STUDY MATERIAL

Subject: Physical Science

Chapter: Chemical Calculations

Class: 10

Date: 21th April 2020

Problems related to mass-mass relationship

• Example 1 : How many grams of oxygen evolve when 122·5 g potassium chlorate is heated ? (Given, K = 39, Cl = 35·5, O = 16)

Ans. The balanced equation is :

$2KClO_3 =$ $2\,KCl + 3O_2$

$2\,[39 + 35{\cdot}5 + 3 \times 16]g$ $3\,[2 \times 16]\,g$

$= 245\ g$ $= 96g$

By heating 245g $KClO_3$ 96g O_2 is obtained

$\therefore$ By heating 122·5 g $KClO_3$ $\frac{96 \times 122{\cdot}5}{245}$ g = 48g O_2 is obtained

• Example 2 : 2·6 g zinc is treated with excess dil H_2SO_4 ; how many gram oxygen combines with the evolved hydrogen ?

Ans. The balanced equation for production of hydrogen is :

$Zn + H_2SO_4 = ZnSO_4 + H_2$

$65\ g$ $(2 \times 1)\ g = 2g$

So, 65g zinc produces 2g hydrogen

$\therefore$ 2-6 zinc produces $\frac{2 \times 2{\cdot}6}{65}$ g = 0·089 g hydrogen

Now, the reaction where hydrogen and oxygen combine is :

$2\,H_2 + O_2 = 2H_2O$

So, 4g hydrogen combine with 32 g oxygen

0·08g hydrogen combine with $\frac{32 \times 0{\cdot}08}{4}$ g = 0·64g oxygen

• Example 3 : What is the observed loss in weight of 5g calcium carbonate when it undergoes thermal decomposition ?

Ans. The balanced equation is :

$CaCO_3 = CaO + CO_2$

$(40+12+16 \times 3)g$ $(12+16\times 2)g$

$= 100g$ $= 44g$

Loss in weight in the weight of CO_2 that escapes

100g $CaCO_3$ produces 44g CO_2

$\therefore$ 5 g $CaCO_3$ produces $\frac{44 \times 5}{1000}$ g = 2·2 g CO_2

• Example 4 : What is the percentage of ammonia in that quantity of ammonium chloride that can produce 5 g ammonia ?

Ans. The balanced equation of reaction is :

$2NH_4Cl + CaO = 2NH_3 + CaCl_2 + H_2O$

$2[14+1\times 4+35{\cdot}5]g$ $2[14+1\times 3]g$

$= 107\ g$ $= 34g$

So, 34g ammonia is obtained form 107g NH_4Cl

• Example 5 : What weight of potassium chlorate of 96% purity will yield 4·8 g oxygen on complete thermal decomposition ?

(Given, K = 39, Cl = 35·5, O = 16)

Ans. The balanced equation is :

$2KClO_3 = 2\ KCl + 3O_2$

$245g \qquad 96g$

$\therefore$ 96g oxygen is obtained from 245g $KClO_2$ of 100% purity

$\therefore$ 4·8 g oxygen is obtained from $\frac{245 \times 4 \cdot 8}{96}$ g

$= 12 \cdot 25$ g $KClO_3$ of 100% purity.

Let x gram of 96% purity contains 12·25g $KClO_3$ of 100% purity

$\therefore \frac{96}{100} \cdot x = 12 \cdot 56$ or, $x = \frac{12 \cdot 25 \times 100}{96} = 12 \cdot 76$ (approx)

So, the required quantity of $KClO_3 = 12 \cdot 76$ g

• Example 6 : On strong heating limestone decomposes into quicklime and carbon dioxide. How much quantity of limestone will produced on complete decomposition, 30 g of quicklime by the above reaction ?

Ans. The balanced equation is :

$CaCO_3 = CaO + CO_2$

$[40+12+3\times16]g \qquad [40+16]g$

$= 100$ g $\qquad = 56$ g

So, 56g CaO is obtained by the complete decomposition of 100g $CaCO_3$

$\therefore$ 30 g CaO is obtained by the complete decomposition of

$\frac{100 \times 30}{56}$ g $CaCO_3 = 53 \cdot 6$ g $CaCO_3$

Thus 53·6 g limestone will have to be decomposed.

• Example 7 : How many grams of magnesium metal will give 1·2 g hydrogen on complete reaction with dilute H_2SO_4 (Mg = 24, H = 1)

Ans. The balanced equation is :

$Mg + H_2SO_4 = MgSO_4 + H_2$

$24g \qquad (1\times 2)g = 2g$

So, 2g H_2 is obtained from 24g Mg

$\therefore$ 1·2 g H_2 is obtained from $\frac{24 \times 1 \cdot 2}{2}$ g Mg = 14·4 g Mg

So, 14·4 g Mg will be required.

Problems based on mass-volume relationship

• Example 8 : What volume of carbon dioxide measured at 300 K and 720mm pressure be obtained on treatment of 1g $CaCO_3$ with dilute HCl ?

Ans. The balanced equation is :

$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

1 mol $(40 + 12 + 3 \times 16)g$ $\qquad$ 1 mol (22·4 lit at NTP)

$= 100g$

So, 100g $CaCO_3$ gives 22·4 lit CO_2 at NTP

1g $CaCO_3$ gives 0·224 lit CO_2 at NTP

Reducing the volume to the given condition applying gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$P_1 = 760$ mm
$V_1 = 0{\cdot}224$ lit
$T_2 = 273$ K
$P_2 = 720$ mm
$V_1 = ?$
$T_2 = 300$ K

Or, $$V_2 = \frac{P_1V_1 \times T_2}{T_1 \times P_2}$$

$$= \frac{760 \times 0{\cdot}224 \times 300}{273 \times 720}$$

= 0-2598 lit = 259-8 ml

Hence, 259·8 ml CO_2 will be obtained at 300K and 720mm pressure on treatment of 1g $CaCO_3$ with HC1.

● **Example 9 :** How much potassium nitrate should be heated to get enough oxygen required to completely burn 56 lit of hydrogen at NTP ?

Ans. The balanced equation is :

$2H_2 + O_2 \rightleftharpoons 2H_2O$

2 moles $= 2 \times 2g = 4g$ $= 2 \times 22{\cdot}4$ lit $= 44{\cdot}8$ lit (at NTP)

1 mol $= 32g = 22{\cdot}4$ lit (at NTP)

So, 44·8 lit H_2 requires 22·4 lit O_2 at NTP

56 lit H, requires $\frac{2{\cdot}24 \times 56}{44{\cdot}8}$ lit O_2 at NTP

$= 28$ lit O_2 at NTP

The other balanced equation is :

$2KNO_3 \rightleftharpoons 2KNO_2 + O_2$

2 moles $(2 \times 101)g = 202g$ 22·4 lit (at NTP)

Now, 22·4 lit O_2 at NTP are obtained by heating 202 g KNO_3

∴ 28 lit O_2 at NTP are obtained by heating $\frac{202}{22{\cdot}4} \times 28$g KNO_3

$= 252{\cdot}5$ g KNO_3

Problems based on volume-volume relationship

● **Example 10 :** In the Ostwald process for the manufacture of nitric acid, ammonia gas is burnt in oxygen in the presence of a pt-catalyst. What volume of O_2 is required and what volume of NO is formed in the combustion of 500 lit of NH_3.

Ans. The balanced equation is :

$4NH_3 + 5O_2 \rightleftharpoons 4NO + 6H_20$

4 vol 5 vol 4 vol

4 lit 5 lit 4 lit

(i) 4 lit of NH_3 requires 5 lit of O_2 for combustion

500 lit of NH_3 requires $\frac{5 \times 500}{4}$ lit = 625 lit O_2

(ii) 4 lit of NH_3 produces 4 lit NO

$\therefore$ 500 lit of NH_3 produces $\frac{4}{4} \times 500$ lit NO = 500 lit NO

● **Example 11 :** Calculate the volume of oxygen necessary to burn completely 5 lit butane gas: What is the volume of carbon dioxide formed ?

Ans. The balanced equation is :

$$2C_4H_{10} + 13O_2 \rightleftharpoons 8CO_2 + 10H_2O$$

2 vol 13 vol 8 vol

2 lit 13 lit 8 lit

So, 2 lit of butane at NTP requires 13 lit O_2 at NTP

$\therefore$ 5 lit of butane at NTP requires $\frac{13 \times 5}{2}$ lit = 32·5 lit of O_2 at NTP.

Also 2 lit of butane at NTP produce 8 lit CO_2 at NTP

$\therefore$ 5 lit of butane of NTP produce

$$= \frac{8}{2} \times 5 \text{ lit} = 20 \text{ lit } C0_2 \text{ at NTP}$$