Name: _____

Chem 1B, Instructor: L. Yee
February 29, 2008

QUIZ 1

Show all work!!

Quiz 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. Experiments show benzene, C_6H_6, has six carbon-carbon bonds of equal length. The Lewis structure of benzene accurately represents the bonding in this compound. For full credit, draw the structure of benzene.

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

2. (7 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. (12 points) Figure 1 shows a protein and the chemical forces that gives the protein its specific shape.

a. In the protein structure in Figure 1, circle one polar organic functional group and one non-polar organic functional group. Write the name of the functional group next to your circle.

b. Note the five arrows that point to specific interactions in the protein. Next to each arrow, identify the specific type of chemical force.

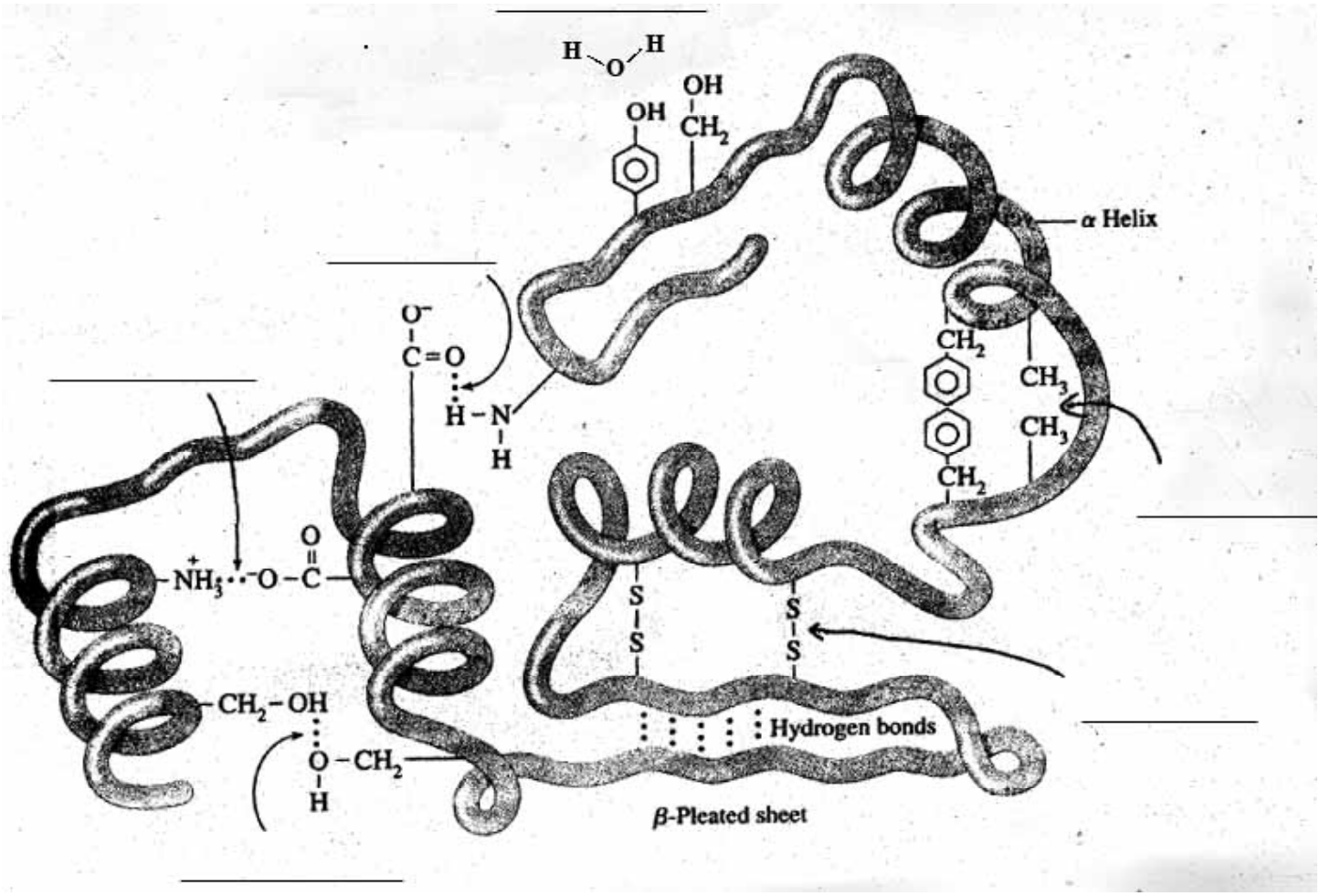


Figure 1. The chemical forces that fold a protein into its specific three dimensional shape.

c. As the protein is heated, which specific interaction in the protein do you think will break first? Give reasons.

4. (7 points) You made ice cream in lab this week.
a. Calculate the mass of rock salt to lower the temperature of 1 kg of ice to -10^{o}C.
b. If you substituted antifreeze (ethylene glycol) for rock salt, could you still make ice cream? Give chemical reasons.

5. (18 points) Your car ran out of gasoline (octane, C_8H_{18}). Although it is a very hot day, you trudge to the nearest gas station to get some gas. You notice that the gas station sells ethanol (C_2H_5OH) in addition to gasoline. Your car can run on ethanol as well as gasoline. All you have is an open 2 liter glass jar (no lid) to carry fuel. You are concerned that all of the fuel will evaporate from the open jar on this hot day before you get back to the car.
a. Which fuel, gasoline or ethanol, would you put in the open glass jar to take back to your car? Give reasons.
b. You have a packet of sugar (10 g), a packet of salt (10 g), and a packet of mayonnaise (assume to be 10 g of vegetable oil, $C_{15}H_{31}COOH$) . Remembering your colligative properties of solutions, you figure you can add one of these substances to the fuel to keep it from evaporating. Which colligative property would you use for this application? Which substance would you add to the fuel you chose in part a? Give reasons.
c. Explain why the substance you chose in part b is soluble in the fuel you chose in part a.
d. You wonder if you can raise the boiling point of ethanol by reacting it with the mayonnaise (vegetable oil). Will ethanol react with mayonnaise? If so, draw the structure of the product of this reaction. Will this product have a higher boiling point than ethanol? Give reasons.
e. Can IR spectroscopy be used to determine whether the product was produced? If so, explain how IR can be used to determine whether the product was produced. If not, what experimental method could you use to determine whether the product was produced?

Chem 1B, QUIZ 2
Posted April 9, 2008

Quiz 2 is worth 10% of your grade (50 points). Quiz 2 will be given on Wednesday, April 16, 2008 during lecture based on questions from this assignment. You are allowed to bring a Periodic Table 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. Between now and next Wednesday, I encourage you to work with other Chem 1B students to determine the solutions to the questions on this quiz. If you work in a group, every person should contribute to the solutions and understand the solutions. You may ask me for a hint; however, each hint will cost you 1 point.

1. Chang, "General Chemistry: The Essential Concepts", 4th ed., 2006, p. 477, Problem 14.105.

2. Consider the three reactions that occur in a car engine:

$2\ CO\ (g) + O_2\ (g) \rightarrow 2\ CO_2\ (g)$ (1)

$2\ C_8H_{18}\ (g) + 25\ O_2\ (g) \rightarrow 16\ CO_2\ (g) + 18\ H_2O\ (g)$ (2)

$2\ NO\ (g) \rightarrow N_2\ (g) + O_2\ (g)$ (3).

a. Determine whether each reaction occurs spontaneously. Give reasons. For each reaction, determine whether the equilibrium constant is greater than 1 or less than 1.

b. According to Moore, et al., "The Chemical World", 2nd ed., p. 548, "The largest growth in catalyst use is in emissions control for both automobiles and power plants." A catalytic converter in a car has two purposes. What are the two purposes?

c. In Reaction (1), CO is converted to CO_2. What is the source of CO? Write a chemical equation that represents the reaction that produces CO.

d. For each of the three reactions, speculate on the rate of the reaction without a catalyst. In other words, do you expect the reaction to occur fast or slow? Give reasons.

e. NO is a considered a serious air pollutant. Look up the toxicity or safety of NO and describe briefly. Cite the reference where you found this information.

f. Describe the optimum temperature and pressure conditions for Reactions (1) and (3).

g. Under the conditions of a car engine, is Reaction (1) likely to occur or is the reverse of Reaction (1) likely to occur? Give reasons. In a car engine, NO is produced when N_2 reacts with O_2. Under the conditions of a car engine, is Reaction (3) likely to occur or is the reverse of Reaction (3) likely to occur? Give reasons.

3. In Lab 1, you made fingernail polish remover by heating an ethanol and vinegar mixture in the presence of a sulfuric acid catalyst. Most reactions are exothermic. Most organic reactions are equilibrium reactions. In the table below, indicate whether the % yield of product will increase, decrease, or stay the same when the specified reaction condition is changed. Do the same for reaction rate. You do not have to give reasons!

Reaction Condition	% Yield	Reaction Rate
Raise the temperature		
Use diluted vinegar solution		
Add sulfuric acid		

4. 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 $H^+ + HCO_3^- \rightarrow H_2O + CO_2$ 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.

$CO_2\ (g) \Leftrightarrow CO_2\ (aq)$ $K_1 = 3 \times 10^{-5}$ at 37°C.

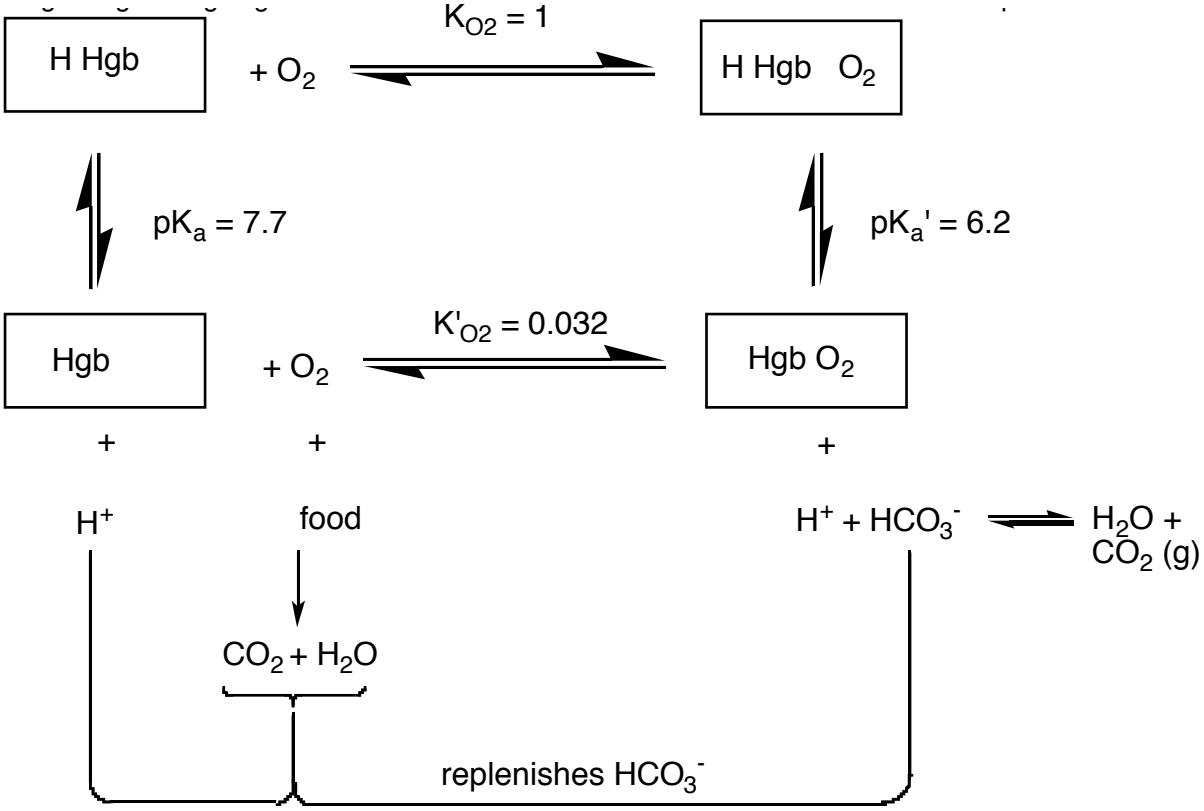
$CO_2\ (aq) + H_2O\ (l) \Leftrightarrow H_2CO_3\ (aq)$ $K_2 = 5 \times 10^{-3}$ at 37°C

$H_2CO_3\ (aq) \Leftrightarrow H^+\ (aq) + HCO_3^-\ (aq)$ $pK_a = 3.8$ at 37°C

$CO_2\ (aq) + H_2O\ (l) \Leftrightarrow H^+\ (aq) + HCO_3^-\ (aq)$ $K_4 = ?$

You calculated the $[HCO_3^-]$ = 0.024 M in blood at pH 7.4. Calculate the $[CO_2\ (aq)]$ in blood at this pH.
0.01 M H^+ is added to blood. You calculated the pH of blood under conditions such that the increased $[CO_2\ (aq)]$ can be released as CO_2 (g). In other words, assume that the blood buffer is an open system. Remember that the $[CO_2\ (aq)]$ remains constant in this open buffer system.
a. Cells cannot function property if the pH of blood falls below 6.8 or rises above 8.0. Calculate the amount in M of H^+ that is **added** to blood for the blood pH to fall to 6.8.
b. Difficulty with ventilation can lead to respiratory acidosis. Explain using equilbirum principles how difficulty with ventilation lowers blood pH.
c. The blood pH can be increased by infusion of bicarbonate. Calculate the amount in M of HCO_3^- that is added to blood for the blood pH of rise to 8.0. Calculate the amount of H^+ in M that is removed when this amount HCO_3^- of is added.

5. 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 4/11/08 lecture, we discussed the relevant equilibrium reactions involving the four different forms hemoglobin.
a. Calculate the ratio of the acid and conjugate base forms of oxyhemoglobin and deoxyhemoglobin at pH 7.4..
b. Of the four forms of hemoglobin, what form of hemoglobin is present in the highest amount in the blood in our lungs? Give reasons.
c. Once hemoglobin is oxygenated, which equilibrium reaction is affected? In which direction does this reaction shift? Give reasons.
d. The reaction in part c 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?
e. Of the four forms of hemoglobin, what form of hemoglobin is present in the highest amount in the blood in our tissues? When O_2 is released, which equilibrium reaction is affected? In which direction does this reaction shift?

6. You know that calcium carbonate is insoluble in water from Chem 1A. However, according to solubility equilibria, calcium carbonate solid is in equilibrium with its ions. In other words, a small amount of calcium carbonate does dissolve in water.

a. 1 mole of calcium carbonate is dumped in 1 l of water. Calculate the concentration of Ca^{2+} ion in this solution. (Hint: use the solubility product constant for this reaction.)
b. You know that calcium carbonate dissolves in HCl. Write a balanced chemical equation that represents this reaction. Calculate the equilibrium constant for this reaction. (Hint: use K_{sp} and K_a of carbonic acid and add a few equations together.) Calculate the mass of calcium carbonate that dissolves in 1 l of pH 4 HCl.
c. Does calcium carbonate dissolve in acetic acid? Write a balanced chemical equation that represents this reaction. Calculate the equilibrium constant for this reaction. (Hint: use K_{sp} and K_a of acetic acid and add a few equations together.) Calculate the mass of calcium carbonate that dissolves in 1 l of pH 4 acetic acid.

Name: _____

Chem 1B, Instructor: L. Yee
April 16, 2008

QUIZ 2
Show all work!

Quiz 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 a Periodic Table and a calculator. You may ask me for a hint; however, each hint will cost you 1 point.
1. (8 points) Chang, "General Chemistry: The Essential Concepts", 4th ed., 2006, p. 477, Problem 14.105.
Polyethylene is used in many items such as water pipes, bottles, electrical insulation, etc. It is a polymer, a molecule with a very high molar mass made by joining many ethylene molecules (monomers) together. The initiation step is

$R_2 - k_i \rightarrow 2\ R\bullet$ initiation

The R• species (called a radical) reacts with an ethylene molecule (M) to generate another radical

$R\bullet + M \rightarrow M_1\bullet$

Reaction of M1• with another monomer leads to the growth or propagation of the polymer chain:

$M_1\bullet + M \text{ -- } k_p \rightarrow M_2\bullet$ propagation

This step can be repeated with hundreds of monomer units. The propagation terminates when two radicals combine

$M'\bullet + M''\bullet \text{ -- } k_t \rightarrow M'\text{-}M''$ termination

The initiator used in the polymerization of ethylene is benzoyl peroxide [$(C_6H_5COO)_2$]:

$(C_6H_5COO)_2 \rightarrow 2\ C_6H_5COO\bullet$

This is a first order reaction. The half-life of benzoyl peroxide at 100°C is 19.8 min.
a. If the half-life of benzoyl peroxide is 7.30 hr or 438 min, at 70°C, what is the activation energy (in kJ/mol) for the decomposition of benzoyl peroxide?
b. What condition would favor the growth of long high molar mass polyethylenes?

2. (16 points) Consider the three reactions that occur in a car engine:

$2\ CO\ (g) + O_2\ (g) \text{ ---> } 2\ CO_2\ (g)$ (1)

$2\ C_8H_{18}\ (g) + 25\ O_2\ (g) \text{ ---> } 16\ CO_2\ (g) + 18\ H_2O\ (g)$ (2)

$2\ NO\ (g) \text{ ----> } N_2\ (g) + O_2\ (g)$ (3).

a. According to Moore, et al., "The Chemical World", 2nd ed., p. 548, "The largest growth in catalyst use is in emissions control for both automobiles and power plants." A catalytic converter in a car has two purposes. What are the two purposes?
b. For each of the three reactions, speculate on the rate of the reaction <u>without</u> a catalyst. In other words, do you expect the reaction to occur fast or slow? Give reasons.
c. Describe the optimum temperature (high or low T) and pressure (high or low P) conditions for Reactions (1) and (3).
d. Under the conditions of a car engine, is Reaction (1) likely to occur or is the reverse of Reaction (1) likely to occur? Give reasons. In a car engine, NO is produced when N_2 reacts with O_2. Under the conditions of a car engine, is Reaction (3) likely to occur or is the reverse of Reaction (3) likely to occur? Give reasons.

3. (6 points) In Lab 1, you made fingernail polish remover by heating an ethanol and vinegar mixture in the presence of a sulfuric acid catalyst. Most reactions are exothermic. Most organic reactions are equilibrium reactions. In the table below, indicate whether the % yield of product will increase, decrease, or stay the same when the specified reaction condition is changed. Do the same for reaction rate. You do <u>not</u> have to give reasons!

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4. (8 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 $H^+ + HCO_3^- \text{---> } H_2O + CO_2$ 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.

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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 = ?

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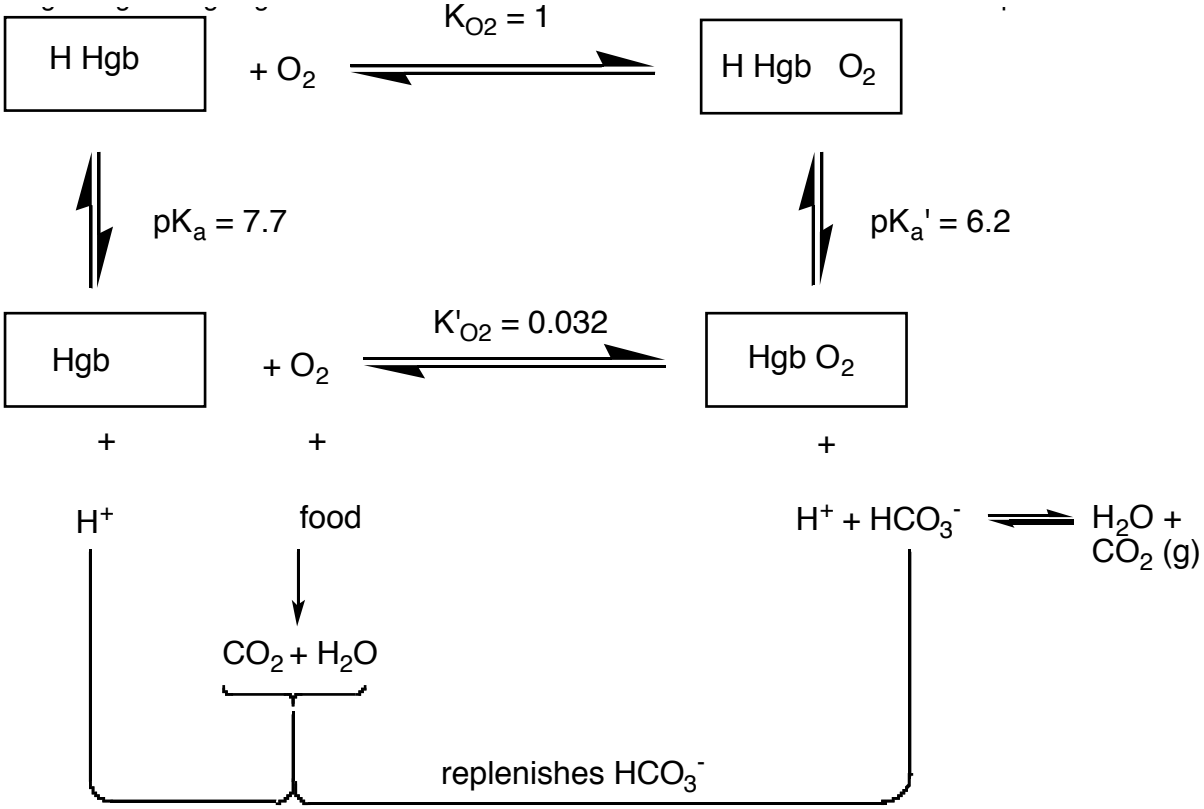
0.01 M H^+ is added to blood. You calculated the pH of blood under conditions such that the increased $[CO_2$ (aq)] can be released as CO_2 (g). In other words, assume that the blood buffer is an open system. Remember that the $[CO_2$ (aq)] remains constant in this open buffer system.

a. Cells cannot function property if the pH of blood falls below 6.8 or rises above 8.0. Calculate the amount in M of H^+ that is **added** to blood for the blood pH to fall to 6.8.

b. Difficulty with ventilation can lead to respiratory acidosis. Explain using equilbirum principles how difficulty with ventilation lowers blood pH.

5. (12 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 4/11/08 lecture, we discussed the relevant equilibrium reactions involving the four different forms hemoglobin.
a. Calculate the ratio of the acid and conjugate base forms of oxyhemoglobin and deoxyhemoglobin at pH 7.4..
b. Of the four forms of hemoglobin, what form of hemoglobin is present in the highest amount in the blood in our lungs? Give reasons.
c. Of the four forms of hemoglobin, what form of hemoglobin is present in the highest amount in the blood in our tissues? When O_2 is released, which equilibrium reaction is affected? In which direction does this reaction shift?

Chem 1B, QUIZ 3
Posted May 9, 2008

Quiz 3 is worth 10% of your grade (50 points). Quiz 3 will be given on Friday, May 16, 2008 during lecture based on questions from this assignment. You are allowed to bring a Periodic Table 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.
Between now and next Wednesday, I encourage you to work with other Chem 1B students to determine the solutions to the questions on this quiz. If you work in a group, every person should contribute to the solutions and understand the solutions. You may ask me for a hint; however, each hint will cost you 1 point.
1. a. A refrigerator works like a heat engine in reverse. In the diagram below, label q_H (heat to or from the hot reservoir), q_C (heat to or from the cold reservoir), and w (work). Show the direction of the heat flow and work with an arrow.
b. In the schematic diagram of a refrigerator, circle the section that acts as the cold reservoir. Explain how this section works as the cold reservoir.

2. Instant Car Kooler™ is a product that consists of 10% ethanol and 90% water compressed by N_2 gas. Two 10 oz. Cans sell for $10.98. Spray Instant CarKooler into a hot car (130^{o}F = 55^{o}C) to cool the air to 77^{o}F = 25^{o}C. The appropriate nozzle is needed so that the drops of spray vaporize immediately.

1 g of H_2O (l) at 55^{o}C (initial state) ----------→ 1 g of H_2O (g) at 25^{o}C (final state)

a. Calculate q, w, ΔE, ΔH, ΔS, and ΔG. Assume that the Instant CarKooler is all water to simplify your calculations.
Hint: choose the appropriate path from the initial state to the final state that allows you to calculate q and w. Then, you will be able to calculate the thermodynamic functions.

b. What gains heat in this process? What loses heat in this process? Based on your answer, calculate the amount of heat lost by air and the mass of air that loses heat. From this mass of air, calculate the volume of air that is cooled inside the car at 55°C.

3. 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. Hydrogen may be the fuel of the next generation. One way to produce hydrogen is by the electrolysis of water.

a. Draw an electrochemical cell that can be used for the electrolysis of water. Use an inert material such as C or Pt for each electrode. Label the anode and cathode. Write the reactions that occur at each electrode. You have the following choices for half reactions (some of which may not be balanced):

$H^+ (aq) + e^- \text{---> } H_2 (g)$

$2\ H_2O (l) + 2\ e^- \text{---> } H_2 (g) + OH^- (aq)$

$O_2 (g) + 4\ H^+ (aq) + 2e^- \text{---> } 2\ H_2O (l)$

$O_2 (g) + 4\ H_2O (l) + 4\ e^- \text{---> } 2\ OH^- (aq)$

Write the net (overall) reaction. State what you will use as the electrolyte (choose prudently; more than one reaction may occur at each electrode). Calculate E^o_{cell}. At which electrode will H_2 be produced?

b. To run your electrolysis cell, you can use either a 1.10 V Zn-Cu Daniell cell or a 1.5 V alkaline (Duracell) battery. Which battery will you use? Give reasons.

c. Calculate ΔG and K_{eq} for your overall reaction in part a at 25°C. Is this electrolysis reaction favored by enthalpy or entropy or both? Give reasons.

d. Predict optimum T and P conditions for this reaction.

e. How can you make the electrolysis of water reaction go faster?

5. In 1996, General Motors produced the first electric car. This car used lead storage batteries. The car went about 90 miles before needing a recharge. Recharging took hours. The battery rating was 200 Amp-hours. Calculate the masses of lead, lead oxide, and sulfuric acid to make a 200 Amp-hour battery.

6. What is the difference between electromagnetic radiation and particle radiation? What is the source of each type of radiation? Which type of radiation involves more energy?

Name: _____

Chem 1B, Instructor: L. Yee
May 16, 2008

QUIZ 3

Show all work!

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1. (3 points) In the schematic diagram of a refrigerator, circle the section that acts as the cold reservoir. Explain how this section works as the cold reservoir.

2. (4 points) 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).

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.

3. (3 points) What is the difference between electromagnetic radiation and particle radiation?

4. (23 points) Instant Car Kooler™ is a product that consists of 10% ethanol and 90% water compressed by N_2 gas. Two 10 oz. Cans sell for $10.98. Spray Instant CarKooler into a hot car (130°F = 55°C) to cool the air to 77°F = 25°C. The appropriate nozzle is needed so that the drops of spray vaporize immediately.

1 g of H_2O (l) at 55°C (initial state) ----------→ 1 g of H_2O (g) at 25°C (final state)

a. Calculate q, w, ΔE, ΔH, ΔS, and ΔG. Assume that the Instant CarKooler is all water to simplify your calculations.
Hint: choose the appropriate path from the initial state to the final state that allows you to calculate q and w. Then, you will be able to calculate the thermodynamic functions.
b. What gains heat in this process? What loses heat in this process? Based on your answer, calculate the amount of heat lost by air and the mass of air that loses heat. From this mass of air, calculate the volume of air that is cooled inside the car at 55°C.

5. (12 points) Hydrogen may be the fuel of the next generation. One way to produce hydrogen is by the electrolysis of water.
a. Draw an electrochemical cell that can be used for the electrolysis of water. Use an inert material such as C or Pt for each electrode. Label the anode and cathode. Write the reactions that occur at each electrode. You have the following choices for half reactions (some of which may not be balanced):

$H^+ (aq) + e^- \rightarrow H_2 (g)$
$2\ H_2O (l) + 2\ e^- \rightarrow H_2 (g) + OH^- (aq)$
$O_2 (g) + 4\ H^+ (aq) + 2e^- \rightarrow 2\ H_2O (l)$
$O_2 (g) + 4\ H_2O (l) + 4\ e^- \rightarrow 2\ OH^- (aq)$

Write the net (overall) reaction. State what you will use as the electrolyte (choose prudently; more than one reaction may occur at each electrode). Calculate E^o_{cell}. At which electrode will H_2 be produced?
c. Calculate ΔG and K_{eq} for your overall reaction in part a at 25°C. Is this electrolysis reaction favored by enthalpy or entropy or both? Give reasons.
d. Predict optimum T and P conditions for this reaction.
e. How can you make the electrolysis of water reaction go faster?

6. (5 points) In 1996, General Motors produced the first electric car. This car used lead storage batteries. The car went about 90 miles before needing a recharge. Recharging took hours. The battery rating was 200 Amp-hours. Calculate the masses of lead, lead oxide, and sulfuric acid to make a 200 Amp-hour battery.

Chem 1B, FINAL EXAM - TAKE-HOME PART

due Wednesday, June 4, 2008 at 8 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 – 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. (14 points) A stove designer decides to use a butane, C_4H_{10}, as a fuel for a stove. The butane is stored in a pressurized container and the pressurized butane is dispensed through a nozzle into the stove.
a. Is the combustion of butane favored by entropy or enthalpy or both? As the temperature increases, does ΔG increase, decrease, or stay the same? Give reasons. Is there a temperature at which the combustion of butane reaction will not occur? If so, calculate this temperature. Give reasons.
b. If butane and air are mixed together at room temperature and pressure, what will happen? Based on your observations of any combustion reaction, would you expect the rate constant for this reaction to be large or small? Give reasons.
c. Some butane is released from the pressurized container (assume an adiabatic process). What happens to the temperature of the butane as it leaves the nozzle? Give reasons based on the 1st law of thermodynamics.
d. As you know, a refrigerator is a heat engine that runs in reverse. Is the situation in part c a good way to run a refrigerator? Give reasons.

2. (10 points) EDTA ($pK_1 = 2.0$, $pK_2 = 2.7$, $pK_3 = 6.2$, $pK_4 = 10.0$), oxalic acid ($pK_1 = 1.2$, $pK_2 = 4.2$), and citric acid ($pK_1 = 3.13$, $pK_2 = 4.76$, $pK_3 = 6.40$) bind to metals, are used as chelating agents, and are used as buffers.

a. Of these three acids, EDTA, oxalic acid, or citric acid, which acid is the strongest acid? Give reasons.
b. For the strongest acid you found in part a, draw a titration curve (pH vs. volume of base). Calculate the starting pH (assume a 0.1 M solution), the pH at each half-way point, and the pH at each end point. Label each pH on your titration curve.
c. The strongest acid you found in part a is a ligand. What type of ligand is this acid? At what pH does this ligand bind to a metal? Draw the structure and show the charge of this ligand to support your answer.

3. (6 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?

4. (10 points) (Taken from Chang, "General Chemistry: The Essential Concepts", 4th ed., p. 683, Problem 20.32) 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.
a. Determine the number of moles of ions produced when 1 mole of $Co(NH_3)_4Cl_3$ is dissolved in water.
b. Draw the structure of this compound. What is the geometry at the Co? What is the charge on the Co in this compound?
c. An absorption spectrum of $[Co(NH_3)_6]^{3+}$ shows an absorption maximum at 470 nm. What color is this compound?
d. Would you expect an absorption spectrum of $Co(NH_3)_4Cl_3$ to show an absorption maximum at 470 nm, greater than 470 nm, or less than 470 nm? Give reasons.

5. (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
June 4, 2008

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. For a fuel cell, E_{cell} and ΔG are negative with a large K and large k if current is low.

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

2. (3 points) How are organic compounds classified? How is IR spectroscopy used to identify organic compounds?

3. (12 points) a. Explain how reverse osmosis can be used to purify seawater (0.70 M NaCl). What happens to the concentration of seawater as osmosis occurs?

b. Difficulty with ventilation can lead to respiratory acidosis. Explain using equilbrium principles how difficulty with ventilation lowers blood pH.

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

d. EDTA (pK_1 = 2.0, pK_2 = 2.7, pK_3 = 6.2, pK_4 = 10.0), oxalic acid (pK_1 = 1.2, pK_2 = 4.2), and citric acid (pK_1 = 3.13, pK_2 = 4.76, pK_3 = 6.40) bind to metals, are used as chelating agents, and are used as buffers. Which substance would you use to make a pH 6 buffer? Calculate the ratio of [base]/[acid] to make this buffer.

4. (12 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. For part d, give a short answer.

a. Dissolution of solid sugar in water ΔG

b. Shuffle a deck of cards ΔS

c. Combustion of butane work

C_4H_{10} (g) + O_2 (g) ---> CO_2 (g) + H_2O (g)

d. For the dissolution of solid sugar in water, is the equilibrium constant, K, greater than 1, less than 1, or equal to 1? How is K related to ΔG?

5. (8 points) Chang, "General Chemistry: The Essential Concepts", 4th ed., 2006, p. 654, Problem 19.2c shows the oxidation of oxalate ion ($C_2O_4^{2-}$) using dichromate ion ($Cr_2O_7^{2-}$).

Standard Reduction Potential: 2 CO_2 (g) + 2 H^+ (aq) + 2 e^- → $H_2C_2O_4$ (aq) E^o = -0.49 V.

a. Will H_2O_2 oxidize oxalate ion? Give reasons. If this reaction occurs, write a balanced chemical equation that represents this reaction.

b. Draw a diagram of an electrochemical cell that oxidizes oxalate ion. Use an inert material such as C or Pt for each electrode. Label the anode and cathode. At which electrode will oxalate be produced? State what you will use as the electrolyte. What is the minimum voltage that is required to oxidize oxalate?

6. (6 points) You need some acid to remove rust from your car bumper. Since you are out of HCl, you decide to make HI from H_2 and I_2:

H_2 (g) + I_2 (g) <===> 2 HI (g)

The observed rate law for this reaction is first order in H_2 and first order in I_2.

a. Write the rate law for this reaction.

b. Fill in the blanks in the table:

Experiment	[H_2], M	[I_2], M	Rate, M/sec

1	6	6	15
2	6	18	____
3	12	____	60

Show how you determined <u>one</u> of your answers, e.g., give sample calculation or explain your logic.

c. Which mechanism, (i) or (ii), best fits the rate law? Give reasons.

(i) I_2 ---> 2 I (slow)
2 I + H_2 ---> 2 HI

(ii) $H_2 + I_2$ ---> HI_2 + H (slow)
HI_2 ---> HI + I
H + I ----> HI

7. (5 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.

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