CHEM 35

General Chemistry

EXAM #1

September 20, 2000

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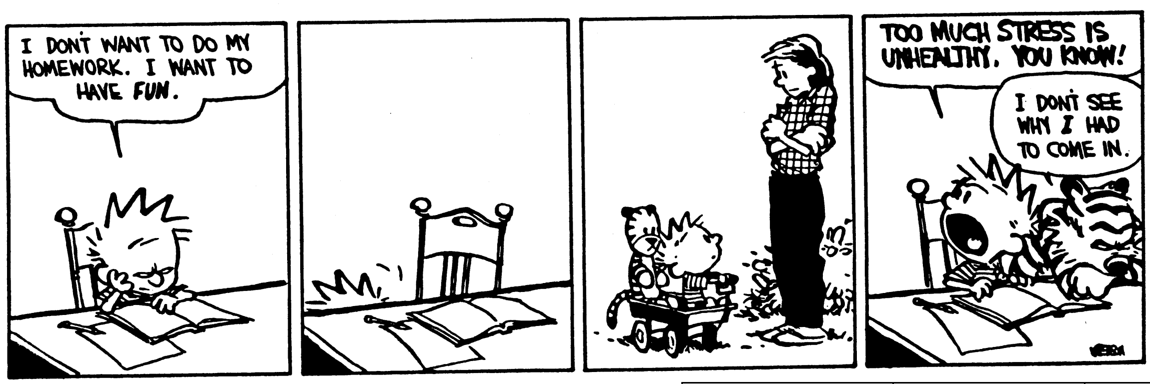
SSN:________________________

Lab T.A.:______________________

INSTRUCTIONS: Read through the entire exam before you begin. Answer all of the questions. For questions involving calculations, shall **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	15	
3	26	
4	26	
5	17	
6	24	
7	24	
8	18	
TOTAL:	***150***	

1. *(3 pts each)* Carry out the following operations, and express the answer with the appropriate number of significant figures:

   a. 1.24056 + 75.8 =

```
  1.24056
+75.8
 77.04056  -> Round to tenths place:  77.0
```

   77.0

   b. 320.55 – (6104.5/2.3) =

```
  320.55
 -2654.1304
 -2333.580  -> round to HUNDREDS place: -2300 or -2.3 x 10^3
```

   -2300 or **-2.3×10^3**

   c. (0.0045 x 20,000.0) + (2813 x 12) =

```
    90.000
+33756.000
 33846.000 -> round to TEN THOUSANDS place: 34000 or 3.4 x 10^4
```

   34000 or **3.4×10^4**

2. *(3 pts each)* The all-time record lowest temperature ever recorded on this planet is –57.63 ^{o}C (recorded on July 21, 1983 in Vostok, the Russian Antarctic station).

   a. Express this temperature in ^{o}F.

   $^{o}F = (9/5)^{o}C + 32$
   $= (9/5)(-57.63) + 32 = -71.734\ ^{o}F \rightarrow$ **$-71.73\ ^{o}F$**

   b. Express this temperature in Kelvins (K).

   $K = {}^{o}C + 273.15$
   $= -57.63 + 273.15 = 215.52\ K \rightarrow$ **215.52 K**

3. *(10 pts)* A 26.27-g sample of a solid is placed in a flask. Toluene, in which the solid is insoluble, is added to the flask so that the volume of the solid and liquid together is 50.00 mL. The solid and liquid toluene together weigh 52.65 g. The density of toluene at the temperature of the experiment is 0.864 g/mL. What is the density of the solid?

```
solid + toluene =   52.65 g
          solid =   26.27 g
Mass of toluene =   26.38 g toluene
```

$$26.38 \text{ g toluene} \times \frac{1 \text{ ml toluene}}{0.864 \text{ g toluene}} = \underline{30.53241 \text{ mL toluene}}$$

```
solid + toluene =   50.00 mL
        toluene =   30.53241 mL
          solid =   19.46759 mL
```

density of the solid $= \frac{26.27 \text{ g}}{19.46759 \text{ mL}}$

$= 1.34942 \text{ g/mL} \rightarrow$ **1.35 g/mL**

4. *(16 pts)* Fill in the gaps in the following table:

Symbol	$^{52}Cr^{3+}$	$^{107}Ag^{+}$	$^{75}As^{3-}$
Protons	*24*	47	33
Neutrons	*28*	60	42
Electrons	*21*	46	*36*
Net Charge	*3+*	*1+*	3-

5. *(2 pts each)* From this list of elements: **Ar, H, Ga, Al, Ca, Br, Ge, K, O**; pick the one that best fits each of the following descriptions. You may use each element only ONCE.

   a. an alkali metal: **K**
   b. an alkaline earth metal: **Ca**
   c. a noble gas: **Ar**
   d. a halogen: **Br**
   e. a metalloid: **Ge**
   f. a nonmetal listed in group IA: **H**
   g. a metal that forms a 3+ ion: **Al**
   h. a nonmetal that forms a 2- ion: **O**
   i. an element that resembles aluminum: **Ga**

6. *(1 pt each)* Give the atomic symbol for the following elements:

   a. calcium: **Ca**

   b. sodium: **Na**

   c. mercury: **Hg**

   d. lead: **Pb**

7. *(1 pt each)* Give the name of the element for the following atomic symbols:

   a. Cu: **Copper**

   b. K: **Potassium**

   c. H: **Hydrogen**

   d. Ag: **Silver**

8. *(3 pts each)* Write a complete, balanced chemical equation for each of the following reactions:

   a. Solid calcium carbide (CaC_2) reacts with water to form an aqueous solution of calcium hydroxide and acetylene gas (C_2H_2).

      $CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + C_2H_2(g)$

   b. $HBr + F_2 \rightarrow HF + Br_2$

      $2HBr + F_2 \rightarrow 2HF + Br_2$

   c. $CH_4 + O_2 \rightarrow CO_2 + H_2O$

      $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

9. *(8 pts)* The element magnesium consists of three naturally occurring isotopes with masses 23.98504, 24.98584, and 25.98259 amu. The relative abundances of these three isotopes are 78.70, 10.13, and 11.17 percent, respectively. From these data, calculate the average atomic mass of magnesium.

23.98504(0.7870) + 24.98584(0.1013) + 25.98259(0.1117) =

18.87622648 + 2.531065592 + 2.9022553 = 24.3095474

= **24.31 amu**

10. *(6 pts)* Show the Lewis structure for CH_3Cl.

4 + 3 + 7 = 14 valence electrons

```
        H
        |    _
    H – C – Cl|
        |    ‾
        H
```

a. *(3 pts)* What shape does VSEPR theory predict for this molecule?

Four bonding electron pairs = ***tetrahedral***

b. *(3 pts)* The electronegativity values for C, H and Cl are 2.55, 2.2 and 3.16, respectively. Which bond(s) is(are) the most polar?

For the C-H bonds: ÄEN = 2.55 – 2.2 = 0.35

For the C-Cl bond: ÄEN = 3.16 – 2.55 = 0.61

C-Cl bond has greatest ÄEN, so it is the most polar.

c. *(3 pts)* Does this molecule have a net dipole? If so, indicate the positive and negative regions, on the Lewis structure, by the symbols δ+ and δ-, respectively.

Yes, there is a net dipole as the C-Cl bond is more polar than the C-H bonds. Since Cl is the most EN, the δ- will be on the Cl. Since H is the least EN, the δ+ will be on the three hydrogens.

11. *(9 pts)* Draw the Lewis and VSEPR structures for SF_6.

S = 6 valence electrons
F = 7 x6 = 42 valence electrons

42 + 6 = 48 valence electrons

```
            F  F
            | /        3 nonbonded electron pairs around
        F - S – F      each F = 36 electrons
           / |                   +
          F  F     6 S-F bonds = 12 electrons = 48 e-
```

The VSEPR structure for SIX electron pairs is **Octahedral**

12. Ibuprofen, a potent headache remedy, has a molar mass of about 206 grams and has been determined to be 75.69 % C, 8.80 % H, and 15.51 % O by mass.

a. *(12 pts)* Determine the empirical formula for ibuprofen.

$$75.69 \text{ g C} \times \frac{1 \text{ mole C}}{12.0107 \text{ g C}} = \mathit{6.30188\ mol\ C}$$

$$8.80 \text{ g H} \times \frac{1 \text{ mole H}}{1.00794 \text{ g H}} = \mathit{8.730678\ mol\ H}$$

$$15.51 \text{ g O} \times \frac{1 \text{ mole O}}{15.9994 \text{ g O}} = \mathit{0.969411\ mol\ O}$$

C: $\frac{6.30188 \text{ mol}}{0.969411 \text{ mol}} = \mathit{6.50} \quad \times 2 \quad = \mathbf{13}$

H: $\frac{8.730678 \text{ mol}}{0.969411 \text{ mol}} = 9.00 \quad \times 2 \quad = \mathbf{18}$

O: $\frac{0.969411 \text{ mol}}{0.969411 \text{ mol}} = 1.00 \quad \times 2 \quad = \mathbf{2}$

So, $\mathbf{C_{13}H_{18}O_2}$

b. *(6 pts)* Determine the molecular formula for ibuprofen.

13 C = 13 x 12 = **156**
18 H = 18 x 1 = **18**
2 O = 2 x 16 = **32**
Empirical Mass = 206 g/mol = molar mass

Empirical Formula = Molecular Formula = $\mathbf{C_{13}H_{18}O_2}$

c. *(6 pts)* Calculate the molar molecular mass of ibuprofen to the nearest mg/mol.

13 C = 13 x 12.0107 = **156.1391**
18 H = 18 x 1.00794 = **18.1429**
2 O = 2 x 15.9994 = **32.9988**
206.2808 g/mol → **206.281 g/mol**

(206,281 mg/mol)

13. *(9 pts each)* A tablet of Advil™ contains 200. mg of ibuprofen.

a. How many molecules of ibuprofen are in a single Advil™ tablet?

$$200.\ \text{mg Ibu} \times \frac{1\ \text{gram}}{1000\ \text{mg}} \times \frac{1\ \text{mol Ibu}}{206.281\ \text{g Ibu}} \times \frac{6.02214 \times 10^{23}\ \text{molecules}}{1\ \text{mol Ibuprofen}} =$$

$$= 5.8387733 \times 10^{20}\ \text{molecules}$$

$$= \underline{\mathbf{5.84 \times 10^{20}\ molecules\ Ibuprofen}}$$

b. How many moles of oxygen (from the ibuprofen) are there in a single Advil™ tablet?

$$200.\ \text{mg Ibu} \times \frac{1\ \text{gram}}{1000\ \text{mg}} \times \frac{1\ \text{mol Ibu}}{206.281\ \text{g Ibu}} \times \frac{2\ \text{moles O}}{\text{mol Ibuprofen}} =$$

$$= 1.93919249 \times 10^{-3}\ \text{mol O}$$

$$= \underline{\mathbf{1.94 \times 10^{-3}\ mol\ O}}$$

<u>EXTRA CREDIT</u>! – 10 points

We've been claiming all semester that, for atomic- and molecular-sized systems, electromagnetic forces between and with atoms are much greater than gravitational forces between atoms and sub-atomic particles. Ok, let's demonstrate that with some calculations!

<u>Calculate</u>:

1) The magnitude of the *coulombic attractive force* between the proton in the nucleus of a hydrogen atom and the electron whirling around it. For the purposes of this calculation, assume that the distance separating the proton and the electron is 5 Å.
2) The magnitude of the *gravitational attractive force* between the same two particles in a hydrogen atom.

Based on your calculations, is our assumption justified?

1) Coulombic attraction:

$$F = \frac{1}{4\pi\varepsilon_o} \times \frac{q_1 q_2}{r^2} \qquad \varepsilon = 8.85 \times 10^{-12}\ C^2\text{-}N^{-1}\text{-}m^{-2}$$

$$= \frac{(1.60 \times 10^{-19} C)(-1.60 \times 10^{-19} C)}{4(3.14159)(8.85 \times 10^{-12}\ C^2\text{-}N^{-1}\text{-}m^{-2})(5 \times 10^{-10}\ m)^2} =$$

$$= -9.20761 \times 10^{-10}\ N = \mathbf{-9.21 \times 10^{-10}\ N}$$

2) Gravitational attraction:

$$F = \frac{-\ Gm_1 m_2}{r^2} \qquad G = 6.67 \times 10^{-11}\ N\text{-}m^2\text{-}kg^{-2}$$

<u>mass electron</u>:

$$5.4858 \times 10^{-4}\ amu \times \frac{1.66054 \times 10^{-24} g}{1\ amu} \times \frac{1\ kg}{1000\ g} = 9.10939 \times 10^{-31}\ kg$$

<u>mass proton</u>:

$$1.007276\ amu\ amu \times \frac{1.66054 \times 10^{-24} g}{1\ amu} \times \frac{1\ kg}{1000\ g} = 1.67262 \times 10^{-27}\ kg$$

$$F = \frac{-(6.67 \times 10^{-11}\ N\text{-}m^2\text{-}kg^{-2})(9.10939 \times 10^{-31}\ kg)(1.67262 \times 10^{-27}\ kg)}{(5 \times 10^{-10}\ m)^2}$$

$$F = -4.065116 \times 10^{-49}\ N = \mathbf{-4.07 \times 10^{-49}\ N}$$