# CHEMISTRY CALCULATIONS WS 4

## Moles & Volume

**1** Consider the following reaction for the synthesis of methanol:

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$$

**a.** What volume of $H_2$ reacts exactly with 2.50 $dm^3$ of CO?

V of $H_2$ = 2x (V of CO) = 5.0 $dm^3$

**b.** What volume of $CH_3OH$ is produced?

2.5 $dm^3$

**2** **a.** Calculate the number of moles in 250 $cm^3$ of $O_2$ @ *r.t.p.*

1 mol in 24 $dm^3$
x in 250 $cm^3$ $\quad x = \frac{1}{24000} \times 250 = 0.0104$ mol

**b.** Calculate the volume of 0.135 mol of $CO_2$ @ *r.t.p.*

$V = 0.135 \times 24 dm^3 = 3.24 dm^3$

**3** Calculate the volume of carbon dioxide (@ *r.t.p.*) produced when 10.01 g of calcium carbonate decomposes according to the equation:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

Mr $CaCO_3$ = 40.1 + 12 + 3(16) = 100.1

n of $CaCO_3$ = 0.1 mol

n of $CO_2$ = 0.1 mol

V of $CO_2$ = 0.1 x 24 $dm^3$ = 2.4 $dm^3$

**4** Potassium chlorate(V) decomposes when heated:

39.1 + 35.5 + 48 = 122.6

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

What mass of potassium chlorate(V) decomposes to produce 100.0 $cm^3$ of oxygen gas measured @ *r.t.p*?

n $O_2 = \frac{100}{24000} = 0.00416$ mol produced.

n $KClO_3 = \frac{0.00416}{3} \times 2 = 0.00277$ mol

Mass of $KClO_3$ = 122.6 x 0.00277 = 0.339 g reacted.

**5** What volume of $SO_2$ is obtained (measured @ *r.t.p*) when 1.000 kg of $As_2S_3$ is heated in oxygen?

$2As_2S_3 + 9O_2 \rightarrow 2As_2O_3 + 6SO_2$

Mr $As_2O_3 = 2(74.9) + 3(32.1)$
$= 246.1$

$n = \frac{1000}{246.1} = 4.064$ mol

$n$ of $SO_2 = \frac{4.064}{2} \times 6 = 12.19$ mol

Vol of $SO_2 = 12.19 \times 24 dm^3$
$= 292.56\ dm^3$

**6** **a.** Calculate the volume of $CO_2$ produced when $100cm^3$ of ethene burns in excess oxygen according to the equation:

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$

$C_2H_4 : CO_2$
$1 : 2$
$1\ mol : 2\ mol$
$1\ cm^3 : 2cm^3$

V of $CO_2 = 200 cm^3$

**b.** Calculate the volume of NO produced when 2.0 $dm^3$ of oxygen is reacted with excess ammonia according to the equation:

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

$O_2 : NO$
$5 : 4$
$2 : x$

$x = \frac{4 \times 2}{5} = 1.6\ dm^3$

**7** Determine the number of moles present in each of the following at standard temperature and pressure:

**a.** $0.240dm^3$ of $O_2$
$10.7 \times 10^{-3}$ mol

**b.** $2.00dm^3$ of $CH_4$
89.2 mol

**c.** $0.100dm^3$ of $SO_2$ $4.46 \times 10^{-3}$ mol.

**d.** 400.0 $cm^3$ of $N_2$
$17.9 \times 10^{-3}$ mol

**e.** $250.0cm^3$ of $CO_2$
$11.16 \times 10^{-3}$ mol.

**8** Work out the volume of each of the following at standard temperature and pressure:

**a.** 0.100 mol $C_3H_8$

$2.24\ dm^3$

**b.** 100.0 mol $SO_3$

$2240\ dm^3$

**c.** 0.270mol $N_2$

$6.048\ dm^3$

**d.** 0.8500 mol $NH_3$

$19.04\ dm^3$

**e.** 0.600 mol $O_2$

$13.44\ dm^3$

**9** Sodium nitrate(V) decomposes according to the equation:

$$2NaNO_3(s) \rightarrow 2NaNO_2(s) + O_2(g)$$

Calculate the volume (in $cm^3$) of oxygen produced (measured @ *r.t.p*) when 0.820 g of sodium nitrate(V) decomposes.

$\eta\ NaNO_3 = \frac{0.82}{85} = 0.00964$ mol

$\eta\ O_2 = \frac{0.007592}{2} = 0.00482$ mol

$V\ of\ O_2 = 0.00482 \times 24000\ cm^3\ mol^{-1}$

$= 115.8\ cm^3$

**10** Tin reacts with nitric acid according to the equation:

$$Sn(s) + 4HNO_3(aq) \rightarrow SnO_2(s) + 4NO_2(g) + 2H_2O(l)$$

If 2.50g of tin are reacted with excess nitric acid what volume of $NO_2$ (in $cm^3$) is produced @ *r.t.p?*

$\eta\ of\ Sn = \frac{2.5}{119} = 0.021$ mol

$\eta\ NO_2 = 4 \times 0.021$

$= 0.084$ mol

$V\ NO_2 = 24000 \times 0.0842$

$= 2.021\ dm^3$

**11** Calculate the mass of sodium carbonate that must be reacted with excess hydrochloric acid to produce 100.0 $cm^3$ of $CO_2$ @ *r.t.p.*

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

$\eta$ of $CO_2 = \frac{100}{24000} = 0.004167$ mol.

$\eta$ $Na_2CO_3 = 0.004167$ mol

mass of $Na_2CO_3 = 0.004167(23x2 + 12 + 48)$

$= 0.4417$ g is required

**12** **a.** Oxygen ($O_2$) can be converted to ozone ($O_3$) by passing it through a silent electric discharge.

$$3O_2(g) \rightarrow 2O_3(g)$$

If 300 $cm^3$ of oxygen is used and 10% of the oxygen is converted to ozone, calculate the total volume of gas present at the end of the experiment.

10% of 300$cm^3$ = 30$cm^3$

$O_2 : O_3$

$3 : 2$

$30 : 20$ → 20$cm^3$ + 270 that wasn't used.

290 $cm^3$ in all.

**b.** Hydrogen reacts with chlorine according to the equation:

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

What is the total volume of gas present in the container at the end of the experiment if 100$cm^3$ of hydrogen is reacted with 200$cm^3$ of chlorine?

$H_2$ is the limiting agent and $Cl_2$ will be left in the tank at the end.

$H_2 : Cl_2 : 2HCl$

$1 : 1 : 2$

$100 : 100 : 200$

Reacted Produced

Total Initial = 100 + 200 = 300$cm^3$

Reacted = 200$cm^3$

Produced = 200$cm^3$

Leftover = (T.i − R) + P

= 300 − 200 + 200

= 300 $cm^3$