Grade 10 IB Bridging Year Chemistry

Topic 5 Stoichiometry

**5.5 Limiting reactant**

When chemicals are mixed together to undergo a reaction, they are often mixed in stoichiometric quantities, that is, in exactly the correct amounts of that all reactants are used up at the same time. However, that is not always the case. Most of the time, one of the reactant will be used up first, and this brings us to the concept of the **limiting reactant** (or **limiting reagent**), which the reactant that is consumed first and therefore limits the amounts of products that can be formed. Any other reactants will be *in excess*since the amount is not limiting the amount of products that can be formed in a reaction.

***Example 1***

Nitrogen, N2, and hydrogen, H2, react to form ammonia, NH3.

Consider the mixture of N2 and H2 shown in the diagram.

1. Write a balanced equation for this reaction.
2. What is the limiting reagent in this reaction?
3. What is the maximum number of ammonia molecules that can be formed in this chemical reaction?



1. Draw a microscopic representation of the contents of the container after the reaction.

***Example 2***

Consider the reaction below:



1. Write a balanced equation for the reaction shown above, which produces a gaseous product.
2. Use the space provided above to draw the correct number of each molecule present in the reaction flask after the reagents have been converted into products.

***Example 3***

The following reaction can be used to generate hydrogen gas from methane, CH4.

CH4 (g) + H2O (g) → CO (g) + H2 (g)

1. Balance the equation for this reaction.
2. Draw a sub-microscopic representation of the reaction.
3. Which is the limiting reagent when 500 g methane reacts with 1300 g water?
4. How many grams of hydrogen can be produced in this reaction?

***Steps for solving a stoichiometry problem involving masses of reactants and products***

***Step 1*** Write and balance the equation for the reaction.

***Step 2*** Convert the known masses of substances to moles.

***Step 3*** Determine which reactant is limiting.

***Step 4*** Using the amount of the limiting reactant and the appropriate mole ratio, calculate the number of moles of the desired product.

***Step 5*** Convert from moles to grams using the molar mass.

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***Example 4***

The following represents a chemical reaction between AB2 and B2 :



a) Write a balanced equation for the reaction.

b) Explain which is the limiting reactant in this reaction.

c) Calculate how many moles of product can be produced when 3 moles B2 react with 5 moles AB2.

d) Calculate how many moles of excess reactant remain after the reaction in part (c) above is complete.

***Example 5***

Suppose 25.0 kg of nitrogen and 5.00 kg of hydrogen are mixed and reacted to form ammonia. Calculate the mass of ammonia produced when this reaction is run to completion (until one of the reactants is completely consumed). Identify the limiting and excess reactant.

* Write the balanced chemical equation:
* Calculate the number of moles of nitrogen reacted:
* Calculate the number of moles of hydrogen reacted:
* Determine the limiting and excess reactant:
* Calculate the number of moles of ammonia produced:
* Calculate the mass of ammonia produced:

***Example 6***

Nitrogen gas can be prepared by passing gaseous ammonia over solid copper (II) oxide at high temperatures. The other products of the reaction are solid copper and water vapor.

If a sample containing 18.1 g of NH3 is reacted with 90.4 of CuO, which is the limiting reactant?

How many grams of N2 will be formed?

***Example 7***

Methanol (CH3OH) is used as a fuel in race cars, and is a potential replacement for gasoline. Methanol can be manufactured by combination of gaseous carbon monoxide and hydrogen.

Suppose 68.5 kg CO (g) is reacted with 8.60 kg H2 (g). Calculate the theoretical yield of methanol.

If 3.57 x 104 g of methanol is actually produced, what is the percent yield of methanol?

***Example 8***

Potassium chromate, K2CrO4, a bright yellow solid, is produced by the reaction of solid chromite ore (FeCr2O4) with solid potassium carbonate and gaseous oxygen at high temperatures. The other products of the reaction are solid iron (III) oxide and gaseous carbon dioxide.

The **unbalanced** chemical equation is shown below:

FeCr2O4 (s) + K2CO3 (s) + O2 (g) 🡪 K2CrO4 (s) + Fe2O3 (s) + CO2 (g)

In a particular experiment, 169 kg chromite ore, 298 kg potassium carbonate, and 75.0 kg oxygen were sealed in a reaction vessel and reacted at a high temperature. The amount of potassium chromate obtained was 194 kg.

Calculate the percent yield of potassium chromate.

***Practice exercise***

1. Consider the reaction

Mg(s) + I2(s) → MgI2(s)

Identify the limiting reagent in each of the reaction mixtures below:

* 1. 100 atoms of Mg and 100 molecules of I2
  2. 150 atoms of Mg and 100 molecules of I2
  3. 200 atoms of Mg and 300 molecules of I2
  4. 0.16 mol Mg and 0.25 mol I2
  5. 0.14 mol Mg and 0.14 mol I2
  6. 0.12 mol Mg and 0.08 mol I2
  7. 6.078 g Mg and 63.455 g I2
  8. 1.00 g Mg and 2.00 g I2
  9. 1.00 g Mg and 20.00 g I2

1. When a mixture of silver metal and sulfur is heated, silver sulfide is formed:



* 1. What mass of Ag2S is produced from a mixture of 2.0 g Ag and 2.0 g S8?
  2. What mass of which reactant is left unreacted?

1. Ammonia is produced from the reaction of nitrogen and hydrogen according to the following balanced equation:

N2(g) + 3H2(g) → 2NH3(g)

* 1. What is the maximum mass of ammonia that can be produced from a mixture of 1.00 x 103 g N2 and 5.00 x 102 g H2?
  2. What mass of which reactant would remain unreacted?