Chemistry 210 • FINAL Exam • Fall 2005 Name: _____ Section: _____

FREE RESPONSE: *Answer the following questions in the spaces provided. Show all work and units to receive credit. Pay attention to significant figures.*

1. (25 points) Write ***complete, balanced equations*** for the following chemical reactions (including state symbols). If you expect ***no reaction***, write ***NR*** and provide a ***brief explanation***.

   A. Aqueous solutions of sulfuric acid (H_2SO_4) and sodium hydroxide (NaOH) are mixed.

   B. Write the ***molecular equation*** and ***net ionic equation*** for the reaction of $Pb(NO_3)_{2(aq)}$ with $Na_3PO_{4(aq)}$.

      MOLECULAR:

      NET IONIC:

   C. Chlorine gas is bubbled through a solution of aluminum fluoride.

2. (15 points) Balance the following REDOX reaction in ***acidic solution***.
   All species are aqueous unless otherwise indicated.

   $MnO_{2(s)} + ClO^- \rightarrow Cl_2 + MnO_4^-$

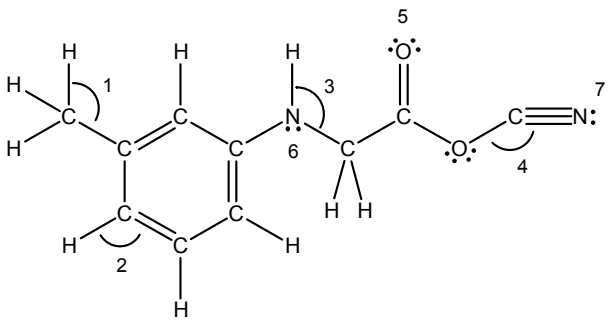
3. (8 points) Write the equation for the reaction with a heat of reaction equal to the heat of formation for $Al(NO_2)_{3(s)}$. *Include state symbols*.

4. (15 points) Draw the electron dot structure for the following molecules – assume a single central atom. Indicate (circle) whether each ***molecule*** is polar or non-polar.

SO_3	PBr_3	NF_3
POLAR or NON-POLAR	POLAR or NON-POLAR	POLAR or NON-POLAR

5. (8 points) Draw the electron dot structure and orbital overlap diagram for CH_3CHO

6. (21 points) Consider the structure below:



Give the approximate bond angles of the four angles:

∠1 = _____ ∠2 = _____

∠3 = _____ ∠4 = _____

Give the hybridizations of the following labeled atoms:

#5 - O = _____ #6 - N = _____

#7 - N = _____

How many π (pi) bonds are in the structure? _____

7. (8 points) Draw the electron dot structure for sulfuric acid, H_2SO_4. Be sure to consider formal charge in drawing a reasonable structure. (A single structure will suffice.)

8. (6 points) Draw the electron dot structure for ***ALL*** of the reasonable resonance structures of the nitrite ion: NO_2^-

(4 points) What is the N-O bond order? _____

9. (15 points) When heated, azomethane decomposes into nitrogen gas and methane gas. Using bond dissociation energies, calculate the enthalpy of reaction.

$$\mathbf{CH_3NNCH_{3(g)} \rightarrow N_{2(g)} + C_2H_{6(g)}}$$

(***note:*** the nitrogens are double bonded in this compound.)

10. (15 points) Calculate the concentration (in mol/L) of aluminum ions and sulfate ions in a solution prepared by mixing 8.00 g of $Al_2(SO_4)_3$ with enough water to make 250.0 mL of solution.

11. (30 points) Consider the reaction: $\mathbf{Fe_2O_{3(s)} + 3\,CO_{(g)} \rightarrow 2\,Fe_{(s)} + 3\,CO_{2(g)}}$

Molar masses (g/mol):
Fe_2O_3 = 159.7 CO = 28.01 Fe = 55.85 CO_2 = 44.01

A) What is the theoretical yield of iron if 16.0 g of iron (III) oxide is reacted with 7.25 g of carbon monoxide?

B) What mass of the excess reagent remains if a complete reaction occurs?

(25 points) Answer 1 of the following 2 questions (12-13).
Cross out the one you DO NOT want graded. Otherwise the first will be graded.

12. Naturally occurring gallium is composed of two isotopes, Gallium-69 and Gallium-71. Calculate the percent abundance of the two isotopes of gallium. You MUST show all work to receive credit.

Isotope	Isotope mass
^{69}Ga	68.917
^{71}Ga	70.922

13. A compound is analyzed and found to contain 65.4% C, 5.5% H, and 29.1% O by mass. In a separate experiment, the compound is found to effuse through an opening at a rate of 3.0×10^{-5} mol/min. A sample of neon gas effused through the same opening at a rate of 7.0×10^{-5} mol/min.

    A) What is the empirical formula of the compound?

    B) What is the molecular formula of the compound?

(30 points) Answer 1 of the following 2 questions (14-15).
Cross out the one you DO NOT want graded. Otherwise the first one will be graded.

14. Consider the reaction:

$$2\ N_2H_{4(l)} + 3\ O_{2\ (g)} \rightarrow 2\ N_2O_{(g)} + 4\ H_2O_{(l)}$$

A) Use standard enthalpies of formation to find the standard enthalpy ($\Delta H°$) for the above reaction.

B) What of mass of N_2H_4 must react to produce 500. kJ of heat?

Species	ΔH°_f (kJ/mol)
$N_2H_{4(l)}$	50.63
$N_2O_{(g)}$	82.05
$H_2O_{(l)}$	–241.83

15. A 3.25 g sample of methanol, CH_3OH, is combusted in a bomb calorimeter. The temperature of the calorimeter increases by 10.6ºC. If the heat capacity of the bomb is 855 J/C° and it contains 1.000 kg of water, what is the heat evolved per mole of ethanol combusted?

    (The specific heat capacity of water is 4.18 J/g·C° and the molar mass of methanol is 32.04 g/mol.)

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BONUS questions:
(Credit will be given only for the correct final answer with all work shown.)

1. (10 points) Under an atmosphere of oxygen, the compound $C_7H_{11}O_4NS_2$ is burned. Write the balanced equation for this reaction. You may assume all of the nitrogen is converted to NO_2 and the sulfur is converted to SO_3. Coefficients should represent the smallest whole number ratio of all reactants and products – no fractional coefficients.

2. (5 points) Draw the electron dot structure and orbital-overlap diagrams for H_2CCNH. The 3-dimensionality of the structure must be reasonably represented to receive credit.

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REFERENCE INFORMATION

General Equations and Information

Metric Prefix	Symbol	Multiple
tera-	T	10^{12}
giga-	G	10^{9}
mega-	M	10^{6}
kilo-	k	10^{3}
hecto-	h	10^{2}
deka-	dk	10^{1}
<base unit>		10^{0}
deci-	d	10^{-1}
centi-	c	10^{-2}
milli-	m	10^{-3}
micro-	μ	10^{-6}
nano-	n	10^{-9}
pico-	p	10^{-12}

$$D = \frac{m}{V}$$

D_{H2O} **=** 1.00 g/mL

$$\%\ \text{error} = \frac{|\text{experimental} - \text{actual}|}{\text{actual}} \times 100\%$$

Absolute Zero **=** −273.15 °C

Avogadro's Number **=** N_A **=** 6.022×10^{23}

$$n = \frac{m}{M_m}$$

Average Atomic Mass = Σ **(**Fractional Abundance • Isotopic Mass**)**

Solutions

$$\text{Molarity} = [\text{solute}] = \frac{\text{moles of solute}}{\text{Liters of solution}} = M$$

$$M_1V_1 = M_2V_2$$

$$\text{mass \%} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100\%$$

EM radiation and Hydrogen atom energy levels

$c = \lambda\nu$ $\qquad$ $E = h\nu$ $\qquad$ $E = \frac{hc}{\lambda}$

$E_{photon} = |\Delta E|$ $\qquad$ $E_n = -\frac{Rhc}{n^2}$ $\qquad$ $\Delta E = -Rhc\left(\frac{1}{n_{final}^2} - \frac{1}{n_{initial}^2}\right)$

$c = 3.00 \times 10^{8}$ m/s $\qquad$ $h = 6.626 \times 10^{-34}$ J•s $\qquad$ $Rhc = 2.18 \times 10^{-18}$ J

Heat Constants & Equations

$-q_{system} = q_{surroundings}$

$-q_{lost} = q_{gained}$

$q = mC_p\Delta T$

q = (heat capacity) ΔT

Gas Laws

Assume all gases on the exam behave as ideal gases unless otherwise stated.

$PV=nRT$

$P_{total} = P_1 + P_2 + P_3 + \ldots\ldots + P_n$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{rate_a}{rate_b} = \frac{\sqrt{M_b}}{\sqrt{M_a}}$$

Standard Temperature = 0 °C = 273.15 K

Standard Pressure = 1.000 atm = 760.0 mmHg
= 101,300 Pa = 101.3 kPa

$$R = 0.08206\ \frac{L \cdot atm}{K \cdot mol} = 62.37\ \frac{L \cdot mmHg}{K \cdot mol}$$

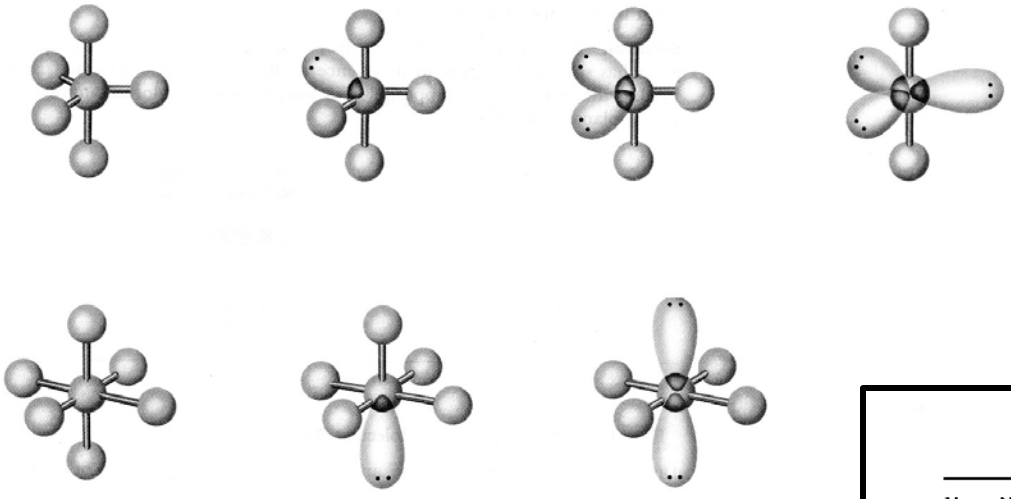
Polyatomic Ions

NH_4^+	ammonium
$C_2H_3O_2^-$	acetate
CO_3^{2-}	carbonate
HCO_3^-	hydrogen carbonate *(bicarbonate)*
NO_3^-	nitrate
SO_4^{2-}	sulfate
SO_3^{2-}	sulfite
PO_4^{3-}	phosphate
ClO_4^-	perchlorate
ClO_3^-	chlorate
ClO_2^-	chlorite
ClO^-	hypochlorite
CN^-	cyanide
OH^-	hydroxide
CrO_4^{2-}	chromate
$Cr_2O_7^{2-}$	dichromate
MnO_4^-	permanganate

Table of Electronegativities

H 2.1

1A	2A											3A	4A	5A	6A	7A
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	3B	4B	5B	6B	7B	8B			1B	2B	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5
Cs 0.7	Ba 0.9	La 1.1	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2



Structures for 5 or 6 electron regions on the central atom.

Multiple Bonds

N═N	418	C═C	610
N≡N	945	C≡C	835
C═N	615	C═O	745
C≡N	887	C≡O	1046
O═O (in O_2)	498		

Average Single- and Multiple-Bond Energies (kJ/mol)

Single Bonds

	H	C	N	O	F	Si	P	S	Cl	Br	I
H	436	413	391	463	565	328	322	347	432	366	299
C		346	305	358	485	—	—	272	339	285	213
N			163	201	283	—	—	—	192	—	—
O				146	—	452	335	—	218	201	201
F					155	565	490	284	253	249	278
Si						222	—	293	381	310	234
P							201	—	326	—	184
S								226	255	—	—
Cl									242	216	208
Br										193	175
I											151