Chemistry 1256 Exam II

Fall 2008
Chapters 3, 4 & 5

Name (PRINTED LEGIBLY)_____

Student ID Number_____

Please read and acknowledge the following commandments.

1. There is a periodic table attached to this exam. You may tear it off the exam, however all exam materials are to be turned in with the exam.
2. You will have 1 hour, 50 minutes to complete the exam.
3. You are responsible for any corrections announced during the first hour of the exam.
4. Anyone arriving more than 15 minutes late will not be allowed to take the exam.
5. You are only allowed a single-line, non-programmable calculator on this exam.
6. **No cell phones, PDAs, or music devices** of any kind are allowed during the exam
7. Use the spaces between questions and the backs of the exam page for scratch paper. No additional scratch paper is allowed.
8. **Show your work for all problems** requiring dimensional analysis to receive full credit and circle your answer for multiple choice questions on this test form..
9. This exam consists of 13 pages total (cover sheet, test pages, misc. information and periodic table). Be sure you have all 13 pages.
10. During the exam if you have a question please raise your hand and the instructor or proctor will come to you.

Signature_____

Date: _____

Chemistry 1256 Exam II

Fall 2008
Chapters 3, 4 & 5: Gilbert, Kirss & Davies

Name _____ _____

There is a periodic table and a section of miscellaneous information at the end of this exam. **Show work for all problems** requiring dimensional analysis to receive full credit and circle your answer for multiple choice questions on this test form. **NO PROGRAMABLE CALCULATORS.**

1. (5 points) Aluminum (d = 2.70 g/mL) and strontium (d = 2.64 g/mL) have nearly the same density.

   If we manufacture two cubes, each containing 1 mole of one element or the other, which cube will be smaller? What are the dimensions of this cube?

2. (4 points) Energy generation results in the addition of an estimated 27 billion metric tons (tonnes) of CO_2 to the atmosphere each year. 1 metric ton = 1000 kg

(a) How many moles of CO_2 does 27 gigatonne represent?

(b) How many kilograms of *carbon* are in 27 gigatonne of CO_2?

3. (4 points) Chemistry of Geothermal Vents Some scientists believe that life on Earth may have originated near deep-ocean vents. Balance the following reactions, which are among those taking place near such vents:

a. $CH_3SH(\ell) + CO(g) \rightarrow CH_3COSCH_3(\ell) + H_2S(g)$

b. $H_2S(g) + CO(g) \rightarrow CH_3CO_2H(g) + S_8(s)$

4. (5 points) Write a balanced chemical equation for the combustion of octane (C_8H_{18}).

5. (5 points) Mining for Gold Unlike most metals, gold is found in nature as the pure element. Miners in California in 1849 searched for gold nuggets and gold dust in streambeds, where the denser gold could be easily separated from sand and gravel. However, larger deposits of gold are found in veins of rock and can be separated chemically in a two-step process:

(1) $4\ Au(s) + 8\ NaCN(aq) + O_2(g) + 2\ H_2O(\ell) \rightarrow 4\ NaAu(CN)_2(aq) + 4\ NaOH(aq)$

(2) $2\ NaAu(CN)_2(aq) + Zn(s) \rightarrow 2\ Au(s) + Na_2[Zn(CN)_4](aq)$

If a 1.0×10^3 kilogram sample of rock is 0.019% gold by mass, how much Zn is needed to react with the gold extracted from the rock? Assume that reactions (1) and (2) are 100% efficient.

5. (5 points) The combustion of 40.5 mg of a compound containing C, H, and O, and extracted from the bark of the sassafras tree, produces 110.0 mg of CO_2 and 22.5 mg of H_2O. The molar mass of the compound is 162 g/mol. Determine its empirical and molecular formulas.

6. (5 points) Baking soda ($NaHCO_3$) can be made in large quantities by the following reaction:

$$NaCl(aq) + NH_3(aq) + CO_2(aq) + H_2O(\ell) \rightarrow NaHCO_3(s) + NH_4Cl(aq)$$

If 10.0 g of NaCl reacts with excesses of the other reactants and 4.2 g of $NaHCO_3$ (84.007 g/mol) is isolated, what is the percent yield of the reaction?

7. (4 points) Zinc and mercury ions are toxic to Atlantic salmon at concentrations of 6.42×10^{-2} m*M* and 5.00×10^{-2} m*M*, respectively. What are the corresponding concentrations in milligrams per liter?

8. (5 points) What volume of 2.5 *M* $SrCl_2$ is needed to prepare 500.0 mL of 5.0 m*M* solution?

9. (6 points) What is the molar concentration of Na^+ ions in 0.025 *M* solutions of the following sodium salts in water?

(a) NaBr

(b) Na_2SO_4

(c) Na_3PO_4

10. (6 points) Complete and balance each of the following neutralization reactions and then write the net ionic equation for each.

a. $H_3PO_4(aq) + Ba(OH)_2(aq) \rightarrow$

b. $Al(OH)_3(s) + HCl(aq) \rightarrow$

11. (5 points) Given the following equation, how many grams of $PbCO_3$ will dissolve when 1.00 L of 1.00 *M* H^+ is added to 500. g of $PbCO_3$ (267.209 g/mol)?

$$PbCO_3(s) + 2\ H^+(aq) \rightarrow Pb^{2+}(aq) + H_2O(\ell) + CO_2(g)$$

12. (3 points) Assuming that the distances between the two ions is the same in all cases, which of the following ion pairs has the greatest electrostatic potential?

a. $Na^+ - Cl^-$
b. $Na^+ - O^{2-}$
c. $Mg^{2+} - O^{2-}$
d. $Al^{3+} - O^{2-}$

13. (6 points) Permanganate ion (MnO_4^-) is used in water purification to remove oxidizable substances. Complete and balance the following reaction for the removal of sulfide. Assume that reaction conditions are basic:

$$MnO_4^-(aq) + S^{2-}(aq) \rightarrow MnS(s) + S(s)$$

14. (5 points) A 10.0 mL dose of an antacid contains 830 mg of magnesium hydroxide (58.32 g/mol). What volume of 0.10 *M* stomach acid (HCl) could one dose neutralize?

15. (4 points) Explain what is meant by a state function.

16. (4 points) An expanding gas does 150.0 J of work on its surroundings at a constant pressure of 1.01 atm. If the gas initially occupied 68 mL, what is the final volume of the gas?

17. (5 points) The complete combustion of 1.200 g of cinnamaldeyde (C_9H_8O, one of the compounds in cinnamon) in a bomb calorimeter ($C_{\text{calorimeter}}$ = 3.640 kJ/°C) produced an increase in temperature of 12.79°C. Calculate the molar enthalpy of combustion of cinnamaldehyde (ΔH_{comb}) in kilojoules per mole of cinnamaldehyde (MW = 132.159).

19. (5 points) Mixtures of fertilizer (ammonium nitrate) and fuel oil (a mixture of long-chain hydrocarbons similar to decane, $C_{10}H_{22}$) are the basis for a powerful explosion. Determine the standard enthalpy change of the following explosive reaction by using the appropriate enthalpies of formation
($\Delta H_f[C_{10}H_{10}(l)] = 249.7$ kJ/mol):

$$3\ NH_4NO_3(s) + C_{10}H_{22}(\ell) + 14\ O_2(g) \rightarrow 3\ N_2(g) + 17\ H_2O(g) + 10\ CO_2(g)$$

20. (3 points) When a sample of gasoline is combusted in a closed container, called a bomb calorimeter,

    a. work is done by the system on the surroundings.
    b. work is done by the surroundings on the system.
    c. no work can occur because the volume does not change.
    d. the work done by the system equals the heat produced by the system.

21. (6 points) A 20.0 g piece of iron and a 20.0 g piece of gold at 100.0°C were dropped into 1.00 L of water at 20.0°C. The molar heat capacities of iron and gold are 25.19 J/(mol·°C) and 25.41 J/(mol·°C), respectively. What is the final temperature of the water and metals? Cp[$H_2O(\ell)$] = 75.3 J/(mol·°C)

20. (**Extra Credit**, 5 points) In 1819, Pierre Dulong and Alexis Petit reported that the product of the atomic mass of a metal times its specific heat is approximately constant, an observation called the *law of Dulong and Petit (Also the name of their band…)*. Use the following data to answer the following questions.

Element	**μ (g/mol)**	**cs [J/(g · °C)]**	**μ × cs**
Bismuth		0.120	
Lead	207.2	0.123	25.5
Gold	197.0	0.125	
Platinum	195.1		
Tin	118.7	0.215	
		0.233	
Zinc	65.4	0.388	
Copper	63.5	0.397	
		0.433	
Iron	55.8	0.460	
Sulfur	32.1		
Average value:			

a. Complete each row in the table by multiplying each given molar mass and specific heat pair (one result has been entered in the table). What are the units of the resulting values in column 4?

b. Next, calculate the average of the values in column 4.

c. Use the mean value from part b to calculate the missing atomic masses in the table. Do you feel confident in identifying the element from the calculated atomic mass?

d. Use the average value from part b to predict the missing specific heat values in the table.

Miscellaneous Formulae and Constants

$w = F \cdot d$ $KE = \frac{1}{2} m\upsilon^2$ $\Delta E = q + w$

$w = P \cdot \Delta V$ $\Delta E = q - P\Delta V$ $H = E + PV$

$\Delta H = \Delta E + P\Delta V$ $q = nc_P\Delta T$ $q = n \cdot \Delta H$

$q = C \cdot \Delta T$ $\Delta H°_{rxn} = \Sigma n\Delta H°_{f,prod} - \Sigma n\Delta H°_{f,react}$

R (gas constant) = 0.082053 (L · atm/mol · K) = 8.3145 (J/mol · K)

Compound	**$\Delta H°_f$ (kJ/mol)**
$H_2O(\ell)$	-241.8
$H_2O(g)$	-285.8
NH_4NO_3	-365.6
CO_2	-393.5