titration curve of cysteine. Assume you have 20 ml of 0.1 M cysteine and are titrating with 0.1 M NaOH. Label the pH at the starting point, each half-way point, and each end point.
b. The pH of hair is 5. What is the charge on hair at this pH?

Under normal conditions, what do you want the charge on your hair to be?

What should be the pH of "pH balanced" shampoo?

c. You want to give your straight hair a perm (make it curly). A perm involves making S-S bonds, which means the S in cysteine has a negative charge. At what pH does cysteine have a negative charge? Draw the structure of cysteine with this charge.

4. (4 units) The diagram below represents a simplified version of the buffering action of hemoglobin as a buffer and the uptake and release of oxygen (Reference: I.H. Segel, "Biochemical Calculations", 2nd ed., Wiley, 1976, p. 88). Hemoglobin is the oxygen carrier in blood that transports oxygen from our lungs to tissues. Diffusion due to partial pressure differences is one mechanism by which oxygen transport occurs.



a. H Hgb is the acid present in our lungs. What forces the H Hgb + O_2 ⇆ H Hgb O_2 toward the products?
b. Which acid is stronger, H Hgb or H Hgb O_2? Give reasons.
c. Two acids (H Hgb and H Hgb O_2) and two bases (Hgb and Hgb O_2) are present in our blood. At pH 7.4, which substance is present in the highest amount? Give reasons. (Hint: what equation do you use?)

Chem 1B, FINAL EXAM - TAKE-HOME PART
due Tuesday, May 29, 2012 at 8:00 am

The Take Home Part of the Final Exam is worth 8% of your grade. For full credit, show all work in a logical and legible sequence. Clearly underline or circle your final answer. Include units where needed. You may work in groups on

Questions 1 – 4 of the Final Exam. **You must do Question 5 on your own.** If you work in a group, make sure every member contributes to the solutions. Turn in one set of solutions with the names of each member of your group. If you discuss any question or part of a question with another student, you are working in a group.

1. (6 units) Chlorine is added to swimming pools to sanitize and disinfect the water from microorganisms. Chlorine gas, calcium hypochlorite ($Ca(OCl)_2$, and sodium hypochlorite (NaOCl) are common forms of chlorine that are used in pools (Reference: B. Selinger, "Chemistry in the Marketplace", 4th ed., Harcourt, 1989, p. 188). For example, when chlorine is bubbled through water, two acids are formed:

$Cl_2 + H_2O$ -----> HOCl + HCl (1).

When bleach (NaOCl) is added to water, several reactions occur:

$NaOCl + H_2O$ -----> $Na^+ + OCl^- + H_2O$ (2)

$OCl^- + H_2O$ -----> _____ + _____ (3)

HOCl -----> _____ + _____ (4).

In each case, hypochlorous acid (HOCl) and hypochlorite ions (OCl^-) are formed. HOCl is more effective in killing bacteria than the hypochlorite ion.

a. How does "chlorine" work in killing bacteria? Why is HOCl more effective in killing bacteria than the hypochlorite ion?

b. Complete Reactions 3 and 4.

c. According to PoolCenter.com (http://www.poolcenter.com/chlor.htm) in 2006,

"The efficacy of chlorine, that is, the power of it to have an effect, is greatly influenced by the care with which you manage your pH levels. As the pH of your pool increases, the killing power of your chlorine decreases. At a pH of 6.0, we'll get 96% or so of the potential out of each lb of chlorine, but at what cost? Such a low pH would wreak havoc on all of the surfaces the water comes in contact with, including swimmers. It's just too corrosive. Move the pH up to 7.0 and the efficacy of the chlorine drops to 73%, but raise it up to 8.0, where many a pool seems to drift to, and it drops dramatically...down to 21%! At a perfect pH level of 7.5, we can expect to have about 50% of our chlorine in the molecular structure of hypochlorous acid, the active, killing form. The remaining half is in the form of a hypochlorite ion, which is also an active form of chlorine, but very weak and slow to kill."

Give one reason that the perfect pH for a swimming pool is 7.5. Based on the information given in this paragraph, calculate the equilibrium constant for Reaction 4. Hint: use the Henderson-Hasselbach equation.

d. Draw a titration curve (pH vs. volume of base) for the titration of 20 ml of 0.1 M HOCl with 0.1 M NaOH. Calculate the starting pH, the pH at each half-way point, and the pH at each end point. Label each pH on your titration curve.

e. A graphical method to represent the Henderson-Hasselbach equation is to plot % acid vs. pH. Plot % HOCl vs. pH.

(i) Prepare a table (or spreadsheet) that shows pH, [HOCl], $[OCl^-]$, $[OCl^-]/[HOCl]$, and % HOCl from pH 5 to pH 10 using increments of 0.5 pH units. Then, graph % HOCl vs. pH.

(ii) Explain how your graph confirms the pH and % "chlorine" in part c.

f. Do any of the chlorine-containing substances in Reactions (1) through (4) serve to buffer the pool? If so, identify the buffer components. (Recall that a buffer contains an acid component and base component.)

2. (2 units) One way to make chlorine is by electrolysis of NaCl.

a. Draw an electrolytic cell that shows how Cl_2 is made from NaCl. Label the anode and cathode. Write the half reaction that occurs at each electrode and the overall reaction. Calculate the minimum voltage to run this cell.

b. Could you operate this cell under room temperature conditions? Give reasons.

c. Explain the role of current in your cell.

3. (2 units) You hold a thick rubber band to your upper lip and quickly stretch it. Your lip feels warm. Stretching a rubber band can be represented by the following chemical equation:

Rubber band (unstretched) → Rubber band (stretched).

a. Determine whether the following quantities are greater than 0 or less than 0 for stretching a rubber band. Give reasons.

(i) q

(ii) w

(iii) ΔG

b. Your lab partner just did her first bungee jump off a bridge! But, the winch to haul her up to the bridge isn't working and she's stuck in mid-air hanging from the bungee cord (assume the bungee cord is a big thick rubber band). Based on your knowledge of the thermodynamics of rubber bands, you figure that cooling the bungee cord should lengthen the bungee cord and allow your lab partner to reach the ground. Explain why cooling the bungee cord makes the cord longer.

4. (4 units) a. Radioactive isotopes that undergo induced fission can be used as a fuel in nuclear power plants and nuclear weapons. Of all the fissionable materials, why are U-235 and Pu-239 most often used?

b. How is carbon-14 used to date fossils? Explain why C-14 dating is limited to dating objects between 1,000 and 50,000 years old. How are fossils older than 50,000 years dated?

c. In boron neutron capture therapy (BNCT), the boron-10/neutron capture reaction is used to produce ionized lithium-7, 2.4 MeV of energy, weak gamma radiation, and a type of particle radiation. The energy released in this reaction is principally kinetic energy. What type of particle radiation is produced? Write a nuclear equation that supports your answer. What therapy is BNCT used for? What is one problem with BNCT?

5. (2 units) According to the Chem 1B Course Information Handout, your "grade will be based on your performance and mastery of the last Course Objective." Each course objective is shown below.
a. For each objective, give yourself a grade (A – F) that reflects your understanding of that objective. Be honest and be fair to yourself. Don't be too easy but don't be too harsh either
b. Give yourself an overall course grade based on your understanding of the course objectives. (The grade you give yourself may not be your official course grade. Your instructor will determine your overall course grade.)

Objective	Description	Grade
1	relate bonding and structure of organic compounds to properties, e.g., solubility, reactivity, color, and smell	
2	relate bonding and structure of coordination compounds to properties, e.g., color and magnetism	
3	describe solutions, the solution process, and solution properties, including colligative properties and related calculations	
4	describe equilibrium reactions, understand meaning of equilibrium constant, perform calculations using equilibrium constant, apply LeChatelier's principle to equilibrium reactions	
5	apply equilibrium principles to acid-base, solubility, and complex ion reactions	
6	describe energy transformations in chemical reactions using thermodynamics, relate and perform calculations using thermodynamic quantities	
7	describe, relate factors, and perform calculations involved in determining the rate of a reaction, describe reaction mechanisms based on rate laws	
8	identify and balance oxidation-reduction reactions and apply redox principles and relevant calculations to galvanic and electrolytic cells	
9	distinguish between chemical and nuclear reactions, describe nuclear radiation sources, nuclear reaction types, safety, protection	
10	perform basic lab techniques and measurements	
11	design experiments, analyze and interpret data and results, draw conclusions	
	Overall Chem 1B Grade	

Name: _____

Chem 1B, Instructor: L. Yee
May 29, 2012

FINAL EXAM

Show all work!!

The In Class part of the Final Exam is worth 12% of your grade. For full credit, show all work in a logical and legible sequence. Clearly underline or circle your final answer. Include units where needed. You may use your textbook, notes, and a calculator. You may ask me for a hint; however, each hint will cost you 1 point.

1. (3 units) a. You are at the beach and feel thirsty. Should you drink sea water? Give reasons.

b. In Lab 1, you reacted an acid and alcohol to make an ester and water. This reaction is exothermic. To increase the reaction rate and % yield, would you raise the reaction temperature or use a catalyst? Give reasons.

2. (6 units) You have a piece of gold metal and want to gold plate a steel spoon.

a. You have hydrogen peroxide (H_2O_2) and bleach (ClO^- (aq) + H_2O (l) + 2 e^- → Cl^- (aq) + 2 OH^- (aq), E_{red} = +0.90 V) as oxidizing agents. Which one would you use to oxidize gold? Give reasons.

b. Why do you need to oxidize gold?

c. Draw an electrochemical cell diagram that shows how you plate gold plate a steel spoon. Label the anode and cathode. Write the half reaction that occurs at each electrode and the overall reaction.

d. Is it possible for the applied voltage to be too high? Give reasons.

3. (5 units) Chlorine is used to sanitize swimming pools. When chlorine is bubbled through water, two acids are formed:

Cl_2 (g) + H_2O (l) -----> HOCl (aq) + HCl (aq)

a. Would you expect K_{eq} for this reaction to be greater than 1 or less than 1? Give reasons based on the solubility of Cl_2 in H_2O. Confirm your answer by calculating K_{eq}. (For HOCl (aq), ΔH_f = -121 kJ/mole, ΔG_f = -80 kJ/mole, S_f = 142 J/mole K; for HCl (aq), ΔH_f = -167 kJ/mole, ΔG_f = -131 kJ/mole, S_f = 56.4 J/mole K)

b. Will more Cl_2 or less Cl_2 dissolve in hot water? In other words, does raising the temperature shift the reaction toward the reactant side or product side? Give reasons.

c. For this reaction, ΔH of reaction = 97.8 kJ/mole. Calculate ΔS for this reaction. Is there a temperature at which this reaction will or will not occur? Give reasons.

4. (4 units) Compare regular chemistry to nuclear chemistry.

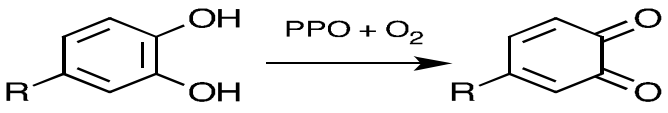
a. Which part of the atom is involved in regular chemistry? Which part of the atom is involved in nuclear chemistry?

b. Does the term “alpha ray” accurately describe the radioactive decay of certain isotopes? Give reasons. Name one source of “alpha rays”.

c. If skin blocks “alpha rays”, why is this type of radiation considered dangerous with a high relative biological effect (RBE)?

d. The conservation of mass law is obeyed in regular chemistry. Is this conservation law obeyed in a nuclear reaction? What equation supports your answer?

5. (6 units) When cut or bitten, phenolic compounds in apples, bananas, and other fruit react and turn the fruit brown Polyphenolase (PPO) catalyzes this reaction. This reaction is shown below.



colorless
1

colored
2

a. Explain how infrared (IR) spectroscopy is used to distinguish between the colorless reactant (1) and the colored product (2).

b. Draw a reaction energy diagram for this reaction with and without the catalyst. Label ΔH and the activation energy on your diagram.

c. Two ways to increase the reaction rate are to raise the temperature and to use a catalyst. Why is an enzyme used in the fruit browning reaction instead of heating the reaction for an hour at $100^{o}C$?

d. Draw a graph that shows the concentration of the Compound (1) vs. time of reaction and the concentration of Compound (2) vs. time of reaction. What happens to the reaction rate as a reaction proceeds?