

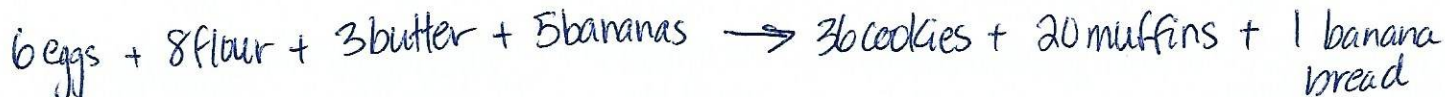
1. Limiting & Excess Reactants

Limiting & Excess

To make 36 cookies, 20 muffins and 1 loaf of banana bread, it requires:

- 6 eggs
- 8 cups of flour
- 3 cups of butter
- 5 bananas

What is the balanced reaction?



How many cookies could you make if you had 6 cups of flour and 6 eggs and 1 cup of butter?

With 6 cups of flour...

$$6 \text{ cups of flour} \times \frac{36 \text{ cookies}}{8 \text{ flour}} = 27 \text{ cookies}$$

With 6 eggs...

$$6 \text{ eggs} \times \frac{36 \text{ cookies}}{6 \text{ eggs}} = 36 \text{ cookies}$$

With 1 cup of butter...

$$1 \text{ cup butter} \times \frac{36 \text{ cookies}}{3 \text{ cups butter}} = 12 \text{ cookies}$$

The limiting ingredient is:

butter

The ingredients you have left over are: flour, eggs

How many muffins could you make if you had 12.5 cups of flour and 8 eggs and 5 cups of butter?

$$12.5 \text{ cups flour} \times \frac{20 \text{ muffins}}{8 \text{ cups flour}} = 31.25 = 31 \text{ muffins.}$$

$$8 \text{ eggs} \times \frac{20 \text{ muffins}}{6 \text{ eggs}} = 26 \text{ muffins}$$

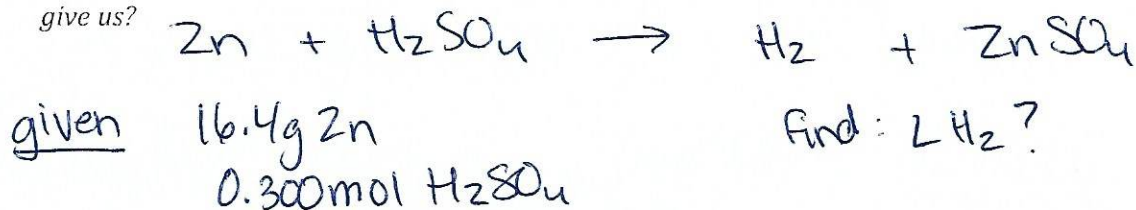
$$5 \text{ cups butter} \times \frac{20 \text{ muffins}}{3 \text{ cups butter}} = 33 \text{ muffins.}$$

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.

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?

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



⇒ Calculate the L of H_2 produced from 16.4 g of Zn.

$$16.4\text{g Zn} \times \frac{1\text{mol Zn}}{65.39\text{g Zn}} \times \frac{1\text{mol H}_2}{1\text{mol Zn}} \times \frac{22.4\text{L H}_2}{1\text{mol H}_2} = 5.62\text{L H}_2$$

⇒ Calculate the L of H_2 produced from 0.300 mol of H_2SO_4

$$0.300\text{mol H}_2\text{SO}_4 \times \frac{1\text{mol H}_2}{1\text{mol H}_2\text{SO}_4} \times \frac{22.4\text{L H}_2}{1\text{mol H}_2} = 6.72\text{L H}_2$$

⇒ 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?

* Start with limiting reactant and convert to excess reactant to determine how much was used!

$$16.4\text{g Zn} \times \frac{1\text{mol Zn}}{65.39\text{g Zn}} \times \frac{1\text{mol H}_2\text{SO}_4}{1\text{mol Zn}} = 0.251\text{mol H}_2\text{SO}_4$$

have - used = excess

$$0.300\text{mol} - 0.251\text{mol} = 0.049\text{mol H}_2\text{SO}_4$$

Example 2.

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

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



given: 74.0g Al
56.0g O_2

find: ? g Al_2O_3

⇒ Calculation using 74.0 g of Al.

$$74.0g Al \times \frac{1 mol Al}{26.98g Al} \times \frac{2 mol Al_2O_3}{4 mol Al} \times \frac{101.96g Al_2O_3}{1 mol Al_2O_3} = 139.8g$$

⇒ Calculation using 56.0 g of O_2 .

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

⇒ What is the limiting reactant?

O_2

⇒ What mass of aluminum oxide is actually produced?

119g Al_2O_3

⇒ What is the excess reactant and how much of it is left over? Excess is Al

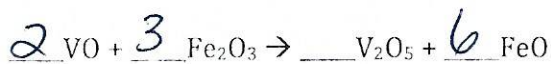
$$56.0g O_2 \times \frac{1 mol O_2}{32.00g O_2} \times \frac{4 mol Al}{3 mol O_2} \times \frac{26.98g Al}{1 mol Al} = 63.0g Al$$

have - used = excess

$$74.0g - 63.0g = 11.0g Al$$

Practice 1.

Balance the following equation.



2.00 g of VO is reacted with 5.75 g Fe₂O₃.

a) What mass of V₂O₅ is produced? (2.18 g V₂O₅)

$$2.00 \text{g VO} \times \frac{1 \text{mol VO}}{66.94 \text{g VO}} \times \frac{1 \text{mol V}_2\text{O}_5}{2 \text{mol VO}} \times \frac{181.88 \text{g V}_2\text{O}_5}{1 \text{mol V}_2\text{O}_5} = 2.72 \text{g V}_2\text{O}_5$$

$$5.75 \text{g Fe}_2\text{O}_3 \times \frac{1 \text{mol Fe}_2\text{O}_3}{159.70 \text{g Fe}_2\text{O}_3} \times \frac{1 \text{mol V}_2\text{O}_5}{3 \text{mol Fe}_2\text{O}_3} \times \frac{181.88 \text{g V}_2\text{O}_5}{1 \text{mol V}_2\text{O}_5} = \boxed{2.18 \text{g V}_2\text{O}_5}$$

b) What is the excess reactant and how much of it is left over? (0.39 g VO)

↳ VO

$$5.75 \text{g Fe}_2\text{O}_3 \times \frac{1 \text{mol Fe}_2\text{O}_3}{159.70 \text{g Fe}_2\text{O}_3} \times \frac{2 \text{mol VO}}{3 \text{mol Fe}_2\text{O}_3} \times \frac{66.94 \text{g VO}}{1 \text{mol VO}} = 1.61 \text{g VO}$$

$$\text{have - excess} = \text{used} \Rightarrow 2.00 - 1.61 = \boxed{0.39 \text{g VO}}$$

Practice 2.

45.0 g of zinc is reacted with 84.0 g of hydrochloric acid at STP:



a) What volume of H₂ is produced? What mass of ZnCl₂ is produced? (15.4 L H₂, 93.8 g ZnCl₂)

$$45.0 \text{g Zn} \times \frac{1 \text{mol Zn}}{65.39 \text{g Zn}} \times \frac{1 \text{mol H}_2}{1 \text{mol Zn}} \times \frac{22.4 \text{L H}_2}{1 \text{mol H}_2} = \boxed{15.4 \text{L H}_2}$$

$$84.0 \text{g HCl} \times \frac{1 \text{mol HCl}}{36.46 \text{g HCl}} \times \frac{1 \text{mol H}_2}{2 \text{mol HCl}} \times \frac{22.4 \text{L H}_2}{1 \text{mol H}_2} = 25.8 \text{L H}_2$$

$$45.0 \text{g Zn} \times \frac{1 \text{mol Zn}}{65.39 \text{g Zn}} \times \frac{1 \text{mol ZnCl}_2}{1 \text{mol Zn}} \times \frac{136.29 \text{g ZnCl}_2}{1 \text{mol ZnCl}_2} = \boxed{93.8 \text{g ZnCl}_2}$$

b) What is the excess reactant and how much of it is left over? (33.8 g HCl)

$$45.0 \text{g Zn} \times \frac{1 \text{mol Zn}}{65.39 \text{g Zn}} \times \frac{2 \text{mol HCl}}{1 \text{mol Zn}} \times \frac{36.46 \text{g HCl}}{1 \text{mol HCl}} = 50.2 \text{g HCl}$$

have - used = excess

$$84.0 - 50.2 = \boxed{33.8 \text{g HCl}}$$