Carleton UNIVERSITY

FINAL
EXAMINATION
DECEMBER 2005

DURATION: 3 HOURS

No. of Students: 150

Department Name & Course Number: CHEMISTRY CHEM 1101 A
Course Instructor(s) PAMELA WOLFF

AUTHORIZED MEMORANDA

CALCULATORS

Students MUST count the number of pages in this examination question paper before beginning to write, and report any discrepancy to a proctor. This question paper has 8 pages.

This examination question paper may be taken from the examination room.

In addition to this question paper, students require: an examination booklet yes☑ no☐
a Scantron sheet yes☐ no☒

ANSWER ALL QUESTIONS. EACH IS WORTH 10 MARKS.

(THIS DOESN'T MEAN YOU SHOULD SPEND THE SAME AMOUNT OF TIME ON EACH!)

You may do the questions in any order

You may detach the pages (you don't need to hand in the exam paper)

1. a) Give the electron configuration for Cu(I)

   b) Show the orbital diagram for the highest energy subshell of Cu(I), and give the quantum numbers for all electrons in it

   c) Show the orbital diagram for the valence shell of Cu(I), and give the quantum numbers for all electrons in it, if different from b)

2. For the following:

draw the Lewis diagram,

draw and name the molecular geometry,

show the bond dipoles,

show the net dipole

a) I_3^- b) SF_5^-

3. a) Draw the band diagram for aluminum, and label the s and p bands, and the valence and the conduction bands

b) Draw the band diagram for silicon and label the valence and conduction bands

c) Identify an element which is used to make silicon into a p-type semiconductor. Show the band diagram for that semiconductor.

4. a) Magnesium acetate is sometimes used as road salt, since it is less harmful to the environment that sodium chloride. Calculate the normal freezing point of a 4.21 M $Mg(CH_3COO)_2$ solution, given that it has a density of 1.58 g/ml

b) Predict the molarity of sodium chloride needed to achieve the same freezing point. (hint: you do not need to repeat a full calculation, although you can if you want.)

5. Given the phase diagram for water (on page 6):

   a) Name each region, line and point. (*Use the letters and numbers given on the diagram and answer in your exam booklet.* ***Don't write it on the question paper; I don't want that handed in!***)

   b) Describe what happens as the pressure of the water is raised from 0.001 atm to 50 atm at a constant temperature of 0°C (make reasonable estimates of temperature and pressure values as needed)

   c) Describe what happens as the temperature of the ~~carbon dioxide~~ water is raised from – 50 °C to + 120 °C at a constant pressure of 25 atm (make reasonable estimates of temperature and pressure values as needed)

   d) Briefly explain whether the phase diagram of water indicates the presence of hydrogen bonding or not, and explain your reasoning.

6. A reaction used to produce nitric oxide from ammonia gas is:

$$NH_{3\,(g)} + O_{2(g)} \rightarrow NO_{(g)} + H_2O_{(g)}$$

   a) Calculate the mass of nitric oxide that can be produced when 320.42g ammonia and 750.13 g of oxygen gas are combined. *show enough work to justify your answer.*

   b) If the reaction has a yield of 79%, calculate the actual mass of ~~oxygen gas~~ Nitic Oxide that will be produced.

7. For the reaction:

$$3\ MnO_{(s)} + 2\ Al_{(s)} \rightarrow 3\ Mn_{(s)} + Al_2O_{3(s)}$$

Given the following reactions:	$\Delta H°$(kJ)	$\Delta S°$(J/K)
$2\ MnO_{2(s)} \rightarrow 2\ MnO_{(s)} + O_{2(g)}$	271	219
$4\ Al_{(s)} + 3\ O_{2(g)} \rightarrow 2\ Al_2O_{3(s)}$	−3348.6	- 625
$MnO_{2(s)} \rightarrow Mn_{(s)} + O_{2(g)}$	543	207

a) Calculate the standard heat of reaction
b) Calculate the standard entropy of reaction
c) Calculate the standard free energy of reaction
d) Calculate the temperature range over which this reaction is spontaneous

8. The decomposition of ammonium hydrogen sulphide is given by:

$$NH_4HS_{(s)} \leftrightarrow NH_{3(g)} + H_2S_{(g)} \qquad \text{with } K_p = 70.2 \text{ at } 22°C$$

If 49.642 g of ammonium hydrogen sulphide is placed in a 2.0 L container at 22°C, Calculate:

a) The mass of hydrogen sulphide gas, $H_2S_{(g)}$, that is produced
b) The mass of ammonium hydrogen sulphide that remains when equilibrium is reached.

9. a) Determine what precipitates when 25.0 ml of 8.9×10^{-4} M $Ca(NO_3)_2$ is mixed with 50.0 ml of 9.3×10^{-5} M Na_2CO_3. *Show enough work to justify your answer.*

   b) Calculate the mass of precipitate that forms

10. Using the list of half-reaction potentials on the data sheet, for the reaction:

   $Co^{2+} + Cr \rightarrow Co + Cr^{3+}$

   a) Show the balanced equation for the overall reaction

   b) Calculate the standard state reaction potential

   c) Calculate the standard state free energy for the reaction

   d) Calculate the reaction potential when the Co^{2+} concentration is 8.7 M and the Cr^{3+} concentration is 0.3 M