Please put your name in the upper RIGHT hand corner.

1. (15 points) 200.00 mL of 0.200 M hydrochloric acid is mixed with 2.00 g of calcium hydrogen carbonate. The reaction proceeds to completion. Carbon dioxide gas is collected over water. The water temperature is 26.13°C, the atmospheric pressure is 784 torr, and the vapor pressure of water is 25.40 torr at this temperature.

$$Ca(HCO_3)_{2(s)} + HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$
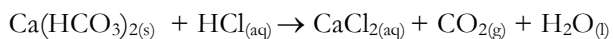
(a) What is the limiting reagent (or reactant)? Show how you determined this.
(b) What is the volume of gas formed?
(c) Calculate the amount of the excess reactant left over after the reaction.

Continue the answer on the page attached. Please don't try to cram it all on this page.

A

b)

Use this page for problem 1

c)

(14 points) Ascorbic acid (vitamin C, $C_6H_8O_6$) is a water-soluble vitamin. A solution containing 80.5 g of ascorbic acid dissolved in 210.0 g of water, has a density of 1.22 g/mL at 55°C. Calculate (a) the mass percentage, (b) the mole fraction, (c) the molality, and (d) the molarity of ascorbic acid in this solution.

Then, using the molality in part (c), determine the boiling point and the freezing point of this solution. For water, K_f = 1.86 °C/m and K_b = 0.51 °C/m.

2. (8 points) The following statements refer to intermolecular forces. Correct the false statements and give supporting evidence for the true statements using complete sentences.
    (a) The more polarizable the molecules, the stronger the dispersion forces between them.
    (b) The boiling points of the noble gases decrease as one goes down the column in the periodic table.
    (c) In general, the smaller the molecule, the strong the dispersion forces.

(d) All other factors being the same, dispersion forces between molecule increases with the number of electrons in the molecules.

3. (8 points) The following statements refer to carbon tetrachloride and carbon tetrabromide. Correct the false statements and give supporting evidence for the true statements using complete sentences.
    (a) CBr_4 is more volatile than CCl_4.
    (b) CBr_4 has a higher boiling point than CCl_4.
    (c) CBr_4 has weaker intermolecular forces than CCl_4.
    (d) CBr_4 has a higher vapor pressure at the same temperature than CCl_4.

4. (8 points) Identify the types of intermolecular forces present in each of the following substances, and select the substance in each pair that has the higher boiling point. Briefly explain your choice:

      (a) C_6H_{14} or C_8H_{18}

      (b) C_3H_8 or CH_3OCH_3

      (c) HOOH or HSSH

      (d) NH_2NH_2 or CH_3CH_3

5. (8 points) Suppose you have two 1-L flasks: one contains nitrogen (N_2) and the other contains methane (CH_4), both at STP. How do these systems compare with respect to

      (a) The number of molecules
      (b) Density
      (c) Average kinetic energy of the molecules
      (d) Rate of effusion through a pinhole.

Use complete sentences with good grammar. You will lose points for lack of clarity.

6. (5 points) Calculate the number of molecules in a deep breath of air whose volume is 2.25 L at body temperature, 37°C, and a pressure of 735 torr.

7. 10 points) Ammonia and hydrogen chloride react to form solid ammonium chloride.

$$NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)}$$
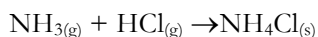
Two, 2.00-L flasks are connected by a stopcock. One flask contains 5.00g of ammonia and the other contains 5.00 g hydrogen chloride. Both gases at 25.00°C. When the stopcock is opened, the gases react until one is completely consumed.

(a) Which gas will remain in the system after the reaction is complete? (6 points)
(b) What will be the final pressure of the system after the reaction is completed? Assume that the temperature at the end of the reaction, is 25°C, and the volume of the ammonium chloride produced is negligible. (4 points)

8. (15 points) Sulfur tetrafluoride (SF_4) reacts slowly with oxygen to form sulfur tetrafluoride monoxide (OSF_4) according to the following unbalanced reaction:

$$SF_{4(g)} + O_{2(g)} \rightarrow OSF_{4(g)}$$
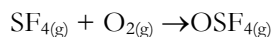
(a) Balance the equation (1 point)
(b) Write a Lewis structure of OSF_4 in which the formal charges of all atoms are zero. (4 points)
(c) Use average bond enthalpies to estimate the enthalpy of the reaction. Is it endothermic or exothermic? Explain. (4 points)

(d) Determine the electron domain geometry of OSF_4, (1 points)
(e) Determine the molecular geometry (1 points)
(f) Draw two possible isomers for the molecule based on this geometry. (4 points

Use this page to finish problem 9

9. (10 points) Microwave ovens use microwave radiation to heat food. The energy is absorbed by water molecules (and other small molecules) in food, and transferred to other components of the food.

    (a) Suppose that the microwave radiation has a wavelength of 11.2 cm. How many photons are required to heat 200.0 mL of coffee from 23.0°C to 60.0°C?   (7 points)

    (b) Suppose the microwave's power is 900W (1 Watt = 1 joule/sec). How long would you have to heat the coffee based on the energy from part a? (3 points)

10. (6 points) A solution is prepared by dissolving 10.8 g aluminum sulfate in enough water to make 100.00-mL of stock solution. A 10.00-mL sample of this stock solution is added to enough water to make 50.00-mL of solution. Calculate the concentration of the aluminum ions and sulfate ions in the **final** solution.

11. (6 points) The concentration of hydrogen peroxide in a solution is determined by titrating a sample of the solution with a known concentration of potassium permanganate solution.

$$2MnO_4^-{}_{(aq)} + 5H_2O_{2(l)} + 6H^+{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 5O_{2(g)} + 8H_2O_{(l)}$$
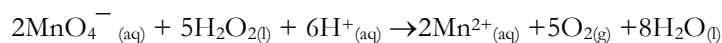
(a) It takes 14.8 mL of 0.134 M permanganate solution to reach the equivalence point when reacted with 10.00 mL of peroxide solution. What is the molarity of the hydrogen peroxide solution? (5 points)

(b) This is a redox reaction. Identify the oxidation numbers of Mn in MnO_4^-. Was manganese oxidized or reduced? Explain. (1 point)

12. (6 points) The titanium (II) ion is iso-electronic with the calcium atom. Briefly explain your answers.

(a) Are there any differences in the electron configurations of titanium (II) and calcium?

(b) Will the 2s orbital in calcium be more stable than the 2s orbital in titanium?

(c) Will calcium and titanium (II) have the same number of unpaired electrons?

13. (10 points) By titration, 15.0 mL of 0.1008 M sodium hydroxide is needed to neutralize a 0.2053-g sample of an organic acid. What is the molar mass of the acid if it is monoprotic? An elemental analysis of the acid indicates that is composed of 5.89% H, 70.6% C, and 23.5%O by mass. What is its molecular formula?

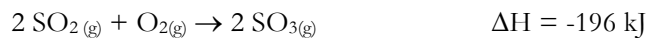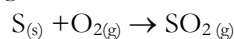14. (10 points) Write the correct name for the given formulas or the correct formulas for the given names:

(a) CuS

(b) $Al(ClO_3)_3$

(c) Iron(III) carbonate

(d) $Co(OH)_2$

(e) Cobalt(II) hydrogen carbonate

(f) Hypochlorus acid

(g) SF_6

(h) XeO_3

(i) Dinitrogen tetroxide

(j) P_4S_6

15. (6 points) Write the molecular, ionic, and net ionic equations for the reaction of lead(II) nitrate and sodium sulfide. For each equation include the phase of the ions, molecules, or compounds needed or produced. Also, when showing ions, include the correct charge.

16. (12 points) The use the combustion of octane, $C_8H_{18(l)}$, the main component of gasoline, to answer the following questions.

   (a) Write the balanced equation for the complete combustion of octane to produce water and carbon dioxide. (2 points)
   (b) Octane has a density of 0.692 g/mL at 20 °C. How many grams of oxygen are required to burn 1.000 gal of octane. (6 points)
   (c) Using the heats of formation table, calculate the heat of formation for octane, if the combustion of 1 mole of octane releases -5520kJ of energy. (4 points)

17. (5 points) From the following enthalpies of reaction (2 equations) listed below, calculate the $\Delta H rxn$ for the reaction of sulfur with oxygen gas:

$$S_{(s)} + O_{2(g)} \rightarrow SO_{2\ (g)}$$

$$2\ SO_{2\ (g)} + O_{2(g)} \rightarrow 2\ SO_{3(g)} \qquad \Delta H = -196\ kJ$$

$$2\ S_{(s)} + 3\ O_{2(g)} \rightarrow 2\ SO_{3(g)} \qquad \Delta H = -790\ kJ$$

18. (7 points) Carbonated drinks are canned under about 4 atm of carbon dioxide at the processing plant. When the can (or bottle) is opened, most of the gas is released as the total pressure above the liquid is lowered to 1 atm. The excess CO_2 bubbles out of solution. The partial pressure of CO_2 at this point is 3.00×10^{-4} atm.

(a) On a particular day, the canning company used 3.87 atm of CO_2 in the sealed can. How many moles of CO_2 are dissolved in a 355-mL can of soda before it is opened? (2 points)

(b) When the can is opened, the excess gas escapes, and a new pressure is is established. How many moles of CO_2 remain after the can is open? (2 points)

(c) What volume (in L) would the released CO_2 occupy at 1.00 atm and 25°C? (You need the answer from part a to solve this problem. Use 0.0678 moles if you did not solve a.) (3 points)

[k(Henry's law for CO_2) = 3.31 X 10^{-2} mol/(L•atm)]

19. (10 points) Nitrogen can form several types of compounds when it reacts with oxygen. Two of these compounds are NO_2^+ and NO_2^-. Draw the best Lewis structure for these two ions and based on resonance (or the lack thereof) pick the ion that has the longest N=O bond. Explain your answer.

20. (7 points) Complete the following statements by filling in the blanks:

    a. Two electrons in the same _____ must have opposite spin.

    b. The presence of un paired electrons in an atom gives rise to _____

    c. When l= 3, ml may have values from _____ to _____ .

    d. The neutral fourth period atom having a total of six d electrons is _____ .

    e. Orbital with the same energy are said to be _____ .

    f. The 2p orbitals of an atom have identical shapes but differ in there _____ .

    g. A nodal surface is one at which the probability of finding and electron is _____

    a. (3 points) Ethyl acetate, $C_4H_8O_2$, is a fragrant substance used both as a solvent and as an aroma enhancer. Its molecular structure is shown below. What is the hybridization at each of the carbon atoms of the molecule? What is the hybridization at each of the oxygen molecules? How many σ (sigma) bonds are in the molecule? How many π (pi) bonds are in the molecule?

| C#1 | | C#2 | O#1 | O#2 | C#3 |
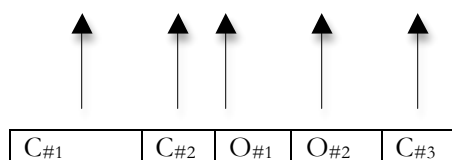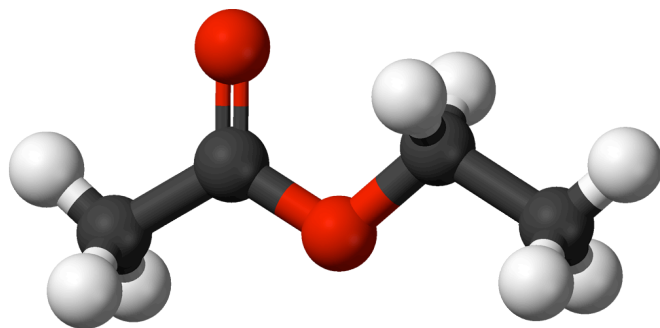
Please put your answer in the table below

Atom in the molecule or bond type	Hybridization
C#1	
C#2	
C#3	
O#1	
O#2	
# sigma bonds	
# pi bonds	

http://en.wikipedia.org/wiki/File:Ethyl-acetate-3D-balls.png