Chem 120
Exam 1, Ch 1-3
100 Points

Name________________________________
September 19, 2008

Please follow the instructions for each section of the exam. Show your work on all mathematical problems. Provide answers with the correct units and significant figures. Be concise in your answers to discussion questions.

Part 0: Warmup. 4 points each

1. When 10.0 g zinc and 8.0 g sulfur are allowed to react, all of the zinc is consumed and 15.0 g zinc sulfide is produced. The mass of unreacted sulfur remaining is:
   a. 2.0 g
   b. 3.0 g
   c. 5.0 g
   d. Impossible to predict from this information alone.

   Answer _____B_______

2. The standard deviation provides information about
   a. the proximity of a value to the "true value"
   b. the scatter of a dataset around a mean.
   c. the accuracy of your data.
   d. the presence of systematic errors in your measurement.

   Answer _____B _______

3. A good example of a homogeneous mixture is:
   a. a cola drink in a tightly capped bottle
   b. pure, distilled water leaving a distillation apparatus
   c. oxygen gas in a cylinder used for welding
   d. the material produced in a kitchen blender

   Answer _____A _______

4. Choose the INCORRECT statement from those given below.
   a. All matter is composed of atoms.
   b. All atoms of a given element are identical.
   c. Atoms combine in small, whole numbered ratios.
   d. Different ratios of atoms produce different compounds.

   Answer _____B _______

Part I: Complete all of problems 5-10

5. Complete the following table. (12 points)

Symbol	^{55}Mn	^{65}Zn	$^{80}Br^{2-}$
# of protons	25	30	35
# of neutrons	30	35	45
# of electrons	25	30	37
Charge	0	0	0
Name	manganese -55	zinc-65	bromide-80 ion

Note that while Br^{2-} is not realistic (Br^- is), it can still be named using regular naming rules

6. Name the following compounds or provide the correct formula for the given names. (18 points)

    a. $Co(NO_3)_2$ — copper (II) nitrate

    b. ammonium chloride — NH_4Cl

    c. BF_3 — boron trifluoride

    d. tricarbon disulfide — C_3S_2

    e. magnesium perchlorate — $Mg(ClO_4)_2$

    f. Na_2SO_4 — sodium sulfate

7. Bromine exists as two isotopes with nearly equal abundance. The average mass of a bromine atom is 79.904 amu. If you were able to pick up a single bromine atom, what is the chance that you would randomly get one with a mass of 79.904 amu? No calculations are needed, but you must clearly justify your answer. (8 points)

   There is zero chance of finding an atom of mass 79.904 amu. Because 79.904 amu must be the “weighted average” of the masses of individual isotopes, and because there are only two isotopes, neither can have mass 79.904 amu. One isotope must have a mass greater than 79.904 amu and one must have a mass smaller than 79.904 amu

8. Magnesium occurs in seawater to the extent of 1.40 g magnesium per kilogram of seawater. What volume of seawater, in liters, would have to be processed to produce 1.00 ton of magnesium? (1 ton = 907.1 kg, density of seawater = 1.08 kg/L). (8 points)

$$1.00\ \cancel{\text{ton Mg}} \times \frac{907.1\ \cancel{\text{kg Mg}}}{1\ \cancel{\text{ton Mg}}} \times \frac{10^3\ \cancel{\text{g}}}{1\ \cancel{\text{kg}}} \times \frac{1\ \cancel{\text{kg sw}}}{1.40\ \cancel{\text{g Mg}}} \times \frac{1\text{ L sw}}{1.08\ \cancel{\text{kg sw}}} = 599{,}934\text{ L sw}$$

So, 600,000 liters of seawater must be processed (3 sig.figs.)

9. Which is the larger mass, 3245 μg or 0.00515 mg? (8 points)

$$3245\ \mu g \times \frac{10^{-6} g}{1\ \mu g} \times \frac{1\ mg}{10^{-3}\ g} = 3.245\ mg \quad \textbf{and} \quad 0.00515\ mg \times \frac{10^{-3} g}{1\ mg} \times \frac{1\ \mu g}{10^{-6}\ g} = 5.15\ \mu g$$

So, 3245 μg is the larger mass.

10. How many copper atoms are present in a piece of sterling silver jewelry weighing 33.24 g? Sterling silver is a silver-copper alloy containing 92.5% silver by mass with the balance being copper. (8 points)

If the alloy is 92.5% silver, it must be 100%-92.5% = **7.5% copper**

$$33.24\ \cancel{\text{g alloy}} \times \frac{7.5\ \cancel{\text{g Cu}}}{100\ \cancel{\text{g alloy}}} \times \frac{1\ \cancel{\text{mol Cu}}}{63.546\ \cancel{\text{g Cu}}} \times \frac{6.022 \times 10^{23}\ \text{atoms}}{1\ \cancel{\text{mol}}} = \mathbf{2.4 \times 10^{22}\,Cu\ atoms}$$

Part II. Answer two (2) of problems 11-14. Clearly mark the problem you do not want graded. 10 points each.

11. Copper has two stable isotopes, ^{63}Cu and ^{65}Cu, with masses of 62.9396 amu and 64.9278 amu, respectively. What are the percent abundances of each of these isotopes? Why aren't the masses of the isotopes 63.0000 and 65.0000?

$$F_{63}M_{63} + F_{65}M_{65} = 63.546\ \text{amu}$$
$$F_{63} + F_{65} = 1$$
$$(1-F_{65})(92.9396\ \text{amu}) + F_{65}(94.9278\ \text{amu}) = 63.546\ \text{amu}$$
$$1.9882\ \text{amu}(F_{65}) = 0.6064\ \text{amu}$$

$$F_{65} = 0.3049 = \mathbf{30.5\%\ ^{65}Cu}$$
$$F_{63} = 1 - F_{65} = 0.6950 = \mathbf{69.5\%\ ^{63}Cu}$$

The fact that the masses of each isotope are not integers is due in large part to the "mass defect", which is the loss in mass due to the energy required to hold the nucleus together.

12. The mineral spodumene has the empirical formula $LiAlSi_2O_6$. Given that the percentage of lithium-6 (^6Li) atoms in naturally occurring lithium is 7.40%, how many lithium-6 atoms are present in a 518 g sample of spodumene?

$$\frac{518\ \cancel{\text{g LiAlSi}_2\text{O}_6}}{} \times \frac{1\ \cancel{\text{mol LiAlSi}_2\text{O}_6}}{186.0899\ \cancel{\text{g LiAlSi}_2\text{O}_6}} \times \frac{1\ \text{mol Li}}{1\ \cancel{\text{mol LiAlSi}_2\text{O}_6}} = 2.7836\ \text{mol Li}$$

$$\frac{2.7836\ \cancel{\text{mol Li}}}{} \times \frac{6.022 \times 10^{23}\ \cancel{\text{atoms Li}}}{1\ \cancel{\text{mol Li}}} \times \frac{7.4\ \text{atoms}\ ^6\text{Li}}{100\ \cancel{\text{atoms Li}}} = \mathbf{1.24 \times 10^{23}\ atoms\ ^6Li}$$

13. The compound di-ethylene glycol monomethyl ether (di-EGME) is added to jet fuel to minimize the possibility of ice formation in the fuel tanks at high altitude. Elemental analysis has determined that di-EMGE is 49.98% carbon and 39.95% oxygen by weight, with the remainder of the compound being hydrogen. If the molar mass of di-EMGE is 120.1469 g/mol, what are the empirical and molecular formulas for this compound?

[100 - (49.98 + 39.95)]% = 10.07% H

Assume 100 g of EGME

$$49.98\ \cancel{g}\ C \times \frac{1\ mol\ C}{12.0112\ \cancel{g}} = 4.153\ mol\ C$$

$$39.95\ \cancel{g}\ O \times \frac{1\ mol\ O}{15.9994\ \cancel{g}} = 2.497\ mol\ O$$

$$10.07\ \cancel{g}\ H \times \frac{1\ mol\ H}{1.0079\ \cancel{g}} = 9.990\ mol\ O$$

$C_{4.153}H_{9.990}O_{2.497} \rightarrow C_{1.66}H_4O \rightarrow$ **$C_5H_{12}O_3$ = Empirical formula**

Is this also the molecular formula?

[5(12.0112 g) + 12(1.0097) + 3(15.9994)] g/mol = 120.1706 g/mol

Therefore $C_5H_{12}O_3$ is also the molecular formula.

14. While Dalton's atomic theory is still the foundation for our understanding of basic chemical principles, our ability to better characterize atoms and compounds has identified a few shortcomings or errors in the theory. Indentify the four key tenets of Dalton's theory and describe at least one shortcoming or error in the theory.

The four key points are

1. All matter is made of <u>Atoms</u>, which are indivisible.
2. All atoms of a given element are identical
3. Compounds are the result of a combination of two or more different kinds of atoms
4. Chemical reactions involve the combination, separation or rearrangement of atoms

The key shortcoming is that Dalton's theory does not account for the presence of isotopes, which are atoms of the same element that are not identical because they have different numbers of neutrons.

We also now know that atoms can be split into smaller components (protons, neutrons, electrons and smaller).

Possibly Useful Information

$e_4 = \sqrt{e_1^2 + e_2^2 + e_3^2}$	$\frac{e_4}{v_4} = \sqrt{\left(\frac{e_1}{v_1}\right)^2 + \left(\frac{e_2}{v_2}\right)^2 + \left(\frac{e_3}{v_3}\right)^2}$
$\mu = \bar{x} + \frac{ts}{\sqrt{n}}$	$\bar{x} = \frac{\sum x_i}{n}$
There's an evil monkey in my closet!	$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$
$N_a = 6.02214 \times 10^{23}\ mol^{-1}$	D = m/v

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.00794																	2 He 4.00260
3 Li 6.941	4 Be 9.01218											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050											13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9381	26 Fe 55.847	27 Co 58.9332	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.904	54 Xe 131.29
55 Cs 132.905	56 Ba 137.327	57 *La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	89 †Ac 227.028	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (271)	111 Rg (272)							

*Lanthanide series	58 Ce 140.115	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
†Actinide series	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)