AP Chemistry Name _____

Period ___ Date ___/___/___

3 – Stoichiometry

WS#1: Compositional Stoichiometry

1. Write the balanced formula equation for the following reactions.
   a. europium is reacted with gaseous hydrogen fluoride to produce solid europium (III) fluoride and hydrogen gas.
   b. sodium fluorosilicate ($Na_2SiF_6(s)$) reacts with solid sodium producing silicon and sodium fluoride.
   c. calcium silicate ($CaSiO_3(s)$) and hydrogen fluoride gas react to produce calcium fluoride, silicon tetrafluoride, and water.
2. Calculate the percent composition by mass of each element in the following compounds.
   a. $CuSO_4 \cdot 5H_2O$ b. $Ca_3(PO_4)_2$
3. The "alum" used in cooking is potassium aluminum sulfate hydrate, $KAl(SO_4)_2 \cdot xH_2O$. To find the value of *x*, you can heat a sample of the compound to drive off all of the water and leave only $KAl(SO_4)_2$. Assume you heat 4.74g of the hydrated compound and that the sample loses 2.16g of water. What is the value of *x*? (Ans: $x = 12$)
4. If "Epsom salt," $MgSO_4 \cdot xH_2O$ is heated to 250°C, all the water of hydration is lost. On heating, a 1.687g sample of the hydrate, 0.824g of $MgSO_4$ remains. What is the formula of Epsom salt? (Ans: $MgSO_4 \cdot 7H_2O$)
5. There are two binary compounds of mercury and oxygen. Heating either of them results in the decomposition of the compound, with oxygen gas escaping into the atmosphere while leaving a residue of pure mercury. Heating 0.6498g of one of the compounds leaves a residue of 0.6018g. Heating 0.4172g of the other compound results in a mass loss of 0.016g. Determine the empirical formula of each compound. (Ans: HgO and Hg_2O)
6. Adipic acid is an organic compound composed of 49.31% C, 43.79% O, and the rest hydrogen. If the molar mass of adipic acid is 146.1g/mol, what are the empirical and molecular formulas for adipic acid? (Ans: $C_3O_2H_5$ and $C_6O_4H_{10}$)

WS#2: Reaction Stoichiometry

7. Cumene is a compound containing only carbon and hydrogen that is used in the production of acetone and phenol in the chemical industry. Combustion of 47.6mg cumene produces some CO_2 and 42.8mg water. The molar mass of cumene is between 115 and 125g/mol. Determine the empirical and molecular formulas. (Ans: C_9H_{12})
8. Lysine is an amino acid which has the following elemental composition: C, H, O, N. In one experiment, 2.175g of lysine was combusted to produce 3.94g of CO_2 and 1.89g H_2O. In a separate experiment, 1.873 g of lysine was burned to produce 0.436 g of NH_3. The molar mass of lysine is approximately 150g/mol. Determine the empirical and molecular formula of lysine. (Ans: C_3H_7NO, $C_6H_{14}N_2O_2$)
9. Aluminum reacts with chlorine gas to form aluminum chloride via the following unbalanced reaction: $\_\_Al + \_\_Cl_2 \rightarrow \_\_AlCl_3$. How many grams of aluminum chloride could be produced from 34.0 g of aluminum and 39.0 g of chlorine gas? (Ans: 48.9g $AlCl_3$)
10. Suppose 316.0 g aluminum sulfide reacts with 493.0 g of water. What mass of the excess reactant remains? The unbalanced equation is: $\_\_Al_2S_3 + \_\_H_2O \rightarrow \_\_Al(OH)_3 + \_\_H_2S$. (Ans: 265.5g)
11. For the unbalanced equation shown below, if the reaction of 91.3 grams of C_3H_6 produces an 81.3% yield, how many grams of CO_2would be produced? $\_\_C_3H_6 + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O$. (Ans: 232g)
12. What is the percent yield of the following reaction if 60.0 grams of $CaCO_3$ is heated to give 15.0 grams of CaO? $CaCO_3 \rightarrow CaO + CO_2$. (Ans: 44.6%)

WS#3: Gases

13. Determine the volume of a cylinder containing 89.4g of NO_2 gas at STP. (Ans: 43.5L NO_2)
14. How many grams of sulfur trioxide occupy a container with a volume 5.89L at STP. (Ans: 21.1g SO_3)
15. Calculate the volume 3.00moles of a gas will occupy at 24.0°C and 762.4mmHg. (Ans: 72.9L)
16. What is the molar mass of a gas which has a density of 0.00249g/mL at 20.0°C and 744.0mmHg? (Ans: 61.2g/mol)
17. Air is a mixture of 21% oxygen gas and 79% nitrogen gas (neglect minor components and water vapor). What is the density of air at 30.0°C and 1.00atm? (Ans: 1.17g/L)
18. How much air is needed (in m^3, at 25.0°C, 1.00atm) to completely burn 10.0moles of propane (C_3H_8). Assume that the air is composed of 21.0% O_2. (Ans: 5.82m^3)
19. Ammonium sulfate, an important fertilizer, can be prepared by the reaction of ammonia with sulfuric acid according to the following unbalanced chemical equation: $\_\_NH_3(g) + \_\_H_2SO_4(aq) \rightarrow \_\_(NH_4)_2SO_4(aq)$. Calculate the volume of NH_3 in liters needed at 20.0°C and 25.0atm to react with 150.0kg of $H_2SO_4(aq)$. (Ans: 2945L NH_3)
20. If 45.0L of natural gas, which is essentially methane (CH_4) undergoes complete combustion at 730mmHg and 20.°C , how many grams of each product are formed? (Ans: 79.2 grams CO_2; 64.8g H_2O)

21. Fritz Haber, a German chemist, discovered a way of to synthesize ammonia gas (NH_3) by combining hydrogen and nitrogen gases at extremely high temperatures and pressures.
    a. Write a balanced equation for this reaction.
    b. If 10.0kg of nitrogen combines with excess hydrogen at 550.^oC and 250.atm, what volume of ammonia gas is produced? (Ans: 193L NH_3)
22. A 3.25gram sample of solid calcium carbide (CaC_2) reacts with water to produce acetylene gas (C_2H_2) and aqueous calcium hydroxide. If the acetylene was collected over water at 17^oC and 740.0mmHg, how many milliliters of acetylene were produced. (Remember to subtract out the pressure of water vapor at 17^oC from the total pressure (740.0mmHg). (Ans: 1250mL C_2H_2)

WS#4: Solution Stoichiometry

23. Sea water contains roughly 28.0 g of NaCl per liter. What is the molarity of sodium chloride in sea water? (Ans: 0.479*M*)
24. What is the molarity of 5.30 g of Na_2CO_3 dissolved in 400.0 mL solution? What is the concentration for each ion in solution? (Ans: 0.125*M*; $[Na^{1+}] = 0.250M$ and $[CO_3^{2-}] = 0.125M$)
25. What weight (in grams) of H_2SO_4 would be needed to make 750.0 mL of 2.00 M solution? (Ans: 147g)
26. What volume (in mL) of 18.0 M H_2SO_4 is needed to contain 2.45 g H_2SO_4? (Ans: 1.39mL)
27. Silver chloride is formed by mixing silver nitrate and barium chloride solutions. What volume of 1.50*M* barium chloride solution is needed to form 0.525g of silver chloride? (Ans: 1.22mL $BaCl_2$)
28. 25.00mL of 0.500*M* barium chloride solution is mixed with 25.00mL of 0.500*M* silver nitrate solution. What mass of silver chloride will be formed? (Ans: 1.79g AgCl)

Free Response Question

29. Three volatile compounds X, Y, and Z each contain element Q. The percent by weight of element Q in each compound was determined. Some of the data obtained are given below.

Compound	Percent by Weight of Element Q	Molecular Weight
X	64.8%	88.1
Y	73.0%	104.
Z	59.3%	64.0

    a. Determine the mass of element Q contained in 1.00 mole of each of the three compounds.
    b. Calculate the most probable value of the atomic weight of element Q.
    c. Compound Z contains carbon, hydrogen, and element Q. When 1.00 gram of compound Z is oxidized and all of the carbon and hydrogen are converted to oxides, 1.37grams of CO_2 and 0.281gram of water are produced. Determine the most probable molecular formula of compound Z.