You have mastered this topic when you can:
1) define and perform calculations involving **LIMITING** and **EXCESS REACTANTS**.

CALCULATING EXCESS AND LIMITING REACTANTS

I) **QUANTITATIVE ANALYSIS**

A) ***QUANTITIVE ANALYSIS involves measuring the amounts of reactants and products involved in a chemical reaction. Quantitative analysis*** is extremely important in scientific and industrial chemistry.

II) **LIMITING AND EXCESS REACTANTS**

A) Consider the reaction between magnesium and chlorine described by the equation: $Mg_{(s)} + Cl_{2(g)} \rightarrow MgCl_{2(s)}$

1) When 1.0 mole of magnesium is reacted with 1.0 mole of chlorine, experimental analysis revealed not all of it was used; a small measurable number of magnesium atoms remained un-reacted. How is this possible? In order for particles to react together they must collide with one another. It is not possible for every magnesium atom to collide with a chloride molecule; as a result, some remain un-reacted. As the reaction happens, the un-reacted Mg atoms, Cl_2 molecules, and newly formed $MgCl_2$ particles exist in the same container. When the reaction is completed, there are very few Mg atoms and Cl_2 molecules in the container because the vast majority of them have been converted to $MgCl_2$ thus it is much more likely that the remaining Mg atoms will not be able to collide with a Cl_2 molecule and therefore remain un-reacted. How could one force every magnesium atom in to react?

a) If the number of chlorine molecules is increased, each remaining magnesium atom would have a greater chance of colliding with one of them and be converted to $MgCl_2$. To ensure all the Mg atoms react extra Cl_2 molecules are made available. Because the supply of Cl_2 has been increased not all of it will be reacted thus the Cl_2 is said to be ***in excess*** and is called ***EXCESS REACTANT***. ***The EXCESS REACTANT is the reactant that is present in more than the amount required to cause all other reactants to be completely reacted.*** In order to react all of a particular reactant, chemists usually ensure all other reactants, the ***excess reactants***, are in excess of the amount predicted by the mole ratio by 10%. There is a 1:1 mole ratio for the reaction between Mg and Cl_2, thus to ensure the entire 1.0 mole sample of Mg reacts we must supply 1.1 mole of Cl_2. The mole ratio predicts that 1.0 mole of Cl_2 will react with 1.0 mole of Mg so 10% of 1.0 mol Cl_2 is 0.10 mol Cl_2.

$$1.0 \text{ mol} \times 10\% = 1.0 \text{ mol} \times 0.1 = 0.10 \text{ mol extra } Cl_2$$

$$1.0 \text{ mol } Cl_2 + 0.10 \text{ mol } Cl_2 = \underline{1.1 \text{ mol } Cl_2}$$

b) When 1.0 mol Mg reacts with ***excess*** chlorine (1.1 mol Cl_2) how many moles of $MgCl_2$ will be produced?

i) By ensuring Cl_2 is in excess, we have decided that the magnesium will react completely while some Cl_2 will remain un-reacted. This means the number of moles of $MgCl_2$ produced is determined by the number of moles of magnesium reacted not the number of moles chlorine reacted. Because the number of moles of magnesium determines the number of moles of $MgCl_2$, magnesium limits the amount of $MgCl_2$ that can be produced and thus is called the ***LIMITING REACTANT***. ***The LIMITING REACTANT is the reactant that is completely consumed in a chemical reaction.***

III) **DETERMINING *LIMITING* AND *EXCESS REACTANTS***

A) ***USE THESE STEPS TO DETERMINE WHICH REACTANT IS LIMITING AND WHICH IS IN-EXCESS***

(1) Write a balanced chemical equation.
(2) Calculate the number of moles of each reactant that are available to react.
(3) Calculate the number of moles of each reactant required to completely react the other reactant.
(4) Complete the table and compare moles have to moles needed to determine which reactant is LIMITING and which is IN-EXCESS.

reactant	moles have	moles needed	excess/limiting

B) **Sample Problems 1**

1) 3.6 moles of hydrogen react with 2.2 moles of nitrogen to produce ammonia. Determine which reactant is limiting and which is in excess?

(1) Write a balanced chemical equation.

(2) Calculate the number of moles of each reactant that are available to react.

(3) Calculate the number of moles of each reactant required to completely react the other reactant.

(4) Complete the table and compare moles have to moles needed to determine which reactant is LIMITING and which is IN-EXCESS.

reactant	moles have	moles needed	excess/limiting

H_2 ***is limiting*** because only 3.6 mol are available and 6.6 mol are needed to react all of the N_2.

N_2 ***is in excess*** because 2.2 mol are available and only 1.2 mol are needed to react all of the H_2.

2) 5.4×10^{-3} moles of hydrogen react with 1.5×10^{-3} moles of nitrogen to produce ammonia. Determine which reactant is limiting and which is in excess?

(1) Write a balanced chemical equation.

(2) Calculate the number of moles of each reactant that are available to react.

(2) Calculate the number of moles of each reactant that are available to react.

Continued on the next page.

(4) Complete the table and compare moles have to moles needed to determine which reactant is LIMITING and which is IN-EXCESS.

reactant	moles have	moles needed	excess/limiting

N_2 *is limiting* because only 1.5 x 10^{-3} mol are available and 1.8 x 10^{-3} mol are needed to react all of the H_2.

H_2 *is in excess* because 5.4 x 10^{-3} mol are available and only 4.5 x 10^{-3} mol are needed to react all of the N_2.

C) **Required Practice 1:** Sodium and Chlorine react according to this balanced equation. **SHOW YOUR WORK!!** **{Answers are on page 3.}**

$$2Na_{(s)} + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$$

1. 3.5 moles of sodium react with 6.9 moles of chlorine. Which reactant is limiting and which is in excess?
2. 1.9 moles of sodium react with 0.50 moles of chlorine. Which reactant is limiting and which is in excess?

ANSWERS TO THE REQUIRED PRACTICE

Required Practice 1 from page 3

1. Sodium is limiting while chlorine is in excess. **2.** Chlorine is limiting while sodium is in excess.
