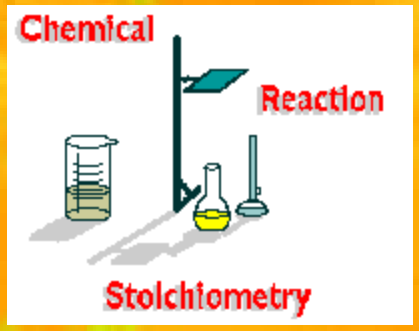
Chapter 9

Stoichiometry!!!



Stoichiometry

- Stoichio metry- “element” “measure”

-the measure of elements

- **Composition Stoichiometry-** mass relationships of elements in compounds (Ch. 3)
- **Reaction Stoichiometry-** mass relationships between reactants and products in a chemical reaction
  - Use given info to solve for an unknown
  - Use mole ratios to determine relationship between reactants and products

4 Problem Types:

1) moles given → moles unknown
2) moles given → moles unknown → mass unknown
3) mass given → moles given → moles unknown
4) mass given → moles given → moles unknown → mass unknown

*NOTE: the only way to go from the given to the unknown is in moles!

*** Mole Ratios

- Mole ratios indicate the relative amount in moles of each substance in a reaction

- Ex: $2\ Al_2O_3 \rightarrow 4\ Al + 3\ O_2$

Determine how many moles of Al will be produced from 13 moles Al_2O_3.

Remember! Molar Mass

- Molar mass (g/mol) can be used to convert the mass to moles or moles to mass of ONE substance.
- Use the molar mass in conjunction with the mole ratio to solve stoichiometry problems
- Ex. 2 Al_2O_3 → 4 Al + 3 O_2

Determine the mass of Al produced by 13 moles Al_2O_3.

Ideal Calculations

- Start with a balanced equation
- Assume all reactants are converted to products

1) Moles → Moles

- use mole ratio
- moles given x mole ratio = moles unknown

$$\left(\frac{mol\ given}{1}\right) x \left(\frac{mol\ unknown}{mol\ given}\right) = mol\ unknown$$

Ex: $CO_2 + 2\ LiOH \rightarrow Li_2CO_3 + H_2O$

How many moles LiOH are required to react with 20 moles CO_2?

- Ex. $3H_2(g) + N_2(g) \rightarrow 2NH_3(l)$

How many moles NH_3 are produced from 6 moles H_2?

- Ex. $2KClO_3 \rightarrow KCl + 3O_2$

How many moles $KClO_3$ are required to produce from 15 moles O_2?

Ideal Calculations

2) Moles → Moles → Mass(g)

- Use mole ratio & multiply by molar mass
- Moles given x mole ratio x molar mass = mass unknown

$$\left(\frac{mol\ given}{1}\right) x \left(\frac{mol\ unknown}{mol\ given}\right) x \left(\frac{g\ unknown\ in\ a\ mol}{1\ mol\ unknown}\right) = g\ unknown$$

Ex: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

What is the mass of glucose produced from 3 moles H_2O?

What mass CO_2 was needed?

Ex. $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

2 moles of Mg will react to yield what mass of MgO?

What mass of O_2 was needed for the reaction?

Ideal Calculations

3) Mass → Moles → Moles

- Multiply by 1 over the molar mass, then use mole ratio
- Mass given x 1/molar mass x mole ratio = moles unknown

$$\left(\frac{g\ given}{1}\right) x \left(\frac{1\ mol\ given}{g\ given\ in\ a\ mol}\right) x \left(\frac{mol\ unknown}{mol\ given}\right) = mol\ unknown$$

Ex: $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$

How many moles of NO are produced from 824g NH_3?

How many moles H2O are produced from 824g NH_3?

Ideal Calculations

4) Mass → Moles → Moles → Mass

- Multiply by 1 over the molar mass, use mole ratio, then multiply by molar mass

$$\left(\frac{g\ given}{1}\right) x \left(\frac{1\ mol\ given}{g\ given\ in\ a\ mol}\right) x \left(\frac{mol\ unknown}{mol\ given}\right) x \left(\frac{g\ unknown\ in\ a\ mol}{1\ mol\ unknown}\right)$$

$$= g\ unknown$$

Mass → Moles → Moles → Mass

Ex: $NH_4NO_3(s) \rightarrow N_2O(g) + 2H_2O(l)$

What mass of NH_4NO_3 is required to produce 33g N_2O?

__ Sn + __ HF → __ SnF_2 + __ H_2

What mass of SnF_2 is produced from 30.00g HF?

Limiting Reactants:

- **Limiting Reactant-** the substance that gets completely used up in a chemical reaction
  - Once the limiting reactant is all used up the reaction stops

- **Excess Reactant-** the substance that is left over after the reaction is complete

Limiting Reactants:

Cookie dough + choc. chips → choc. chip cookies

1 Tub cookie dough + 5 choc. chips → ?

What is the greatest number of choc. chip cookies I can make? Which reactant is limiting my reaction? Which reactant will be in excess?

Limiting/Excess Reactants

- Multiple each given number of moles by the mole ratio to find the number of moles of product each could make
- Whichever reactant could make LESS product, is the L.R.

Limiting/Excess Reactants

- Ex: **SiO_2 + 4 HF → SiF_4 + 2 H_2O**

If 6 moles HF are added to 4.5 moles SiO_2, which is the limiting reactant?

(given mol x mol ratio = mol product)

mol HF x (mol SiF_4/mol HF) = ___ mol SiF_4

AND

mol SiO_2 x (mol SiF_4/mol SiO_2) = ___ mol SiF_4

Of these two reactants, which could make LESS SiF_4?

- Ex. $N_2H_4(l) + 2H_2O_2(l) \rightarrow N_2(g) + 4H_2O(g)$

a. When .75 moles N_2H_4 are combined with .5 moles H_2O_2, which reactant will limit the reaction?

b. How much excess reactant remains unchanged?

c. How many moles of each product are produced? How many grams of each?

d. How many grams of each reactant were used?

Percent(%) Yield

- **Theoretical Yield-** the maximum amount of product that can be formed from a given amount of a reactant
- **Actual Yield-** measured amount of a product actually produced in a reaction

% Yield = (Actual Yield / Theoretical Yield) x 100

Suggested Method

- Determine the theoretical yield of products in the given reaction
- Calculate the % Yield based on comparison between the actual and theoretical yields

Ex: **$C_6H_6 + Cl_2 \rightarrow C_6H_5Cl + HCl$**

When 38.8g C_6H_6 react with excess Cl_2, the actual yield is 38.8g C_6H_5Cl. Find the % yield of C_6H_5Cl.

Practice Problem

1. Benzene, C_6H_6, is reacted with bromine, Br_2, to produce bromobenzene, C_6H_5Br, and hydrogen bromide, HBr, as shown below. When 40.0 g of benzene are reacted with 95.0 g of bromine, 65.0 g of bromobenzene is produced.

$$\mathbf{C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr}$$

a. Which compound is the limiting reactant?

b. What is the theoretical yield of bromobenzene?

c. What is the reactant in excess, and how much remains after the reaction is completed?

d. What is the percentage yield?

Extended Response

1. Benzene, C_6H_6, is reacted with bromine, Br_2, to produce bromobenzene, C_6H_5Br, and hydrogen bromide, HBr, as shown below. When 40.0 g of benzene are reacted with 95.0 g of bromine, 65.0 g of bromobenzene is produced.

$$\mathbf{C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr}$$

a. Which compound is the limiting reactant? **benzene**

b. What is the theoretical yield of bromobenzene? **80.4 g**

c. What is the reactant in excess, and how much remains after the reaction is completed? **bromine, 13.2 g**

d. What is the percentage yield? **80.8%**

END OF CHAPTER 9 NOTES!!!