Chem 130
Exam 1, Ch 1-4
100 Points

Name________________________________
June 22, 2016

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. Which of the following have roughly the same mass:
   a. a proton and an electron
   b. an electron and a neutron
   c. a neutron and a proton
   d. a proton and a bowling ball

   Answer _____ c_________

Part I: Complete all of problems 3-8

3. Complete the following table. (12 points)

Symbol	^{26}Mg	^{65}Zn	^{81}Br
# of protons	12	30	35
# of neutrons	14	35	46
# of electrons	12	30	36
Charge	0	0	-1
Name	magnesium-26	zinc-65	bromide-81 ion

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

   a. $Co(NO_3)_2$ cobalt (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

5. 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

6. 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 1.11 ton of magnesium? (1 ton = 907.1 kg, density of seawater = 1.08 kg/L). (8 points)

$$1.11\ \cancel{\text{ton Mg}} \times \frac{907.1\ \cancel{\text{kg Mg}}}{1\ \cancel{\text{ton Mg}}} \times \frac{10^3\ \cancel{\text{g}}}{1\ \cancel{\text{kg}}} \times \frac{1\ \cancel{\text{kg sw}}}{1.40\ \cancel{\text{g Mg}}} \times \frac{1\ \text{L sw}}{1.08\ \cancel{\text{kg sw}}} = 665{,}926\ \text{L sw}$$

So, 666,000 liters of seawater must be processed (3 sig.figs.)

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

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

   So, 3245 μg is the larger mass.

8. 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 three (3) of problems 9-12. Clearly mark the probl=em you do not want graded. 10 points each.

9. 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.

10. Nitrogen gas, N_2, can be created by passing gaseous ammonia over solid copper (II) oxide, with the other product of the reaction being solid copper and water vapor. If a reaction mixture containing 18.1 g NH_3 and 90.4 g CuO produces 6.63 g N_2, what is the percent yield for the reaction? (10 points)

$$2NH_3 + 3CuO \rightarrow 3Cu + N_2 + 3H_2O$$

We need to find the limiting reactant in order to calculate a theoretical yield

$$18.1\ \cancel{\text{g } NH_3} \times \frac{1\ \cancel{\text{mol } NH_3}}{17.0305\ \cancel{\text{g } NH_3}} \times \frac{1\ \cancel{\text{mol } N_2}}{2\ \cancel{\text{mol } NH_3}} \times \frac{28.0134 \text{ g } N_2}{1\ \cancel{\text{mol } N_2}} = 14.89 \text{ g } N_2$$

$$90.4\ \cancel{\text{g CuO}} \times \frac{1\ \cancel{\text{mol CuO}}}{79.5454\ \cancel{\text{g CuO}}} \times \frac{1\ \cancel{\text{mol } N_2}}{3\ \cancel{\text{mol CuO}}} \times \frac{28.0134 \text{ g } N_2}{1\ \cancel{\text{mol } N_2}} = 10.61 \text{ g } N_2$$

Therefore, CuO is our limiting reactant and the theoretical yield is 10.61 g.

The percent yield is:

$$\frac{6.63 \text{ g}}{10.61 \text{ g}} \times 100\% = \mathbf{62.5\ \%\ yield}$$

11. 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.

12. 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.

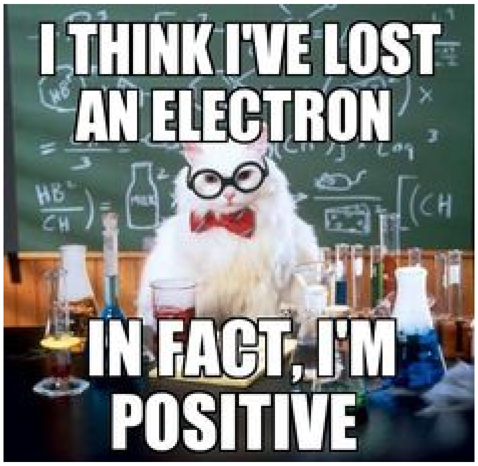
The four key points are

1. All matter is made of Atoms, 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

	$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$
$N_a = 6.02214 \times 10^{23}\ mol^{-1}$	$D = m/v$

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)