Chemistry 11

Stoichiometry IV

Everything prior to this was stoichiometrically proportionate, but now it's not...

Name:
Date:
Block:

1. Limiting & Excess Reactants

Limiting & Excess

To make 36 cookies, you require:

- 6 cups of flour
- 2 cups of butter
- 3 cups of sugar

← conversion factors

What is the balanced reaction?

$\underbrace{\text{6 cups flour} + \text{2 cups butter} + \text{3 cups sugar}}_{\text{"reactants"}} \rightarrow \underbrace{\text{36 cookies}}_{\text{"products"}}$

How many cookies could you make if you had 5 cups of flour and 3 cups of butter and 2 cups of sugar?

With 5 cups of flour...

$$5 \text{ cups flour} \times \frac{36 \text{ cookies}}{6 \text{ cups flour}} = 30 \text{ cookies}$$

Based on your reactants, how much product can be made?

With 3 cups of butter...

$$3 \text{ cups butter} \times \frac{36 \text{ cookies}}{2 \text{ cups butter}} = 54 \text{ cookies}$$

With 2 cups of sugar...

$$2 \text{ cups sugar} \times \frac{36 \text{ cookies}}{3 \text{ cups sugar}} = 24 \text{ cookies}$$

limiting reactant

← limiting reaction = the real reaction

With these ingredients, how many cookies will you be making? 24 cookies

The ingredient you run out of is: sugar

This is your limiting reactant

The ingredients you have left over are: flour & butter

These are your reactants in excess

When reactions occur, the reactants come together in proportions which do not react completely with each other, because one reactant is in excess. **We cannot tell which reactant is in excess just by looking at their masses.** We have to carry out preliminary calculations to determine the limiting reactant.

This determines the reaction! It determines how much product is actually formed and it determines how much of your other reactant is actually needed

Example 1.

16.4 g of zinc and 0.300 mol of H_2SO_4 are mixed and reacted together. Hydrogen and $ZnSO_4$ are produced. What volume of H_2 gas is produced at standard temperature and pressure?

STP

⇒ What is the balanced chemical equation? *What is the question asking for? What does the question give us?*

$$\underset{16.4g}{Zn} + \underset{0.300\,mol}{H_2SO_4} \rightarrow \underset{?\,L}{H_2} + ZnSO_4$$

⇒ Calculate the L of H_2 produced from 16.4 g of Zn *(5.62 L H_2)*

$$16.4\,g_{Zn} \times \frac{1\,mol_{Zn}}{65.39\,g_{Zn}} \times \frac{1\,mol_{H_2}}{1\,mol_{Zn}} \times \frac{22.4\,L_{H_2}}{1\,mol_{H_2}} = \boxed{5.62\,L_{H_2}}$$

limiting reaction

⇒ Calculate the L of H_2 produced from 0.300 mol of H_2SO_4 *(6.72 L H_2)*

$$0.300\,mol_{H_2SO_4} \times \frac{1\,mol\,H_2}{1\,mol\,H_2SO_4} \times \frac{22.4\,L_{H_2}}{1\,mol\,H_2} = 6.72\,L_{H_2}$$

⇒ Which is the limiting reactant?

Zn

⇒ Which is the excess reactant?

H_2SO_4

⇒ How much of the excess reactant do you have left over? *(0.049 mol H_2SO_4)*

* Start with your limiting reactant and convert to excess reactant to determine how much was actually used.

$$16.4\,g_{Zn} \times \frac{1\,mol_{Zn}}{65.39\,g_{Zn}} \times \frac{1\,mol_{H_2SO_4}}{1\,mol\,Zn} = 0.251\,mol_{H_2SO_4}$$

How much is actually Used

given in the question

$$\boxed{\text{Have} - \text{Used} = \text{Excess}}$$

$$0.300_{mol} - 0.251_{mol} = \boxed{0.049\,mol_{H_2SO_4}}$$

Example 2.

Aluminum is burned with O_2 to give Al_2O_3. 74.0g of aluminum are mixed and reacted with 56.0g of O_2. What mass of aluminum oxide is produced?

⇒ Balanced reaction: *What does the question give us? What are we looking for?*

$$\underset{74.0\,g}{4\,Al} + \underset{56.0\,g}{3O_2} \longrightarrow \underset{?\,g}{2\,Al_2O_3}$$

⇒ Calculation using 74.0g of Al *(140. g Al_2O_3)*

3 sf

$$74.0\,g_{Al} \times \frac{1\ mol_{Al}}{26.98\ g_{Al}} \times \frac{2\ mol\,Al_2O_3}{4\ mol\,Al} \times \frac{101.96\ g\,Al_2O_3}{1\ mol\,Al_2O_3} = 140.\,g\ Al_2O_3$$

⇒ Calculation using 56.0g of O_2 *(119 g Al_2O_3)*

$$56.0\,g_{O_2} \times \frac{1\ mol_{O_2}}{32.00\ g_{O_2}} \times \frac{2\ mol\ Al_2O_3}{3\ mol\ O_2} \times \frac{101.96\,g\ Al_2O_3}{1\ mol\,Al_2O_3} = \boxed{119\,g\,Al_2O_3}$$

⇒ What is the limiting reactant?

O_2

⇒ What mass of aluminum oxide is actually produced?

$119\,g\,Al_2O_3$

⇒ What is the excess reactant and how much of it is left over? *(11.0 g Al)*

$\boxed{Al}$

Used

$$56.0\,g_{O_2} \times \frac{1\ mol_{O_2}}{32.00\,g_{O_2}} \times \frac{4\ mol_{Al}}{3\ mol_{O_2}} \times \frac{26.98\ g_{Al}}{1\ mol_{Al}} = 63.0\,g_{Al}$$

Have − used = Excess

$$74.0\,g_{Al} - 63.0\,g_{Al} = \boxed{11.0\,g_{Al}}$$

Complete Limiting & Excess Reactants Worksheet