CHEM 35

General Chemistry

EXAM #3

November 15, 2000

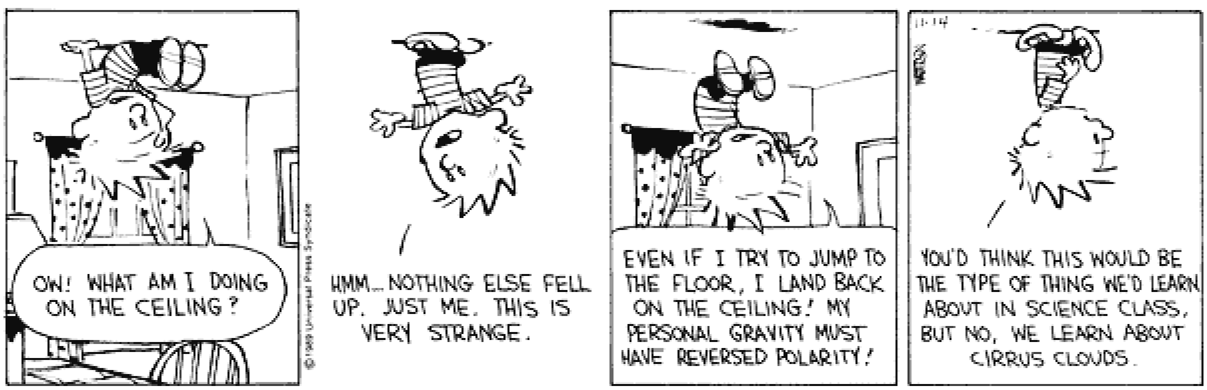
Name: Largo, Key

SSN:______________________________

Lab T.A.:___________________________

INSTRUCTIONS: Read through the entire exam before you begin. Answer all of the questions. For questions involving calculations, show **all** of your work -- **HOW** you arrived at a particular answer is **MORE** important than the answer itself! Circle your final answer to numerical questions.

The entire exam is worth a total of 150 points. Attached are a periodic table and a formula sheet jam-packed with useful stuff. Good Luck!



Page	**Possible Points**	***Points Earned***
2	30	*30*
3	30	*30*
4	15	*15*
5	30	*30*
6	20	*20*
7	25	*25*
TOTAL:	***150***	*150*

1. For the Hydrogen atom:
   a. *(10 pts)* Calculate the energy change (in Joules) associated with an n=2 to n=4 electronic transition.

$$\Delta E = R_H(1/(n_i)^2 - 1/(n_f)^2)$$
$$= (2.1798741 \times 10^{-18}\ J)(1/(2)^2 - 1/(4)^2)$$
$$= (2.1798741 \times 10^{-18}\ J)(1/4 - 1/16)$$
$$= (2.1798741 \times 10^{-18}\ J)(0.1875)$$
$$= 4.0872639 \times 10^{-19}\ J$$
$$= \underline{\mathbf{4.0873 \times 10^{-19}\ J}}$$

   b. *(5 pts)* Is a photon *emitted* or *absorbed* as a result of this transition?

EMITTED **ABSORBED** (circled) circle one

   c. *(10 pts)* Calculate the wavelength (nm) of the photon having the same energy as the energy change associated with this transition.

$$E = hc/\lambda \rightarrow \lambda = hc/E$$
$$\lambda = \frac{(6.62606876 \times 10^{-34}\ J\text{-}s)(2.9979 \times 10^{8}\ m/s)}{4.0872639 \times 10^{-19}\ J}$$
$$= 4.860046 \times 10^{-7}\ m$$
$$= 4.860046 \times 10^{-7}\ m \times \frac{10^{9}\ nm}{m}$$
$$= \underline{\mathbf{4.860 \times 10^{2}\ nm}} \text{ or } \underline{\mathbf{486.0\ nm}}$$

   d. *(5 pts)* Is the photon in the visible portion of the electromagnetic spectrum?

YES (circled) **NO** circle one

2. *(5 pts each)* Write the ground state electron configurations for the following atoms and ions (use noble gas abbreviations for core electrons where appropriate):

   a. Na: ***[Ne]3s^1***

   b. Co: ***[Ar]4s^{2}3d^7***

   c. Cu^{3+}: ***[Ar]3d^8***

   d. Au: ***[Xe]4f^{14}6s^{1}5d^{10}***

3. *(10 pts)* Give the values of the 4 quantum numbers (n, l, m_l, and m_s) for each of calcium's two valence electrons.

   Ca: [Ar]4s^2 $\Rightarrow$ $n = 4,\ l = 0,\ m_l = 0,\ m_s = +½$

   $n = 4,\ l = 0,\ m_l = 0,\ m_s = -½$

4. *(5 pts each)* Circle the number next to the appropriate response for each of the following:

   a. That no two electrons in an atom can possess the same set of 4 quantum numbers is a consequence of:

      1. The Aufbau Principle
      2. The Heisenberg Uncertainty Principle
      3. Hund's Rule
      4. Pauli Exclusion Principle
      5. Robert's Rules of Order

   b. Einstein's explanation of the *photoelectric effect*:

      1. illustrated the wave properties of matter
      2. inspired Thomas Edison to invent the light bulb
      3. applied Planck's quantum theory of electromagnetic radiation
      4. utilized his newly developed theory of relativity
      5. was inspired by his observations of how a violin string vibrates

   c. The Bohr model of the atom:

      1. was first proposed by Balmer more than 30 years before Bohr
      2. accurately predicts the line emission spectrum for the hydrogen atom
      3. is based on the wave properties of the electron in a hydrogen atom
      4. was originally made out of balsa wood using simple hand tools in Bohr's garage
      5. is also known as the "plum pudding" model of the atom

5. *(5 pts each)* For the following, circle the species in each row with the desired property:

a. largest atomic radius	Na	Al	S	Ar	(K)
b. smallest radius	(Al^{3+})	O^{2-}	F^-	Ne	Na^+
c. greatest electron affinity	(F)	Cl	Br	I	At
d. smallest 1st ionization energy	B	(Al)	C	Si	P

6. *(10 pts)* Recall the thermite reaction:

$$2\ Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2\ Fe(s)$$

This highly exothermic reaction is used for welding massive objects, such as propellers for large ships. Using the standard molar enthalpies of formation given below, calculate ΔH^o (kJ) for this reaction.

$\Delta H^o_f\ (Fe_2O_3(s)) = -822.16$ kJ
$\Delta H^o_f\ (Al_2O_3(s)) = -1669.8$ kJ

ΔH^o = [(-1669.8 kJ) + 2(0)] – [(-822.16 kJ) + 2(0)]
= -847.64 kJ
= *-847.6 kJ*

7. *(10 pts)* The specific heat of copper metal is 0.385 J/g-K. How many Joules of heat are necessary to raise the temperature of a 1.42-kg block of copper from 25.0 ^oC to 88.5 ^oC?

$$m = 1.42 \text{ kg} \times \frac{1000 \text{ g}}{\text{kg}} = 1.42 \times 10^3 \text{ kg}$$

$$\Delta T = 88.5 - 25.0\ ^oC = 63.5\ ^oC = 63.5 \text{ K}$$

$$c_s = 0.385 \text{ J/g-K}$$

$$q = mc_s\Delta T = (1.42 \times 10^3 \text{ kg})(0.385 \text{ J/g-K})(63.5 \text{ K})$$
$$= 3.4715 \times 10^4 \text{ J}$$
$$= \underline{3.47 \times 10^4 \text{ J}}$$

8. *(10 pts)* Given the following data:

$N_2(g) + O_2(g) \rightarrow 2\ NO(g)$	$\Delta H = +180.7$ kJ
$2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$	$\Delta H = -113.1$ kJ
$2\ N_2O(g) \rightarrow 2\ N_2(g) + O_2(g)$	$\Delta H = -163.2$ kJ

use Hess's law to calculate ΔH (kJ) for the following reaction:

$N_2O(g) + NO_2(g) \rightarrow 3\ NO\ (g)$

½ Rxn 3:	$N_2O(g) \rightarrow N_2(g) + \frac{1}{2}O_2(g)$	$\Delta H = \frac{1}{2}(-163.2) = -81.60$ kJ
-½ Rxn 2:	$NO_2(g) \rightarrow NO(g) + \frac{1}{2}O_2(g)$	$\Delta H = -\frac{1}{2}(-113.1) = +56.55$ kJ
Rxn 1:	$N_2(g) + O_2(g) \rightarrow 2\ NO(g)$	$\Delta H = +180.7 = +180.7$ kJ

$N_2O(g) + NO_2(g) \rightarrow 3\ NO\ (g)$ $\quad\Delta H = +155.65$ kJ
$= \underline{+155.6 \text{ kJ}}$

9. For N_2:

a. *(5 pts)* Write the ground-state electron configuration, using the appropriate building-up sequence.

7 x 2 = 14 e^-

N_2: $(s_{1s})^2(s^*_{1s})^2(s_{2s})^2(s^*_{2s})^2(p_{2p})^4(s_{2p})^2$

b. *(10 pts)* Show the orbital populations on a molecular orbital energy diagram.

For the p-electrons:

_____ σ^*_{2p}

_____ _____ π^*_{2p}

2p _↑_ _↑_ _↑_   _↑_ _↑_ _↑_ 2p

_↑↓_ σ_{2p}

_↑↓_ _↑↓_ π_{2p}

N   **N_2**   **N**

c. *(5 pts)* What is its bond order?

bo = ½(6 – 0) = *3*

d. *(5 pts)* Is the system paramagnetic? Why/why not?

All of the electrons are *paired*, so the system is *not paramagnetic*.