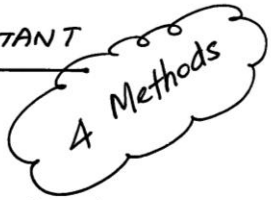
STOICHIOMETRY : LIMITING REACTANT

METHODS OF DETERMINING LIMITING REACTANT : 4 METHODS

- Often, chemical reactions are run with an excess of one or more starting materials. The reactant that runs out is called the <u>limiting reactant</u> because it limits the amount of product that can be made. The other starting materials are said to be in excess.
- A Limiting reactant is the reactant that is completely converted to products during a reaction. Once the limiting reactant has been used up, no more product can form.
  The limiting reactant must be used as the basis for calculating the maximum possible amount of product(s) because the limiting reactant limits the amount of product(s) that can be formed. "The moles of product formed are always determined by the starting number of moles of the limiting reactant."

METHODS TO DETERMINE THE LIMITING REACTANT



There are 4 methods :

<u>Example :</u>

One step in the industrial production of nitric acid is the reaction of ammonia with molecular oxygen to form nitrogen oxide.

$$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$$

In a study of this reaction, a chemist mixed 132 g of ammonia with 273 g oxygen and allowed them to react to completion. What is the limiting reactant.

<u>Solution</u>

We need the molar masses :

$M_r(NH_3) = 17.03\ g\,mol^{-1}$

$M_r(O_2) = 32.00\ g\,mol^{-1}$

$M_r(NO) = 30.01\ g\,mol^{-1}$

$M_r(H_2O) = 18.02\ g\,mol^{-1}$

Limiting Reactant

Convert masses to moles. $n\,(\text{moles}) = \dfrac{m\,(\text{grams})}{M_r\,(\text{molar mass, g mol}^{-1})}$

$$n_{NH_3} = \frac{m_{NH_3}}{M_r(NH_3)} = \frac{132\,g}{17.03\,g\,mol^{-1}} = 7.75\ mols.$$

$$n_{O_2} = \frac{m_{O_2}}{M_r(O_2)} = \frac{273\,g}{32.00\,g\,mol^{-1}} = 8.53\ mols.$$

Method 1

- The limiting reactant is the one whose number of moles divided by its stoichiometric coefficient has the smallest value.

$$\textcircled{4}NH_3 + \textcircled{5}O_2 \longrightarrow 4NO + 6H_2O$$

stoichiometric coefficient for NH_3 = 4

stoichiometric coefficient for O_2 = 5

$$\frac{n_{NH_3}}{4} = \frac{7.75\ mols\ NH_3}{4\ mols\ NH_3} = 1.94$$

(4 = stoichiometric coefficient)

$$\frac{n_{O_2}}{5} = \frac{8.53\ mols\ O_2}{5\ mols\ O_2} = \textcircled{1.71}$$ ← smaller value

The ratio for O_2 is smaller, so oxygen is the limiting reactant.

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