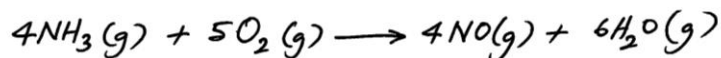


METHOD 4 : Example

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



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

Solution

We need the molar masses :

$$M_r(\text{NH}_3) = 17.03 \text{ g mol}^{-1}$$

$$M_r(\text{O}_2) = 32.00 \text{ g mol}^{-1}$$

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

$$M_r(\text{H}_2\text{O}) = 18.02 \text{ g mol}^{-1}$$

Limiting Reactant

Convert masses to moles.

$$n(\text{moles}) = \frac{m(\text{grams})}{M_r(\text{molar mass, g mol}^{-1})}$$

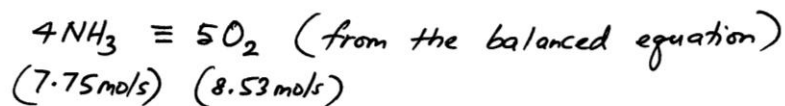
$$n_{\text{NH}_3} = \frac{m_{\text{NH}_3}}{M_r(\text{NH}_3)} = \frac{132\text{g}}{17.03 \text{ g mol}^{-1}} = 7.75 \text{ mols.}$$

$$n_{\text{O}_2} = \frac{m_{\text{O}_2}}{M_r(\text{O}_2)} = \frac{273\text{g}}{32.00 \text{ g mol}^{-1}} = 8.53 \text{ mols.}$$

METHOD 4

- By comparing moles of the reactant required for the reaction with the available moles of the same reactant.
- If the required reactant is more than the available reactant, then this reactant will be the limiting reagent. If the required reactant is less than the available reactant, then this reactant is in excess.

STOICHIOMETRY : LIMITING REACTANT : Method 4



Consider 2 possibilities:

a) If O_2 is the limiting reactant.

$$\frac{n_{\text{NH}_3}}{n_{\text{O}_2}} = \frac{4}{5} \rightarrow n_{\text{NH}_3} = \frac{4}{5} \times n_{\text{O}_2}$$

$$= \left(\frac{4}{5} \times 8.53\right) \text{ mols}$$

We have excess of
(7.75 - 6.82) = 0.93 mols
of NH_3 .

$n_{\text{NH}_3} = 6.82$ mols (required)
(but n_{NH_3} available = 7.75 mols)

Since the available NH_3 is more than enough, thus our assumption that O_2 is the limiting reactant is correct.

b) If NH_3 = limiting reactant

$$n_{\text{O}_2} = \frac{5}{4} \times n_{\text{NH}_3}$$

$$= \left(\frac{5}{4} \times 7.75\right) = 9.69 \text{ mols (required)}$$

(but n_{O_2} available is not enough - ie 8.53 mols only)

So NH_3 cannot be the limiting reactant.

Reaction:	4NH_3	+	5O_2	\longrightarrow	4NO	+	$6\text{H}_2\text{O}$
Starting amount (mol)	7.75		8.53		0		0
change in amount (mol)	-6.82		-8.53		+6.82		+10.24
Final amount (mol)	0.93		0		6.82		10.24