Chemistry 11 - Week 5: May 11 – May 15

Anticipated time required: 3 hours

New learning objective: **Stoichiometry and crossing the mole bridge**

Goals to be completed:

1. Learn how to apply the rule of coefficients in a balanced chemical reaction to solve basic stoichiometric problems
2. Fill in the template note set
3. Practice Problems
4. Assignment

This PDF package contains several notes, examples and practice problems. The only formal portion that you are required to submit is the section titled "Formal Assignment to be Submitted". This can be sent to Charlie.feht@yesnet.yk.ca either as a scanned and uploaded PDF attachment to email, or as a jpeg image file. Midterm assignments will be scored and sent back to you as I receive them.

Upcoming next week:

Limiting and Excess Reactant

Percent Yield

Stoichiometry Introduction

Background:

Stoichiometry is a branch of chemistry that focuses on measuring the amount of reactants and products in a chemical reaction. In order to be successful in your stoichiometric calculations, you need to have a strong grasp of the following previously studied concepts:

1. Nomenclature – When given a chemical reaction in words, you should know how to write the chemical symbols of the molecules involved with proper charges and subscripts.
2. Chemical reactions – When provided with a set of reactants, you should know how they react to form new compounds and be able to accurately determine the chemical formula of these compounds.
3. Balancing – When you have determined how the reactants combine to form new products, you will need to know how to accurately balance the equation. If prerequisite skill #1 or #2 have an error, you balancing will be incorrect.

Stoichiometry tracks the transfer of mass within a chemical reaction. We solve these problems exactly like we have solve multi-step mole conversions, just with one added twist…

YOU MUST PROPERLY BALANCE THE CHEMICAL REACTION AND USE THE COEFFICIENTS TO KEEP ACCURATE RATIOS IN THE CALCULATION

In stoichiometry, we assume that the coefficients represent how many moles of a compound is reacting.

For example. If 50L of hydrogen gas at STP will react with silicon tetrachloride, how much pure silicon can be obtained in the reaction?

1. We need to know how to write the chemical formula for this equation. We are told we have hydrogen gas (H_2) and silicon tetrachloride ($SiCl_4$) reacting to form pure silicon (Si)

$$H_2 + SiCl_4 \rightarrow Si$$

2. We need to know what type of reaction is occurring and be able to predict the products. Since Silicon has been displaced, we know it is a single replacement reaction:

$$H_2 + SiCl_4 \rightarrow Si + HCl$$

3. Now we need to properly balance the reaction using coefficients.

$$2H_2 + SiCl_4 \rightarrow Si + 4HCl$$

Now we are ready to perform our stoichiometry calculation.

We start with 50 L of hydrogen gas at STP and need to solve how many moles that is

$$\frac{50L\ H_2}{} \times \frac{1\ mol H_2}{22.4 L H_2} \times \frac{1\ mol\ Si}{2\ mol\ H_2} \times \frac{28\ g\ Si}{1\ mol\ Si} = 31.25 g\ Si$$

Convert from moles of silicon to the desired unit (grams) using a standard molar mass conversion

There is a ratio in this equation that says **for every 2 mol of hydrogen gas used, 1 mol of Si is produced!** Based on the amount of hydrogen gas moles we found to have used in the first part of the calculation, we can see from the ratio how many Si moles we have

Solution: When 50 L of hydrogen gas at STP react with silicon tetrachloride, 31.25 g of pure silicon is produced.

Please watch the following tutorials to assist in solidifying your understanding of conversion factors and stoichiometry:

Video #1: https://www.youtube.com/watch?v=Gle1bPAZsgg

Video #2: https://www.youtube.com/watch?v=SjQG3rKSZUQ

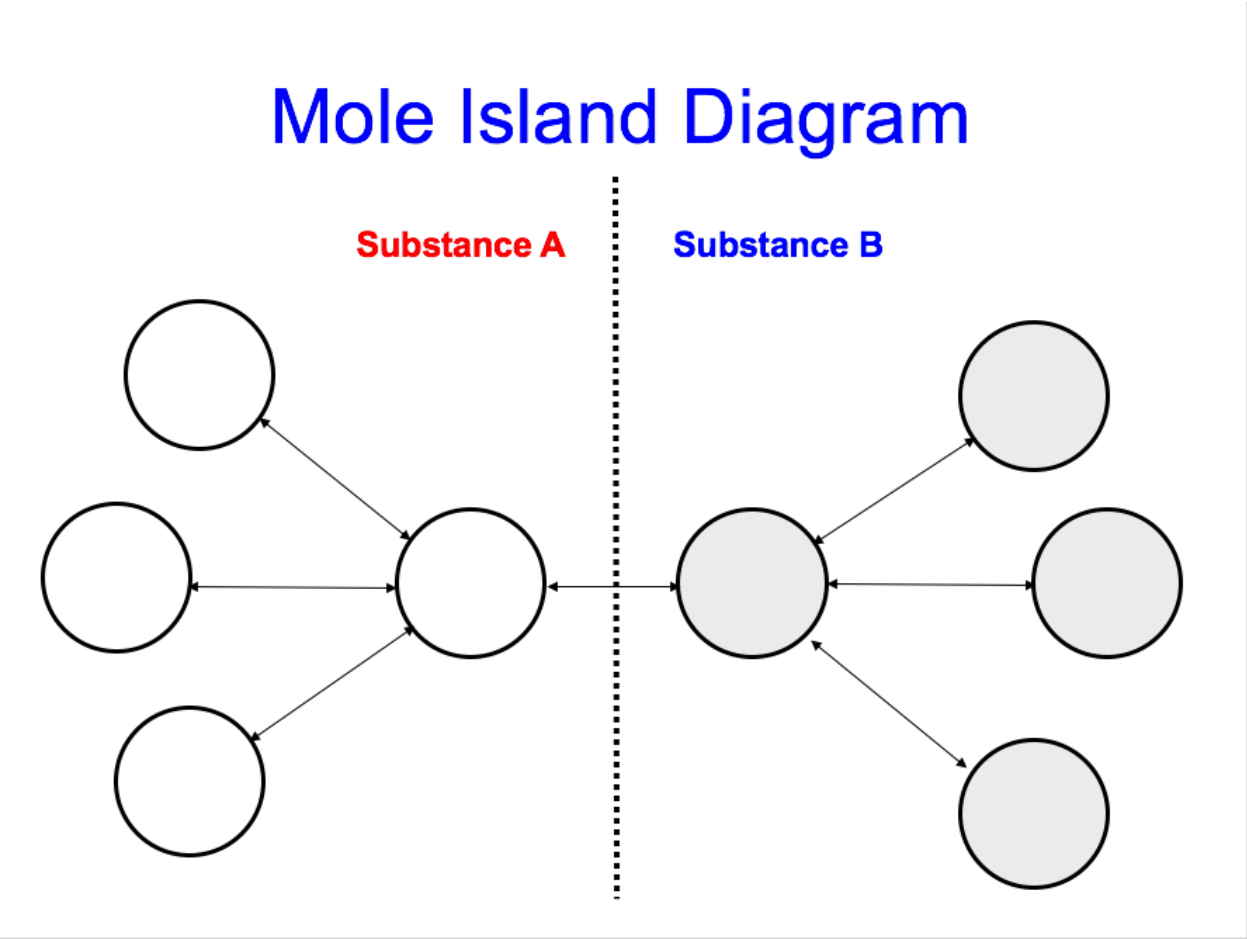
Summary:

Molecules in a chemical reaction always react with a constant ratio among them. The ratios are given by the coefficients from the balanced chemical formula. The application of these ratios when solving stoichiometric calculations is referred to as “crossing the mole bridge”

Use the following template note set paired with the associated PowerPoint slide show from slides 1 - 19

Stoichiometry and Mole Island
Template Note Set

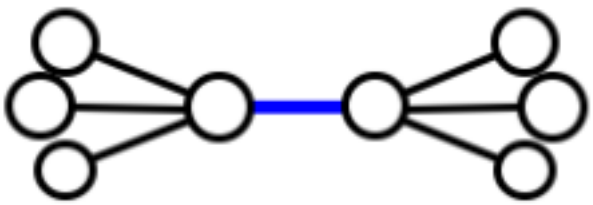
Mole Island Diagram



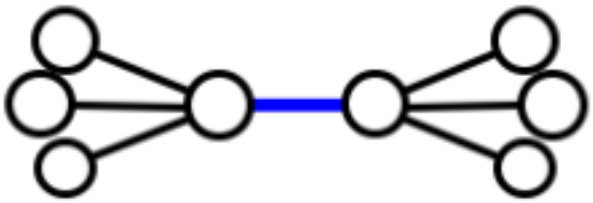
Stoichiometry Practice Problems

____TiO_2 + ____Cl_2 + ____C → ___$TiCl_4$ + ____CO_2 + ____CO

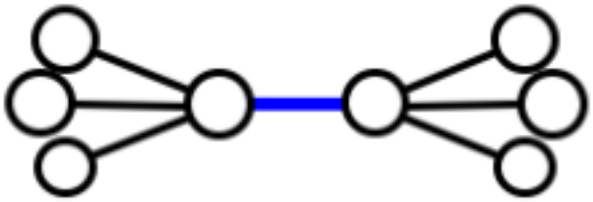
1. How many mol chlorine will react with 4.55 mol of carbon?



2. What mass of titanium (IV) will react with 4.55 mol of carbon?



3. How many molecules of titanium (IV) chlrode can be made from 115g titanium (IV) oxide?



Additional Stoich Problems

$$2\ Ir + Ni_3P_2 \rightarrow 3\ Ni + 2\ IrP$$

4. If 5.33×10^{28} molecules nickel (II) phosphide react w/excess iridium, what mass of iridium (III) phosphide is produced?

5. How many grams of iridium react with 465 grams of nickel (II) phosphide?

6. How many moles of nickel are produced if 8.7×10^{25} atoms of iridium are consumed?

7. What volume of hydrogen gas is liberated at STP if 50 g of zinc react with excess hydrochloric acid?

Reaction:

8. At STP, how many molecules of oxygen react with $632 dm^3$ of butane (C_4H_{10})? How many atoms will react?

Reaction:

Energy and Stoichiometry

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + 891\ kJ$$

9. How many kJ of energy are released when 54 g of methane are burned?

10. At STP, what volume of oxygen is consumed in producing 5430kJ of energy?

11. What mass of water is made if 10,540 kJ are released?

Name:_____ Date:_____

Homework Practice

1. Consider the unbalance chemical reaction: $B_2H_6 + O_2 \rightarrow HBO_2 + H_2O$
   a. What mass of O_2 will be needed to burn 36.1 g of B_2H_6?

   b. How many moles of water are produced from 19.2 g of B_2H_6?

2. Calculate the number of moles of carbon dioxide formed when 40 mol of oxygen is consumed in the burning of propane (C_3H_8). *Hint: You must complete and balance the equation first.*

3. Consider the following reaction: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO$
   a. Determine the volume of carbon dioxide that will be produced from 112.5 g of iron at STP

4. Given the following reaction, find the volume of sulfur dioxide gas that is produced from 25.36 ml of 0.966 M hydrochloric acid at STP.
   a. $Na_2SO_3 + 2HCl \rightarrow 2NaCl + SO_2 + H_2O$

Name:_____ Date:_____

5. Sodium hydroxide is used to neutralize sulfuric acid. If 19.52 mL of 0.285 M sulfuric acid was needed to titrate 42.81 mL of sodium hydroxide. Find the molarity of the sodium hydroxide. Hint: *You must first write out and balance the reaction*

To be Submitted **Stoichiometry Assignment #2**

1. **Lithium nitride reacts with water to form ammonia (NH_3) and aqueous lithium hydroxide. What mass of water is needed to react with 98.7 g of Li_3N?**

   ____ Li_3N + ____ H_2O → ___ NH_3 + ____ LiOH

2. **Carbon monoxide reacts with hydrogen gas to produce methanol.**

   $CO + 2H_2 \rightarrow CH_3OH$ (Equation is balanced)

   a. How many moles of CO are needed to react with 0.48 mol of hydrogen gas?

   b. How many grams of CH_3OH are produced from the complete reaction of 3.5 moles of hydrogen gas?

   c. How many molecules of methanol (CH_3OH) are produced with 4.0 L of CO?

   d. What volume of hydrogen would be needed to produce 30 g of methanol?

3. **Sulfuric acid is formed when sulfur trioxide combines with water:**

   $$\mathbf{SO_{3(g)} + H_2O_{(l)} \rightarrow H_2S0_{4(l)}}$$

   a. What is the minimum mass of water required to convert 8.00g of sulfur trioxide into sulfuric acid?

   b. What mass of sulfur trioxide is needed in order to produce 10.0g of sulfuric acid?

4. **Sodium carbonate, Na_2CO_3, is used in the manufacture of glass and is made from calcium carbonate and sodium chloride according to the equation:**

   $$\mathbf{CaCO_{3(s)} + 2NaCl_{(aq)} \rightarrow Na_2CO_{3(g)} + CaCl_{2(aq)}}$$

   a. What mass of sodium chloride is required to completely react with 1.00kg of calcium carbonate?

   b. What mass of sodium carbonate could be produced from the reaction of 1.00kg of sodium chloride?

   c. What volume of $CaCl_2$ would be produced if 2.60L of NaCl was completely reacted