Limiting Reactant

Key Concepts:

- The limiting reactant is the reactant that is completely used up during the chemical reaction.
- Excess reactant - reactant not completely used up - some of this reactant left over.

Example 1

Hydrazine, N_2H_4 and dinitrogen tetraoxide, N_2O_4 which ignite to form nitrogen gas and water vapor. How many grams of nitrogen gas form when 1.00×10^2 g of N_2H_4 and 2.00×10^2 g of N_2O_4 are mixed?

Solution:

* Because of amounts of two reactants are given, we know this is a limiting-reactant problem.

Balanced equation:

$$N_2O_4(l) + 2N_2H_4(l) \xrightarrow{\Delta} 3N_2(g) + 4H_2O(g)$$

$$n_{N_2H_4} = \left(\frac{1.00 \times 10^2 \text{ g}}{32.05 \text{ g mol}^{-1}}\right) = 3.12 \text{ mol}$$

$$n_{N_2O_4} = \left(\frac{2.00 \times 10^2 \text{ g}}{92.02 \text{ g mol}^{-1}}\right) = 2.17 \text{ mol}$$

$M_r(N_2H_4) = 32.05 \text{ g mol}^{-1}$
$M_r(N_2O_4) = 92.02 \text{ g mol}^{-1}$
$M_r(N_2) = 28.02 \text{ g mol}^{-1}$

$$r_{theory} = \frac{n_{N_2H_4}}{n_{N_2O_4}} = \frac{2}{1} = 2.0 \quad \text{(from the balanced equation)}$$

$$r_{experiment} = \frac{n_{N_2H_4}}{n_{N_2O_4}} = \frac{2.17 \text{ mol}}{3.12 \text{ mol}} = 0.696$$

$r_{experiment}\ (0.696) < r_{theory}\ (2.0)$

So the numerator ($n_{N_2H_4}$) is a small value, i.e. N_2H_4 is a limiting reactant, whereas the denominator, $n_{N_2O_4}$ is a large value, ie. N_2O_4 is in excess.

Since N_2H_4 is a limiting reactant,

$$N_2O_4(l) + 2N_2H_4(l) \longrightarrow 3N_2(g) + 4H_2O$$

$3.12\ mol$ $\quad$ $?g$

$$\frac{n_{N_2}}{n_{N_2H_4}} = \frac{3}{2} \quad \text{or} \quad n_{N_2} = \frac{3}{2} \times n_{N_2H_4}$$

$$\frac{m_{N_2}}{28.02\ g mol^{-1}} = \frac{3}{2} \times 3.12\ mol$$

$$\therefore m_{N_2} = \left(\frac{3 \times 3.12 \times 28.02}{2}\right) g$$

$$= 131\ g\ (Ans)$$

Common Mistakes done by students !!

- The limiting reactant is not the reactant present in fewer moles (2.17 mol N_2O_4 & 3.12 mol of N_2H_4).
- The limiting reactant that forms fewer moles of product.
- The limiting reactant is not the reactant present in fewer mass. Rather it forms the lower mass of product.

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