Chem 130
Exam 1, Ch 1-4.2
100 Points

Name___________________________________
September 21, 2018

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. Which of the following aspects of Dalton's atomic theory remains unchanged in our current understanding:
   a. Atoms are indivisible.
   b. All atoms of a particular element are identical.
   c. Compounds are the result of a combination of two or more different kinds of atoms in fixed ratios.
   d. None of the above.

   Answer _____**c**______

2. Which of the elements below DOES NOT exist naturally as a diatomic molecule?
   a. hydrogen
   b. helium
   c. nitrogen
   d. chlorine

   Answer _____**b**______

3. An atom of sodium contains 11 protons, 11 electrons and 12 neutrons. Adding the masses of all of the protons, neutrons and electrons in a sodium atom will produce a value that is
   a. equal to the true mass of a sodium atom.
   b. greater than to the true mass of a sodium atom.
   c. less than to the true mass of a sodium atom.
   d. eleven times the true mass of a sodium atom.

   Answer _____**b**______

Part I: Complete all of problems 4-10

4. Gallium is solid at 20ºC. There are 1.16×10^{21} atoms in 134 mg of gallium at this temperature. Above 30ºC, gallium melts (it melts in your hand!). How many atoms are there in 134 mg of gallium at 40ºC? Briefly justify your answer. (4 points)

   Since all that has occurred is a phase change, the number of atoms will not change, therefore there are 1.16×10^{21} atoms!

5. When it ionizes, does aluminum tend to form anions or cations? What is the charge on the ion? Briefly justify your answer. (4 points)

   Since calcium is a Group 2A element, it will form cations with +2 charge because losing two electrons allows it to reach a noble gas electron configuration. Were it to become an anion, it would need to gain 6 electrons, which is much less favorable energetically.

6. Complete the following table. (12 points)

Symbol	$^{79}Se^{2-}$	$^{56}Fe^{3+}$	^{112}Cd
# of protons	34	**26**	48
# of neutrons	45	**30**	64
# of electrons	**36**	**23**	48
Charge	-2	**+3**	**0**
Name	**selenide-79**	**iron-56 (III) ion**	**cadmium-112**

7. Name the following compounds or provide the correct formula for the given names. (16 points)

a. $Mo(NO_3)_4$ **molybdenum (IV) nitrate**

b. B_2Br_4 **diboron tetrabromide**

c. $(NH_4)_2S$ **ammonium sulfide**

d. $Na_2CO_3 \cdot 10H_2O$ **sodium carbonate decahydrate**

e. xenon hexafluoride **XeF_6**

f. magnesium perchlorate **$Mg(ClO_4)_2$**

g. chromium (VI) cyanide **$Cr(CN)_6$**

h. strontium hydroxide **$Sr(OH)_2$**

8. The atomic mass of fluorine is 18.998 amu and all fluorine atoms in a naturally occurring sample of fluorine have this mass. The atomic mass of chlorine is 35.453 amu, but no chlorine atoms in a naturally occurring sample of chlorine have this mass. Explain this observation. (8 points)

Since all fluorine atoms have the same mass, this implies that there is only a single fluorine isotope (^{19}F), since the atomic mass is the weighted average of the masses and abundances of all of the isotopes. Note that we don't say fluorine has *no isotopes*. Since no chlorine atom has a mass that corresponds to its atomic mass, there must be more than one isotope of chlorine. We can't say how many with the information that we are given. The best that we can say is that there are at least two chlorine isotopes and that the weighted average of their masses and abundances must be 35.453 amu.

9. Write balanced reactions, specifying the state for all reactants and products. (8 points)

a. __**2**__Al(s) + __**2**__KOH(aq) + __**6**__$H_2O(l)$ → __**2**__$KAl(OH)_4(s)$ + __**3**__$H_2(g)$ (2 points)

b. __**2**__$BCl_3(l)$ + __**3**__$H_2(g)$ → __**2**__B(s) + __**6**__HCl(g) (2 points)

c. Aqueous potassium carbonate reacts with aqueous iron (III) nitrate to produce aqueous potassium nitrate and solid iron (III) carbonate. (4 points)

$3K_2CO_3(aq) + 2Fe(NO_3)_3(aq) \rightarrow 6KNO_3(aq) + Fe_2(CO_3)_3(s)$

10. A brand new penny is 19.05 mm in diameter and 1.52 mm thick and is 97.5% zinc and 2.5% copper by mass. Assuming the penny has the same density as zinc (7.13 g/cm^3), how many zinc atoms are in a new penny? You may assume the penny is a cylinder with a volume of $\pi r^2 h$, where $\pi = 3.14159$, r is the radius and h is the thickness.(8 points)

First find the volume of the penny:

$d = 2r = 19.05 \text{ mm} = 1.905 \text{ cm}$, so the radius is $1.905 \text{ cm}/2 = 0.9525 \text{ cm}$

$V = \pi r^2 h = 3.14159 \times (0.9525 \text{ cm})^2 \times 0.152 \text{ cm} = 0.4332 \text{ cm}^3$

Now that we know the volume, we use the density to find the mass:

$$0.4332 \text{ cm}^3 \times \frac{7.13 \text{ g penny}}{1 \cancel{\text{cm}^3}} = 3.089 \text{ g penny}$$

But, only 97.5 % of this mass is zinc:

$$3.089 \cancel{\text{g penny}} \times \frac{97.5 \cancel{\text{g Zn}}}{100 \cancel{\text{g penny}}} \times \frac{1 \cancel{\text{mol Zn}}}{65.39 \cancel{\text{g Zn}}} \times \frac{6.022\times10^{23} \text{ atoms Zn}}{1 \cancel{\text{mol Zn}}} = 2.77\times10^{22} \text{ atoms Zn}$$

Answer_______2.77×10^{22} atoms Zn_______

Part II. Answer three (3) of problems 11-14. Clearly mark the problem you do not want graded. 10 points each.

11. Glucose, $C_6H_{12}O_6$, is used as an energy source by the human body. The overall reaction in the body is described by the ***unbalanced*** equation below. If 55.5 grams of glucose is converted to CO_2, what mass of oxygen gas is required? What mass of water is produced?

$$C_6H_{12}O_6\,(s) + \quad O_2(g) \rightarrow \quad CO_2(g) + \quad H_2O\,(l)$$

We first need a balanced reaction:

$$C_6H_{12}O_6\,(s) + 6\,O_2(g) \rightarrow 6\,CO_2(g) + 6\,H_2O\,(l)$$

To find the mass of oxygen required:

$$55.5\ \cancel{g\ C_6H_{12}O_6} \times \frac{1\ \cancel{mol\ C_6H_{12}O_6}}{180.158\ \cancel{g\ C_6H_{12}O_6}} \times \frac{6\ \cancel{mol\ O_2}}{1\ \cancel{mol\ C_6H_{12}O_6}} \times \frac{31.9988\ g\ O_2}{1\ \cancel{mol\ O_2}} = 59.1\ g\ O_2$$

To find the mass of water produced:

$$55.5\ \cancel{g\ C_6H_{12}O_6} \times \frac{1\ \cancel{mol\ C_6H_{12}O_6}}{180.158\ \cancel{g\ C_6H_{12}O_6}} \times \frac{6\ \cancel{mol\ H_2O}}{1\ \cancel{mol\ C_6H_{12}O_6}} \times \frac{18.015\ g\ H_2O}{1\ \cancel{mol\ H_2O}} = 33.3\ g\ H_2O$$

Answers_____59.1 g O_2 and 33.3 g H_2O_____

12. There are two isotopes of boron, ^{10}B (atomic mass 10.01294 amu) and ^{11}B (atomic mass 11.00931 amu). What are the percent abundances of each of the two isotopes?

Since only two isotopes exist:

$$f_{10} + f_{11} = 1 \text{ and}$$

$$10.01294f_{10} + 11.00931f_{11} = 10.811$$ (this is the average atomic mass from the periodic table)

So

$$f_{10} = 1 - f_{11}$$
$$10.01294(1 - f_{11}) + 11.00931f_{11} = 10.811$$
$$10.01294 - 10.01294f_{11} + 11.00931f_{11} = 10.811$$
$$(11.00931 - 10.01294)f_{11} = 10.811 - 10.01294$$
$$0.9964f_{11} = 0.7891$$
$$f_{11} = 0.8009$$
$$\%^{11}B = 100\% \times 0.8009 = 80.1\%$$

$$\text{And } \%^{10}B = 100\% - 80.1\% = 19.9\%$$

Answer__19.9% ^{10}B and 80.1% ^{11}B_________

13. Isobutylene contains only carbon and hydrogen and is an important industrial chemical used in the production of a variety of products, ranging from antioxidants to polymers. Combustion of 1.00 grams of isobutylene results in the production of 3.14 grams of carbon dioxide and 1.28 grams of water. If the molar mass of isobutylene is 56.106 g/mol, what is its molecular formula?

$$3.14 \text{ g } CO_2 \times \frac{1 \text{ mol } CO_2}{44.01 \text{ g } CO_2} \times \frac{1 \text{ mol C}}{1 \text{ mol } CO_2} = 0.07134 \text{ mol C}$$

$$1.28 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.01 \text{ g } H_2O} \times \frac{2 \text{ mol H}}{1 \text{ mol } H_2O} = 0.1422 \text{ mol H}$$

So, a start at the empirical formula is $C_{0.07134}H_{0.1422}$. Since these are not whole number subscripts, we divide by the smallest one to produce C_1H_2 or CH_2 as the empirical formula. If this were also the molecular formula, the formula mass (14.03 g/mol) would match the molar mass, but it does not. Relating the molar mass to the formula mass tells us how many empirical formula "units" are in the molecular formula:

$$\frac{56.106 \text{ g/mol}}{14.03 \text{ g/mol}} = 3.999$$

This implies that our molecular formula contains four times as many atoms of each element as the empirical formula. **Therefore the molecular formula is C_4H_8**

Answer__________ C_4H_8______________

14. A compound that contains only potassium, chromium and oxygen was analyzed. If was found that the compound contained 26.58% potassium and 35.45% chromium by mass. What is the formula for this compound?

Given the percent composition, in 100 grams of the compound, there would be 26.58 g K, 35.45 g Cr and 100-(26.58+35.45) = 37.97 g O. We need a ratio of moles to determine the formula.

$$26.58 \text{ g K} \times \frac{1 \text{ mol K}}{39.10 \text{ g K}} = 0.6798 \text{ mol K}$$

$$35.45 \text{ g Cr} \times \frac{1 \text{ mol Cr}}{51.99_6 \text{ g K}} = 0.6818 \text{ mol Cr}$$

$$37.97 \text{ g O} \times \frac{1 \text{ mol O}}{15.99_9 \text{ g O}} = 2.373 \text{ mol O}$$

So, a first shot at a formula is $K_{0.6798}Cr_{0.6818}O_{2.373}$. Dividing by the smallest subscript, the formula becomes $KCrO_{3.49}$. We now double each subscript to produce whole number values, making the formula **$K_2Cr_2O_7$**.

Answer_________ $K_2Cr_2O_7$____________

Possibly Useful Information

$\% \text{ by mass} = \frac{\text{g component}}{100 \text{ g sample}}$	$d = m/v$	$N_A = 6.022 \times 10^{23}$

To save some calculation time, you may round all atomic masses to two (2) decimal points.

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	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)