Name: _____

Chem 1B, Instructor: L. Yee
March 12, 2010

EXAM 1

Show all work!!

Exam 1 is worth 10% of your grade (50 points). 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 a Periodic Table, a 3.5"x5" card for notes, and a calculator. You may ask me for a hint; however, each hint will cost you 1 point.

Constants: R = 8.31 J/mole ^{o}K = 0.082 l atm/mole ^{o}K; K_f (water) = 1.86^{o}C/m, K_b (water) = 0.52^{o}C/m, K_f (ethanol) = 1.99^{o}C/m, K_b (ethanol) = 1.22^{o}C/m, K_b (ethylene glycol) = 2.26 ^{o}C/m.

1. (6 points) Agree or disagree with the following statements. Support your answer with chemical reasoning, calculations, analogies, examples, etc.

a. Since sugar is soluble in water, the lattice energy must be greater than the hydrogen bonds holding water together.

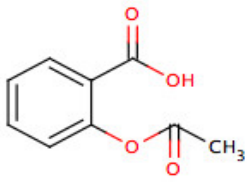
b. The addition of salt to water raises the boiling point, lowers the freezing point, lowers the vapor pressure, and makes the water boil faster.

c. The three factors that determine how fast a chemical reaction occurs are concentration, half-life, and enthalpy.

2. (8 points) a. Explain what happens when a can of soda is opened. Give chemical reasons. How can you keep the soda from going flat?

b. Sugar is used to preserve home-made jam and jelly by killing bacteria that may cause botulism. The appropriate sugar concentration will allow water to pass out of the cell and collapse (crenation) the cell. Should the sugar concentration that is used to preserve the jam be higher or lower than the sugar concentration inside bacteria cells? Give reasons.

3. (8 points) a. Circle the functional group(s) in aspirin. Write the name of the functional group next to your circle.



b. Does aspirin react with ethanol, C_2H_5OH? If so, draw the structure of the organic product of this reaction.

(Extra credit: 1 point) Is it a good idea to drink alcohol with aspirin? Give reasons.

4. (10 points) You made ice cream in Chem 1B lab.

a. What is the solvent in ice cream? Name one solute in ice cream.

b. Calculate the mass of rock salt to lower the temperature of 1 pound (454 g) of ice to -10^{o}C.

c. If you substituted antifreeze (ethylene glycol) for rock salt, could you still make ice cream? Give chemical reasons.

5. (18 points) In Lab 3, you studied the rate of the iodine clock reaction:

$$IO_3^- + 3\ HSO_3^- \text{ ---> } I^- + 3\ SO_4^{2-} + 3\ H^+.$$

You determined the rate law to be: rate = k $[IO_3^-][HSO_3^-]$ where k = 6.3 M^{-1} sec^{-1} at 26^{o}C and activation energy = 19.7 kJ/mole.

a. For the iodine clock reaction, determine whether the rate, rate constant, and activation energy increases, decreases, or stays the same when the following reaction conditions are changed. Fill in your answers in the table below.

Reaction condition	Rate	Rate constant	Activation energy
Add water to the reaction mixture			
Lower the reaction temperature			
Increase the $[HSO_3^-]$			

b. You want the iodine clock reaction to turn blue in 30 seconds. Identify the reaction conditions ($[IO_3^-]$, $[HSO_3^-]$, temperature) that will make it turn blue in 30 seconds.

Remember that rate = $\Delta[IO_3^-]/\Delta t$ where $\Delta[IO_3^-]$ = 0.00033 M and for Solution 1, $[IO_3^-]$ = 0.01 M after mixing, $[HSO_3^-]$ = 0.001 M after mixing.

c. Which mechanism best fits the rate law? Give reasons.

Mechanism A:

IO_3^- ---> IO^- + O_2
IO^- + HSO_3^- ---> I^- + SO_4^{2-} + H^+
O_2 + HSO_3^- ---> O + SO_4^{2-} + H^+
O + HSO_3^- ---> SO_4^{2-} + H^+

Mechanism B:
IO_3^- + HSO_3^- ---> IO_2^- + HSO_4^-
IO_2^- + HSO_3^- ---> IO^- + HSO_4^-
IO^- + HSO_3^- ---> I^- + HSO_4^-

Mechanism C:
IO_3^- + HSO_3^- ---> I^- + O_2 + SO_4^- + H^+
O_2 + 2HSO_3^- ---> 2 SO_4^{2-} + 2 H^+

Chem 1B, EXAM 2
Posted April 28, 2010

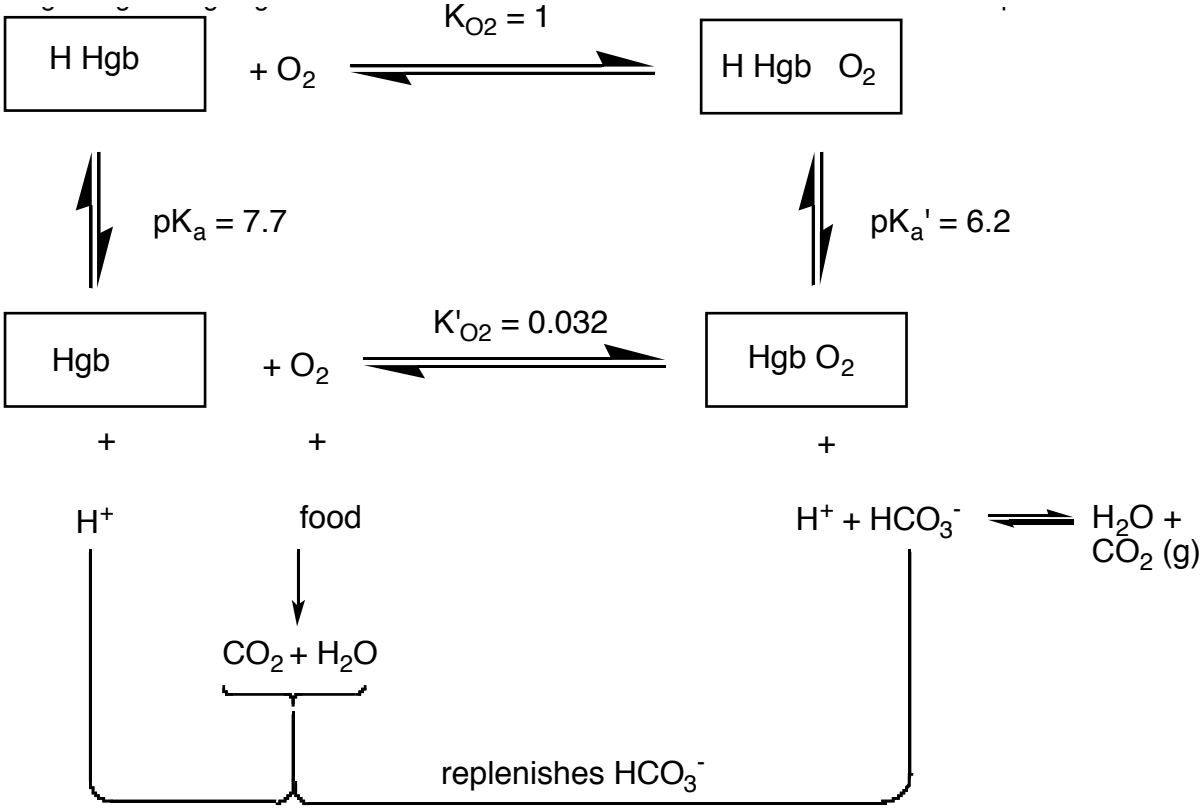
Exam 2 is worth 10% of your grade (50 points) and will be given on Monday, May 3, 2010 during lecture. You may use your textbook, notes, and a calculator. For full credit, show all work in a logical and legible sequence. Clearly underline or circle your final answer. Include units where needed.
Questions from the following topics will be given on Exam 2. **Part of Exam 2 will involve questions on these topics.**
The remaining half of Exam 2 will cover other Chem 1B topics.
Between now and Monday, I encourage you to work with other Chem 1B students to attempt to identify questions from each topic and the solutions. If you work in a group, every person should contribute.
1. Draw titration curve of a polyprotic acid. Calculate the pH at starting point, each half-way point, and each end point.

2. Blood has a normal pH of 7.35-7.45 and contains two major buffer systems. It is important that the pH of blood remains relatively constant because at pH below 6.8 or greater than 8.0, cells cannot function properly and death may result. The HCO_3^-/CO_2 (aq) blood buffer *in vivo* is an *open system* in which the concentration of dissolved CO_2 is maintained constant. Any excess CO_2 produced by the reaction $H^+ + HCO_3^-$ ---> $H_2O + CO_2$ is expelled by the lungs. Note that a typical laboratory buffer is a *closed system*. The concentration of conjugate acid increases when H^+ reacts with the conjugate base.
You calculated the K_{eq} and pK of Reaction (4) from the following reactions and K values in lecture.

CO_2 (g) <==> CO_2 (aq)	$K_1 = 3 \times 10^{-5}$ at 37°C.
CO_2 (aq) + H_2O (l) <==> H_2CO_3 (aq)	$K_2 = 5 \times 10^{-3}$ at 37°C
H_2CO_3 (aq) <==> H^+ (aq) + HCO_3^- (aq)	$pK_a = 3.8$ at 37°C
CO_2 (aq) + H_2O (l) <==> H^+ (aq) + HCO_3^- (aq)	K_4 = ?

The $[HCO_3^-] = 0.024$ M in blood at pH 7.4. You calculated the $[CO_2$ (aq)] in blood at this pH.

3. 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.



During the 4/5/10 lecture, we discussed the relevant equilibrium reactions involving the four different forms hemoglobin.

Name: _____

Chem 1B, Instructor: L. Yee
May 3, 2010

EXAM 2
Show all work!

Exam 2 is worth 10% of your grade (50 points). 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. (6 points) Agree or disagree with the following statements. Support your answer with chemical reasoning, calculations, analogies, examples, etc.

a. A buffer contains a strong base and a weak acid.

b. The combustion of methane is a fast reaction that releases a lot of energy. This means that this reaction has a high activation energy and is exothermic.

2. (15 points) Blood has a normal pH of 7.35-7.45 and contains two major buffer systems. It is important that the pH of blood remains relatively constant because at pH below 6.8 or greater than 8.0, cells cannot function properly and death may result. The HCO_3^-/CO_2 (aq) blood buffer *in vivo* is an *open system* in which the concentration of dissolved CO_2 is maintained constant. Any excess CO_2 produced by the reaction $H^+ + HCO_3^-$ ---> $H_2O + CO_2$ is expelled by the lungs. Note that a typical laboratory buffer is a *closed system*. The concentration of conjugate acid increases when H^+ reacts with the conjugate base.

You calculated the K_{eq} and pK of Reaction (4) from the following reactions and K values in lecture.

CO_2 (g) <==> CO_2 (aq)	$K_1 = 3 \times 10^{-5}$ at 37°C.
CO_2 (aq) + H_2O (l) <==> H_2CO_3 (aq)	$K_2 = 5 \times 10^{-3}$ at 37°C
H_2CO_3 (aq) <==> H^+ (aq) + HCO_3^- (aq)	pK_a = 3.8 at 37°C
CO_2 (aq) + H_2O (l) <==> H^+ (aq) + HCO_3^- (aq)	K_4 = ?

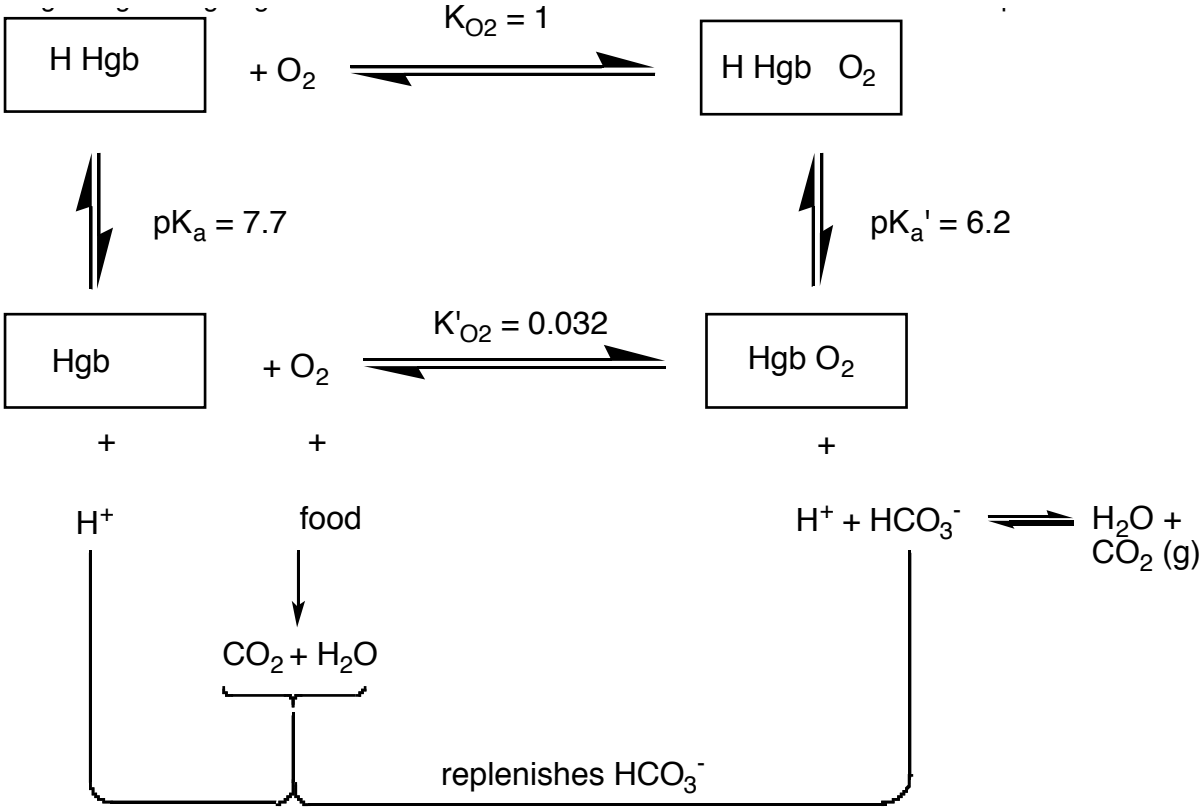
At pH 7.4, the $[HCO_3^-]$ = 0.024 M and the $[CO_2\ (aq)]$ = 0.0014 M in blood.

a. Draw the titration curve of 20 ml of 0.1 M H_2CO_3 (aq) being titrated with 0.1 M NaOH. Calculate the pH at starting point, each half-way point, and each end point.

b. What is the ratio of $[H_2CO_3]$ to $[HCO_3^-]$ at pH 7.4?

c. Is the CO_2 (aq)/ HCO_3^- (aq) equilibrium reaction exothermic or endothermic? Give reasons. Will a drop in temperature from 37°C to 25°C change the ratio of $[CO_2\ (aq)]$/ $[HCO_3^-]$? Give reasons.

3. (8 points) 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.



During the 4/5/10 lecture, we discussed the relevant equilibrium reactions involving the four different forms hemoglobin.

a. Once hemoglobin is oxygenated, which equilibrium reaction is affected? In which direction does this reaction shift? Give reasons.

b. The reaction in part a increases the $[H^+]$ and forces another equilibrium reaction to shift which releases CO_2 to the atmosphere. Which equilibrium reaction is affected and in which direction does this reaction shift? Give reasons. What happens to the blood pH when this equilibrium reaction shifts?

4. (9 points) For parts a, b, and c, predict the sign (> 0, = 0, or < 0) of the specified quantities for the following processes. Use the table of thermodynamic values as needed (although you can receive full credit without doing calculations). Give reasons for your answer.

a. Dissolution of solid sugar in water	ΔG
b. Shuffle a deck of cards	ΔS
c. CO_2 (s) ---> CO_2 (g)	work

5. (12 points) a. Draw schematic diagrams of a heat engine and refrigerator. Use arrows to show heat in, heat out, and work in each diagram. Describe how work is produced or supplied in each process.

b. The operating conditions in a heat engine are high temperature and high pressure. As more reactants (fuel and air) are added to the engine, products are removed. Using your knowledge of thermodynamics, equilibrium, and reaction rate, explain why these T and P conditions are used.

Chem 1B, FINAL EXAM - TAKE-HOME PART

due Friday, May 28, 2010 at 11:30 am

The Take Home Part of the Final Exam is worth 10% of your grade (50 points). 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 – 3 of the Final Exam. **You must do Question 4 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. (25 points) 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. Would you expect K_{eq} for Reaction (1) 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}.

b. Would you expect K_{eq} for Reaction (2) to be greater than 1 or less than 1? Give reasons based on the solubility of NaOCl in H_2O.

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

d. Complete Reactions 3 and 4.

e. According to PoolCenter.com (http://www.poolcenter.com/chlor.htm),

"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.

f. 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.

g. 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) Does your graph confirm the pH and % "chlorine" in part e? Give reasons.

2. (7 points) One use of radioactive isotopes is in medicine (see Chang, "General Chemistry: The Essential Concepts", 4th ed., p. 707).

a. Name 2 radioisotopes that are used in medicine. For each radioisotope, briefly describe the medical application and write a nuclear equation that shows how the radioisotope is used.

b. 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 suppports your answer. What therapy is BNCT used for? What is one problem with BNCT?

3. (8 points) When $CoCl_2$ is dissolved in aqueous ammonia, NH_3 (aq), and then oxidized in air, four cobalt (III) compounds are formed. Each compound is a different color.

$CoCl_3 \bullet 6\ NH_3$ (orange-yellow)
$CoCl_3 \bullet 5\ NH_3$ (purple)
$CoCl_3 \bullet 4\ NH_3$ (green)
$CoCl_3 \bullet 4\ NH_3$ (violet)
Three different experiments are performed to determine the structure of these compounds.
a. (Taken from Chang, "General Chemistry: The Essential Concepts", 4th ed., p. 683, Problem 20.32) To determine the structure of $CoCl_3 \bullet 4\ NH_3$ (the chemical formula of this compound can also be written $Co(NH_3)_4Cl_3$), 0.875 g of $Co(NH_3)_4Cl_3$ is dissolved in 25.0 g of water. The resulting solution freezes at –0.56°C. Determine the number of moles of ions produced when 1 mole of $Co(NH_3)_4Cl_3$ is dissolved in water.
b. Draw the two isomers of $Co(NH_3)_4Cl_3$. What is the geometry at the Co? Show $Co(NH_3)_4Cl_3$ follows the 18 electron rule.
c. Color is used to identify these cobalt compounds. Compare $CoCl_3 \bullet 6\ NH_3$ to $CoCl_3 \bullet 4\ NH_3$. Which substance absorbs more energy? Based on the spectrochemical series, explain why this substance absorbs more energy than the other one.
d. The addition of excess Ag^+ (aq) to form AgCl (s) can be used to determine the strucure of these cobalt compounds.
(i) One mole of $CoCl_3 \bullet 6\ NH_3$ is treated with excess Ag^+ (aq). How many moles of AgCl are produced? Give reasons.
(ii) One mole of $CoCl_3 \bullet 4\ NH_3$ is treated with excess Ag^+ (aq). How many moles of AgCl are produced? Give reasons.

4. (10 points) 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. Identify the course objective that you understand the best. What did you do to help you understand this objective so well?
c. Identify the course objective that you understand the worst. What could you have done to understand this objective better?
d. 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 28, 2010

FINAL EXAM

Show all work!!

The In Class part of the Final Exam is worth 10% of your grade (50 points). 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 points) Agree or disagree with the following statements. Support your answer with chemical reasoning, calculations, analogies, examples, etc.

a. Beta particles are more dangerous to living tissue than alpha particles because beta particles are heavier and move faster than alpha particles.

b. In a refrigerator, air is cooled inside the refrigerator because work is supplied to the compressor to compress the low pressure refrigerant to high pressure refrigerant.

2. (6 points) a. How are organic compounds classified? How is IR spectroscopy used to identify organic compounds?

b. Explain why the same metal cannot be used as the anode and cathode in a battery.

3. (10 points) An alcohol reacts with a carboxylic acid to produce an ester and water. This reaction is an exothermic, equilibrium reaction and is catalyzed with sulfuric acid.

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

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

c. Draw a graph that shows the concentration of acid vs. time of reaction and the concentration of ester vs. time of reaction. What happens to the reaction rate as a reaction proceeds?

4. (15 points) If you believe advertising and marketing "Diamonds are forever." Consider the following reaction:

C (diamond) ----> C (graphite)

The rate of conversion from diamond to graphite is too slow to observe.

a. According to thermodynamics, are diamonds forever? Give reasons. Show calculations to support your reasons as needed.

b. Calculate the equilibrium constant for this reaction. Based on your answer, are diamonds forever?

c. According to reaction rates, are diamonds forever? Give reasons. Show calculations to support your reasons as needed.

d. If this reaction does (or does not) occur, is there a temperature at which this reaction does not (or does) occur? If so calculate this temperature.

e. According to Sienko and Plane, "Chemical Principles and Properties", 2^{nd} ed., 1974, p. 578, "At high pressure, LeChatelier's principle predicts that diamond should become stable since its density (3.51 g/cm^3) is greater than that of graphite (2.25 g/cm^3)." Explain this statement using LeChatelier's principle.

5. (9 points) The electricity just went out in your house and you need 3 V to run your study lamp to study for your "How to Download Music for Free" class. You remember you have a tin (Sn) cup, silver (Ag) spoon, copper (Cu) wire, iron (Fe) nail, and zinc (Zn) rod and the corresponding metal ion solutions.

a. To make the highest voltage battery, which combination of oxidizing agent and reducing agent would you want to use? Choose one only. Give reasons. Calculate the voltage of this battery.

(i) the strongest oxidizing agent and strongest reducing agent
(ii) the strongest oxidizing agent and weakest reducing agent
(iii) the weakest oxidizing agent and strongest reducing agent
(iv) the weakest oxidizing agent and weakest reducing agent.

b. Which metals would you use to make a 3 V battery? Write the half reaction at each electrode and the overall cell reaction. Calculate the cell voltage.

6. (6 points) The following poem is taken from B. Selinger, "Chemistry in the Marketplace".

Chant of the Radioactive Workers

We're not afraid of the alpha ray,
A sheet of paper will keep it away!
A beta ray needs much more care,
Place sheets of metal here and there.
And as for the powerful gamma ray
(Pay careful heed to what we say)
Unless you wish to spend weeks in bed

Take cover behind thick slabs of lead!
Fast neutrons pass through everything.
Wax slabs remove their nasty sting.
These slow them down, and even a moron
Knows they can be absorbed by boron.
Remember, remember all that we've said,
Because it's no use remembering when you're dead.

You are offered a job at a nuclear power plant to monitor the control rods in the nuclear reactor. You see this poem posted in the control room.

a. What type(s) of radiation would you encounter if you worked in a nuclear power plant? Identify the specific source of each type of radiation. For one radiation type, write a nuclear equation that shows the source of radiation.

b. Boron is used as the control rods in a nuclear reactor. What is the function of the control rods?