CLASS 10TH WORKSHEET CHAPTER – MOLE CONCEPT AND STIOCHIOMETRY

Exercise 5A

Question 1(a)

Calculate the volume of oxygen at STP required for the complete combustion of 100 litres of carbon monoxide at the same temperature and pressure.

$2CO + O_2 \longrightarrow 2CO_2$

Answer

From equation:

$$\begin{array}{ccccc} 2CO & + & O_2 & \longrightarrow & 2CO_2 \\ 2 \text{ vol.} & : & 1 \text{ vol.} & \longrightarrow & 2 \text{ vol.} \end{array}$$

[By Gay Lussac's law]

2 V of CO requires = 1V of O_2

∴ 100 litres of CO requires = $\frac{1}{2}$ x 100 = 50 litres.

Hence, **required volume of oxygen is 50 litres**.

Question 1(b)

200 cm^3 of hydrogen and 150 cm^3 of oxygen are mixed and ignited, as per the following reaction,

$2H_2 + O_2 \longrightarrow 2H_2O$

What volume of oxygen remains unreacted?

Answer

$$\begin{array}{ccccc} 2H_2 & + & O_2 & \longrightarrow & 2H_2O \\ 2 \text{ vol.} & : & 1 \text{ vol.} & \longrightarrow & 2 \text{ vol.} \end{array}$$

2 Vol. of hydrogen reacts with 1 Vol. of oxygen

∴ 200 cm^3 of hydrogen reacts with = $\frac{1}{2}$ x 200 = 100 cm^3 of oxygen.

Hence, **unreacted oxygen is 150 - 100 = 50cm^3**

Question 2

24 cc Marsh gas (CH_4) was mixed with 106 cc oxygen and then exploded. On cooling, the volume of the mixture became 82 cc, of which, 58 cc was unchanged oxygen. Which law does this experiment support? Explain with calculations.

Answer

This experiment supports Gay-Lussac's law of combining volumes.

Since the unchanged oxygen is 58 cc so, used oxygen 106 - 58 = 48cc

According to Gay-Lussac's law, the volumes of gases reacting should be in a simple ratio.

$$\begin{array}{ccccc} CH_4 & + & 2O_2 & \longrightarrow & 2CO_2 + H_2O \\ 1 \text{ vol.} & : & 2 \text{ vol.} & & \\ 24 \text{ cc} & : & 48 \text{ cc} & & \end{array}$$

Hence, **methane and oxygen are in the ratio 1:2 .**

Question 3

What volume of oxygen would be required to burn completely 400 ml of acetylene [C_2H_2]? Also calculate the volume of carbon dioxide formed.

$2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$ (l)

Answer

$$\begin{array}{ccccccc} 2C_2H_2 & + & 5O_2 & \longrightarrow & 4CO_2 & + & 2H_2O \\ 2 \text{ vol.} & : & 5 \text{ vol.} & \longrightarrow & 4 \text{ vol.} & & \end{array}$$

[By Gay Lussac's law]

2 Vol. of C_2H_2 requires 5 Vol. of oxygen

∴ 400 ml C_2H_2 will require $\frac{5}{2}$ x 400

= 1000 ml of Oxygen

Hence, **required volume of oxygen = 1000 ml**
Similarly,
2 Vol. of C_2H_2 produces 4 Vol. of Carbon dioxide
∴ 400 ml of C_2H_2 produces $\frac{4}{2}$ x 400
= 800 ml of Carbon dioxide
Hence, **carbon dioxide produced = 800 ml**

Question 4

112 cm^3 of H_2S (g) is mixed with 120 cm^3 of Cl_2 (g) at STP to produce HCl (g) and sulphur (s). Write a balanced equation for this reaction and calculate
(i) the volume of gaseous product formed
(ii) composition of the resulting mixture

Answer

$$\begin{array}{ccccccccc} H_2S & + & Cl_2 & \longrightarrow & 2HCl & + & S \\ 1\text{ vol.} & : & 1\text{ vol.} & \longrightarrow & 2\text{ vol.} & : & 1\text{ vol.} \end{array}$$

(i) At STP,
1 mole gas occupies = 22.4 L.
1 mole H_2S gas produces = 2 moles HCl gas,
∴ 22.4 L H_2S gas produces
= 22.4 × 2
= 44.8 L HCl gas.
Hence, 112 cm^3 H_2S gas will produce
= 112 × 2
= 224 cm^3 HCl gas.
Hence, **224 cm^3 HCl gas is produced.**
(ii) 1 mole H_2S gas consumes = 1 mole Cl_2 gas.
Hence, 22.4 L H_2S gas consumes = 22.4 L Cl_2 gas at STP.
∴ 112 cm^3 H_2S gas consumes = 112 cm^3 Cl_2 gas.
120 cm^3 - 112 cm^3 = 8 cm^3 Cl_2 gas remains unreacted.
Hence, **the composition of the resulting mixture is 224 cm^3 HCl gas + 8 cm^3 Cl_2 gas.**

Question 5

1250 cc of oxygen was burnt with 300 cc of ethane [C_2H_6]. Calculate the volume of unused oxygen and the volume of carbon dioxide formed:
$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$

Answer

$$\begin{array}{ccccccc} 2C_2H_6 & + & 7O_2 & \longrightarrow & 4CO_2 & + & 6H_2O \\ 2\text{ vol.} & : & 7\text{ vol.} & \longrightarrow & 4\text{ vol.} & & \end{array}$$

[By Gay Lussac's law]
2 Vol. of C_2H_6 requires 7 Vol. of oxygen
∴ 300 cc C_2H_6 will require $\frac{7}{2}$ x 300
= 1050 cc of Oxygen
Hence, **unused oxygen = 1250 - 1050 = 200 cc**
Similarly,
2 Vol. of C_2H_6 produces 4 Vol. of carbon dioxide
∴ 300 cc C_2H_6 produces $\frac{4}{2}$ x 300
= 600 cc of Carbon dioxide
Hence, **carbon dioxide produced = 600 cc.**

Question 6

What volume of oxygen at STP is required to affect the combustion of 11 litres of ethylene [C_2H_4] at 273°C and 380 mm of Hg pressure?

$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$

Answer

$$\begin{array}{ccccc} C_2H_4 & + & 3O_2 & \longrightarrow & 2CO_2 + 2H_2O \\ 1\text{ vol.} & : & 3\text{ vol.} & & \\ 11\text{ lit} & : & 33\text{ lit} & & \end{array}$$

STP	Given Values
P_1 = 760 mm of Hg	P_2 = 380 mm of Hg
V_1 = x lit	V_2 = 33 lit
T_1 = 273 K	T_2 = 273 + 273 K = 546 K

Using the gas equation,

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

Substituting the values we get,

$$\frac{760 \times x}{273} = \frac{380 \times 33}{546} x = \frac{380 \times 33 \times 273}{546 \times 760} x = \frac{3,423,420}{414,960} x = 8.25 \text{ lit}$$

Hence, **volume of oxygen required = 8.25 lit.**

Question 7

Calculate the volume of HCl gas formed and chlorine gas required when 40 ml of methane reacts completely with chlorine at STP.

$CH_4 + 2Cl_2 \longrightarrow CH_2Cl_2 + 2HCl$

Answer

$$\begin{array}{ccccccc} CH_4 & + & 2Cl_2 & \longrightarrow & CH_2Cl_2 & + & 2HCl \\ 1\text{ vol.} & : & 2\text{ vol.} & \longrightarrow & 1\text{ vol.} & : & 2\text{ vol.} \end{array}$$

volume of HCl gas formed = ?

[By Gay Lussac's law]

1 Vol of methane produces = 2 Vol. HCl

∴ 40 ml of methane produces = 80 ml HCl

volume of chlorine gas required = ?

For 1 Vol of methane = 2V of Cl_2 required

∴ for 40 ml of methane = 40 x 2 = 80 ml of Cl_2 is required.

Hence, **volume of HCl gas formed = 80 ml and chlorine gas required = 80 ml**

Question 8

What volume of propane is burnt for every 500 cm^3 of air used in the reaction under the same conditions? (Assuming oxygen is 1/5th of air)

$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

Answer

Given, oxygen is $1/5^{th}$ of air = $\frac{1}{5}$ of 500 = 100 cm^3

$$\begin{array}{ccccccc} C_3H_8 & + & 5O_2 & \longrightarrow & 3CO_2 & + & 4H_2O \\ 1\text{ vol.} & : & 5\text{ vol.} & \longrightarrow & 3\text{ vol.} & & \end{array}$$

[By Gay Lussac's law]

5 Vol. of O_2 requires 1 Vol. of propane

∴ 100 cm^3 of O_2 will require = $\frac{1}{5}$ x 100 = 20 cm^3

Hence, **propane burnt = 20 cm^3 or 20 cc**

Question 9

450 cm^3 of nitrogen monoxide and 200 cm^3 of oxygen are mixed together and ignited. Calculate the composition of the resulting mixture.

$2NO + O_2 \longrightarrow 2NO_2$

Answer

$$\begin{array}{ccccc} 2NO & + & O_2 & \longrightarrow & 2NO_2 \\ 2 \text{ vol.} & : & 1 \text{ vol.} & \longrightarrow & 2 \text{ vol.} \end{array}$$

[By Gay Lussac's law]

1 Vol. of O_2 reacts with = 2V of NO

200 cm^3 oxygen will react with

= 200 × 2

= 400 cm^3 of NO

∴ remaining NO is 450 - 400 = 50 cm^3

NO_2 = ?

1 Vol. of O_2 produces 2 Vol. of NO_2

∴ 200 cm^3 of oxygen produces = $\frac{2}{1}$ x 200 = 400cm^3

Hence, **NO_2 produced = 400 cm^3 and unused oxygen is 50 cm^3, so total mixture = 400 + 50 = 450 cm^3**

Question 10

If 6 litres of hydrogen and 4 litres of chlorine are mixed and exploded and if water is added to the gases formed, find the volume of the residual gas.

Answer

$$\begin{array}{ccccc} H_2 & + & Cl_2 & \longrightarrow & 2HCl \\ 1 \text{ vol.} & : & 1 \text{ vol.} & \longrightarrow & 2 \text{ vol.} \end{array}$$

[By Gay Lussac's law]

1 Vol. of chlorine reacts with = 1 Vol. of hydrogen

∴ 4 litres of chlorine will react with only 4 litres of hydrogen,

hence, 6 - 4 = 2 litres of hydrogen will remain unreacted.

Since, vol. of HCl gas formed is twice that of chlorine used,

∴ vol.of HCl formed will be 4 x 2 = 8 litres However HCl dissolves in water.

Hence, **2 litres of hydrogen is the residual gas, as HCl formed dissolves in water.**

Question 11

Ammonia may be oxidised to nitrogen monoxide in the presence of a catalyst according to the following equation.

$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$

If 27 litres of reactants are consumed, what volume of nitrogen monoxide is produced at the same temperature and pressure?

Answer

$$\begin{array}{ccccccc} 4NH_3 & + & 5O_2 & \longrightarrow & 4NO & + & 6H_2O \\ 4 \text{ vol.} & : & 5 \text{ vol.} & \longrightarrow & 4 \text{ vol.} & & \end{array}$$

[By Gay Lussac's law]

9 litres of reactants produces = 4 litres of NO

So, 27 litres of reactants will produces

$$= \frac{4}{9} \times 27 = 12 \text{ litres}$$

Hence, **volume of nitrogen monoxide produced = 12 litres**

Question 12

A mixture of hydrogen and chlorine occupying 36 cm^3 was exploded. On shaking it with water, 4 cm^3 of hydrogen was left behind. Find the composition of the mixture.

Answer

According to Gay lussac's law,

$$\begin{array}{ccccc} H_2 & + & Cl_2 & \longrightarrow & 2HCl \\ 1 \text{ vol.} & : & 1 \text{ vol.} & \longrightarrow & 2 \text{ vol.} \end{array}$$

As, 4 cm^3 of hydrogen was left behind, hence, 36 - 4 = 32 cm^3 of mixture of hydrogen and chlorine exploded.

As, 1 Vol. of hydrogen requires 1 Vol. of oxygen

∴ 16 cm^3 hydrogen requires 16 cm^3 of oxygen

∴ Mixture is 20 cm^3 (i.e., 16 + 4) of hydrogen and 16 cm^3 of chlorine.

Question 13

What volume of air (containing 20% O_2 by volume) will be required to burn completely 10 cm^3 each of methane and acetylene?

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

$2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$

Answer

$$\begin{array}{ccccccc} CH_4 & + & 2O_2 & \longrightarrow & CO_2 & + & 2H_2O \\ 1 \text{ vol.} & : & 2 \text{ vol.} & \longrightarrow & 1 \text{ vol.} & & \\ 2C_2H_2 & + & 5O_2 & \longrightarrow & 4CO_2 & + & 2H_2O \\ 2 \text{ vol.} & : & 5 \text{ vol.} & \longrightarrow & 4 \text{ vol.} & & \end{array}$$

[By Gay Lussac's law]

1 Vol. CH_4 requires 2 Vol. of O_2

∴ 10 cm^3 CH_4 will require 2 x 10

= 20 cm^3 of O_2

Given, air contains 20% O_2 by volume.

Let x volume of air contain 20 cm^3 of O_2

$$\Rightarrow \frac{20}{100} \times x = 20 \Rightarrow x = \frac{100}{20} \times 20 \Rightarrow x = 100 \text{ cm}^3$$

∴ 20 cm^3 O_2 is present in **100 cm^3 of air.**

Similarly, 2 Vol C_2H_2 requires 5 Vol. of oxygen

∴ 10 cm^3 C_2H_2 will require $\frac{5}{2}$ x 10

= 25 cm^3 of oxygen

Given, air contains 20% O_2 by volume

Let x volume of air contain 25 cm^3 of O_2

$$\Rightarrow \frac{20}{100} \times x = 25 \Rightarrow x = \frac{100}{20} \times 25 \Rightarrow x = 125 \text{ cm}^3$$

∴ 25 cm^3 O_2 is present in **125 cm^3 of air.**

Hence, total volume of air required is 100 + 125 = 225 cm^3

Question 14

LPG has 60% propane and 40% butane: 10 litres of this mixture is burnt. Calculate the volume of carbon dioxide added to the atmosphere.

$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

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

Answer

Given, 10 litres of this mixture contains 60% propane and 40% butane. Hence, propane is 6 litres and butane is 4 litres

$$\begin{array}{ccccccc} C_3H_8 & + & 5O_2 & \longrightarrow & 3CO_2 & + & 4H_2O \\ 1 \text{ vol.} & : & 5 \text{ vol.} & \longrightarrow & 3 \text{ vol.} & & \\ 2C_4H_{10} & + & 13O_2 & \longrightarrow & 8CO_2 & + & 10H_2O \\ 2 \text{ vol.} & : & 13 \text{ vol.} & \longrightarrow & 8 \text{ vol.} & & \end{array}$$

1 Vol. C_3H_8 produces carbon dioxide = 3 Vol

So, 6 litres C_3H_8 will produce carbon dioxide = 3 x 6 = 18 litres

2 Vol. C_4H_{10} produces carbon dioxide = 8 Vol

So, 4 litres C_4H_{10} will produce carbon dioxide = $\frac{8}{2}$ x 4 = 16 litres

Hence, 34 (i.e., 18 + 16) litres of CO_2 is produced.

Question 15

Water decomposes to O_2 and H_2 under suitable conditions as represented by the equation below:

$2H_2O \longrightarrow 2H_2 + O_2$

(a) If 2500 cm^3 of H_2 is produced, what volume of O_2 is liberated at the same time and under the same conditions of temperature and pressure?

(b) The 2500 cm^3 of H_2 is subjected to $2\frac{1}{2}$ times increase in pressure (temp. remaining constant). What volume will H_2 now occupy?

(c) Taking the value of H_2 calculated in 5(b), what changes must be made in Kelvin (absolute) temperature to return the volume to 2500 cm^3 pressure remaining constant.

Answer

$$\begin{array}{cccc} 2H_2O & \longrightarrow \quad 2H_2 & + & O \\ 2 \text{ Vol.} & 2 \text{ Vol.} & & 1 \text{ Vol.} \end{array}$$

2 Vol. of water gives 2 Vol. of H_2 and 1 Vol. of O_2

∴ If 2500 cm^3 of H_2 is produced, volume of O_2 produced = $\frac{2500}{2}$ = **1250 cm^3**

(b) V_1 = 2500 cm^3

P_1 = 1 atm = 760 mm

$T_1 = T$

$T_2 = T$

$P_2 = [760 \text{ x } 2\frac{1}{2}] + [760] = 760\ [\frac{5}{2} + 1] = 760 \text{ x } \frac{7}{2} = 2660$ mm

V_2 = ?

Using formula:

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

$\frac{760 \times 2500}{T} = 2660 \times \frac{V_2}{T}$

$V_2 = \frac{760 \times 2500}{2660} = \frac{5000}{7}$

(c) $V_1 = \frac{5000}{7} = 714.29$ cm^3

$P_1 = P_2 = P$

$T_1 = T$

V_2 = 2500 cm^3

T_2 = ?

Using formula:

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

$\frac{P \times 714.29}{T} = \frac{P \times 2500}{T_2}$

$T_2 = \frac{2500}{714.29}$ x T

T_2 = 3.5 x T

Hence, **T_2 = 3.5 times T** or **temperature should be increased by 3.5 times**

Question 16

The gases chlorine, nitrogen, ammonia and sulphur dioxide are collected under the same conditions of temperature and pressure. The following table gives the volumes of gases collected and the number of molecules (x) in 20 litres of nitrogen. You are to complete the table giving the number of molecules in the other gases in terms of x.

Gas	Volume (in litres)	Number of molecules
Chlorine	10	
Nitrogen	20	x
Ammonia	20	
Sulphur dioxide	5	

Answer

Gas	Volume (in litres)	Number of molecules
Chlorine	10	x/2
Nitrogen	20	x
Ammonia	20	x
Sulphur dioxide	5	x/4

Reason — According to Avogadro's law, equal volumes of all gases under similar conditions of temperature and pressure contain same number of molecules. If 20 lit of nitrogen contains x molecules then 20 lit of ammonia will also contain x molecules. As volume of chlorine is half that of nitrogen so it will contain half the number of molecules of nitrogen i.e., x/2. Similarly, sulphur dioxide will contain x/4 molecules.

Question 17

(i) If 150 cc of gas A contains X molecules, how many molecules of gas B will be present in 75 cc of B?
The gases A and B are under the same conditions of temperature and pressure.

(ii) Name the law on which the above problem is based

Answer

(a) Given, 150 cc of gas A contains X molecules. According to Avogadro's law, 150 cc of gas B will also contain X molecules.

So, 75 cc of gas B will contain $\frac{x}{2}$ molecules.

(b) The problem is based on Avogadro's law.

Exercise 5B

Question 1

Calculate the relative molecular masses of :

(a) Ammonium chloroplatinate [$(NH_4)_2PtCl_6$]

(b) Potassium chlorate [$KClO_3$]

(c) $CuSO_4.5H_2O$

(d) $(NH_4)_2SO_4$

(e) CH_3COONa

(f) $CHCl_3$

(g) $(NH_4)_2Cr_2O_7$

Answer

(a) $(NH_4)_2PtCl_6$

= (2N) + (8H) + (Pt) + (6Cl)

= (2 x 14) + (8 x 1) + 195 + (6 x 35.5)

= 28 + 8 + 195 + 213

= **444 a.m.u.**

(b) $KClO_3$
= (K) + (Cl) + (3O)
= 39 + 35.5 + (3 x 16)
= 39 + 35.5 + 48
= **122.5 a.m.u.**
(c) $CuSO_4.5H_2O$
= (Cu) + (S) + (4O) + 5(2H + O)
= 63.5 + 32 + (4 x 16) + 5[(2 x 1) + 16]
= 63.5 + 32 + 64 + (5 x 18)
= 63.5 + 32 + 64 + 90
= **249.5 a.m.u.**
(d) $(NH_4)_2SO_4$
= (2N) + (8H) + (S) + (4O)
= (2 x 14) + (8 x 1) + 32 + (4 x 16)
= 28 + 8 + 32 + 64
= **132 a.m.u.**
(e) CH_3COONa
= (C) + (3H) + (C) + (2O) + (Na)
= 12 + (3 x 1) + 12 + (2 x 16) + 23
= 12 + 3 + 12 + 32 + 23
= **82 a.m.u.**
(f) $CHCl_3$
= (C) + (H) + (3Cl)
= 12 + 1 + (3 x 35.5)
= 12 + 1 + 106.5
= **119.5 a.m.u.**
(g) $(NH_4)_2Cr_2O_7$
= (2N) + (8H) + (2Cr) + (7O)
= (2 x 14) + (8 x 1) + (2 x 51.9) + (7 x 16)
= 28 + 8 + 103.8 + 112
= 251.8 ≈ **252 a.m.u.**

Question 2

Find the:
(a) number of molecules in 73 g of HCl,
(b) weight of 0.5 mole of O_2,
(c) number of molecules in 1.8 g of H_2O,
(d) number of moles in 10 g of $CaCO_3$,
(e) weight of 0.2 mole of H_2 gas,
(f) number of molecules in 3.2 g of SO_2.

Answer

(a) Number of molecules in 73 g of HCl —
Molecular wt. of any substance contain 6.022×10^{23} molecules.
Mass of 1 mole of HCl is 1 + 35.5 = 36.5 g
36.5 g of HCl contains 6.022×10^{23} molecules
∴ 73 g of HCl contains $\frac{6.022\times10^{23}\times73}{36.5}$
= **1.2×10^{24} molecules**
(b) Weight of 0.5 mole of O_2 —
1 mole of O_2 weighs = 2O = 2 x 16 = 32 g

∴ 0.5 moles will weigh = $\frac{32}{2}$ = **16 g**

(c) Number of molecules in 1.8 g of H_2O —

Molecular wt. of any substance contains 6.022×10^{23} molecules.

Mass of 1 mole of H_2O is (2 x 1) + 16 = 2 + 16 = 18 g

18 g of H_2O contains 6.022×10^{23} molecules

∴ 1.8 g of H_2O contains $\frac{6.022 \times 10^{23} \times 1.8}{18}$

= **6.02×10^{22} molecules**

(d) Number of moles in 10 g of $CaCO_3$ —

Mass of 1 mole of $CaCO_3$ = 40 + 12 + 3(16) = 52 + 48 = 100 g

100 g of $CaCO_3$ = 1 mole

∴ 10 g of $CaCO_3$ = $\frac{1 \times 10}{100}$

= **0.1 mole**

(e) Weight of 0.2 mole H_2 gas —

1 mole of H_2 weighs = 2 g

∴ 0.2 moles will weigh = $\frac{2 \times 0.2}{1}$ = **0.4 g**

(f) No. of molecules in 3.2 g of SO_2 —

Molecular wt. of any substance contain 6×10^{23} molecules.

Mass of 1 mole of SO_2 is 32 + 2(16) = 32 + 32 = 64 g

64 g of SO_2 contains 6×10^{23} molecules

∴ 3.2 g of SO_2 contains $\frac{6 \times 10^{23} \times 3.2}{64}$

= **3 x 10^{22} molecules.**

Question 3

Which of the following would weigh most?

(a) 1 mole of H_2O

(b) 1 mole of CO_2

(c) 1 mole of NH_3

(d) 1 mole of CO

Answer

1 mole of CO_2

Reason —

Weight of H_2O = 2 + 16 = 18 g

Weight of CO_2 = 12 + (2 x 16) = 12 + 32 = 44 g

Weight of NH_3 = 14 + (3 x 1) = 14 + 3 = 17 g

Weight of CO = 12 + 16 = 28 g

As weight of CO_2 is maximum, hence 1 mole of CO_2 will weigh the most.

Question 4

Which of the following contains the maximum number of molecules?

(a) 4 g of O_2

(b) 4 g of NH_3

(c) 4 g of CO_2

(d) 4 g of SO_2

Answer

4 g of NH_3

Reason —

(a) No. of molecules in 4 g of O_2

Molecular wt. of any substance contain 6.022×10^{23} molecules.

Mass of 1 mole of O_2 is 2(16) = 32 g
32 g of O_2 contains 6.022×10^{23} molecules
∴ 4 g of O_2 contains $\frac{6.022\times10^{23}\times4}{32}$
= 7.5×10^{22} molecules.
Similarly,
(b) 4 g of NH_3 [14 + 3 = 17g] contains $\frac{6.022\times10^{23}\times4}{17}$
(c) 4 g of CO [12 + 16 = 28g] contains $\frac{6.022\times10^{23}\times4}{28}$
(d) 4 g of SO_2 [32 + 32 = 64g] contains $\frac{6.022\times10^{23}\times4}{64}$
∴ 4g of NH_3 having minimum molecular mass contains maximum molecules.
Note : The fraction with lowest denominator gives the highest value. Hence, by observation we can say that 4 g of NH_3 has maximum number of molecules.

Question 5(a)
Calculate the number of particles in 0.1 mole of any substance.
Answer
No. of particles in 1 mole = 6.022×10^{23}
∴ No. of particles in 0.1 mole = $\frac{6.022\times10^{23}\times0.1}{1}$
= **6.022×10^{22}**

Question 5(b)
Calculate the number of hydrogen atoms in 0.1 mole of H_2SO_4.
Answer
1 mole of H_2SO_4 contains ($2 \times 6.022 \times 10^{23}$) hydrogen atoms
∴ 0.1 mole of H_2SO_4 contains = $\frac{6.022\times10^{23}\times2\times0.1}{1}$
= **1.2×10^{23}** atoms of hydrogen

Question 5(c)
Calculate the number of molecules in one kg of calcium chloride.
Answer
Mass of 1 mole of $CaCl_2$ = Ca + 2Cl = 40 + (2 x 35.5) = 40 + 71 = 111 g
111 g of $CaCl_2$ contains 6.022×10^{23} molecules
∴ 1000 g of $CaCl_2$ contains $\frac{6.022\times10^{23}\times1000}{111}$
= **5.42×10^{24}** molecules

Question 6(a)
How many grams of Al are present in 0.2 mole of it?
Answer
1 mole of aluminium has mass = 27 g
0.2 mole of aluminium has mass
= $\frac{27}{1}$ x 0.2
= **5.4 g**

Question 6(b)
How many grams of HCl are present in 0.1 mole of it?
Answer
1 mole of HCl has mass = 1 + 35.5 = 36.5 g
0.1 mole of HCl has mass
= $\frac{36.5}{1}$ x 0.1

= **3.65 g**

Question 6(c)

How many grams of H_2O are present in 0.2 mole of it?

Answer

1 mole of H_2O has mass = 2(1) + 16 = 2 + 16 = 18 g

0.2 mole of H_2O has mass

$= \frac{18}{1} \times 0.2$

= **3.6 g**

Question 6(d)

How many grams of CO_2 is present in 0.1 mole of it?

Answer

1 mole of CO_2 has mass = 12 + 2(16) = 12 + 32 = 44 g

0.1 mole of CO_2 has mass

$= \frac{44}{1} \times 0.1$

= **4.4 g**

Question 7(a)

The mass of 5.6 litres of a certain gas at S.T.P. is 12 g. What is the relative molecular mass or molar mass of the gas?

Answer

5.6 litres of gas at S.T.P. has mass = 12 g

∴ 22.4 litre (molar volume) has mass

$= \frac{12}{5.6} \times 22.4$

= **48 g**

Question 7(b)

Calculate the volume occupied at S.T.P. by 2 moles of SO_2.

Answer

1 mole of SO_2 has volume = 22.4 litres

∴ 2 moles will have = 22.4 × 2 = **44.8 litre**

Question 8(a)

Calculate the number of moles of CO_2 which contain 8.00 g of O_2

Answer

Oxygen in 1 mole of CO_2 = 2O = (2 x 16) = 32 g

or we can say, 32 g of oxygen is present in 1 mole of CO_2

∴ 8 gm of O_2 is present in $\frac{1}{32} \times 8$

= **0.25 moles**

Question 8(b)

Calculate the number of moles of methane in 0.80 g of methane.

Answer

Molar mass of methane (CH_4) = C + 4H = 12 + 4 = 16 g

16 g of methane = 1 mole

∴ 0.80 g of methane = $\frac{1}{16} \times 0.80$

= **0.05 moles**

Question 9

Calculate the weight/mass of :

(a) an atom of oxygen

(b) an atom of hydrogen

(c) a molecule of NH_3

(d) 10^{22} atoms of carbon
(e) the molecule of oxygen
(f) 0.25 gram atom of calcium

Answer

(a) Number of oxygen atoms in 16 g of atomic oxygen = 6.022×10^{23} atoms
∴ mass of 1 atom of oxygen
$= \frac{16}{6.022\times10^{23}}$
= 2.657×10^{-23} g

(b) Number of hydrogen atoms in 1 g of atomic hydrogen = 6.022×10^{23} atoms
∴ Mass of 1 atom of hydrogen
$= \frac{1}{6.022\times10^{23}}$
= 1.666×10^{-24} g

(c) Gram molecular mass of NH_3 = 14 + 3 = 17 g
Number of NH_3 molecules in 17 g of NH_3 = 6.022×10^{23} molecules
Mass of 6.022×10^{23} molecules of NH_3 = 17g
∴ Mass of 1 molecule of $NH_3 = \frac{17}{6.022\times10^{23}}$
= 2.823×10^{-23} g

(d) Mass of 6.022×10^{23} atoms of atomic carbon = 12 g
∴ Mass of 10^{22} atoms of carbon $= \frac{12}{6.022\times10^{23}} \times 10^{22}$
= 0.2 g

(e) Gram molecular mass of oxygen (O_2) = 2 x 16 = 32 g
Mass of 6.022×10^{23} molecules of O_2 = 32 g
∴ Mass of 1 molecule of $O_2 = \frac{32}{6.022\times10^{23}}$
= 5.314×10^{-23} g

(f) Atomic weight of calcium = 40 g
Gram atom $= \frac{\text{Mass of element}}{\text{Atomic mass}}$
Therefore, $0.25 = \frac{\text{Mass of calcium}}{40}$
Mass of calcium = 40 x 0.25 = **10 g**

Question 10

Calculate the mass of 0.1 mole of each of the following
(a) $CaCO_3$
(b) $Na_2SO_4.10H_2O$
(c) $CaCl_2$
(d) Mg
(Ca = 40, Na = 23, Mg =24, S = 32, C = 12, Cl = 35.5, O = 16, H = 1)

Answer

(a) Mass of 1 mole of $CaCO_3$
= Ca + C + 3O = 40 + 12 + (3 x 16) = 52 + 48 = 100 g
∴ Mass of 0.1 mole of $CaCO_3$ = 0.1 x 100 = **10 g**

(b) Mass of 1 mole of $Na_2SO_4.10H_2O$
= 2Na + S + 4O + 10(2H + O) = (2 x 23) + 32 + (4 x 16) + 10(2 + 16) = 46 + 32 + 64 + 180 = 322 g
∴ Mass of 0.1 mole of $Na_2SO_4.10H_2O$ = 0.1 x 322 = **32.2 g**

(c) Mass of 1 mole of $CaCl_2$
= Ca + 2Cl = 40 + (2 x 35.5) = 40 + 71 = 111 g
∴ Mass of 0.1 mole of $CaCl_2$ = 0.1 x 111 = **11.1 g**

(d) Mass of 1 mole of Mg = 24 g
∴ Mass of 0.1 mole of Mg = 24 x 0.1 = **2.4 g**

Question 11(a)

Calculate the number of oxygen atoms in 0.10 mole of $Na_2CO_3.10H_2O$.

Answer

1 molecule of $Na_2CO_3.10H_2O$ contains 13 atoms of oxygen
∴ 6.022×10^{23} molecules (ie., 1 mole) has $13 \times 6.022 \times 10^{23}$ atoms
∴ 0.1 mole will have atoms = $0.1 \times 13 \times 6.022 \times 10^{23}$
= **7.8×10^{23} atoms**

Question 11(b)

Calculate the number of gram atoms in 4.6 gram of sodium.

Answer

Atomic mass of Na = 23
23 g of sodium = 1 gram atom of sodium
∴ 4.6 gram of sodium = $\frac{4.6}{23}$
= **0.2 gram atom of sodium**

Question 11(c)

Calculate the number of moles in 12 g of oxygen gas.

Answer

32 g of oxygen = 1 mole
∴ 12 g of oxygen = $\frac{12}{32} = \frac{3}{8}$
= **0.375 mole**

Question 12

What mass of Ca will contain the same number of atoms as are present in 3.2 g of S?

Answer

1 mole of Sulphur weighs 32 g and contains 6.02×10^{23} atoms
∴ 3.2 g of Sulphur will contain = $\frac{6.02\times10^{23}}{32} \times 3.2$
= 6.02×10^{22} atoms.
6.02×10^{23} atoms of Ca weighs = 40 g
∴ 6.02×10^{22} atoms of Ca will weigh = $\frac{40}{6.02\times10^{23}} \times 6.02 \times 10^{22}$ = **4 g**.

Question 13

Calculate the number of atoms in each of the following:
(a) 52 moles of He
(b) 52 amu of He
(c) 52 g of He

Answer

(a) No. of atoms = Moles x 6.022×10^{23}
= $52 \times 6.022 \times 10^{23}$ = **3.131×10^{25} atoms**
(b) 4 amu = 1 atom of He
∴ 52 amu = $\frac{52}{4}$ = **13 atoms of He**
(c) Mass of 1 mole of He is 4 g
4 g of He contains 6.022×10^{23} atoms
∴ 52 g of He contains $\frac{6.022\times10^{23}}{4} \times 52$
= **7.828×10^{24} atoms**

Question 14

Calculate the number of atoms of each kind in 5.3 grams of sodium carbonate.

Answer

Molecular mass of Na_2CO_3 = 2Na + C + 3O = (2 x 23) + 12 + (3 x 16) = 46 + 12 + 48 = 106 g

(i) 106 g of Na_2CO_3 has = 2 × 6.022 × 10^{23} atoms of Na

∴ 5.3 g of Na_2CO_3 will have = $\frac{2\times6.022\times10^{23}\times5.3}{106}$ = **6.022 × 10^{22} atoms of Na**

(ii) 106 g of Na_2CO_3 has = 6.022 × 10^{23} atoms of carbon

∴ 5.3 g of Na_2CO_3 will have = $\frac{6.022\times10^{23}\times5.3}{106}$ = **3.01 × 10^{22} atoms of carbon**

(iii) 106 g of Na_2CO_3 has 3 x 6.022 × 10^{23} atoms of oxygen

∴ 5.3 g of Na_2CO_3 will have = $\frac{3\times6.022\times10^{23}\times5.3}{106}$ = **9.03 × 10^{22} atoms of oxygen**

Question 15(a)

Calculate the mass of nitrogen supplied to soil by 5 kg of urea [$CO(NH_2)_2$]

[O = 16; N = 14; C = 12 ; H = 1]

Answer

Molar mass of urea [$CO(NH_2)_2$] = 12 + 16 + 2(14 + (2 x 1))

= 28 + 2(16)

= 28 + 32

= 60 g

Molar mass of nitrogen = 2 x 14 = 28 g

60 g urea has mass of nitrogen = 28 g

∴ 5000 g urea will have mass

= $\frac{28\times5000}{60}$

= 2333 g = **2.33 kg**

Question 15(b)

Calculate the volume occupied by 320 g of sulphur dioxide at S.T.P.

[S = 32; O = 16]

Answer

Molar mass of sulphur dioxide (SO_2) = S + 2O = 32 + (2 x 16) = 32 + 32 = 64 g

64 g of sulphur dioxide has volume = 22.4 litre

∴ 320 g of sulphur dioxide will have volume = $\frac{22.4\times320}{64}$

= **112 litres**

Question 16

(a) What do you understand by the statement that 'vapour density of carbon dioxide is 22'?

(b) Atomic mass of Chlorine is 35.5. What is it's vapour density?

Answer

(a) Vapour density of carbon dioxide is 22 implies that 1 molecule of carbon dioxide is 22 times heavier than 1 molecule of hydrogen.

(b) Vapour density = $\frac{\text{Molecular mass}}{2}$

Molecular mass of chlorine Cl_2 = 2Cl = 2 x 35.5 = 71 g

Substituting in formula;

Vapour density = $\frac{71}{2}$ = 35.5

Hence, vapour density of Chlorine atom is **35.5**

Question 17

What is the mass of 56 cm^3 of carbon monoxide at S.T.P.?

(C = 12, O = 16)

Answer

22400 cm^3 of CO has mass = 12 + 16 = 28 g

∴ 56 cm^3 will have mass = $\frac{28}{22400}$ x 56 = **0.07 g**

Question 18

Determine the number of molecules in a drop of water which weighs 0.09 g.

Answer

Molecular wt. of any substance contain 6.022×10^{23} molecules.

Mass of 1 mole of water is 2H + O = 2 + 16 = 18 g

18 g of H_2O contains 6.022×10^{23} molecules

∴ 0.09 g of H_2O contains $\frac{6.022 \times 10^{23} \times 0.09}{18}$

= **3.01×10^{21} molecules**

Question 19

The molecular formula for elemental sulphur is S_8. In a sample of 5.12 g of sulphur:

(a) How many moles of sulphur are present?

(b) How many molecules and atoms are present?

Answer

(a) Mass of 1 mole of S_8 = 8S = 8 x 32 = 256 g

∴ Moles in 5.12 g of sulphur = $\frac{5.12}{256}$ = **0.02 moles**

(b) 1 mole = 6.022×10^{23} molecules

∴ 0.02 moles will have = $0.02 \times 6.022 \times 10^{23}$

= $1.2044 \times 10^{22} \approx$ **1.2×10^{22} molecules**

No. of atoms in 1 molecule of S_8 = 8

∴ No. of atoms in 1.2044×10^{22} molecules = 1.2044 x $10^{22} \times 8$

= **9.635×10^{22} molecules**

Question 20

If phosphorus is considered to contain P_4 molecules, then calculate the number of moles in 100 g of phosphorus?

Answer

Mass of 1 mole of P_4 = 4P = 4 x 31 = 124 g

124 g of phosphorus (P_4) = 1 mole

∴ 100 g of phosphorus (P_4) = $\frac{1}{124}$ x 100 = **0.806 moles**

Question 21

Calculate:

(a) The gram molecular mass of chlorine if 308 cm^3 of it at S.T.P. weighs 0.979 g

(b) The volume of 4 g of H_2 at 4 atmospheres.

(c) The mass of oxygen in 2.2 litres of CO_2 at S.T.P.

Answer

(a) The mass of 22.4 L of a gas at S.T.P. is equal to it's gram molecular mass.

308 cm^3 of chlorine weighs 0.979 g

∴ 22,400 cm^3 of chlorine will weigh

= $\frac{0.979}{308} \times 22400$ = 71.2 g

(b) Molar mass of H_2 = 2H = 2 x 1 = 2 g

2g H_2 at 1 atm has volume = 22.4 dm^3

∴ 4 g H_2 at 1 atm will have volume 2 x 22.4 = 44.8 dm^3

Now, For 4 g H_2

P_1 = 1 atm, V_1 = 44.8 dm^3

P_2 = 4 atm, V_2 = ?

Using formula $P_1V_1 = P_2V_2$

$$V_2 = \frac{P_1 V_1}{P_2} V_2 = \frac{1 \times 44.8}{4} = \mathbf{11.2\ d} \qquad \mathbf{m^3}$$

(c) Molar mass of oxygen in carbon dioxide = 2O = 2 x 16 = 32 g

Mass of oxygen in 22.4 litres of CO_2 = 32 g

∴ Mass of oxygen in 2.2 litres of CO_2

= $\frac{32}{22.4}$ x 2.2 = **3.14 g**

Question 22

A student puts his signature with graphite pencil. If the mass of carbon in the signature is 10^{-12} g, calculate the number of carbon atoms in the signature.

Answer

No. of atoms in 12 g C = 6.022×10^{23}

∴ no. of carbon atoms in 10^{-12} g

$\frac{6.022 \times 10^{23}}{12}$ x 10^{-12}

= **5.019×10^{10} atoms**

Question 23

An unknown gas shows a density of 3 g per litre at 273°C and 1140 mm Hg pressure. What is the gram molecular mass of this gas?

Answer

Given:

P = 1140 mm Hg

Density = D = 3 g per L

T = 273 °C = 273 + 273 = 546 K

gram molecular mass = ?

At S.T.P., the volume of one mole of any gas is 22.4 L

Volume of unknown gas at S.T.P. = ?

By Charle's law.

V_1 = 1 L

T_1 = 546 K

T_2 = 273 K

V_2 = ?

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Hence, $V_2 = \frac{1}{546}$ x 273 = **0.5 L**

Volume at standard pressure = ?

Apply Boyle's law.

P_1 = 1140 mm Hg

V_1 = 0.5 L

P_2 = 760 mm Hg

V_2 = ?

$P_1 \times V_1 = P_2 \times V_2$

$V_2 = \frac{1140 \times 0.5}{760}$ = 0.75 L

Now,

22.4 L = 1 mole of any gas at S.T.P.,

then 0.75 L = $\frac{0.75}{22.4}$

= 0.0335 moles

The original mass is 3 g

Molecular mass = $\frac{\text{Mass of compound}}{\text{Moles of compound}}$

= $\frac{3}{0.0335}$ = 89.55 ≈ 89.6 g per mole

Hence, the gram molecular mass of the unknown gas is **89.6g**

Question 24

Cost of Sugar ($C_{12}H_{22}O_{11}$) is ₹40 per kg; calculate it's cost per mole.

Answer

Molar mass of $C_{12}H_{22}O_{11}$ = 12C + 22H + 11O = (12 x 12) + (22 x 1) + (11 x 16) = 144 + 22 + 176 = 342 g

1000 g of sugar costs = ₹40

∴ 342 g of sugar will cost = $\frac{40}{1000}$ x 342 = **₹13.68 per mole**

Question 25

Calculate the number of molecules in one kg of NaOH.

Answer

Mass of 1 mole of NaOH = Na + O + H = 23 + 16 + 1 = 40 g

40 g of NaOH contains 6.022×10^{23} molecules

∴ 1000 g of NaOH contains = $\frac{6.022 \times 10^{23} \times 1000}{40}$

= 1.5×10^{25} molecules

Question 26

Calculate the number of atoms present in :

(a) 10 g of Chlorine

(b) 10 g of Nitrogen

Answer

(a) Mass of 1 mole of chlorine (Cl) is 35.5 g

35.5 g of chlorine (Cl) contains 6.022×10^{23} atoms

∴ 10g of chlorine (Cl) contains = $\frac{6.022 \times 10^{23} \times 10}{35.5}$

= 1.7 x 10^{23} atoms

(b) Mass of 1 mole of nitrogen (N) is 14 g

14 g of nitrogen (N) contains 6.022×10^{23} atoms

∴ 10g of nitrogen (N) contains = $\frac{6.022 \times 10^{23} \times 10}{14}$

= 4.3 x 10^{23} atoms

Question 27

Correct the following:

(a) Equal volumes of any gas, under similar conditions, contain an equal number of atoms.

(b) 22 g of CO_2, occupies 22.4 litres at STP.

(c) The unit of atomic weight is grams.

Answer

(a) Equal volumes of any gas, under similar conditions, contain an equal number of ***molecules***.

(b) ***44*** g of CO_2, occupies 22.4 litres at STP.

(c) The unit of atomic weight is ***atomic mass unit (a.m.u)***.

Exercise 5C

Question 1

Give the empirical formula of:

(a) C_6H_6

(b) $C_6H_{18}O_3$

(c) C_2H_2

(d) CH_3COOH

Answer

(a) Molecular formula is C_6H_6

∴ Ratio of C and H is 6 : 6

Simple ratio is 1 : 1

Hence, empirical formula = **CH**

(b) Molecular formula is $C_6H_{18}O_3$

∴ Ratio of C, H and O is 6 : 18 : 3

Simple ratio is 2 : 6 : 1

Hence, empirical formula = **C_2H_6O**

(c) Molecular formula is C_2H_2

∴ Ratio of C and H is 2 : 2

Simple ratio is 1 : 1

Hence, empirical formula = **CH**

(d) Molecular formula is CH_3COOH i.e. $C_2H_4O_2$

∴ Ratio of C, H and O is 2 : 4 : 2

Simple ratio is 1 : 2 : 1

Hence, empirical formula = **CH_2O**

Question 2

Find the percentage of water of crystallisation in $CuSO_4.5H_2O$. (At. Mass Cu = 64, H = 1, O = 16, S = 32)

Answer

Relative molecular mass of $CuSO_4.5H_2O$

= 64 + 32 + (4×16) + [5(2+16)]

= 96 + 64 + 90 = 250

250 g of $CuSO_4.5H_2O$ contains 90 g of water of crystallisation

∴ 100 g of $CuSO_4.5H_2O$ contains

= $\frac{90}{250}$ x 100 = **36%**

Question 3

Calculate the percentage of phosphorus in

(a) Calcium hydrogen phosphate $Ca(H_2PO_4)_2$

(b) Calcium phosphate $Ca_3(PO_4)_2$

Answer

(a) Molecular mass of $Ca(H_2PO_4)_2$

= Ca + 2[2H + P + 4O]

= 40 + 2[2(1) + 31 + 4(16)]

= 40 + 2[2 + 31 + 64]

= 40 + 194

= 234

234 g of $Ca(H_2PO_4)_2$ contains 62 g of P

∴ 100 g of $Ca(H_2PO_4)_2$ contains

= $\frac{62}{234}$ x 100 = **26.5%**

(b) Molecular mass of $Ca_3(PO_4)_2$

= 3Ca + 2[P + 4O]

= (3 x 40) + 2[31 + 4(16)]

= 120 + 2[31 + 64]

= 120 + 190

= 310

310 g of $Ca_3(PO_4)_2$ contains 62 g of P

∴ 100 g of $Ca_3(PO_4)_2$ contains

$= \frac{62}{310}$ x 100 = **20 %**

Question 4

Calculate the percent composition of Potassium chlorate $KClO_3$.

Answer

Molecular mass of $KClO_3$

= K + Cl + 3O

= 39 + 35.5 + (3 x 16)

= 39 + 35.5 + 48

= 122.5 g

% of K = ?

Since, 122.5 g of $KClO_3$ contains 39 g of K

∴ 100 g of $KClO_3$ contains

$= \frac{39}{122.5}$ x 100

= 31.83%

Similarly, 122.5 g of $KClO_3$ contains 35.5 g of Cl

∴ 100 g of $KClO_3$ contains

$= \frac{35.5}{122.5}$ x 100

= 28.98%

And, 122.5 g of $KClO_3$ contains 48 g of O

∴ 100 g of $KClO_3$ contains

$= \frac{48}{122.5}$ x 100

= 39.18%

Question 5

Find the empirical formula of the compounds with the following percentage composition:

Pb = 62.5%, N = 8.5%, O = 29.0%

Answer

Element	% composition	At. mass	Relative no. of atoms	Simplest ratio
Pb	62.5	207	$\frac{62.5}{207}$ = 0.301	$\frac{0.301}{0.301}$ = 1
N	8.5	14	$\frac{8.5}{14}$ = 0.607	$\frac{0.607}{0.301}$ = 2
O	29	16	$\frac{29}{16}$ = 1.81	$\frac{1.81}{0.301}$ = 6

Hence, Simplest ratio of whole numbers = Pb : N : O = 1 : 2 : 6

Hence, **empirical formula is $Pb(NO_3)_2$**.

Question 6

Calculate the mass of iron in 10 kg of iron ore which contains 80% of pure ferric oxide.

Answer

Atomic wt. of Fe = 56 and O = 16

Molecular mass of Fe_2O_3 = 2Fe + 3O

=(2 x 56) + (3 x 16)

= 112 + 48

= 160 g

Iron present in 80% of Fe_2O_3 = $\frac{112}{160}$ x 80

= 56 g

∴ Mass of iron in 100 g of iron ore = 56 g

Hence, mass of iron present in 10 kg (i.e., 10,000 g) of iron ore = $\frac{56}{100}$ x 10000

= 5600 g = **5.6 kg**

Question 7

If the empirical formula of two compounds is CH and their Vapour densities are 13 to 39 respectively, find their molecular formula.

Answer

Empirical formula is CH

Empirical formula weight = 12 + 1 = 13

Vapour density (V.D.) = 13

Molecular weight = 2 x V.D. = 2 x 13

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{2 \times 13}{13} = 2$$

∴ Molecular formula = n[E.F.] = 2[CH] = $\mathbf{C_2H_2}$

Similarly,

Empirical formula is CH

Empirical formula weight = 12 + 1 = 13

Vapour density (V.D.) = 39

Molecular weight = 2 x V.D. = 2 x 39

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{2 \times 39}{13} = 6$$

∴ Molecular formula = n[E.F.] = 6[CH] = $\mathbf{C_6H_6}$

Question 8

Find the empirical formula of a compound containing 17.64% hydrogen and 82.35% nitrogen.

Answer

Element	**% composition**	**At. wt.**	**Relative no. of atoms**	**Simplest ratio**
Nitrogen	82.35	14	$\frac{82.35}{14} = 5.88$	$\frac{5.88}{5.88} = 1$
Hydrogen	17.64	1	$\frac{17.64}{1} = 17.64$	$\frac{17.64}{5.88} = 3$

Simplest ratio of whole numbers = N : H = 1 : 3

Hence, **empirical formula is NH_3**

Question 9

On analysis, a substance was found to contain

C = 54.54%, H = 9.09%, O = 36.36%

The vapour density of the substance is 44, calculate;

(a) it's empirical formula, and

(b) it's molecular formula

Answer

Element	**% composition**	**At. wt.**	**Relative no. of atoms**	**Simplest ratio**
Carbon	54.54	12	$\frac{54.54}{12} = 4.545$	$\frac{4.545}{2.275} = 1.99 = 2$

Element	% composition	At. wt.	Relative no. of atoms	Simplest ratio
Hydrogen	9.09	1	$\frac{9.09}{1} = 9.09$	$\frac{9.09}{2.275} = 3.99 = 4$
Oxygen	36.36	16	$\frac{36.36}{16} = 2.275$	$\frac{2.275}{2.275} = 1$

Simplest ratio of whole numbers = C : H : O = 2 : 4 : 1
Hence, **empirical formula is C_2H_4O**
Empirical formula weight = 2(12) + 4(1) + 16 = 24 + 4 + 16 = 44
V.D. = 44
Molecular weight = 2 x V.D. = 2 x 44 = 88

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{88}{44} = 2$$

So, molecular formula = $(C_2H_4O)_2 = C_4H_8O_2$

Question 10

An organic compound, whose vapour density is 45, has the following percentage composition
H = 2.22%, O = 71.19% and remaining carbon.
Calculate,
(a) it's empirical formula, and
(b) it's molecular formula

Answer

Element	% composition	At. wt.	Relative no. of atoms	Simplest ratio
Hydrogen	2.22	1	$\frac{2.22}{1} = 2.22$	$\frac{2.22}{2.21} = 1$
Oxygen	71.19	16	$\frac{71.19}{16} = 4.44$	$\frac{4.44}{2.21} = 2$
Carbon	26.59	12	$\frac{26.59}{12} = 2.21$	$\frac{2.21}{2.21} = 1$

Simplest ratio of whole numbers = H : O : C = 1 : 2 : 1
Hence, **empirical formula is CHO_2**
Empirical formula weight = 12 + 1 + (2 x 16) = 13 + 32 = 45
V.D. = 45
Molecular weight = 2 x V.D. = 2 x 45 = 90

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{90}{45} = 2$$

So, molecular formula = $2(CHO_2)$ = **$C_2H_2O_4$**

Question 11

An organic compound contains 4.07% hydrogen, 71.65% chlorine and remaining carbon. Its molar mass is 98.96. Find its,
(a) Empirical formula
(b) Molecular formula

Answer

Element	% composition	At. wt.	Relative no. of atoms	Simplest ratio
Hydrogen	4.07	1	$\frac{4.07}{1} = 4.07$	$\frac{4.07}{2.01} = 2$

Element	% composition	At. wt.	Relative no. of atoms	Simplest ratio
chlorine	71.65	35.5	$\frac{71.65}{35.5} = 2.01$	$\frac{2.01}{2.01} = 1$
Carbon	24.28	12	$\frac{24.28}{12} = 2.02$	$\frac{2.02}{2.01} = 1$

Simplest ratio of whole numbers = H : Cl : C = 2 : 1 : 1

Hence, **empirical formula is CH_2Cl**

Empirical formula weight = 12 + (2 x 1) + 35.5 = 49.5

molar mass = 98.96

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{98.96}{49.5} = 1.99 = 2$$

So, molecular formula = $2(CH_2Cl)$ = **$C_2H_4Cl_2$**

Question 12

A hydrocarbon contains 4.8 g of carbon per gram of hydrogen. Calculate

(a) the gram atom of each

(b) find the empirical formula

(c) find molecular formula, if it's vapour density is 29.

Answer

(a) Given, hydrocarbon contains 4.8 g of carbon per gram of hydrogen

Gram atom = $\frac{\text{Mass of element}}{\text{Atomic mass}}$

∴ g atom of carbon = $\frac{4.8}{12}$ = **0.4** and

g atom of hydrogen = $\frac{1}{1}$ = **1**

(b)

Element	Mass	At. wt.	Gram atoms	Simplest ratio
Hydrogen	1	1	$\frac{1}{1} = 1$	$\frac{1}{0.4} = \frac{5}{2}$
Carbon	4.8	12	$\frac{4.8}{12} = 0.4$	$\frac{0.4}{0.4} = 1$

Simplest ratio of whole numbers = H : C = $\frac{5}{2}$: 1 = 5 : 2

Hence, **empirical formula is C_2H_5**

(c) Empirical formula weight = (2 x 12) + (5 x 1) = 24 + 5 = 29

V.D. = 29

Molecular weight = 2 x V.D. = 2 x 29 = 58

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{58}{29} = 2$$

So, molecular formula = $2(C_2H_5)$ = **C_4H_{10}**

Question 13

0.2 g atom of silicon combine with 21.3 g of chlorine. Find the empirical formula of the compound formed.

Answer

Gram atom = $\frac{\text{Mass of element}}{\text{Atomic mass}}$

g atom of silicon = 0.2 = $\frac{\text{Mass of silicon}}{28}$

∴ Mass of silicon = **5.6 g** and

Mass of chlorine = **21.3 g**

Element	Mass	At. wt.	gram atoms	Simplest ratio
Silicon	5.6	28	$\frac{5.6}{28} = 0.2$	$\frac{0.2}{0.2} = 1$
Chlorine	21.3	35.5	$\frac{21.3}{35.5} = 0.6$	$\frac{0.6}{0.2} = 3$

Simplest ratio of whole numbers = Si : Cl = 1 : 3

Hence, **empirical formula is $SiCl_3$**

Question 14

A gaseous hydrocarbon contains 82.76% of carbon. Given that it's vapour density is 29, find it's molecular formula.

Answer

Element	% composition	At. wt.	Relative no. of atoms	Simplest ratio
Carbon	82.76	12	$\frac{82.76}{12} = 6.89$	$\frac{6.89}{6.89} = 1$
Hydrogen	17.24	1	$\frac{17.24}{1} = 17.24$	$\frac{17.24}{6.89} = \frac{5}{2}$

Simplest ratio of whole numbers = C : H = 1 : $\frac{5}{2}$ = 2 : 5

Hence, **empirical formula is C_2H_5**

Empirical formula weight = 2(12) + 5(1) = 29

V.D. = 29

Molecular weight = 2 x V.D. = 2 x 29

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{2 \times 29}{29} = 2$$

∴ Molecular formula = n[E.F.] = 2[C_2H_5] = **C_4H_{10}**

Question 15

In a compound of magnesium (Mg = 24) and nitrogen (N = 14), 18 g of magnesium combines with 7g of nitrogen. Deduce the simplest formula by answering the following questions.

(a) How many gram-atoms of magnesium are equal to 18g?

(b) How many gram-atoms of nitrogen are equal to 7g of nitrogen?

(c) Calculate simple ratio of gram-atoms of magnesium to gram-atoms of nitrogen and hence the simplest formula of the compound formed.

Answer

(a) Gram atom = $\frac{\text{Mass of element}}{\text{Atomic mass}}$

∴ g atom of magnesium = $\frac{18}{24} = \frac{3}{4}$

Hence, $\frac{3}{4}$ gram atoms of magnesium are equal to 18g of magnesium.

(b) g atom of nitrogen = $\frac{7}{14} = \frac{1}{2}$

Hence, $\frac{1}{2}$ gram atoms of nitrogen are equal to 7g of nitrogen.

(c) simple ratio of gram-atoms of magnesium to gram-atoms of nitrogen

$= \frac{\frac{3}{4}}{\frac{1}{2}} = \frac{3}{2}$ = magnesium : nitrogen

So, the formula is **Mg_3N_2**

Question 16

Barium chloride crystals contain 14.8% water of crystallisation. Find the number of molecules of water of crystallisation per molecule.

Answer

Barium chloride = $BaCl_2.xH_2O$

Molecular weight of $BaCl_2.xH_2O$ = Ba + 2Cl + x(2H + O)

= 137 + (2 x 35.5) + x(2+16)

= 137 + (2 x 35.5) + x(2+16)

= 137 + 71 + 18x

= (208 + 18 x)

(208 + 18 x) contains 14.8% of water of crystallisation in BaCl2.x H_2O

∴ 14.8% of (208 + 18 x) = 18x

$[\frac{14.8}{100}]$ x [208 + 18 x] = 18x

[0.148 x 208] + [0.148 x 18x] = 18x

30.784 = 18x - [0.148 x 18x]

30.784 = 18x - 2.664x

30.784 = 15.336x

$x = \frac{30.784}{15.336} = 2$

Hence, Barium chloride crystals contain **2 molecules of water of crystallisation** per molecule.

Question 17

Urea is a very important nitrogenous fertilizer. It's formula is CON_2H_4. Calculate the percentage of nitrogen in urea. (C = 12, O = 16, N = 14 and H = 1).

Answer

Molar mass of urea (CON_2H_4) = 12 + 16 + 28 + 4 = 60 g

Molar mass of nitrogen (N_2) = 2 x 14 = 28 g

60 g urea has mass of nitrogen = 28 g

∴ 100 g urea will have mass

$= \frac{28 \times 100}{60}$

= **46.67%**

Question 18

Determine the formula of the organic compound if it's molecule contains 12 atoms of carbon. The percentage compositions of hydrogen and oxygen are 6.48 and 51.42 respectively.

Answer

Element	**% composition**	**At. wt.**	**Relative no. of atoms**	**Simplest ratio**
Oxygen	51.42	16	$\frac{51.42}{16} = 3.21$	$\frac{3.21}{3.21} = 1$
Hydrogen	6.48	1	$\frac{6.48}{1} = 6.48$	$\frac{6.48}{3.21} = 2$
Carbon	42.1	12	$\frac{42.1}{12} = 3.50$	$\frac{3.50}{3.21} = 1$

Simplest ratio of whole numbers = O : H : C = 1 : 2 : 1

Hence, **empirical formula is CH_2O**

Since the compound has 12 atoms of carbon, so the formula is **$C_{12}H_{24}O_{12}$**.

Question 19(a)

A compound with empirical formula AB_2, has the vapour density equal to it's empirical formula weight. Find it's molecular formula.

Answer

Empirical formula = AB_2

Empirical formula weight = V.D.

Molecular weight = 2 x V.D.

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} n = \frac{2 \text{ x V.D.}}{\text{V.D.}} n = 2$$

∴ Molecular formula = n[E.F.] = 2[AB_2] = $\mathbf{A_2B_4}$

Question 19(b)

A compound with empirical formula AB has vapour density three times it's empirical formula weight. Find the molecular formula.

Answer

Given,

Empirical formula = AB

V.D. = 3 x Empirical formula weight

Hence, Empirical formula weight = $\frac{\text{V.D.}}{3}$

and we know, Molecular weight = 2 x V.D.

Substituting in the formula for n we get,

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} n = \frac{2 \text{ x V.D.}}{\frac{\text{V.D.}}{3}} n = \frac{3 \text{ x } 2 \text{ x V.D.}}{\text{V.D.}} n = 6$$

∴ Molecular formula = n[E.F.] = 6[AB] = $\mathbf{A_6B_6}$

Question 19(c)

10.47 g of a compound contains 6.25 g of metal A and rest non-metal B. Calculate the empirical formula of the compound (At. wt of A = 207, B = 35.5)

Answer

Element	% composition	At. wt.	Relative no. of atoms	Simplest ratio
Metal A	6.25	207	$\frac{6.25}{207} = 0.03$	$\frac{0.03}{0.03} = 1$
Non-metal B	4.22	35.5	$\frac{4.22}{35.5} = 0.11$	$\frac{0.11}{0.03} = 3.96 = 4$

Simplest ratio of whole numbers = A : B = 1 : 4

Hence, **empirical formula is AB_4**

Question 20

A hydride of nitrogen contains 87.5% percent by mass of nitrogen. Determine the empirical formula of this compound.

Answer

Element	% composition	At. wt.	Relative no. of atoms	Simplest ratio
Nitrogen	87.5	14	$\frac{87.5}{14} = 6.25$	$\frac{6.25}{6.25} = 1$
Hydrogen	12.5	1	$\frac{12.5}{1} = 12.5$	$\frac{12.5}{6.25} = 2$

Simplest ratio of whole numbers = N : H = 1 : 2

Hence, **empirical formula is NH_2**

Question 21

A compound has O = 61.32%, S = 11.15%, H = 4.88% and Zn = 22.65%.The relative molecular mass of the compound is 287 a.m.u. Find the molecular formula of the compound, assuming that all the hydrogen is present as water of crystallisation.

Answer

Element	% composition	At. wt.	Relative no. of atoms	Simplest ratio
Zn	22.65	65	$\frac{22.65}{65} = 0.3484$	$\frac{0.3484}{0.3484} = 1$
S	11.15	32	$\frac{11.15}{32} = 0.3484$	$\frac{0.3484}{0.3484} = 1$
O	61.32	16	$\frac{61.32}{16} = 3.832$	$\frac{3.832}{0.3484} = 10.99 = 11$
H	4.88	1	$\frac{4.88}{1} = 4.88$	$\frac{4.88}{0.3484} = 14$

Simplest ratio of whole numbers = Zn : S : O : H = 1 : 1 : 11 : 14

Hence, **empirical formula is $ZnSO_{11}H_{14}$**

Molecular weight = 287

Empirical formula weight = 65 + 32 + 11(16) + 14(1) = 65 + 32 + 176 + 14 = 287

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{287}{287} = 1$$

Molecular formula = n[E.F.] = 1[$ZnSO_{11}H_{14}$] = $ZnSO_{11}H_{14}$

Since all the hydrogen in the compound is in combination with oxygen as water of crystallization .

Therefore, 14 atoms of hydrogen and 7 atoms of oxygen = $7H_2O$ and hence, 4 atoms of oxygen remain.

∴ **Molecular formula is $ZnSO_4.7H_2O$.**

Exercise 5D

Question 1

The reaction between 15 g of marble and nitric acid is given by the following equation:

$CaCO_3 + 2HNO_3 \longrightarrow Ca(NO_3)_2 + H_2O + CO_2$

Calculate:

(a) the mass of anhydrous calcium nitrate formed

(b) the volume of carbon dioxide evolved at S.T.P.

Answer

(a)

$CaCO_3$	+ 2 HNO_3 $\longrightarrow$	$Ca(NO_3)_2$	+
40 + 12 + 3(16)		40 + 2(14) + 6(16)	
= 40 + 12 + 48		40 + 28 + 96	
= 100 g		164 g	

100 g of $CaCO_3$ produces = 164 g of $Ca(NO_3)_2$

∴ 15 g $CaCO_3$ will produce = $\frac{164}{100}$ x 15

= **24.6 g**

Hence, **mass of anhydrous calcium nitrate formed = 24.6 g**

(b) 100 g of $CaCO_3$ produces = 22.4 litres of carbon dioxide

∴ 15 g of $CaCO_3$ will produce = $\frac{22.4}{100}$ x 15

= **3.36 litres** of CO_2

Question 2

66 g of ammonium sulphate is produced by the action of ammonia on sulphuric acid.
Write a balanced equation and calculate:
(a) Mass of ammonia required.
(b) The volume of the gas used at S.T.P.
(c) The mass of acid required.

Answer

	$2NH_3$	+	H_2SO_4	$\longrightarrow$	$(NH_4)_2SO_4$
(a)	$2[14+3(1)]$ $= (2\times 17)$ $= 34$ g		$2(1)+32+4(16)$ $= 2+32+64$ $= 98$ g		$2[14+4(1)]+32+4(16)$ $= 36+32+64$ $= 132$ g
	2 mole				

132 g ammonium sulphate is produced by 34 g of NH_3

$\therefore$66 g ammonium sulphate is produced by $\frac{34}{132}$ x 66 = 17 g of NH_3

Hence, **17g** of NH_3 is required.

(b) 132 g ammonium sulphate uses 2 x 22.4 L of gas

$\therefore$ 66 g of ammonium sulphate will use $\frac{2\times 22.4}{132}$ x 66 = **22.4 litres**

(c) For 132 g ammonium sulphate 98 g of acid is required

$\therefore$ For 66 g ammonium sulphate $\frac{98}{132}$ x 66 = 49 g

Hence, **49g** of acid is required.

Question 3

The reaction between red lead and hydrochloric acid is given below:

$Pb_3O_4 + 8HCl \longrightarrow 3PbCl_2 + 4H_2O + Cl_2$

Calculate

(a) the mass of lead chloride formed by the action of 6.85 g of red lead,
(b) the mass of the chlorine and
(c) the volume of chlorine evolved at S.T.P.

Answer

(a)

Pb_3O_4	+	$8HCl$	$\longrightarrow$
$3(207)+4(16)$ $= 621+64$ $= 685$ g		$8[1+35.5]$ $= 8(36.5)$ $= 292$ g	

$3PbCl_2$	+	$4H_2O$	+	Cl_2
$3[207+2(35.5)]$ $= 3[207+71]$ $= 834$ g				$2(35.5)$ $= 71$g

685 g of Pb_3O_4 gives = 834 g of $PbCl_2$

$\therefore$ 6.85 g of Pb_3O_4 will give

= $\frac{834}{685}$ x 6.85 = **8.34 g**

(b) 685g of Pb_3O_4 gives = 71g of Cl_2

$\therefore$ 6.85 g of Pb_3O_4 will give

= $\frac{71}{685}$ x 6.85 = **0.71 g** of Cl_2

(c) 685 g of Pb_3O_4 produces 22.4 L of Cl_2

$\therefore$ 6.85 g of Pb_3O_4 will produce

$\frac{22.4}{685}$ x 6.85 = **0.224 L** of Cl_2

Question 4

Find the mass of KNO_3 required to produce 126 kg of nitric acid. Find whether a larger or smaller mass of $NaNO_3$ is required for the same purpose.

$KNO_3 + H_2SO_4 \longrightarrow KHSO_4 + HNO_3$

$NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$

Answer

KNO_3	+	H_2SO_4	$\longrightarrow$	$KHSO_4$	$+HNO_3$
$39 + 14 + 3(16)$					$1 + 14 + 3(16)$
$= 39 + 14 + 48$					$= 1 + 14 + 48$
$= 101$ g					$= 63$ g

63 g of HNO_3 is formed by 101 g of KNO_3

$\therefore$ 126000 g of HNO_3 is formed by $\frac{101}{63}$ x 126000

= **202000 g = 202 kg**

Similarly,

$NaNO_3$	+	H_2SO_4	$\longrightarrow$	$NaHSO_4$	$+HNO_3$
$23 + 14 + 3(16)$					$1 + 14 + 3(16)$
$= 23 + 14 + 48$					$= 1 + 14 + 48$
$= 85$ g					$= 63$ g

63 g of HNO_3 is formed by 85 g of $NaNO_3$

$\therefore$ 126000 g of HNO_3 is formed by $\frac{85}{63}$ x 126000

= **170000 g = 170 kg**

So, a smaller mass of $NaNO_3$ is required.

Question 5

Pure calcium carbonate and dilute hydrochloric acid are reacted and 2 litres of carbon dioxide was collected at 27°C and normal pressure.

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

Calculate:

(a) The mass of salt required.

(b) The mass of the acid required

Answer

(a) Given,

$CaCO_3$	+	$2HCl$	$\longrightarrow$	$CaCl_2$	$+H_2O +$	CO_2
$40 + 12 + 3(16)$		$2[1 + 35.5]$				1 mole
$= 40 + 12 + 48$		$= 73$ g				
$= 100$ g						

First convert the volume of carbon dioxide to STP:

$V_1 = 2$ L

$T_1 = 27 + 273$ K $= 300$ K

$T_2 = 273$ K

$V_2 = ?$

Using formula:

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Substituting in the formula,

$\frac{2}{300} = \frac{V_2}{273}$

$V_2 = \frac{2}{300}$ x $273 = 1.82$ L

As, 22.4 L of carbon dioxide is obtained using 100 g $CaCO_3$

∴ 1.82 L of carbon dioxide is obtained from $\frac{100}{22.4}$ x 1.82

= **8.125 g of $CaCO_3$**

(b) Similarly, 22.4 L of carbon dioxide is obtained using 73 g of acid

∴ 1.82 L of carbon dioxide is obtained from $\frac{73}{22.4}$ x 1.82

= **5.93 g of acid**

Question 6

Calculate the mass and volume of oxygen at S.T.P., which will be evolved on electrolysis of 1 mole (18 g) of water

Answer

$$2H_2O \longrightarrow 2H_2 + O_2$$
$$2(2+16) \qquad 2(16)$$
$$36g \qquad 32g$$

36 g of water produces 32 g of O_2

∴ 18 g of water will produced

= $\frac{32}{36}$ x 18 = **16 g** of O_2

$$2H_2O \longrightarrow 2H_2 + O_2$$
$$2\text{ mole} \qquad 1\text{ mole}$$

2 moles of water produces 1 mole of oxygen

∴ 1 mole of water will produce $\frac{1}{2} \times 1$ = 0.5 moles of O_2

1 mole of O_2 occupies 22.4 L volume

∴ 0.5 moles will occupy = 22.4 × 0.5

= **11.2 L**

Question 7

1.56 g of sodium peroxide reacts with water according to the following equation:

$2Na_2O_2 + 2H_2O \longrightarrow 4NaOH + O_2$

Calculate:

(a) mass of sodium hydroxide formed,

(b) volume of oxygen liberated at S.T.P.

(c) mass of oxygen liberated.

Answer

$$2Na_2O_2 + 2H_2O \longrightarrow 4NaOH +$$
$$2[2(23)+2(16)] \qquad 4(23+16+1)$$
$$156g \qquad 160g$$

(a) 156 g of sodium peroxide produces 160 g of sodium hydroxide

∴ 1.56 g of sodium peroxide will produce $\frac{160}{156}$ x 1.56

= 1.6 g of sodium hydroxide

(b) 156 g of sodium peroxide produces 22.4 L of oxygen

∴ 1.56 g of sodium peroxide will produce $\frac{22.4}{156}$ x 1.56

= 0.224 L

Converting L to cm^3

As 1 L = 1000 cm^3

So, 0.224 L = **224 cm^3**

(c) 156 g of sodium peroxide produces 32 g of oxygen

∴ 1.56 g of sodium peroxide will produce $\frac{32}{156}$ x 1.56 = **0.32 g**

Question 8

(a) Calculate the mass of ammonia that can be obtained from 21.4 g of NH_4Cl by the reaction:

$2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O + 2NH_3$

(b) What will be the volume of ammonia when measured at S.T.P?

Answer

$2NH_4Cl \quad + Ca(OH)_2 \longrightarrow CaCl_2 \quad + 2$

$2[14 + 4(1) + 35.5]$

$107g$

(a) 107 g NH_4Cl gives 34 g of NH_3

∴ 21.4 g NH_4Cl will give $\frac{34}{107}$ x 21.4

= **6.8 g of NH_3**

(b) Volume of ammonia produced by 107 g NH_4Cl = 2 x 22.4 L

∴ Volume of ammonia produced by 21.4 g NH_4Cl = $\frac{2\times22.4}{107}$ x 21.4

= **8.96 L**

Question 9

Aluminium carbide reacts with water according to the following equation.

$Al_4C_3 + 12H_2O \longrightarrow 3CH_4 + 4Al(OH)_3$

(a) What mass of aluminium hydroxide is formed from 12g of aluminium carbide?

(b) What volume of methane is obtained from 12g of aluminium carbide?

Answer

$$\begin{array}{ccccccccc} Al_4C_3 & + & 12H_2O & \longrightarrow & 4Al(OH)_3 & + & 3CH_4 \\ 4(27)+3(12) & & & & 4(78) & & 3(22.4) \\ = 144\text{ g} & & & & = 312\text{ g} & & = 67.2\text{ lit.} \end{array}$$

144 g of aluminium carbide forms 312 g of aluminium hydroxide.

∴ 12 g of aluminium carbide will form $\frac{312}{144}$ x 12 = 26 g of aluminium hydroxide

Hence, **26 g of aluminium hydroxide is formed.**

(ii) 144 g of aluminium carbide forms 67.2 lit of methane.

∴ 12 g of aluminium carbide will form $\frac{67.2}{144}$ x 12 = 5.6 lit.

Hence, **vol. of methane obtained = 5.6 L**

Question 10

$MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$

0.02 moles of pure MnO_2 is heated strongly with conc. HCl. Calculate:

(a) mass of MnO_2 used,

(b) moles of salt formed,

(c) mass of salt formed,

(d) moles of chlorine gas formed,

(e) mass of chlorine gas formed,

(f) volume of chlorine gas formed at S.T.P.,

(g) moles of acid required,

(h) Mass of acid required.

Answer

$$\begin{array}{ccccccccc} MnO_2 & + & 4HCl & \longrightarrow & MnCl_2 & + & 2H_2O & + & Cl_2 \\ 1\text{ mole} & & 4\text{ mole} & & 1\text{ mole} & & & & 1\text{ mole} \\ 55+2(16) & & 4[1+35.5] & & 55+2(35.5) & & & & 2(35.5) \\ = 87\text{ g} & & = 146\text{ g} & & = 126\text{ g} & & & & = 71\text{ g} \end{array}$$

(a) 1 mole of MnO_2 weighs 87 g

∴ 0.02 mole will weigh $\frac{87}{1}$ x 0.02 = **1.74 g**

(b) 1 mole MnO_2 gives 1 mole of $MnCl_2$

∴ 0.02 mole MnO_2 will give **0.02** mole of $MnCl_2$

(c) As, 1 mole $MnCl_2$ weighs 126 g

∴ 0.02 mole $MnCl_2$ will weigh $\frac{126}{1}$ x 0.02 = **2.52 g**

(d) 1 mole MnO_2 gives 1 mole of Cl_2

∴ 0.02 mole MnO_2will form **0.02 moles** of Cl_2

(e) 1 mole of Cl_2 weighs 71 g

∴ 0.02 mole will weigh $\frac{71}{1}$ x 0.02 = **1.42 g**

(f) 1 mole of chlorine gas has volume 22.4 dm^3

∴ 0.02 mole will have volume $\frac{22.4}{1}$ x 0.02 = **0.448 dm^3**

(g) 1 mole MnO_2 requires 4 moles of HCl

∴ 0.02 mole MnO_2 will require $\frac{4}{1}$ x 0.02 = **0.08 mole**

(e) Mass of 1 mole of HCl = 36.5 g

∴ Mass of 0.08 mole = 0.08 × 36.5 = **2.92 g**

Question 11

Nitrogen and hydrogen react to form ammonia.

N_2 (g) + $3H_2$ (g) ⟶ $2NH_3$ (g)

If 1000 g of H_2 react with 2000 g of N_2:

(a) Will any of the two reactants remain unreacted? If yes, which one and what will be it's mass?

(b) Calculate the mass of ammonia (NH_3) that will be formed?

Answer

$$\begin{array}{ccccc} N_2 & + & 3H_2 & \longrightarrow & 2NH_3 \\ 2(14) & & 6(1) & & 2[14+3(1)] \\ 28g & & 6g & & 34\ g \end{array}$$

(a) 28 g of nitrogen requires 6 g of hydrogen

∴ 2000 g of nitrogen requires $\frac{6}{28}$ x 2000

= 428.57 g of hydrogen.

So mass of hydrogen left unreacted = 1000 - 428.57 = 571.42 g

571.42 g of **hydrogen** is left unreacted.

(b) 28 g of nitrogen forms 34 g NH_3

∴ 2000 g of nitrogen forms $\frac{34}{28}$ x 2000

= **2428.57 g of NH_3**