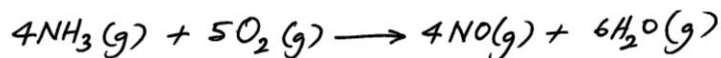


## METHOD 2 : Example

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 2

- Comparing mole ratio of the theoretical and the experimental value.
- The mole ratio of the theoretical value is from the stoichiometric coefficient.

$$r_{\text{theoretical}} = \frac{n_{\text{NH}_3}}{n_{\text{O}_2}} = \frac{4}{5} = 0.8$$

← stoichiometric coefficient of NH<sub>3</sub>

## STOICHIOMETRY : LIMITING REACTANT : Method 2

- The mole ratio of the experimental value is from the calculated value (ie. 7.75 mols of  $\text{NH}_3$  ; 8.53 mols of  $\text{O}_2$ )

$$= \frac{n_{\text{NH}_3}}{n_{\text{O}_2}} = \frac{7.75 \text{ mols of NH}_3}{8.53 \text{ mols of O}_2} = 0.91$$

$$r_{\text{theoretical}} = 0.8 \quad ; \quad r_{\text{experimental}} = 0.9$$

$$\therefore r_{\text{experimental}} > r_{\text{theoretical}}$$

Thus the numerator is larger (ie moles of  $\text{NH}_3$  is larger - in excess) whereas the denominator is smaller (ie. moles of  $\text{O}_2$  is smaller - the limiting reactant)

Remember !!

- example:
- $\frac{7}{2}$  ← larger (numerator)  
          ← smaller (denominator)
- In a fraction form (ratio form): if the fraction value is large, it means the numerator is larger than the denominator.
    - The larger numerator = excess reactant
    - The smaller denominator = limiting reactant

- OR
- $\frac{2}{7}$  ← smaller  
          ← larger
- If the fraction value is small, it means the numerator is smaller than the denominator.
    - The smaller numerator = limiting reactant
    - The larger denominator = excess reactant

- Always compare the  $r_{\text{experimental}}$  value to the  $r_{\text{theoretical}}$  value NOT the other way around.

eg. If the  $r_{\text{experimental}} > r_{\text{theoretical}}$  : It means the numerator is larger - is in excess.  
If the  $r_{\text{experimental}} < r_{\text{theoretical}}$  : It means the numerator is smaller - is the Limiting Reactant.