Name: _____

Chem 1A, Instructor: L. Yee
October 4, 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"x5" card for 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. 0.025 M $HC_2H_3O_2$ is a weak acid that has a pH of 2, high conductivity, and turns blue litmus red. For full credit, show your pH calculation.

b. The oxygen ion is found in Period 2, Group VIA with 8 protons and 10 electrons.

2. (6 points) Each week, you check out your car to make sure it won't break down. When you look under the car, you see a few drops of liquid. The liquid could either be oil (a large hydrocarbon, $C_{20}H_{42}$), battery acid (sulfuric acid), or antifreeze (ethylene glycol, $C_2H_6O_2$, a type of alcohol). You perform the following tests on this liquid:

Test/Observation	Conclusion
(i) blue litmus stays blue	
(ii) red litmus stays red	
(iii) conductivity = 90 μS	

a. Draw a conclusion for each observation in the space above. For example, "test/observation shows subtance is an acid.

b. What is the identity of this liquid? If you can't definitively identify the liquid, what other observation or test would you need to do to identify the liquid under your car?

3. (14 points) Your pet dog, Ralph, is relaxing on a hot summer day in the pool and sipping mineral water. A radio playing cool music that is plugged into a 120V outlet accidentally drops into the pool. Although you've heard of people (or animals) getting electrocuted when this happens, Ralph is safe and unharmed.

a. Did the pool contain champagne (assumed to be pure ethanol, C_2H_5OH) or did it contain mineral water (water that contains Ca^{2+}, Mg^{2+}, HCO_3^-, K^+, Cl^-, and NO_3^-)? Give reasons.

b. Ralph forgets to put the cap back on his bottle of mineral water (water that contains Ca^{2+}, Mg^{2+}, HCO_3^-, K^+, Cl^-, and NO_3^-). A few hours later, the water is gone and you see some white solid on the inside of the bottle. Explain what happened to the water. What property of a substance is involved in this process?

c. Name and give the chemical formula of <u>two</u> possible substances that the white solid could be. Name one way you could identify this solid.

d. Ralph gives you a fresh bottle of mineral water. You decide you don't want Ca^{2+} in the water. What substance could you add to the mineral water that removes the Ca^{2+}, e.g., as a precipitate, and leaves everything else behind? Write a chemical equation that shows how the Ca^{2+} is removed from the mineral water.

4. (14 points) Your car battery has leaked a quarter cup (60. ml) of acid (18 M H_2SO_4). Rather than wiping the acid with a paper towel and risk an acid burn, you decide to neutralize the acid by adding a(n) _____.

a. Which substance, baking soda or sugar or aspirin, would you use to neutralize the acid? Give reasons. Write a balanced molecular equation and net ionic equation that represents this reaction.

b. You add 150 g of your substance in part a to the acid. Calculate the mass of acid or your substance in part a left over. Is the acid completely neutralized?

5. (12 points) Aspirin is synthesized by reacting salicylic acid with acetic anhydride using phosphoric acid as a catalyst:

$$C_7H_6O_3 + C_4H_6O_3 \xrightarrow{-H_3PO_4} C_9H_8O_4 + HC_2H_3O_2.$$

Table 1 shows some properties of aspirin and salicylic acid.

Table 1. Properties of Aspirin and Salicylic Acid.

Property	Salicylic Acid	Aspirin
Chemical formula	$C_7H_6O_3$	$C_9H_8O_4$
Melting point, ^oC	159	140
Density, g/cm^3	1.44	1.35
Solubility in 100 ml of water	0.2 g at 25^oC	0.1 g at 23^oC

a. You synthesize aspirin starting with 1.00 g of salicylic acid and an excess of acetic anhydride. After purifying and drying a white solid (assumed to be aspirin), the % yield of the white solid is 75%. Calculate the actual yield of aspirin.
b. You measure the melting point of the white solid to be 145-150^{o}C. You measure the density to be 1.4 g/cm^{3}. Since you can't really conclude whether you made aspirin or have unreacted salicylic acid, you do an elemental analysis which shows 60.0%C, 4.44%H, 35.6%O. Did you make aspirin? Give reasons to support your answer.

The following is a label taken from a 1.5 liter (50.7 oz.) bottle of Castle Rock Spring Water.

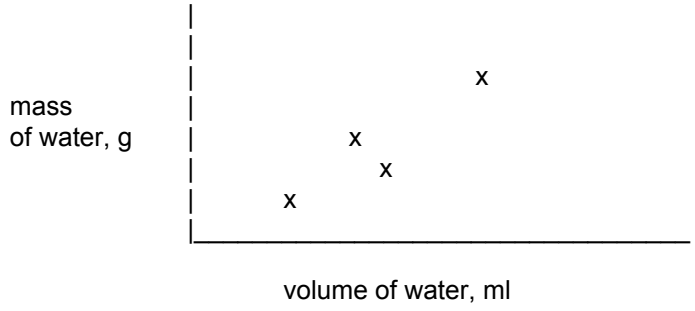
Nutrition Facts: Serving Size 8 oz. (240 ml)	**ANALYSIS** (mg/liter)
About 6 servings per container	Calcium 10
Amount per serving	Magnesium 5
Calories 0	Bicarbonates 65
Total Fat 0 g	Potassium 2
Sodium 0 mg	Chloride 2
Total Carb. 0 g	Nitrate ..... <1
Protein 0 g	TDS Approximately 80

(TDS stands for Total Dissolved Solids)

a. Compare calcium to bicarbonates in the Analysis section of the label. Which number has the smaller uncertainty? Give reasons.
b. Name one metal in Castle Rock Spring Water. Give the atomic symbol for this metal, the group and period this metal is located in the Periodic Table, and the number of protons, electrons, and neutrons in the most abundant isotope of this element.
c. The label states that the bottle contains 1.5 L of water. For the metal you chose in part b, calculate the mass of this substance that is present in 1.5 L of Castle Rock Spring Water. (Use significant figures appropriately in this part.)
d. Your boss wants to test Castle Rock Spring Water for magnesium. She suggests that you add a substance but all you can remember is that the substance starts with a "C". You look at the appropriate table and figure you should add either chloride or carbonate. Which substance will you add? Write a chemical equation that represents this reaction. How would you make sure that all of the magnesium precipitates out of solution?
e. You boil a 10 ml sample of Castle Rock Spring Water to dryness and see a white solid. Give the chemical formula and chemical name of <u>two</u> possible substances this white solid could be.

You accidentally spill a 1.00 pound (1 lb = 454 g) bag of TSP (sodium phosphate) in your bird bath that contains 45 liters of water. Since you know phosphates can cause algae to grow (eutrophication), you want to remove the phosphate. For this problem, use significant figures appropriately.
a. Calculate the concentration of TSP in molarity in the bird bath.
b. What substance could you add to chemically remove the phosphate? Write a net ionic equation that represents this reaction.
c. Calculate the <u>minimum</u> mass of the substance you chose in part b to remove all of the phosphate. Show your calculations for full credit.

b. A linear fit on the following graph of mass of water vs. volume of water showed a slope of 0.848 with a correlation of 0.940. The results are accurate and precise.



Sugar can be separated from salt based on their solubility property in water. If you disagree with this statement, what property would you use to separate sugar from salt?
Distillation, which uses a difference in melting point, can be used to separate and purify an ethanol-water mixture up to 95% ethanol at which composition an azeotrope forms.

Describe two methods to separate an ethanol-water mixture. For each method, identify the property that is used to accomplish this separation.
Battery acid dissolves $CaCO_3$. Write a balanced molecular equation and net ionic equation that represents this reaction.

Name: _____

Chem 1A, Instructor: L. Yee
November 17, 2010

EXAM 2
Show all work!

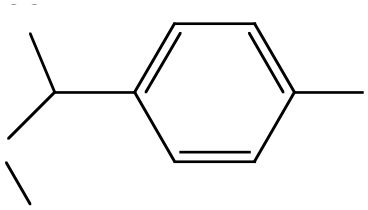
Exam 2 is worth 10% of your grade (50 points). For full credit, show all work in a logical and legible sequence. Clearly underline or circle your final answer. Include units where needed. Use the back of the page if you need more room. You may use your textbook, notes, and a calculator. You may ask me for a hint; however, each hint will cost you 1 point.

1. (17 points) a. Galvanized iron is iron coated with zinc. Explain why zinc is used. What other metal could be used besides zinc? Give reasons.
b. An electron microscope with a resolution limit of 0.6 Angstroms (0.6×10^{-10} m) was reported in Chemical and Engineering New (9/20/04, p. 13). What property of an electron is used in an electron microscope? What equation is used to calculate the velocity of electron in this microscope?
c. Briefly describe how light is produced from a fluorescent light. Why does electricity need to be supplied to a fluorescent light?
d. Chlorophyll, the green pigment in plants, shows an absorption peak at 662 nm. Explain why chlorophyll is green.
e. Draw the Lewis structure of water. Identify the intermolecular forces between water molecules. Which chemical force(s) is/are broken when water boils?

2. (9 points) In his model of a hydrogen atom, Bohr postulated that:
(i) the energy of an electron in a H atom is quantized, i.e., an electron can only have specific energy values called energy levels
(ii) a H atom radiates or absorbs energy only when the electron makes a transition from one energy level to another
(iii) in each allowed energy state, an electron moves around the nucleus in a circular orbit of fixed radius
(iv) in each allowed energy state, the angular momentum of the electron is quantized.
a. According to current atomic theory, is Postulate (iii) correct? Give reasons.
b. Explain how probability is related to atomic orbital shape.
c. What experiment elucidated the structure of the atom? Briefly explain how this experiment elucidated the structure of the atom.

3. (10 points) In the World of Chemistry, Part 13 The Driving Forces, a chemical process in an industrial plant is designed so the highest energy products are produced first followed by successively lower energy products in a chain of reactions. The video showed a coal or petroleum processing plant that produced ethane (C_2H_6) first, followed by ethanol (C_2H_5OH), ethylene glycol ($C_2H_6O_2$), acetic acid (CH_3COOH), and finally, carbon dioxide and water.
a. What are the two driving forces in a chemical reaction?
b. Ethanol is used as a gasoline additive. Write a chemical equation that represents the combustion of ethanol. Then, calculate ΔH of this reaction.
c. 2.0 g of ethanol is burned to heat 1 cup (240 ml) of water at 25°C. Calculate the final temperature of water.
d. (Extra credit: 1 point) Compare the ΔH of formation of ethane to ethanol. Based on this heat of formation explain why ethane has a higher ΔH of combustion than ethanol.

4. (14 points) Sunscreens, such as PABA (p-amino benzoic acid), absorbs UV-B radiation (280-320 nm). However, PABA also is absorbed through your skin and will show up in your urine later. The partial Lewis structure of PABA is shown below.
a. Draw in the double bonds, lone pairs of electrons, and the remaining hydrogens to complete the Lewis structure of PABA. What is the molecular geometry at the N in PABA? Circle the functional group(s) in PABA. Write the name of each functional group next to your circle.



b. Is PABA soluble in water? Is the solubility of PABA in water a desirable property for a sunscreen? Give reasons.
c. Draw an absorption spectrum of PABA. Label each axis on your spectrum. Be specific!
d. Based on your absorption spectrum of PABA, draw a simple energy level diagram of PABA. Calculate the energy difference between energy states in J.

Chem 1A, FINAL EXAM - TAKE-HOME PART
due Wednesday, December 15, 2010 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 – 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. (12 points) Chemical and Engineering News, 11/1/10, p. 2 Letter: "A Breath of Fresh Air". The writer states the "world's human population – people breathing – is a significant source of carbon dioxide added to our atmosphere daily. … Very simple calculations show that simply by being alive, the global population of human beings produces 5-10% of the estimated CO_2 generated from all sources.
A resting adult breathes 15 times a minute, and a breath is 0.5 L. Breathing by an adult increases the amount of CO_2 from a mole fraction of 0.000395 inhaled to 0.042 exhaled, which amounts to an increase of 0.88 kg CO_2 /person/day. Of course, a mole of CO_2 occupies 22.4 L at standard temperature/pressure (STP) and weighs 44 g. This simple model ignores the fact that we don't all live and breathe in an STP environment, we aren't all resting, and we aren't all adults. World CO_2 production is 29.3 billion metric tons per year, and world population is 6.9 billion people."
a. What is mole fraction? What is standard temperature/pressure? Do a calculation to confirm that one mole of an ideal gas has a volume of 22.4 L at STP.
b. Using the numbers given above, do a calculation to confirm that a resting adult produces 0.88 kg CO_2 /person/day.
c. Using the numbers given above, do a calculation to confirm that the global population of human beings produces 5-10% of the estimated CO_2 generated from all sources.
d. Briefly explain the big concern about CO_2.

2. (8 points) a. The Hall process is used to make aluminum from aluminum ore. (Recall the World of Chemistry video on Metals). Write a chemical equation that represents this industrial reaction. When exposed to air, Al metal becomes coated with an oxide layer whereas Au metal does not become coated with an oxide layer. Explain this observation in terms of the Activity Series of the Elements.
b. Lime is used to increase the pH of soil in farming. What is the chemical formula of lime? Why does the addition of lime increase pH? When water is added to calcium metal, a gas evolves and a white, powdery solid forms. However, when HCl is added to calcium metal, a gas evolves and no solid forms. Write net ionic equations for these reactions and explain why a solid is formed with water and not with HCl. Which reaction is used to make lime?

3. (20 points) Chemical and Engineering News occasionally publishes a column called "What's That Stuff?" Go to the "What's That Stuff" website (http://pubs.acs.org/cen/whatstuff/stuff.html). Click on Sunscreens. Read the article. Use and apply your knowledge of chemistry and science to describe how sunscreen works.
a. The Lewis structures of two organic sunscreens, OMC and 4-MBC, are shown. For each sunscreen, give the chemical name, write the chemical formula, draw the Lewis structure, and identify the functional group(s) by drawing a circle around each functional group and writing the name of the group next to your circle.
b. Describe the bonding in the inorganic sunscreens, zinc oxide and titanium oxide.
c. Determine the polarity of each sunscreen. Using your knowledge of chemical forces, explain whether each sunscreen needs to be reapplied after a swim.

d. In what region of the UV is the skin most sensitive? In what region of the UV is the sun most intense? Cite the reference where you found this information. Draw an absorption or emission spectrum of skin sensitivity and sun intensity. Show your two spectra on the same graph. Identify the peak wavelength for each spectrum.
e. Compare SPF 20 sunscreen to SPF 30 sunscreen. What do these SPF numbers represent? How is SPF of a sunscreen related to absorbance or transmittance? Which of the two sunscreens has a higher SPF?
f. In what region of the UV does each sunscreen work? Draw or sketch an absorption spectrum of each one on the same graph. You do not have to identify the actual peak wavelength for each sunscreen.
g. You have a job interview with Coppertone. The interviewer asks you, "what wavelength(s) are important to block from the skin in an ideal sunscreen? Give reasons for your choice."

4. (10 points) According to the Chem 1A 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	use the Periodic Table to obtain information about elements, identify elements and compounds by type, write chemical formulas, name compounds, identify atomic structure, calculate molar mass	
2	predict properties of elements, compounds, and mixtures based on element or compound type and structure	
3	identify and describe acids and bases by name, structure, properties, and reactions; relate these compounds to pH	
4	determine the solubility of substances in water and perform solution calculations involving volume, concentration, and moles	
5	represent chemical reactions with balanced chemical equations; predict whether a reaction occurs from a net ionic equation	
6	perform chemical calculations, e.g., mass to moles, for compounds and reactions, such as empirical formula and stoichiometry	
7	distinguish between and describe the different states of matter, including the chemical forces that hold them together	
8	describe and calculate heat transfer calculations in physical and chemical processes; calculate the heat of reaction using Hess' law	
9	describe the atomic and electronic structure of atoms using quantum theory; describe the role of light in understanding atoms and molecules	
10	describe bonding in ionic and molecular compounds, draw molecular (Lewis) structures, determine molecular geometry using VSEPR theory to predict properties, such as polarity and solubility	
11	perform basic lab techniques and measurements	
12	design experiments, analyze and interpret data and results, draw conclusions	
13	clearly communicate experimental data, results, and conclusions in an oral poster presentation.	
	Overall Chem 1A Grade	

a. Your company is testing various fuels. You are testing a hydrocarbon with a molar mass between 115 and 125 g/mole. When 47.8 g of this hydrocarbon undergoes a combustion reaction, 42.6 g of water are produced. What is the chemical formula of this hydrocarbon? Show your calculations for full credit.

1. (8 points) a. The Hall process is used to make aluminum from aluminum ore. (Recall the World of Chemistry video on Metals). Write a chemical equation that represents this industrial reaction. When exposed to air, Al metal becomes coated with an oxide layer whereas Au metal does not become coated with an oxide layer. Explain this observation in terms of the Activity Series of the Elements.
b. Lime is used to increase the pH of soil in farming. What is the chemical formula of lime? Why does the addition of lime increase pH? When water is added to calcium metal, a gas evolves and a white, powdery solid forms. However, when HCl is added to calcium metal, a gas evolves and no solid forms. Write net ionic equations for these reactions and explain why a solid is formed with water and not with HCl. Which reaction is used to make lime?
c. In Lab 5, you observed several reactions involving rust, Fe_2O_3. You also know how to remove rust. Using a double replacement reaction, name one substance that reacts with rust. Write a net ionic equation that represents this reaction. Using a single replacement reaction, name one substance that reacts with rust. Write a net ionic equation that represents this reaction.
d. You see a piece of wood and a gold cup lying in the middle of the Hartnell parking lot at noon on a really hot day. Which one transfers more heat when you touch it? Give reasons.

2. (6 points) You need a cup of coffee. So, you heat 1 cup (240 ml) of water from 25°C to 100°C using either your gas stove or electric stove.
a. Calculate the energy in J, therms, and kilowatt-hours (kW•hr) that is required to heat the water. (1 therm = 105.4804 mega joules = 100,000 BTU = 29.3 kW•hr = 100 cubic feet (ccf) natural gas x usage factor (1.03)
b. PGE sells energy at the following September 2005 rates: electricity = $0.1143/kW•hr, natural gas = $1.07/therm. Calculate the cost of heating 1 cup of water using an electric stove. Calculate the cost of heating 1 cup of water using a gas stove.
c. Calculate the mass of natural gas that burns to **boil** 1 cup (240 ml) of water from 25°C to 100°C.

3. (8 points) Sulfuric acid is the most produced chemical in the U.S. Its production and manufacture is described on the following website: http://www.ausetute.com.au/sulfacid.html. In 1995, 95.4 billion lbs of sulfuric acid was manufactured.
a. Write a chemical equation that represents each step of the manufacture of sulfuric acid. Which of these reactions are oxidation-reduction reactions? For each oxidation-reduction reaction, identify the oxidizing agent and reducing agent.
b. The overall reaction for the sulfuric acid manufacturing process is :

___ S (s) + ____ O_2 (g) + _____ H_2O (l) ------> _____ H_2SO_4 (l)

Add the four reactions from part a to determine the coefficients in the overall reaction. Note: no other reactants or products are involved in the overall reaction. You may have to reverse a reaction or multiply/divide a reaction by a factor to get the overall reaction.
c. Assume a 90% yield for each step in the sulfuric acid manufacturing process. Calculate the mass in kg of sulfur, oxygen, and water that is required to make 95.4 billion lbs of sulfuric acid.
d. Calculate the heat of reaction for the overall reaction you found in part b.
e. Calculate the volume of water that could be boiled using the heat produced in the manufacture of one mole of sulfuric acid.

5. (10 points) In the World of Chemistry, Part 13 The Driving Forces, a chemical process in an industrial plant is designed so the highest energy products are produced first followed by successively lower energy products in a chain of reactions. The video showed a coal or petroleum processing plant that produced ethane (C_2H_6) first, followed by ethanol (C_2H_5OH), ethylene glycol ($C_2H_6O_2$), acetic acid, and finally, carbon dioxide and water.
a. Explain this energy chain. In other words, why is ethane the highest energy substance and CO_2 and H_2O the lowest energy? Confirm that the energy order (ethane, ethanol, ethylene glycol, acetic acid, and carbon dioxide) of each product goes from highest to lowest. Draw an energy diagram to show your answer. (This diagram was shown in the video). Give quantitative energy values for each substance in your energy diagram.
b. For what reason is a plant designed so that the highest energy products are produced first followed by successively lower energy products?
c. Calculate the heat of combustion of each substance in kJ/mole and kJ/g. Write a chemical equation that represents each reaction. Show your results in a table.
d. Based on your answer in part c, which substance is the best fuel in terms of energy released? Give reasons. Is there a trend in the energy of the substance and the energy content of a fuel? Give reasons.
e. Where would ethylene (C_2H_4) be located on the energy chain? Give reasons.

6. (5 points) Chang, "General Chemistry: The Essential Concepts", 3rd ed., 2003, p. 190, Problem 6.97**b**. When air is pumped into a bicycle tire, a warming effect at the valve stem occurs. The action of the pump compresses the air inside the pump and the tire. The process is rapid enough to be treated as an adiabatic process. Apply the first law of thermodynamics to account for the warming effect.

7. (8 points) a. Using Hess's law, you can calculate the heat of reaction of the dissolution of NaCl in water. How would you measure this heat of reaction by experiment? Design an experiment to measure this heat of reaction. Describe the steps you would take, the equipment you would use, and the amounts of substances you would use to determine this heat of reaction.
b. Every experiment involves error. Identify one possible systematic error that would lead to a different heat of reaction than the true heat of reaction. Would this error cause the experimental heat of reaction to be higher or lower than the true heat of reaction? Give reasons.

(10 points) You turn on your study lamp with its 100 W light bulb. Where does the electricity come from that turns on the light bulb? Much of the electricity produced in this country come from coal fired power plants. Go to the Chem 1A website (http://lyee.pageout.net), click on the Chem 1A link, then on the Course Content link, then on the Homework link, and then on the Energy Use and Coal link. Read the three articles and refer to the Energy Conversion and Tables website (http://www.uwsp.edu/cnr/wcee/keep/Mod1/Whatis/energyresourcetables.htm).
a. For this question, assume coal is 100% carbon. Write a chemical equation that represents the burning of coal. Calculate the heat of reaction in kJ/mole and kJ/g of C for the coal burning reaction.
b. The Energy Conversion and Tables website shows a table of coal types and composition. What is the % carbon in coal? Based on this %C, calculate the heat of reaction in kJ per g of coal.
c. In the first article, "Your Personal Greenhouse" states " for a coal-fired power plant's efficiency, the electricity lost in the power lines, and the energy content of coal, each kWh of electricity delivered to your home requires the burning of 0.77 kg (1.7 pounds) of western coal and produces 1.1 kg (2.4 pounds) of CO_2." If 0.77 kg of coal is burned, calculate the mass of CO_2 produced. Does your calculated mass match 1.1 kg? If not, what could be a reason for the difference in mass? Based on your calculation, calculate the % C in coal.
d. The third article, "Ask A Scientist", states "Typically, Coal has a "heating value" of 8,800 to 11,000 btu's per lb." Convert from btu's per lb to kJ/g of coal. Compare this heating value to the heat of reaction you found in part a. Account for any discrepancy. Based on your calculation, calculate the % C in coal.
e. You study 3 hours each night, 6 days a week for 18 weeks this semester using your study lamp. Calculate the mass of CO_2 produced from a coal fired power plant. Of course, you want to get good grades and will continue to study the same amount each semester. Name two ways to reduce the amount of electricity used for you studying and the amount of greenhouse gas emitted by power plants.

Name: _____

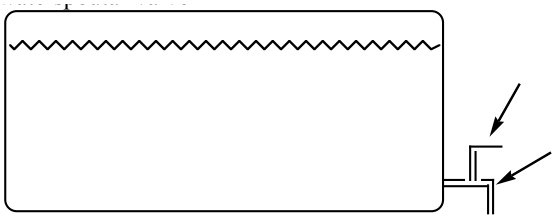
Chem 1A, Instructor: L. Yee
December 15, 2010

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 text book, 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. When water boils, the covalent bonds in water breaks. If you disagree with this statement, identify the chemical forces that are broken.
b. In an explosion reaction, such as the decomposition of NI_3 to N_2 and I_2, heat is released and work is produced.

2. (9 points) In Lab 9, you heated up water in a flask, put a rubber stopper on the flask, removed it from the heating source, and rubbed ice on the outside walls of the flask. The water boiled.
a. Explain why water boils. Discuss what happens to the pressure, temperature, and volume in the flask. What diagram helps you support your explanation?
b. Right after you did this demonstration, the stopper was hard to remove from the flask. Explain why.
c. What could you have done to make the stopper easier to remove from the flask?

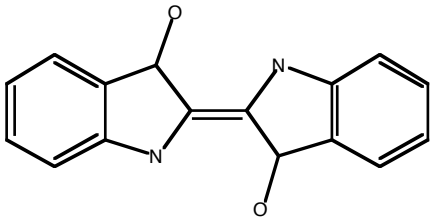
3. (12 points) a. You buy a 2.5 gallon container of drinking water at the supermarket. You open the valve at the bottom but only a cup or two of water is dispensed. Use gas laws to explain why.



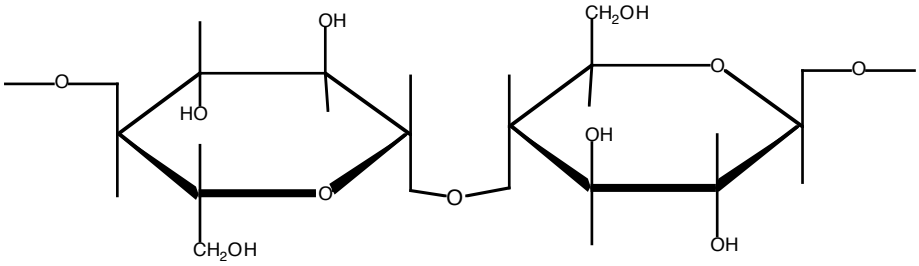
b. Diamond is the hardest known substance. Fe metal is a soft substance. Using your knowledge of bonding, explain why diamond is hard and iron is soft.
c. You are bathing in pure distilled water when your dog, Spot, jumps into the bathtub and accidentally knocks the toaster plugged into the 120 V outlet and some Ajax, which contains $CaCO_3$ as an abrasive, into your tub. Would you and Spot get electrocuted? Give reasons.
d. 1.5 g of baking soda ($NaHCO_3$) reacts with 8 ml of 0.87 M vinegar ($HC_2H_3O_2$). Which reactant is the limiting reactant? Show your calculations.

4. (15 points) Concentrated sulfuric acid (18 M, density = 1.84 g/ml) is used in new car batteries. As a car battery gets discharged, the acid reacts with the lead metal plates leaving the acid less concentrated and dense. You don't have a hydrometer (a device that measures the density of a liquid) to measure the density of the acid; however, you can titrate the acid with NaOH and relate the concentration to density.
a. Write a balanced chemical equation that represents the reaction of lead with sulfuric acid. (Hint: activity series)
b. Describe how you would make 400 ml of 2.5 M NaOH solution from solid NaOH. Calculate the mass of NaOH that you need to prepare this solution.
c. You standardized your NaOH solution with _____ and stopped adding NaOH, which was contained in a _____, when the solution turned _____ due to the addition of a few drops of _____. Your titration results for your three runs are 2.55 M, 2.41 M, and 2.62 M. Fill in the blanks. Comment on the accuracy and precision of this standardization. Calculate the % error or % difference or both from these results.
d. 98.25 ml of your NaOH solution from part c is used to titrate 10.00 ml of battery acid. Calculate the concentration of the battery acid. Then, calculate the pH of this battery acid solution.
e. Do you think your battery needs to be replaced based on your results? Give reasons.

5. (10 points) Indigo ($C_{16}H_{10}N_2O_2$, partial structure shown below) is the blue dye used for blue jeans. The complete structure cotton is also shown below.
a. For indigo only, draw in the double bonds, lone pairs of electrons, and the remaining hydrogens to complete the Lewis structure of indigo. Then, circle <u>one</u> organic functional group and write the name of the functional group next to your circle. For <u>one</u> of the nitrogens in indigo, determine the molecular geometry at the N.



Indigo



Cotton

b. Identify the chemical forces between the dye and fabric. If H bonds exist, use a dashed line to show the H bond between the dye and fabric.
c. Indigo is blue. What color is absorbed by indigo? Draw a simple energy level diagram of indigo. Calculate the energy difference between energy levels.