METHOD 2 : 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 :

$M_r(NH_3) = 17.03\ g\,mol^{-1}$
$M_r(O_2) = 32.00\ g\,mol^{-1}$
$M_r(NO) = 30.01\ g\,mol^{-1}$
$M_r(H_2O) = 18.02\ g\,mol^{-1}$

Limiting Reactant

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

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

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

Method 2

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

$$r_{theoretical} = \frac{n_{NH_3}}{n_{O_2}} = \frac{4}{5} = 0.8$$

(4 ← stoichiometric coefficient of NH_3)

- The mole ratio of the experimental value is from the calculated value (ie. 7.75 mols of NH_3 ; 8.53 mols of O_2)

$$= \frac{n_{NH_3}}{n_{O_2}} = \frac{7.75 \text{ mols of } NH_3}{8.53 \text{ mols of } O_2} = 0.91$$

$r_{theoretical} = 0.8$; $r_{experimental} = 0.9$

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

Thus the numerator is larger (ie moles of NH_3 is larger – in excess) whereas the denominator is smaller (ie. moles of O_2 is smaller – the limiting reactant)

Remember !!

1. 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

example: $\frac{7}{2}$ (7 ← larger (numerator); 2 ← smaller (denominator))

OR

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

$\frac{2}{7}$ (2 ← smaller; 7 ← larger)

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

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

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