10.3 Limiting Reactants

1. What makes a reaction stop?

Discuss this and write down your ideas.

Candle demonstrations:

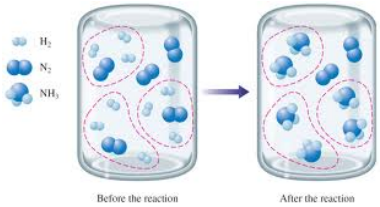
Candle burns in large volume of calm air – what stops it?

Candle burns in jar – predict how long it burns.

Limiting Reactant

Def : The reactant consumed first in a reaction.
When it runs out, the reaction **stops**.
The opposite is an excess reactant.

We have to calculate the limiting reactant because it is used to determine the amount of product formed.



Which is limiting?

2. Limiting Reactant Process

Chlorine gas (Cl_2) and sulfur (S_8) react to form disulfur dichloride (S_2Cl_2).

Step 0. Balance the reaction!

Which will run out first if you start with 100.0 g of chlorine and 100.0 g of sulfur?

2. Limiting Reactant Process

Step 1: Convert mass to moles for each reactant.

Chlorine: $100.0\,\cancel{g\,Cl_2} \times \frac{1\,mol\,Cl_2}{70.91\,\cancel{g\,Cl_2}} = 1.41\,mol\,Cl_2$

Sulfur: $100.0\,\cancel{g\,S_8} \times \frac{1\,mol\,S_8}{256.5\,\cancel{g\,S_8}} = 0.39\,mol\,S_8$

2. Limiting Reactant Process

Step 2: Make a mole ratio of available reactants,

$$\frac{1.41\,mol\,Cl_2}{0.39\,mol\,S_8}$$

then set it up as a proportion: divide top value by the bottom and write it thusly:

$$\frac{1.41\,mol\,Cl_2}{0.39\,mol\,S_8} = \frac{3.62\ mol\,Cl_2}{1.00\,mol\,S_8}$$

2. Limiting Reactant Process

Step 3: Make a mole ratio of reactants from the balanced equation – position reactants (top & bottom) as you did in step 2.

$4\ Cl_2 + S_8 \longrightarrow 4\ S_2Cl_2$ $\quad \frac{4\,mol\,Cl_2}{1\,mol\,S_8}$

If necessary, make a proportion so 1 mol is on bottom - divide top by bottom, and rewrite with that number as numerator, and 1 mol as denominator:

$$\frac{3\,mol\,X}{2\,mol\,Y} = \frac{1.5\,mol\,X}{1\,mol\,Y}$$

2. Limiting Reactant Process

Step 4: Compare the two ratios:

Available Reactants: $\frac{3.62\,mol\,Cl_2}{1.0\,mol\,S_8}$

Balanced Formula: $\frac{4.0\,mol\,Cl_2}{1.0\,mol\,S_8}$

Which reactant is limiting? Vote!

Chemocracy	
Cl_2	S_8

Chlorine is limiting – only 3.62 mol Cl_2 are available instead of the 4 mol Cl_2 that's needed.

Example 3: Product

$4\,Cl_2 + S_8 \rightarrow 4\,S_2Cl_2$

Calculate the mass of S_2Cl_2 produced.

Since LIMITING reactant (Cl_2) determines yield, we must start with it.

We already calculated moles of Cl_2 available, so:

$$1.41\,\cancel{mol\,Cl_2} \times \frac{4\,mol\,S_2Cl_2}{4\,\cancel{mol\,Cl_2}} \times \frac{135\,g\,S_2Cl_2}{1\,mol\,S_2Cl_2} = \boxed{190.4\,g\,S_2Cl_2}$$

Actual Chlorine Amount

Mole Ratio From Bal. Equation

Molar Mass of S_2Cl_2

Example 4: Excess Sulfur

$4\,Cl_2 + S_8 \rightarrow 4\,S_2Cl_2$

How many grams of sulfur are left over?

A. Determine the mass of sulfur used, starting with limiting reactant.

$$1.41\,\cancel{mol\,Cl_2} \times \frac{1\,\cancel{mol\,S_8}}{4\,\cancel{mol\,Cl_2}} \times \frac{256.5\,g\,S_8}{1\,\cancel{mol\,S_8}} = 90.42\,g\,S_8$$

Available Chlorine Amount

Mole Ratio From Equation

Molar Mass of S_8

B. Subtract amount used from amount available.

100.0 g S_8 – 90.42 g S_8 = 9.6 g S_8 in excess.

Why use excess reactant?

A. Not all reactions go to completion when perfect theoretical mixtures react → some reactants remain.

B. When one reactant is more abundant (the cheaper one), reactions can occur faster and more completely.

Homework

10.3 Booklet Problems.
Due Next Class.