AMSAT Chem 1H Mr. Dehne

Name: _____

Date: _____

Per#: ___

Stoichiometry Topic#10
Worksheet Packet

WS#1: Percent Composition

Find the percent composition of each element in each compound.

1. H_3PO_4
2. $Mg_3(PO_4)_2$
3. $(NH_4)_3PO_4$
4. What is the percentage of carbon in carbon dioxide, CO_2? (Ans: 27.3%)
5. What is the percent of water in $Sn_3(PO_4)_4 \cdot 6H_2O$? (Ans: 12.8%)
6. Water of hydration was discussed in class. Strong heating will drive of water as a vapor in hydrates copper (II) sulfate. Use the data table below to answer the following:

Mass of empty crucible	4.00g	Mass of system after heating	4.32g
Mass of crucible plus hydrate sample	4.50g	Mass of system after second heating	4.32g

   a. Determine the mass percentage of water in the original sample. (Ans: 36%)
   b. The compound has the formula $CuSO_4 \cdot xH_2O$, determine the value of *x*. (Ans: 5)
   c. What might be the purpose of the second heating?

WS#2: Empirical Formula

1. Write the empirical formula for the following molecular formulas:
   a. $C_2H_6O_4$ b. N_2O_5 c. Hg_2Cl_2 d. C_6H_{12}
2. Determine the empirical formula for an unknown compound composed of 38.4% potassium, 23.7% carbon, 1.66% hydrogen, and 36.3% oxygen. (Ans: $K_3C_6H_5O_7$)
3. What is the empirical formula for a compound containing 57.6% strontium, 13.8% phosphorus, and 28.6% oxygen? (Ans: $Sr_3(PO_4)_2$)
4. A compound contains 27.9% iron, 24.1% sulfur, and 48.0% oxygen by mass. What is the empirical formula of this compound? (Ans: $Fe_2S_3O_{12}$ or $Fe_2(SO_4)_3$)
5. A chemist used gravimetric analysis to determine the mass of each element in a compound containing copper and fluorine. After analysis of 0.858g of the compound, it is found to contain 0.537 grams of copper and 0.321 grams of fluorine. What is the empirical formula of this compound? (Ans: CuF_2)
6. Determine the empirical formula of a compound that contains manganese, nitrogen, and oxygen. A 0.470 gram sample contains 0.144 grams of manganese and 0.074 grams of nitrogen. (Ans: MnN_2O_6 or $Mn(NO_3)_2$)

WS#3: Molecular Formula

1. A certain hydrocarbon has an empirical formula of CH_2 and a *MM* of 56.12g/mol. What is its molecular formula?
2. What is the molecular formula for a compound with an empirical formula of C_2H_4S and an experimental molar mass of 179g/mol? (Ans: $C_6H_{12}S_3$)
3. Using the experimental molar mass of 116.07g/mol to determine the molecular formula for the compound that is 41.39% carbon, 3.47% hydrogen, 55.14% oxygen. (Ans: $C_4H_4O_4$)
4. A compound contains 64.27% carbon, 7.19% hydrogen, and the remainder oxygen. What is the molecular formula for this compound if the experimental molar mass is 168.19g/mol? (Ans: $C_9H_{12}O_3$)
5. A 2.65g sample of a salmon-colored powder contains 0.70g of chromium, 0.65g sulfur, and 1.30g of oxygen. The molar mass is 392.2. What is the formula of the compound? (Ans: $Cr_2S_3O_{12}$ or $Cr_2(SO_4)_3$)
6. Gas X is found to be 24.0% carbon and 76% fluorine by mass.
   a. Determine the empirical formula of gas X. (Ans: CF_2)
   b. Given the *MM* of gas X is 200.04g/mol, determine its molecular formula. (Ans: C_4F_8)
7. A compound is found to contain 43.2% copper, 24.1% chlorine, and 32.7% oxygen by mass.
   a. Determine its empirical formula. (Ans: $CuClO_3$)
   b. What is the name of the compound?
8. Histamine is a substance that is released by cells in response to injury, infection, stings, and materials that cause allergic responses, such as pollen. Histamine causes dilation of blood vessels and swelling due to accumulation of fluid in tissues. People sometimes take *anti*histamine drugs to counteract the effects of histamine. A sample of histamine having a mass of 385mg is composed of 208mg carbon, 31mg hydrogen, and 146mg of nitrogen. The molar mass of histamine is 111g/mol. What is the molecular formula for histamine? (Ans: $C_5H_9N_3$; empirical and molecular formulas are the same)

WS#4: Reaction Stoichiometry

Part A – Multiple Choice, Fill in the Blank, and True-False

1. The coefficients in a chemical equation represent the
   a. masses in grams of all reactants and products.
   b. relative number of moles of reactants and products.
   c. number of atoms of each element in each compound in a reaction.
   d. number of valence electrons involved in a reaction.
2. Which of the following would not be studied within the topic of stoichiometry?
   a. The mole ratio of Al to Cl in the compound aluminum (III) chloride
   b. The mas of carbon produced when a known mass of sucrose decomposes
   c. The number of moles of hydrogen that will react with a known quantity of oxygen
   d. The amount of energy required to break the ionic bonds in CaF_2
3. A balanced chemical equation allows you to determine the
   a. mole ratio of any substances in a reaction.
   b. energy releases in the reaction.
   c. electron configuration of all elements in the reaction.
   d. reaction mechanism involved in the reaction.
4. The relative number of moles of hydrogen to moles of oxygen that react to form water represents a(n)
   a. reaction sequence.
   b. bond energy.
   c. mole ratio.
   d. element proportion.

Fill in the Blank (reactants/molar ratios/quantitative/actual/particles/conservation of matter/coefficients/subscripts/mass)

5. Stoichiometry is the study of the _____ relationships that exist in chemical reactions.
6. Stoichiometry can be used to determine how much product will form from a given amount of _____.
7. The _____ in a balanced equation indicate(s) the number of particles of each substance taking place in the reaction.
8. It is possible to interpret the coefficients in a balanced chemical equation as either the number of moles or the number of _____ involved in the reaction.
9. The coefficients in an equation do not show the _____ number of moles, only the relative number involved.
10. You must determine the _____ in a balanced equation before solving any stoichiometry problem.
11. A balanced equation verifies the law of _____.

Identify as true or false. Change underlined word(s) to make statement true if it is false.

12. The term stoichiometry is derived from the Greek words *stoicheion*, meaning element, and *metron*, meaning measure.
13. You can determine the number of moles of any substance produced in a reaction if you know the number of moles of at least two of the reactants.
14. The molar ratio of hydrogen to oxygen in the equation $2H_2 + O_2 \rightarrow 2H_2O$ is 1:2.
15. The total mass of the reactants is equal to the total mass of the products in a chemical reaction.
16. Mole-Mole problems involve conversions from moles of one substance to mass of another.
17. In a mass-mass problem, the coefficients in the balanced equation represent the actual numbers of moles of reactants and products.
18. In solving a mass-mass problem, it is necessary to convert the given mass to volume.
19. When the mass of a reactant is given, the number of moles can be found by dividing the mass by the reactant's molar mass.

Part B – Problems (Moles and Mass)

20. Given the equation: $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
    a. Determine the molar mass (*MM*) of each substance.
    b. There are six different mole ratios in this system. Write out each one.
21. Given the reaction of the following unbalanced equation: $N_2O(g) + O_2(g) \rightarrow NO_2(g)$.
    a. Balance the equation.
    b. What is the mole ration of NO_2 to O_2?
    c. If 20.0mol of NO_2 form, how many moles of O_2 must have been consumed? (Ans: 26.7moles O_2)
    d. Twice as many moles of NO_2 form as moles of N_2O are consumed. Tue or False?
    e. Twice as many grams of NO_2 form as grams of N_2O are consumed. True or False?

22. Given the equation: $4NH_3(g) + 6NO(g) \rightarrow 5N_2(g) + 6H_2O(g)$
    a. What is the mole ratio of NO to H_2O?
    b. What is the mole ratio of NO to NH_3?
    c. If 0.240mol of NH_3 reacts, how many moles of NO will be consumed? (Ans: 0.36moles of NO)
23. Al reacts with hydrochloric acid to produce aluminum (III) chloride and hydrogen gas. Calculate the number of moles of HCl required to react with 0.87mol of aluminum. (Ans: 2.6 moles HCl)
24. Glucose ($C_6H_{12}O_6$) combines with O_2 in the body producing carbon dioxide and water. How many moles of O_2 are required to combine with 0.25mol of glucose? How many moles of carbon dioxide and water would be produced in this reaction? (Ans: 1.5 moles O_2; 1.5 moles H_2O and 1.5 moles CO_2)
25. How many moles of HNO_3 will be produced when 0.51mol of N_2O_5 reacts according to the following equation? $N_2O_5 + H_2O \rightarrow HNO_3$ (Ans: 1.0 mol HNO_3)
26. Determine the mass of lithium hydroxide produced when 0.38 g of lithium nitride reacts with water according to the following reaction: $Li_3N + H_2O \rightarrow NH_3 + LiOH$. (Ans: 0.78g LiOH)
27. Determine the mass of antimony produced when 0.46g of antimony (III) oxide reacts with carbon according to the following equation: $Sb_2O_3 + C \rightarrow Sb + CO$. (Ans: 0.38g Sb)
28. What mass of hydrogen peroxide (H_2O_2) must decompose to produce 0.77g of water? (Ans: 1.4g H_2O_2)
29. Determine the mass of sodium nitrate produced when 0.73g of nickel (II) nitrate reacts with sodium hydroxide according to the following equation: $Ni(NO_3)_2 + NaOH \rightarrow Ni(OH)_2 + NaNO_3$. (Ans: 0.68g $NaNO_3$)
30. Determine the mass of calcium hydroxide produced when calcium carbide reacts with 0.64g of water according to the following reaction. $CaC_2 + H_2O \rightarrow Ca(OH)_2 + C_2H_2$. (Ans: 1.3g $Ca(OH)_2$)
31. How many grams of ozone (O_3) must decompose to produce 0.87g of oxygen? (Ans: 0.87g O_3)
32. If a reaction starts with 2.48g of tungsten, how many grams of tungsten (IV) chloride will be produced from the chlorination of tungsten? (Ans: 4.39 WCl_4)

WS#5: Limiting Reactant

1. Identify the limiting reactant when 65.14g $CaCl_2$ reacts with 74.68g of Na_2CO_3 to produce $CaCO_3$ and NaCl. (Ans: $CaCl_2$)
2. Identify the limiting reactant when 4.687g of SF_4 reacts with 6.281g of I_2O_5 to produce IF_5 and SO_2. (Ans: SF_4)
3. Identify the limiting reactant when 9.01g of NH_4OH reacts with 15.6g of H_2SO_4 to produce $(NH_4)_2SO_4$ and HOH. (Ans: NH_4OH)
4. If 4.1g of Cr is heated with 9.3g of Cl_2, what mass of $CrCl_3$ will be produced? (Ans: 12.5g $CrCl_3$)
5. What mass of SO_2 is produced from the reaction between 31.5g of S_8 and 8.65g of O_2? (Ans: 17.3g SO_2)
6. If 21.4 g of Al is reacted with 91.3g of Fe_2O_3, the products will be Al_2O_3 and Fe. What mass of Fe will be produced? (Ans: 44.3g Fe)
7. If 41.6g of N_2O_4 reacts with 20.8g of N_2H_4, the products will be nitrogen and water. What mass of water will be produced? (Ans: 23.4g H_2O)
8. If 16.8g of CO is mixed under high pressure with 1.78g of H_2, what mass of methanol (CH_3OH) will be produced? (Ans: 14.1g CH_3OH)
9. What mass of NaCl will be produced by the reaction of 58.7g of NaI with 29.4g of Cl_2 gas if the products are sodium chloride and I_2? How much of the excess reactant remains after the reaction? (Ans: 22.9g NaCl; 15.5g NaCl)
10. If 5.48g of $Fe(NO_3)_3$ reacts with 2.85g of $Ca(OH)_2$, the products will be $Fe(OH)_3$ and $Ca(NO_3)_2$. What mass of $Ca(NO_3)_2$ will be produced? How much of the excess reactant remains after the reaction? (Ans: 5.59g $Ca(NO_3)_2$; 0.330g $Ca(OH)_2$)

WS#6: Percent Yield

Part A – True/False

Identify as true or false. Change underlined word(s) to make statement true if it is false.

1. When quantities of reactants are available in the exact ratio described by the balanced equation, they are said to be <u>molar</u> proportions.
2. The reactant that limits the amount of product that can be formed is the <u>limiting</u> reactant.
3. Identifying the limiting reactant in a reaction is similar to solving a <u>mass-volume</u> problem.
4. If the amount of the limiting reactant is known, it is possible to predict the amount of <u>all</u> products formed by the reaction.
5. Even though it is possible to predict the amount of product formed in a chemical reaction, the <u>expected yield</u> often differs from this prediction.
6. The actual yield of a chemical reaction is <u>never</u> more than the expected yield.

Part B – Problems

7. Determine the percent yield for the reaction between of 12.1g C with excess O_2 if 32.2g of CO_2 is recovered. (Ans: 72.7%)
8. If a reaction has a percent yield of 85.2% and the theoretical yield is 23.2g. What is the actual yield for the reaction? (Ans: 19.8g)
9. If a reaction has a percent yield of 74.5% and the actual yield is 58.7g. What is the theoretical yield for the reaction? (Ans: 78.8g)
10. Determine the percent yield for the reaction between 3.74g of Na and excess O_2 if 5.34g of Na_2O_2 is recovered. (Ans: 84.2%)
11. Determine the percent yield for the reaction between 6.92g of K and 4.28g of O_2 if 7.36g of K_2O is recovered. (Ans: 88.2%)
12. Determine the percent yield for the reaction between 45.9g of NaBr and excess chlorine gas to produce 12.8g of NaCl and an unknown quantity of bromine gas. (Ans: 49.0%)
13. Determine the percent yield for the reaction between 15.8g of NH_3 and excess oxygen to produce 21.8g of NO gas and water. (Ans: 78.3%)
14. Determine the percent yield for the reaction between 98.7g of Sb_2S_3 and excess oxygen if 72.4g of Sb_4O_6 is recovered along with an unknown amount of sulfur dioxide gas. (Ans: 85.5%)
15. Determine the percent yield for the reaction between 46.5g of ZnS and 13.3g of oxygen if 18.4g of ZnO is recovered along with an unknown quantity of sulfur dioxide. (Ans: 81.4%)
16. Determine the percent yield for the reaction between 112.5g of $SnCl_4$ and 15.3g of HF if 20.2g of SnF_4 is recovered along with an unknown quantity of HCl. (Ans: 54.3%)

WS#7: Review

1. Given the following equation: $C_3H_4(g) + xO_2(g) \rightarrow 3CO_2(g) + 2H_2O(g)$
   a. What is the value of the coefficient *x* on this equation? (Ans: $x = 4$)
   b. What is the molar mass (*MM*) of C_3H_4? (Ans: 40.07g/mol)
   c. What is the mole ratio of O_2 to H_2O in the above equation? (Ans: 2:1)
   d. How many moles are in 8.0g sample of C_3H_4? (Ans: 0.20moles)
   e. If *z* moles of C_3H_4 react, how many moles of CO_2 are produced, in terms of *z*? (Ans: $3(z)\ CO_2$)
2. What is meant by *ideal conditions* relative to stoichiometric calculations?
3. What function do ideal stoichiometric calculations serve?
4. Are actual yields typically larger or smaller than theoretical yields?
5. Assume the reaction represented by the following equation goes all the way to completion: $N_2 + 3H_2 \rightarrow 2NH_3$.
   a. If 6 mole of H_2 are consumed, how many moles of NH_3 are produced? (Ans: 4mol NH_3)
   b. How many grams are in a sample of NH_3 that contain $3.0x10^{23}$ molecules? (Ans: 8.5g NH_3)
   c. If 0.1 mol of N_2 combine with H_2, what must be true about the quantity of H_2 for N_2 to be the limiting reactant? (Ans: at least 0.3mol pf H_2 must be provided)
6. If a reaction's theoretical yield is 8.0g and the actual yield is 6.0g, what is the percentage yield? (Ans: 75%)
7. Joseph Priestley generated oxygen gas by strongly heating mercury (II) oxide according to the following equation: $2HgO(s) \rightarrow 2Hg(l) + O_2(g)$.
   a. If 15.0g HgO decompose, how many moles of HgO does this represent? (Ans: 0.0693mol)
   b. How many moles of O_2 are theoretically produced? (Ans: 0.0346mol)
   c. How many grams of O_2 is this? (Ans: 1.11g)
   d. If the density of O_2 gas is 1.41g/L, how many liters of O_2 are produced? (Ans: 0.786L)
   e. If the percentage yield is 95.0%, how many grams of O_2 are actually collected? (Ans: 1.05g)