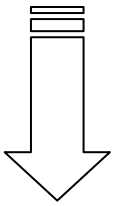
STOICHIOMETRY : LIMITING REACTANT

REVIEW QUESTIONS

Q1.

Ammonium chloride and Aluminium nitrite react to form aluminium chloride, nitrogen and water. What mass of each substance is present after 172.5g of aluminium nitrite and 150.8 g of ammonium chloride react completely?

ANSWER



Q1: $3NH_4Cl + Al(NO_2)_3 \longrightarrow AlCl_3 + 3N_2 + 6H_2O$

150.8 g 172.5 g

$M_r(NH_4Cl) = 53.49$ gmol
$M_r(Al(NO_2)_3) = 164.997$ gmol
$M_r(AlCl_3) = 133.34$ gmol
$M_r(N_2) = 28.014$ gmol
$M_r(H_2O) = 18.015$ gmol

To find the limiting reactant:

Method 1

$$n_{NH_4Cl} = \left(\frac{150.8}{53.49}\right) = 2.82 \text{ mol}$$

$$n_{Al(NO_2)_3} = \left(\frac{172.5}{164.997}\right) = 1.05 \text{ mol}$$

Ratio of the reactants

$$r_{theoretical} = \frac{n_{NH_4Cl}}{n_{Al(NO_2)_3}} = \frac{3}{1} = 3.0$$

$$r_{experimental} = \frac{n_{NH_4Cl}}{n_{Al(NO_2)_3}} = \frac{2.82}{1.05} = 2.7$$

$r_{experimental}\ (2.7) < r_{theoretical}\ (3.0)$

So the numerator is small (ie. NH_4Cl = limiting reactant) whereas the denominator is large (ie. $Al(NO_2)_3$ = excess)

Method 2

* The limiting reactant is the one whose number of moles divided by its stoichiometric coefficient has the smallest value.

$\frac{n_{NH_4Cl}}{3}$ compared with $\frac{n_{Al(NO_2)_3}}{1}$

$\frac{2.82}{3}$ → smallest value → (0.94)

$\frac{1.05}{1}$ → (1.05) ← bigger value

$Al(NO_2)_3$ = excess.

∴ NH_4Cl = limiting reactant

Method 3

* Limiting reactant that forms fewer moles of product. (ie. to produce N_2)

$$\frac{n_{N_2}}{n_{NH_4Cl}} = \frac{3}{3} = 1 \Rightarrow n_{N_2} = n_{NH_4Cl} = 2.82\ mol$$

$$\frac{n_{N_2}}{n_{Al(NO_2)_3}} = \frac{3}{1} \Rightarrow n_{N_2} = 3 \times n_{Al(NO_2)_3}$$

$$= (3 \times 1.05) = 3.15\ mol$$

NH_4Cl = limiting reactant because it yields fewer moles of N_2.

To find the mass of the products: (NH_4Cl = limiting reactant)

$$n_{N_2} = n_{NH_4Cl} = 2.82\ mol$$

$$\therefore m_{N_2} = (2.82 \times 28.014)g = 79.0g\ (Ans)$$

$$n_{H_2O} = \frac{6}{3} \times n_{NH_4Cl} = (2 \times 2.82)mol = 5.64\ mol$$

$$\therefore m_{H_2O} = (5.64 \times 18.015)g = 101.60g\ (Ans)$$

$$n_{AlCl_3} = \frac{1}{3} \times n_{NH_4Cl} = \left(\frac{2.82}{3}\right)mol = 0.94\ mol$$

$$\therefore m_{AlCl_3} = (0.94 \times 133.34)g\,mol^{-1} = 125.3g\ (Ans)$$

Prepared by
V. Manoharan
vmano@usm.my
manovv1955@yahoo.com
04-6533888 ext 3566