STOICHIOMETRY : LIMITING REACTANT

METHODS OF DETERMINING LIMITING REACTANT : **4 METHODS**

METHOD 3 : Example

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 132g of ammonia with 273 g oxygen and allowed them to react to completion. What is the limiting reactant.

Solution

We need the molar masses:

$M_r(NH_3) = 17.03\ gmol^{-1}$

$M_r(O_2) = 32.00\ gmol^{-1}$

$M_r(NO) = 30.01\ gmol^{-1}$

$M_r(H_2O) = 18.02\ gmol^{-1}$

Limiting Reactant

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

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

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

METHOD 3

* The limiting reactant is the reactant that forms the lower mass of product / fewer moles of product.

- To identify NH_3 as the limiting reactant is to calculate the mass of NO that would be produced from 7.75 mols of NH_3 and excess of O_2

OR • To identify O_2 as the limiting reactant is to calculate the mass of NO (the same product) that would be produced from 8.53 mols of O_2 and excess of NH_3.

* The limiting reactant will be the one that produces the smaller mass/moles of NO.

If NH_3 = limiting reactant (7.75 mols)

$$\frac{n_{NO}}{n_{NH_3}} = \frac{4}{4} \Longrightarrow n_{NO} = n_{NH_3}$$

stoichiometric coefficient

$$\frac{m_{NO}}{30.01\ g\,mol^{-1}} = 7.75\ mols$$

$$\therefore m_{NO} = (7.75 \times 30.01)\ g$$

$$= 232.6\ g \ @\ 7.75\ mols$$

If O_2 = limiting reactant (8.53 mols)

$$\frac{n_{NO}}{n_{O_2}} = \frac{4}{5} \Longrightarrow n_{NO} = \frac{4}{5} \times n_{O_2}$$

stoichiometric coefficient

$$\frac{m_{NO}}{30.01} = \frac{4}{5} \times 8.53$$

$$\therefore m_{NO} = \left(\frac{4 \times 8.53 \times 30.01}{5}\right) g$$

$$= 204.8\ g \ @\ 6.82\ mols$$

This comparison shows that the amount of available oxygen (8.53 mols of O_2) would produce less NO than the amount of NH_3 available.

$\therefore$ O_2 = limiting reactant

NH_3 = excess reactant.

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