Chapter 9

Stoichiometry

Intro to Stoichiometry

9.1

Objectives

- **Define** *stoichiometry.*
- **Describe** the importance of the *mole ratio* in stoichiometric calculations.
- **Write** a mole ratio relating two substances in a chemical equation

Stoich Definitions

- **Composition stoichiometry** deals with the mass relationships of elements in compounds.
- **Reaction stoichiometry** involves the mass relationships between reactants and products in a chemical reaction.

VC - Stoich

Stoich

- Stoichiometry is based on the law of conservation of mass.
- The mass of reactants equals the mass of the products.

Stoich

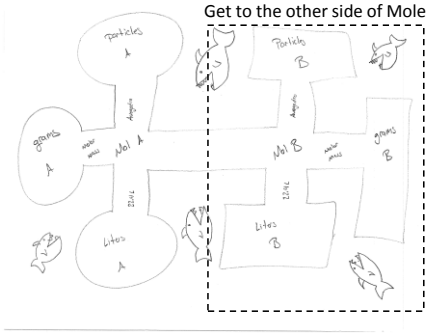
- A **mole ratio** is a ratio between the numbers of moles of any two substances in a balanced equation.
- Example
- $2\ H_2O \rightarrow 2\ H_2 + O_2$

$$\frac{2\ H_2O}{2\ H_2} \quad \frac{2\ H_2O}{1\ O_2} \quad \frac{2\ H_2}{1\ O_2}$$

$$\frac{2\ H_2}{2\ H_2O} \quad \frac{1\ O_2}{2\ H_2O} \quad \frac{1\ O_2}{2\ H_2}$$

What can we do with Stoich?

Get to the other side of Mole Island!



Stoich

- The mole ratio is the key to getting to the other side!
- It will give you the ratio between the reactants and the product that will be produced

Assignment

- 9.1 Worksheet

Ideal Stoich Calculations

9.2

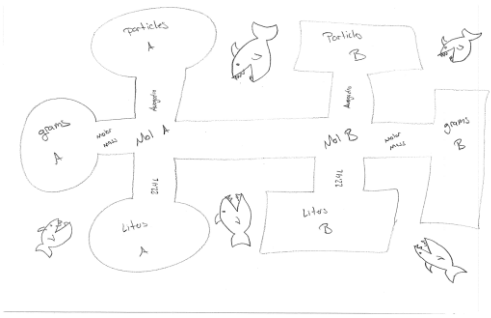
Objectives

- **Calculate** the amount in moles of a reactant or a product from the amount in moles of a different reactant or product.
- **Calculate** the mass of a reactant or a product from the amount in moles of a different reactant or product

Objectives (cont)

- **Calculate** the amount in moles of a reactant or a product from the mass of a different reactant or product.
- **Calculate** the mass of a reactant or a product from the mass of a different reactant or product.

Get it out and get ready for some FUN!



Mole to Mass

- Example $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$
- How many grams of Fe_2O_3 are produce when you start with 8 moles of Fe?

$$\frac{8 \text{ mol Fe}}{} \left| \frac{2 \text{ mol } Fe_2O_3}{4 \text{ mol Fe}} \right| \frac{159.70 \text{ g } Fe_2O_3(s)}{1 \text{ mol } Fe_2O_3} = 638.8 \text{ g } Fe_2O_3$$

Mole ratio — grams / mole

Practice

- Page 289
  - 1 – In class
  - 2 – You!

Moles to mass (and vice versa)

- $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$
- How many grams of oxygen does it take to produce 6 moles of Fe_2O_3?

1. Convert from moles of Fe_2O_3 to moles of O_2
2. Convert from moles of O_2 to grams of O_2

$$\frac{6 \text{ mol } Fe_2O_3}{} \left| \frac{3 \text{ mol } O_2}{2 \text{mol } Fe_2O_3} \right| \frac{32 \text{ grams of } O_2}{1 \text{ mol } O_2} = 288 \text{ grams } O_2$$

Practice

- Page 291
  - 1 – In class
  - 2 – You!
- Page 293
  - 1 – You!

Mass to Mass

- Example

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$$

- How many grams of Fe are needed to produce 529 grams of Fe_2O_3?

1. Convert grams of Fe_2O_3 into moles of Fe_2O_3
2. Convert moles of Fe_2O_3 into moles of Fe
3. Convert moles of Fe into grams of Fe

$$\frac{529 \text{ g } Fe_2O_3}{} \left| \frac{1 \text{ mol } Fe_2O_3}{159.7 \text{ g } Fe_2O_3} \right| \frac{4 \text{ mol Fe}}{2 \text{ mol } Fe_2O_3} \left| \frac{55.85 \text{ g Fe}}{1 \text{ mol Fe}} \right. = 370 \text{ g Fe}$$

Practice

- Page 295 (white box)
  - 1 – In Class
  - 2 – You!

Assignment

- 9.2 Worksheet

Limiting Reactants and Percent Yield

9.3

Objectives

- **Describe** a method for determining which of two reactants is a limiting reactant.
- **Calculate** the amount in moles or mass in grams of a product, given the amounts in moles or masses in grams of two reactants, one of which is in excess.
- **Distinguish** between theoretical yield, actual yield, and percentage yield.
- **Calculate** percentage yield, given the actual yield and quantity of a reactant.

Limiting Reactants

- Reactions proceed until one of the reactants is used up and one is left in excess.
- The **limiting reactant** limits the extent of the reaction and, thereby, determines the amount of product formed.
- The **excess reactants** are all the leftover unused reactants.

Limiting Reactant

- Ex. 300 people want a hamburger for lunch and there are only 250 hamburgers for lunch
- The limiting reactant is the hamburgers and the excess reactant is the people
- The same can be applied to a chemical equation!

- $C + O_2 \rightarrow CO_2$
- 1 mole of C reacts with 1 mole of O to produce 1 mole of CO_2
- If you have 10 moles of carbon and 15 moles of oxygen, how many carbon dioxides can you make?

•10, because after 10 there is no more carbon available

Why do Reactions Stop?

- Determining the limiting reactant is important because the amount of the product formed depends on this reactant.

Cheese Burger

- You want to make as many cheese burgers as possible.
- Each cheese burger needs: 2 buns slices, 1 patty, 1 slice of cheese, 4 pickles, 3 onion slices, and 1 olive.
- How many cheese burgers can you make if you have the following: 36 buns slices, 22 patties, 25 slices of cheese, 80 pickles, 48 onion slices, and 78 olives?
- What is/are the limiting reactant(s)?
- What is/are the excess reactant(s)?

Demo

- Colored Circles on board
  - How many ___ can you make from ____ and ____

Method for figuring out which reactant is limiting

- Calculate the amount of moles of the other reactant, B, which is required by A
- Find the number of moles/grams of B
- Then compare the calculated amount with the amount of B you actually have
- If the required amount is more than you have available, B is the limiting reactant
- - If the required amount is less than you have available, B is the excess reactant (A it limiting)

- $SiO_2 + 4\ HF \rightarrow SiF_4 + 2H_2O$
- If 2 moles of HF is combined with 4.5 moles of SiO_2, which is the limiting reactant?

- 2 mol HF x $\frac{1 \text{ mole } SiO_2}{4 \text{ mol HF}}$ = **0.50 mol SiO_2**

- So, under ideal conditions, 2 moles of HF will require 0.50 moles of SiO_2 for a complete reaction.
- Since you have 4.5 moles of SiO_2 available, HF is the limiting reactant

- $SiO_2 + 4\ HF \rightarrow SiF_4 + 2H_2O$
- If 2 moles of HF is combined with 4.5 moles of SiO_2, which is the limiting reactant?
- 4.5 mol SiO_2 x $\frac{4 \text{ moles HF}}{1 \text{ mol } SiO_2}$ = **18 mole of HF**

- So, under ideal conditions, 4.5 moles of SiO_2 will require 18 moles of HF for a complete reaction.
- Since you have 2 moles of HF available, HF is the limiting reactant

- You get the SAME limiting reactant both ways

More Practice

- $SiO_2 + 4\ HF \rightarrow SiF_4 + 2H_2O$
- You have 1234 grams of HF and combine it with 2222 grams of SiO_2, which is the limiting reactant? HAVE
- $\frac{1234\ g\ HF}{} \left| \frac{1\ mol\ HF}{20.1\ g\ HF} \right| \frac{1\ mol\ SiO_2}{4\ mol\ HF} \left| \frac{60.09\ g\ SiO_2}{1\ mole\ SiO_2} \right.$

  = **922.28 grams of SiO_2** NEED

  so **HF is limiting**

Practice

- Page297
  - 1 – In Class
- Page 299
  - 1 – You!
- 9.2 Practice Problems wkst
  - 1 – In Class

Assignment

- 9.3 Worksheet to STOP 1
- There is more practice on the LR Problem Sets

Percent Yield

- The **theoretical yield** is the maximum amount of product that can be produced from a given amount of reactant.
  - what you get from doing the reactions from yesterday
- The **actual yield** of a product is the measured amount of that product obtained from a reaction.
  - What you "actually" got in a reaction
    - May be given to you (worksheets) or what you measured in a lab experiment

Percent Yield

- The **percentage yield** is the ratio of the actual yield to the theoretical yield, multiplied by 100

$$Percent\ Yield = \frac{Actual\ Yield}{Theoretical\ Yeild} * 100$$

Practice

C_6H_6 (l) + Cl_2(g) → C_6H_5Cl(l) + HCl(g)

- When 36.8 g C_6H_6 react with an excess of Cl2, the actual yield of C_6H_5Cl is 38.8 g.
- What is the percentage yield of C_6H_5Cl?

Step 1

Write down Givens:

Mass of C_6H_6 = 36.8 g
Mass of Cl_2 = excess
Actual yield of C_6H_5Cl = 38.8 g
% Y = _____

Step 2

Find Theoretical Yield (from yesterday)
Lets do this…

Step 3

Find % Yield

$$Percent\ Yield = \frac{Actual\ Yield}{Theoretical\ Yeild} * 100$$

Actual yield of C_6H_5Cl = 38.8 g
Theoretical Yield C_6H_5Cl = 53 g

$$Percent\ Yield = \frac{38.8\ g}{53} * 100 = 73.2\%$$

Practice

- Page 302
  - 1 – In Class
  - 2 – You!

Assignment

- 9.3 Worksheet (Finish)