Limiting and Excess Regents

J. KROPAC

Limiting Regents

* **Limiting Reagents**: the reactant that is used up first

* $2Na(s) + Cl_{(g)} \rightarrow 2NaCl_{(s)}$

* A reaction mixture contains 45.98g of sodium an 142.0 g of chlorine. Calculate the mass of sodium chloride that is produced.

Step 1

* Step 1: List Given Values and Balance Equation

* m_{Na}= 45.98g
* m_{Cl} = 142.0 g
* M_{Na}= 22.99 g/mol
* M_{Cl2} = 2 x 35.45 g/mol

  =70.90 g/mol

Step 2

* Step 2: Convert each substance from mass to moles

Step 2

* Step 2: Convert each substance from mass to moles

* Sodium:

$$n = \frac{m}{M}$$

$$n = \frac{45.98\ g}{22.98\ g/mol}$$

$$n = 2.0\ mol$$

Step 2

* Step 2: Convert each substance from mass to moles
  * Chlorine:

$$n = \frac{m}{M}$$

$$n = \frac{142.00\ g}{70.90\ g/mol}$$

$$n = 2.0\ mol$$

Step 3

Complete molar ratio for both

$$\frac{\text{Amount given}}{\text{Amount required}} = \frac{n_{given}}{n_{required}}$$

* Sodium

* Chlorine

Step 3

Complete molar ratio for both

$$\frac{\text{Amount given}}{\text{Amount required}} = \frac{n_{given}}{n_{required}}$$

* Sodium

$$\frac{2}{2} = \frac{2.0\ mol}{n_{required}}$$

$$2n = 4$$
$$n = 2$$

* Chlorine

Step 3

Complete molar ratio for both

$$\frac{\text{Amount given}}{\text{Amount required}} = \frac{n_{given}}{n_{required}}$$

* Sodium

$$\frac{2}{2} = \frac{2.0\ mol}{n_{required}}$$

$$2n = 4$$
$$n = 2$$

* Chlorine

$$\frac{1}{2} = \frac{2.0\ mol}{n_{required}}$$

$$1n = 4$$
$$n = 4$$

Whichever is the smaller number is the limiting reagent

You will now use this to find this value to find the mass of the substance

Step 4

* Convert from moles of limiting reagent to mass of substance
  * $m = n \times M$

$n = 2.0$ mol

$M = Na + Cl$

$= 22.99$ g/mol $+ 35.45$ g/mol

$= 58.44$ g/mol

Step 4

* Convert from moles of limiting reagent to mass of substance
  * $m = n \times M$

$n = 2.0$ mol

$M = Na + Cl$

$= 22.99$ g/mol $+ 35.45$ g/mol

$= 58.44$ g/mol

$m = 2.0$ mol $\times 58.44$ g/mol

$m = 116.88$ g

Therefore 116.88 g of NaCl will be created.

Now you try . . .

* $4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$

* A reaction mixture contains 134.9 g of aluminum and 96.0 g of oxygen. Calculate the mass of aluminum oxide that is present.

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

List given values

$m_{Al} = 134.9\ g$
$M_{Al} = 26.98\ g/mol$

$m_{O2} = 96.0\ g$
$M_{O2} = 32.00\ g/mol$

$m_{Al2O3} = ?$
$M_{Al2O3} = 101.96\ g/mol$

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

List given values

$m_{Al} = 134.9\ g$
$M_{Al} = 26.98\ g/mol$

$m_{O2} = 96.0\ g$
$M_{O2} = 32.00\ g/mol$

$m_{Al2O3} = ?$
$M_{Al2O3} = 101.96\ g/mol$

Convert from mass to moles

$n = m/M$

$$n = \frac{134.9\ g}{26.98\ g/mol}$$

$n = 5.00\ mols$

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

$m_{Al} = 134.9\ g$
$M_{Al} = 26.98\ g/mol$

$m_{O2} = 96.0\ g$
$M_{O2} = 32.00\ g/mol$

$m_{Al2O3} = ?$
$M_{Al2O3} = 101.96\ g/mol$

Convert from mass to moles

$n = m/M$

$n = \frac{134.9\ g}{26.98\ g/mol}$

$n = 5.00\ mols$

$n = m/M$

$n = \frac{96\ g}{32.00\ g/mol}$

$n = 3.00\ mols$

n= 5.0 mol

n= 3.0 mol

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

$m_{Al} = 134.9\ g$
$M_{Al} = 26.98\ g/mol$

$m_{O2} = 96.0\ g$
$M_{O2} = 32.00\ g/mol$

$m_{Al2O3} = ?$
$M_{Al2O3} = 101.96\ g/mol$

$n = m/M$

$n = \frac{134.9\ g}{26.98\ g/mol}$

$n = 5.00\ mols$

$n = m/M$

$n = \frac{96\ g}{32.00\ g/mol}$

$n = 3.00\ mols$

n= 5.0 mol

n= 3.0 mol

Molar Ratio

$$\frac{\text{Ratio given}}{\text{Ratio required}} = \frac{n_{given}}{n_{required}}$$

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

$m_{Al} = 134.9\ g$
$M_{Al} = 26.98\ g/mol$

$m_{O2} = 96.0\ g$
$M_{O2} = 32.00\ g/mol$

$m_{Al2O3} = ?$
$M_{Al2O3} = 101.96\ g/mol$

$n = m/M$

$n = \frac{134.9\ g}{26.98\ g/mol}$

$n = 5.00\ mols$

$n = m/M$

$n = \frac{96\ g}{32.00\ g/mol}$

$n = 3.00\ mols$

$n = 5.0\ mol$

$n = 3.0\ mol$

Molar Ratio

$$\frac{4}{2} = \frac{5}{n_{required}}$$

$4n = 10$

$n = 2.5$

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

$m_{Al} = 134.9\ g$
$M_{Al} = 26.98\ g/mol$

$m_{O2} = 96.0\ g$
$M_{O2} = 32.00\ g/mol$

$m_{Al2O3} = ?$
$M_{Al2O3} = 101.96\ g/mol$

$n = m/M$

$n = \frac{134.9\ g}{26.98\ g/mol}$

$n = 5.00\ mols$

$n = m/M$

$n = \frac{96\ g}{32.00\ g/mol}$

$n = 3.00\ mols$

Molar Ratio

$n = 5.0\ mol$

$\frac{4}{2} = \frac{5}{n_{required}}$

$4n = 10$

$n = 2.5$

$n = 3.0\ mol$

$\frac{3}{2} = \frac{3}{n_{required}}$

$3n = 6$

$n = 2.0$

Since oxygen is the smaller number, it is the limiting reagent.

Use it to calculate the mass of product.

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

$m_{O2} = 96.0\ g$
$M_{O2} = 32.00\ g/mol$

$m_{Al2O3} = ?$
$M_{Al2O3} = 101.96\ g/mol$

$$n = m/M$$

$$n = \frac{96\ g}{32.00\ g/mol}$$

$n = 3.00$ mols

n= 3.0 mol → **n= 2.0 mol**

$$\frac{3}{2} = \frac{3}{n_{required}}$$

$3n = 6$
$n = 2.0$

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

m_{O2} = 96.0 g
M_{O2} = 32.00 g/mol

m_{Al2O3} = ?
M_{Al2O3} = 101.96 g/mol

$$n = m/M$$

$$n = \frac{96\ g}{32.00\ g/mol}$$

$$n = 3.00\ mols$$

Convert from moles to mass

n= 3.0 mol → n= 2.0 mol

$$\frac{3}{2} = \frac{3}{n_{required}}$$

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

m_{O2} = 96.0 g
M_{O2} = 32.00 g/mol

m_{Al2O3} = ?
M_{Al2O3} = 101.96 g/mol

$n = m/M$

$$n = \frac{96\ g}{32.00\ g/mol}$$

n = 3.00 mols

Convert from moles to mass

$m = n \times M$

n = 3.0 mol → n = 2.0 mol

$$\frac{3}{2} = \frac{3}{n_{required}}$$

$$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$$

m_{O2} = 96.0 g
M_{O2} = 32.00 g/mol

m_{Al2O3} = ?
M_{Al2O3} = 101.96 g/mol

$n = m/M$

$n = \frac{96\ g}{32.00\ g/mol}$

n = 3.00 mols

n= 3.0 mol → **n= 2.0 mol**

Convert from moles to mass

$m = n \times M$

$m = 2.0 \times 101.96$

m = 203.92 g

$\frac{3}{2} = \frac{3}{n_{required}}$