

AP Chemistry Problem Set #3

1. Convert each of the following. Assume that all substances are at standard temperature and pressure(STP) – even though I hate STP:

- 43.0 grams of nitrogen dioxide to liters – **20.9 L**
- 56.0 milligrams of cesium iodide to molecules – **1.30×10^{20} molecules**
- 2.6×10^{15} molecules of ammonium phosphate to grams – **6.4×10^{-7} grams**
- 2.40 liters of carbon monoxide to moles – **0.107 moles**
- 5.70 millimoles of sodium chlorate to grams – **0.607 grams**

2. Tetrahydrocannabinol(THC), $C_{21}H_{30}O_2$, is a psychoactive compound extracted from the resin of Cannabis sativa (marihuana, hashish). Show all of your work.

- Calculate the molar mass of THC. – **314.468 g/mol**
- Calculate the percent composition of the elements in THC. – **C (80.2%), H (9.6%), O (10.2%)**
- What is the mass in grams of 6.66 moles of THC? – **2090 g**
- How many molecules are there in 4.20 mg of THC? – **8.04×10^{18}**
- What is the mass of one molecule of THC? – **5.22×10^{-22} g**

3. Calculate the average atomic mass for each of the following groups of isotopes. The percentage listed with each isotope is the relative abundance.

- ^{28}Si (92.21%), ^{29}Si (4.70%), ^{30}Si (3.09%) – **28.1 g/mol**
- ^{113}In (4.3%), ^{115}In (95.7%) – **114.9 g/mol**
- ^{32}S (95.0%), ^{33}S (0.8%), ^{34}S (4.2%) – **32.1 g/mol**
- ^{64}Zn (48.89%), ^{66}Zn (27.81%), ^{67}Zn (4.11%), ^{68}Zn (18.57%), ^{70}Zn (0.62%) – **65.5 g/mol**
- ^{70}Ge (21.2%), ^{72}Ge (27.7%), ^{73}Ge (7.7%), ^{74}Ge (34.9%), ^{76}Ge (7.4%) – **72.0 g/mol**

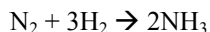
4. Solve each of the following empirical and molecular formulas:

- A compound that contains only nitrogen and oxygen is 30.4% N by mass; the molar mass of the compound is 92 g/mol. What is the empirical formula of the compound? What is the molecular formula of the compound? **NO_2 & N_2O_4**
- Maleic acid is an organic compound composed of 41.39% C, 3.47% H, and the rest oxygen. If 0.129 mol of maleic acid has a mass of 15.0 g, what are the empirical and molecular formulas of maleic acid? **CHO & $\text{C}_4\text{H}_4\text{O}_4$**
- Ascorbic acid, also known as vitamin C, has a percentage composition of 40.9% carbon, 4.58% hydrogen, and 54.5% oxygen. Its molecular mass is 176.1 g/mol. What is its molecular formula? – **$\text{C}_6\text{H}_8\text{O}_6$**
- Aspirin contains 60.0% carbon, 4.48% hydrogen, and 35.5% oxygen. It has a molecular mass of 180.0 g/mol. What are its empirical and molecular formulas? – **$\text{C}_9\text{H}_8\text{O}_4$ & $\text{C}_9\text{H}_8\text{O}_4$**
- A substance has a percent composition of 39.6% carbon, 1.7% hydrogen, 58.7% chlorine. Determine the molecular formula of the substance if it has a molecular mass of 544.5 g/mol – **$\text{C}_{18}\text{H}_9\text{Cl}_9$**

5. Write complete balanced equations for each of the following:

- calcium oxide + hydrochloric acid \rightarrow calcium chloride + water – **$\text{CaO} + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O}$**
- barium chloride + sodium sulfite \rightarrow barium sulfite + sodium chloride –
 $\text{BaCl}_2 + \text{Na}_2\text{SO}_3 \rightarrow \text{BaSO}_3 + 2\text{NaCl}$
- benzene (C_6H_6) + oxygen \rightarrow carbon dioxide + water – **$2\text{C}_6\text{H}_6 + 15\text{O}_2 \rightarrow 12\text{CO}_2 + 6\text{H}_2\text{O}$**
- lead(II) nitrate + potassium iodide \rightarrow lead(II) iodide + potassium nitrate –
 $\text{Pb}(\text{NO}_3)_2 + 2\text{KI} \rightarrow \text{PbI}_2 + 2\text{KNO}_3$
- fluorine + calcium chloride \rightarrow calcium fluoride + chlorine – **$\text{F}_2 + \text{CaCl}_2 \rightarrow \text{CaF}_2 + \text{Cl}_2$**

6. Consider the reaction:



Identify the limiting reagent in each of the mixtures below. Assume all experiments occur at STP:

- 30 molecules of N_2 & 45 molecules of H_2 – **H_2**
- 3 moles of N_2 & 1 mole of H_2 – **H_2**
- 50.00 L of N_2 & 50.00 L of H_2 – **H_2**
- 28.00 grams of N_2 & 8.00 grams of H_2 – **N_2**
- 12 atoms of N_2 & 20 atoms of H_2 – **H_2**

7. For each of the following identify the limiting reagent, theoretical yield and percent yield.

a. Aluminum reacts with aqueous chromium(II) oxide to form aluminum oxide and chromium. Determine the limiting reagent, theoretical yield and percent yield if 187.0 grams of chromium(II) oxide were used with 214.0 grams of aluminum and 88.0 grams of aluminum oxide were actually produced.

L.R.: CrO

Theoretical: 93.46 g

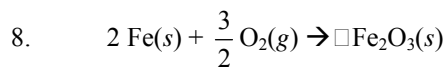
% Yield: 94.2%

b. Zinc reacts with hydrochloric acid to form zinc chloride and hydrogen gas. Calculate the limiting reagent, theoretical yield and percent yield if you are given 79.2 grams of zinc and 79.2 grams of hydrochloric acid and you actually produce 9.1 liters of hydrogen gas?

L.R.: HCl

Theoretical: 24.32 L

% Yield: 37.4%



Iron reacts with oxygen to produce iron(III) oxide, as represented by the equation above. A 95.0 g sample of $\text{Fe}(s)$ is mixed with 15.1 L of $\text{O}_2(g)$ at STP.

a. Calculate the number of moles of each of the following before the reaction begins.

(i) $\text{Fe}(s)$ – **1.70 moles**

(ii) $\text{O}_2(g)$ – **0.674 moles**

b. Identify the limiting reactant when the mixture is heated to produce $\text{Fe}_2\text{O}_3(s)$. Support your answer with calculations. – **O_2**

c. Calculate the number of moles of $\text{Fe}_2\text{O}_3(s)$ produced when the reaction proceeds to completion.

0.449 moles