Mole Concept & Stoichiometry

Gay Lussac's Law – Avogadro's Law

Practice Questions

Question 1.
What volume of oxygen would he required to burn completely 400 ml of acetylene (C_2H_2) ? Calculate the volume of CO_2 formed.
Answer:

$$\underbrace{2C_2H_2}_{2\text{ vol.}} + \underbrace{5O_2}_{5\text{ vol.}} \longrightarrow \underbrace{4CO_2}_{4\text{ vol.}} + \underbrace{2H_2O\,(l)}_{2\text{ vol.}}$$

$$2 \quad : \quad 5$$

$$400\text{ ml of }C_2H_2 = \frac{5}{2} \times 400\text{ml.}$$

Volume of O_2 needed = 1000 ml.

2 vol. of C_2H_2 produce CO_2 = 4 vol.

$$\therefore\ 400\text{ ml of }C_2H_2\text{ produce }CO_2 = \frac{4}{2} \times 400 = 800\text{ ml}$$

Volume of CO_2 produced = 800 ml.

Question 2.

2500 cc of oxygen was burnt with 600 cc of ethane (C_2H_6). Calculate the volume of unused oxygen and the volume of carbon dioxide formed, after writing the balanced equation :
Ethane + Oxygen → Carbon dioxide + Water vapour
Answer:

$$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$$

2 volumes of C_2H_6 need O_2 = 7 vols.

$$\therefore\ 600\text{ cc of }C_2H_6\text{ needs }O_2 = \frac{7}{2} \times 600 = 2100\text{ cc}$$

$$\therefore\ \text{Volume of }O_2\text{ unused} = 2500 - 2100 = 400\text{ cc}$$

2 vols. of C_2H_6 produce CO_2 = 4 vols.

$$\therefore\ 600\text{ cc of }C_2H_6\text{ will produce }CO_2 = \frac{4}{2} \times 600 = 1200\text{ cc}$$

Question 3.
80 cm^3 of methane are mixed with 200 cm^3 of pure oxygen at similar temperature and pressure. The mixture is then ignited. Calculate the composition of resulting mixture if it is cooled to initial room temperature and pressure.
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
Answer:

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$$

(By Gay Lussac's Law) 1 vol. 2 vol. 1 vol. Nil

1 vol. of CH_4 reacts with O_2 = 2 vols.
∴ 80 cm^3 of CH_4 need $O_2 = 80 \times 2 = 160\ cm^3$
∴ Excess oxygen $= 200 - 160 = 40\ cm^3$
Again 1 vol. of CH_4 produces CO_2 = 1 vol.
∴ CO_2 produced = 80 cm^3
Thus, gaseous composition after reaction is :
Excess oxygen $= 200 - 160 = 40\ cm^3$
$CO_2 = 80\ cm^3$
water = negligible

Question 4.
Calculate the volume of HCl gas formed and chlorine gas required when 40 mL of methane reacts completely with chlorine at S.T.P.
$CH_4 + 2Cl_2 \rightarrow CH_2Cl_2 + 2HCl$
Answer:
We know that

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

1 vol. 2 vol. 2 vol.

1 vol. of CH_4 produces 2 vols. of HCl
∴ 40 ml of CH_4 produces $2 \times 40 = 80$ ml of CO_2
40 ml of CH_4 reacts completely with $Cl_2 = 2 \times 40 = 80$ ml

Question 5.
What volume of propane is burnt for every 500 cm^3 of air used in the reaction under the same conditions ?
$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Answer:

Volume of O_2 in 500 cm^3 of air = 20%

$$= \frac{20}{100} \times 500 = 100 \text{ cm}^3$$

$$\underset{1 \text{ vol.}}{C_3H_8} + \underset{5 \text{ vol.}}{5O_2} \longrightarrow 3CO_2 + 4H_2O$$

$\therefore$ Volume of propane burnt $= \frac{100}{5} = 20 \text{ cm}^3$

Question 6.

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

$2NO + O_2 \rightarrow 2NO_2$

Answer:

$$\underset{2 \text{ vols.}}{2NO} + \underset{\substack{1 \text{ vol.} \\ 200 \text{ cm}^3}}{O_2} \longrightarrow \underset{2 \text{ vols.}}{2NO_2}$$

O_2 (200 cm^3) combines with 2 vols. = 2 × 200 = 400 cm^3 of NO

2 vols. of NO produces = 2 vols. of NO_2

400 cm^3 of NO produces NO_2 = 400 cm^3

$\therefore$ Volume of NO left unused = 450 – 400 = 50 cm^3

Question 7.

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 were unchanged oxygen. Which law does their experiment supports ? Explain with calculations.

Answer:

Marsh gas (CH_4) exploded with oxygen

$$\underset{\substack{1 \text{ vol.} \\ 24 \text{ cc}}}{CH_4} + \underset{\substack{2 \text{ vol.} \\ 48 \text{ cc}}}{2O_2} \longrightarrow \underset{\substack{1 \text{vol.} \\ 24 \text{ cc}}}{CO_2} + \underset{0 \text{ vol.}}{2H_2O}$$

1 vol. of CH_4 requires O_2 = 2 vols.

$\therefore$ 24 cc of CH_4 requires O_2 = 2 × 24 = 48 cc

Also 24 cc of CH_4 produce CO_2 = 24 cc

$\therefore$ Vol. of O_2 unused = 106 – 48 = 58 cc

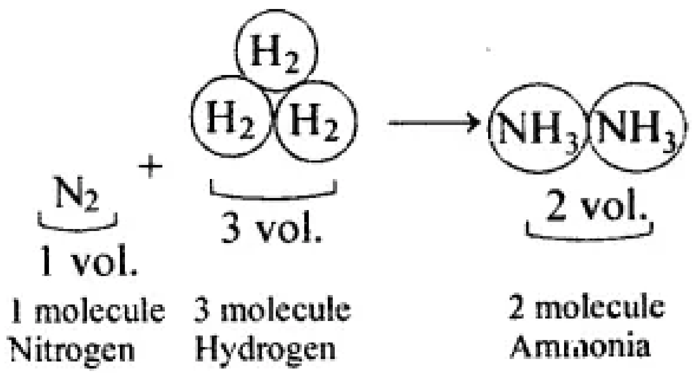
$\therefore$ Vol. of mixture on cooling = (unused oxygen + CO_2 formed)

= 58 + 24 = 82 cc

Gay-Lussac's Law supports the experiment.

Avogadro's Law : "Under the same conditions of temperature and pressure equal volumes of all gases contain die same number of molecules."
If we assume that 7 litre of oxygen gas contains 'n' molecules of the gas then by Avogadro's Law :

1. 1 litre of oxygen will contain 'n' molecules of hydrogen
2. 1 litre of nitrogen will contain 'n' molecules of nitrogen.
3. 1 litre of any gas will contain 'n' molecules of that gas. e.g.



Relative Molecular Mass : "It is the number that represents how many times one molecule of a substance is heavier than one atom of hydrogen whose weight has been taken unity or 1/12 of $_6C^{12}$.
Relative Molecular Mass : "It is the number that represents how many times one molecule of a substance is heavier than one atom of hydrogen whose weight has been taken unity or 1/12 of $_6C^{12}$.
Avogadro's Number : "The number of atoms present in 12 g (gm atomic mass) of $_6C^{12}$ is called Avogadro's number.
Na or L = 6.023×10^{23}

Atomic and Molecular weight of some elements.

Element	Symbol	Rel atomic mass	Gram atomic mass
1. Carbon	C	12.0	12g
2. Hydrogen	H	1.008	1 gm
3. Chlorine	Cl	35.453	55.5g
4. Nitrogen	N	14.007	14g
5. IronFe	55.847	56g	
6. Sulphur	S	32.064	32g

Mole : Mole is the mass of substance containing particles equal to Avogadro's number i.e. 6.023×10^{23}.
Gram Atom : "The relative atomic mass of an element expressed in grams is called gram atom.
Gram Mole : "The relative atomic mass of a substance expressed in grams is called gram mole.
Molar Volume : Volume occupied by one mole of any gas at STP is called molar volume.

Applications Of Avogadro'S Law :

1. Determines the atomicity of the gas.
2. Determines the molecular formula of a gas.
3. Determines the relation between molecular weight and vapour density.
4. Explains Gay-Lussac's law.
5. Determines the relationship between gram molecular weight and gram molecular volume.

1. Determines the atomicity of a gas :
Atomicity : The number of atoms present in one molecule of that element is called atomicity.
Monoatomic : Elements which have one atom in their molecules e.g. Helium, Neon.
Diatomic : Elements which have two atoms in their molecule e.g. Hydrogen, nitrogen, oxygen.
e.g. of Determination of atomicity of a gas :

$$\underset{\text{1 vol.}}{\text{Nitrogen}} + \underbrace{\text{Oxygen}}_{\text{1 vol.}} \longrightarrow \underset{\text{2 vol.}}{\text{Nitric oxide}}$$

$$N_2 + O_2 \longrightarrow 2NO$$

$$\text{1 molecule} + \text{1 molecule} \longrightarrow \text{2 molecules.}$$

A molecules of nitrogen contains two atoms : atomicity – Diatomic

2. Determines the molecular formula of a gas.
Molecular formula : A chemical formula which gives the actual or exact number of atoms of the elements present in one molecule of a compound.

e.g. Hydrogen + Chlorine $\longrightarrow$ Hydrogen chloride

1 vol. 1 vol. 2 vol. 1 By Gay-Lussac's law

A mole of hydrogen and chlorine contain two atoms-DIATOMIC.

3. Determines the relation between molecular weight and vapour density.
Molecular weight: It is the ratio of the weight of 1 molecule of a substance to the weight of one atom of hydrogen.

$$\text{Mol. wt} = \frac{\text{mass of 1 molecule of a substance}}{\text{mass of 1 mol. of hydrogen}}$$

Vapour Density : It is the ratio of the mass of a certain volume of gas or vapour of the mass of the same volume of hydrogen.
Mol. wt. = 2× vapour density

4. Explains Gay-Lussac's Law :
Gay-Lussac's Law is explained by Avogadro's Law which states "Under similar conditions of temperature and pressure, equal volumes of different gases have same number of molecules."
Since substances react in simple ratio of number of molecules, volumes of gaseous reactants and products will also bear a simple ratio to one another. This is what Gay-Lussac's Law says.

H_2	+	Cl_2	$\longrightarrow$	2HCl	
1 vol.		1 vol.		2 vol.	(by Gay-Lussac's Law)
n-molecules		*n*-molecules		2*n*-molecules	(by Avogadro's Law)

5. Determines relationship between gram molecular mass and gram molecular volume :
Gram molecular mass is the relative molecular mass of a substance expressed in grams. It is also called gram molecule of that element.
Gram molecular volume : The volume occupied by e.g. molecular wt. of a gas at s.t.p.

$$\text{Gram molecular volume} = \frac{\text{Gram molecular weight}}{\text{wt. per litre of gas at s.t.p.}}$$

$$e.g.\ \text{Molar volume of } O_2 = \frac{32\,(\text{mol. wt.})}{1.429\text{ g/litre}} = \frac{2.016\,(\text{mol.wt})}{0.09\text{ g}/l}$$

$$= 22.4 \text{ lit. at s.t.p.}$$

Additional Problems

Q.1. Lussac'S Law

Question 1.
Nitrogen reacts with hydrogen to give ammonia. Calculate the volume of the ammonia gas formed when nitrogen reacts with 6 litres of hydrogen. All volumes measured at s.t.p.
Answer:

$$\underset{1\text{ vol.}}{N_2} + \underset{3\text{ vol}}{3H_2} \longrightarrow \underset{2\text{ vol.}}{2NH_3}$$

3 volumes of hydrogen produces 2 volumes of Ammonia.

6 litres of H_2 produces $= \frac{2}{3} \times 6$ litres of $NH_3 = 4$ lits.

Question 2.
2500 cc of oxygen was burnt with 600 cc of ethane [C_2H_6]. Calculate the volume of unused oxygen and the volume of carbon dioxide formed.
Answer:

$$\underset{2\text{ vol.}}{2C_2H_6} + \underset{7\text{ vol.}}{7O_2} \longrightarrow \underset{4\text{ vol.}}{4CO_2} + 6H_2O$$

2 cc of C_2H_6 reacts with oxygen = 7 cc

$\therefore$ 600 cc of C_2H_6 reacts with oxygen $= \frac{7 \times 600}{2} = 2100$ cc

$\therefore$ Oxygen left unused $= 2500 - 2100 = 400$ cc

2 vols. of C_2H_6 produce $CO_2 = 4$ vols.

$\therefore$ 600 cc of C_2H_6 produce $CO_2 = \frac{600 \times 4}{2} = 1200$ cc

Question 3.
20 ml. each of oxygen and hydrogen and 10 ml. of carbon monoxide are exploded in an enclosure. What will be the volume and composition of the mixture of the gases when they are cooled to room temperature.

Answer:

$$2CO + O_2 \longrightarrow 2CO_2$$

2 vol. 1 vol. 2 vol.

10 ml 5 ml 10 ml

$\therefore$ Vol. of oxygen needed = 5 ml

and vol. of CO_2 produced = 20 ml

Now $2H_2 + O_2 \longrightarrow 2H_2O$

2 vol. 1 vol. Nil

20 ml 10 ml

$\therefore$ Vol. of oxygen used = 10 ml

$\therefore$ Total vol. of oxygen used = 10 + 5 = 15 ml

$\therefore$ Vol. of O_2 left = 20 – 15 = 5 ml

and vol. of CO_2 = 10 ml

Question 4.
224 cm^3 of ammonia undergoes catalytic oxidation in presence of Pt to given nitric oxide and water vapour. Calculate the volume of oxygen required for the reaction. All volumes measured at room temperature and pressure.
Answer:

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

4 vol. 5 vol.

4 volume of NH_3 require O_2 = 5 vol.

OR

4 cm^3 of NH_3 require O_2 = 5 cm^3

$\therefore$ 224 cm^3 of ammonia will need $O_2 = \frac{5}{4} \times 224 = 280\ cm^3$

Question 5.
Acetylene [C_2H_2] burns in air forming carbon dioxide and water vapour. Calculate the volume of air required to completely burn 50 cm^3 of acetylene. [Assume air contains 20% oxygen].

Answer:

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

2 vol. 5 vol.

For complete burning

$2cm^3$ of C_2H_2 needs oxygen = $5\ cm^3$

$\therefore$ $50\ cm^3$ of C_2H_2 needs oxygen = $50 \times \frac{5}{2} = 125\ cm^3$

But if O_2 is $20\ cm^3$ air = $100\ cm^3$

$\therefore$ If $125\ cm^3$ is O_2, air = $\frac{100 \times 125}{20} = 625\ cm^3$

Question 6.

On igniting a mixture of acetylene [C_2H_2] and oxygen, 200 cm^3 of CO_2 is collected at s.t.p. Calculate the volume of acetylene & O_2 at s.t.p. in the original mixture.

Answer:

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

2 vol. 5 vol. 4 vol. ml

Vol. of C_2H_2

For 4 vol. of CO_2 vol. of C_2H_2 is 2

For $200\ cm^3$ of CO_2, vol. of C_2H_2 is = $\frac{2}{4} \times 200 = 100\ cm^3$

Vol. of O_2

For $4\ cm^3$ of CO_2 vol. of O_2 needed = $5\ cm^3$

$\therefore$ For $200\ cm^3$ of CO_2 vol. of O_2 = $\frac{5}{4} \times 200 = 250\ cm^3$

Question 7.

Ammonia is formed from the reactants nitrogen and hydrogen in presence of a catalyst under suitable conditions. Assuming all volumes are measured in litres at s.t.p. Calculate the volume of ammonia formed if only 10% conversion has taken place.

Answer:

$$N_2 \quad + \quad 3H_2 \rightleftharpoons 2NH_3$$

1 Vol. 3 vol. 2 vol.

1 lit. 3 lit. 2 lit.

Vol. of ammonia formed is 10% of reactants

$$\therefore \; 10\% \text{ of } 2 \text{ lit.} = \frac{10}{100} \times 2 = 0.2 \text{ litres}$$

of vol. of N_2 and H_2

Question 8.
100 cc. each of water gas and oxygen are ignited and the resultant mixture of gases cooled to room temp. Calculate the composition of the resultant mixture. [Water gas contains CO and H_2 in equal ratio]
Answer:

This means vol. of CO = 50 cc

and volume of H_2 = 50 cc

$$2CO \; + \; O_2 \longrightarrow 2CO_2$$

2 vol. 1 vol. 2 vol.

1 vol. of O_2 produces CO_2 = 2 vol.

25 cc of O_2 produces CO_2 = 50 cc

$$2H_2 + O_2 \longrightarrow 2H_2O$$

1 vol Nil

25 cc

25 cc of O_2 is consumed in burning H_2

$\therefore$ Vol of O_2 used = 50 cc and vol. of CO_2 produced = 50 cc

Q.2. Mole Concept – Avogadro’S Law – Avogadro’S Number
Calculate the following : [all measurement at s.t.p. or as stated in the problem]

Question 1.
The mass of 2.8 litres of $C0_2$. [C = 12, O = 16]
Answer:

Molecular mass of $CO_2 = C + 2\,(O)$

$= 12 + 2\,(16) = 44 g\ mol^{-1}$

s.t.p. 22.4 litres of CO_2 has mass = 44g

$$\therefore \text{ 2.8 lits. of } CO_2 \text{ has mass} = \frac{44 \times 2.8}{12.4} = \frac{44}{8} = \frac{11}{2} = 5.5g$$

Question 2.
The volume occupied by 53.5g of Cl_2. [Cl = 35.5]
Answer:

At. s.t.p. volume occupied by

$Cl_2 = 35.2 \times 2 = 71 g\ mol^{-1}$

71g of Cl_2 at STP has mass = 22.4 lits.

$$\therefore \text{ Vol. occupied by 53.5 g of } Cl_2 = \frac{22.4 \times 53.5}{71}$$

$$= \frac{1198.40}{71} = 16.87 \text{ lits.}$$

Question 3.
The number of molecules in 109.5 g of HCl. [H = 1, Cl = 35.5]
Answer:

Molar mass of HCl = 1 + 35.5 = 36.5g mol^{-1}

At s.t.p. 36.5g of HCl = 1 mole = 6.023×10^{23} molecules

$$\therefore \text{ 109.5g of HCl} = \frac{109.5 \times 6.023 \times 10^{23}}{36.5} = \frac{219}{73} \times 6.023 \times 10^{23}$$

$= 3 \times 6.023 \times 10^{23}$ molecules of HCl

Question 4.
The number of

1. molecules [S = 32]
2. atoms in 192 g. of sulphur. [S_8]

Answer:

(i) No. of molecules in S = 6.023×10^{23} molecules (Avog. No.)

(ii) S_8 = 8 atoms

$= 8 \times 32 = 256$

256 g of S contains atoms = 6.023×10^{23} atoms

192 g of S contains atoms $= \frac{6.023 \times 10^{23}}{256} \times 192$

$= 0.75 \times 6.023 \times 10^{23}$ atoms

Question 5.
The mass of (Na) sodium which will contain 6.023×10^{23} atoms. [Na = 23]
Answer:

One gram atom of sodium = 23 g

We know that one gram atom of an element

$= 6.023 \times 10^{23}$ atoms

Mass of Na containing 6.023×10^{23} atoms = Atomic mass of sodium = 23 g

Question 6.
The no. of atoms of potassium present in 117 g. of K. [K = 39]
Answer:

At. wt. of K = 39

$\therefore$ Gram atoms of K $= \frac{117}{39} = 3$ gram atoms

One gram atom has $= 6.023 \times 10^{23}$ atoms

$\therefore$ 3 gram atoms has $= 3 \times 6.023 \times 10^{23}$ atoms of K

Question 7.
The number of moles and molecules in 19.S6 g. of Pb $(NO_3)_2$. [Pb = 207, N = 14, O = 16]

Answer:

Gram molecular mass of Pb $(NO_3)_2$ = 1 mole

= Pb + 2 [N + 3 (O)]

= 207 + 2 [14 + 48] = 331 g = 1 mole

$\therefore$ 19.86 g of Pb $(NO_3)_2$ = $\frac{19.86 \times 1}{331}$ = 0.06 moles

One mole of Pb $(NO_3)_2$ has 6.023×10^{23} molecules

$\therefore$ 0.06 moles has = $0.06 \times 6.023 \times 10^{23}$ moleules

Question 8.
The mass of an atom of lead [Pb = 202].
Answer:

1 mole of lead (Pb) *i.e.* 202 g has = 6.023×10^{23} atoms

$\therefore$ 6.023×10^{23} atoms of lead = 202 g

$\therefore$ 1 atom has mass = $\frac{202}{6.023 \times 10^{23}}$ = 33.48×10^{-23} g

Question 9.
The number of molecules in 1 1/2 litres of water. [density of water 1.0 g./cm^3. — ∴ mass of water = volume × density]
Answer:

Vol. of water = 1.5 L = 150 mL = 1500 cm^3

Density of water = 1 g/cm^3

$\therefore$ Mass of water = Volume × Density

= 1500 cm^3 × 1 g cm^{-3} = 1500 g

Molar mass of water = 18 g mol^{-1}

$\therefore$ 18 g of water contain molecules = 6.023×10^{23}

1500 g of water will contain molecules = $\frac{6.022 \times 1500 \times 10^{23}}{18}$

= $83.33 \times 6.022 \times 10^{23}$ molecules

Question 10.
The gram-atoms in 88.75 g of chlorine [Cl = 35.5]

Answer:

Gram-atom = Atomic mass in grams

At. mass of chlorine = 35.5 g

35.5 g of chlorine = 1 gram-atoms

$$\therefore\ 88.75 \text{ g of chlorine} = \frac{88.75 \times 1}{35.5} = \frac{8875}{3550} = 2.5$$

$$= 2.5 \text{ gram-atoms}$$

Question 11.
The number of hydrogen atoms in 0.25 mole of H_2SO_4.

Answer:

H_2SO_4 = 1 mole of sulphuric acid

1 mole of H_2SO_4 has hydrogen atoms = $2 \times 6.023 \times 10^{23}$

$$\therefore\ 0.25 = \frac{1}{4} \text{ mole of } H_2SO_4 \text{ has H atoms} = \frac{1}{4} \times 2 \times 6.023 \times 10^{23}$$

$$= 3.0115 \times 10^{23} \text{ atoms}$$

Question 12.
The gram molecules in 21 g of nitrogen [N = 14]
Answer:

Gram molecular mass of $N_2 = 2 \times 14 = 28$ g

28 g of N_2 = 1 gram molecule

$$\therefore\ 21 \text{ g of } N_2 = \frac{1 \times 21}{28} = \frac{3}{4} = 0.75 \text{ g molecular of } N_2$$

Question 13.
The number of atoms in 10 litres of ammonia [N = 14, H = 1]

Answer:

NH_3 (Ammonia) mole has $1N + 3H = 4$ atoms

$NH_3 = 1$ mole $= 22.4$ litres at s.t.p.

1 mole of NH_3 has atoms $= 4 \times 6.023 \times 10^{23}$ atoms

i.e. 22.4 litres of NH_3 has $= 4 \times 6.023 \times 10^{23}$ atoms

$$\therefore \text{ 10 litres of } NH_3 \text{ has} = \frac{10 \times 4 \times 6.023 \times 10^{23}}{22.4}$$

$$= 1.786 \times 6.23 \times 10^{23} \text{ atoms}$$

Question 14.
The number of atoms in 60 g of neon [Ne = 20]

Answer:

1 g atoms $= 6.023 \times 10^{23}$ atoms

Gram atomic mass of Ne = 20 g

20 g of Ne $= 6.023 \times 10^{23}$ atoms

$$\therefore \text{ 60 g of Ne} = \frac{60}{20} \times 6.023 \times 10^{23}$$

$$= 3 \times 6.023 \times 10^{23} \text{ atoms}$$

Question 15.
The number of moles of ‘X’ atoms in 93 g of ‘X’ [X is phosphorus = 31]

Answer:

Gram atomic mass of phosphorus = 31 g = 1 mole

31 g of X = 1 mole

$$\therefore \text{ 93 g of X} = \frac{93}{31} = 3 \text{ moles of X}$$

Question 16.
The Volume occupied by 3.5 g of O_2 gas at 27°C and 740 mm presure. [O = 16]

Answer:

Mass of 1 mole of gas = O_2 = 16 × 2 = 32 g

At. s.t.p. 32 g of O_2 occupies vol. = 22.4 lits.

$\therefore$ 3.5 g of O_2 occupies vol. = $\frac{22.4 \times 3.5}{32}$ = 2.45 lits.

To find, vol. occupied by 3.5 g of O_2 at 27°C and 740 mm

$P_1 = 760$ mm	$P_2 = 740$ mm
$T_1 = 273$ K	$T_2 = 27 + 273 = 300$ K
$V_1 = 2.45$ L	$V_2 = ?$

Now, applying gas equation,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad \therefore \quad V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{760 \times 2.45 \times 300}{273 \times 740}$$

$= 2.76$ lits. $= V_2 = 2.76$ lits.

Question 17.
The moles of sodium hydroxide contained in 160 g of it. [Na = 23, O = 16, H = 1]

Answer:

1 g molecular weight of NaOH = Na + O + H

= 23 + 16 + 1 = 40 g = 1 mole

40 g of NaOH represent = 1 mole of NaOH

$\therefore$ 160 g of NaOH will represent = $\frac{160}{40}$ = 4 moles of NaOH

Question 18.
The weight in g. of 2.5 moles of ethane [C_2H_6]. [C = 12, H = 1]
Answer:

1 mole of ethane [C_2H_6] = 2 (C) + 6 (H)

= 2 (12) = 6 (1)

= 24 + 6 = 30

1 mole of C_2H_6 weighs = 30 g

$\therefore$ 2.5 moles of C_2H_6 weighs = 30 × 2.5 = 75 g

Question 19.
The molecular weight of 2.6 g of a gas which occupies 2.24 lits. at 0°C and 760 mm press.

Answer:

Volume occupied at 0°C and 760 mm means volume occupied at s.t.p.

2.24 lits of gas at s.t.p. by = 2.6 g of gas

$$\therefore \text{ 22.4 lits. at. s.t.p. is occupied by} = \frac{2.6 \times 22.4}{2.24} = 26 \text{ g of gas}$$

But vol. of 22.4 lits. of gas at s.t.p. = molecular mass

$\therefore$ Molecular weight of gas = 26 g

Question 20.
The gram atoms in 46 g of sodium [Na = 23]
Answer:

1-g-atoms of Na = 23 g

23 g of Na = 1g-atom

$$\therefore \text{ 46 g of Na} = \frac{1 \times 46}{23} = 2 \text{ gram atoms}$$

Question 21.
The number of moles of $KCl0_3$ that will be required to give 6 moles of oxygen.
Answer:

$$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$$

2 moles   3 moles

To produce 3 moles of O_2, moles of $KClO_3$ required = 2

To produce 6 moles of O_2, moles of $KClO_3$ required

$$= \frac{2 \times 6}{3} = 4 \text{ moles}$$

Question 22.
The weight of the substance of its molecular weight is 70 and in the gaseous form occupies 10 lits. at 27°C and 700 mm pressure.

Answer:

ns. Molecular weight of substance = 70

$P_1 = 700$ mm $\quad\quad P_2 = 760$ mm

$V_1 = 10$ lits. $\quad\quad V_2 = ?$

$T_1 = 27 + 273 = 300$ K $\quad\quad T_2 = 273$ K

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

$$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{700 \times 10 \times 273}{300 \times 76} = \frac{7 \times 273}{3 \times 76} = \frac{637}{76}$$

at. s.t.p. molecular mass occupies 22.4 lits.

22.4 lits of the gas at STP has mass = 70 g

$\therefore \frac{637}{76}$ lits. of the gas at STP will weigh

$$= \frac{70}{22.4} \times \frac{637}{76} = \frac{100 \times 637}{32 \times 76} = \frac{25 \times 637}{8 \times 76}$$

$$= \frac{15925}{608} = 26.19 \text{ g}$$

Question 23.
Has higher number of moles : 5 g. of N_2O or 5 g. of NO [N = 14, O = 16]

Answer:

Molar mass of $N_2O = (2 \times 14) + 16 = 44$ g

Molar mass of NO = 14 + 16 = 30 g

$\therefore$ 5 g of N_2O has number of moles = $\frac{5}{44}$ moles

$\therefore$ 5 g of NO has number of moles = $\frac{5}{30} = \frac{1}{6}$ moles

and $\frac{5}{30} > \frac{5}{44}$ $\therefore$ NO has higher number of moles

Question 24.
Has higher mass : 1 mole of CO_2 or 1 mole of CO [C = 12, O = 16]

Answer:

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

1 mole of CO has mass = 12 + 16 = 28 g

∴ Mass of 1 mole of CO_2 has more mass

Question 25.
Has higher no. of atoms : 1 g of O_2 or 1 g of Cl_2 [O = 16, Cl = 35.5]

Answer:

Molar mass of $O_2 = 2 \times 16 = 32\ g\ mol^{-1}$

32 g of O_2 have atoms $= 2 \times 6.023 \times 10^{23}$

$$1\text{ g of } O_2 \text{ will have atoms} = \frac{2\times6.023\times10^{23}}{32}$$

$= 0.0625 \times 6.022 \times 10^{23}$ atoms

Molar mass of $Cl_2 = 2 \times 35.5 = 71\ g\ mol^{-1}$

∴ 71 g of Cl_2 have atoms $= 2 \times 6.023 \times 10^{23}$

$$1\text{ g of } Cl_2 \text{ will have atoms} = \frac{2\times6.023\times10^{23}}{71}$$

$= 0.028 \times 6.023 \times 10^{23}$

Thus 1 g of O_2 has more number of atoms than 1 g of Cl_2.

Q.3. Vapour Density And Molecular Weight

Question 1.
500 ml. of gas 'X' at s.t.p. weighs 0.50 g. Calculate the vapour density and molecular weight of the gas. [1 lit. of H_2 at s.t.p. weighs 0.09 g].

Answer:

$$\text{Vapour density of gas 'X'} = \frac{\text{weight of 1 lit. of 'X'}}{\text{weight of 1 lit. of } H_2}$$

at same temp. and pressure

$$\therefore \text{ V.D.} = \frac{\text{weight of 1000 ml of X}}{\text{weight of 1 lit. of } H_2} = \frac{2\times0.50}{0.09} = \frac{100}{9} = 11.1$$

Molecular weight of 'X' = 2 × V.D.

= 2 × 11.1 = 22.2 g

Question 2.
A gas cylinder holds 85 g of a gas 'X'. The same cylinder when filled with hydrogen holds 8.5 g of hydrogen under the same conditions of temperature and pressure Calculate the molecular weight of 'X'.

Answer:

$$\text{V.D. of 'X'} = \frac{\text{Weight of certain volume of gas}}{\text{Weight of equal vol. of } H_2}$$

Under similar conditions of temp. and pressure

$$\therefore \text{ V.D. of gas 'X'} = \frac{\text{wt. of 1 gas cylinder of gas 'X'}}{\text{wt. of 1 gas cylinder of } H_2} = \frac{85 \text{ g}}{8.5 \text{ g}}$$

$$\text{V.D. of 'X'} = 10$$

$$\therefore \text{ Molecular weight of gas 'X'} = 2 \times 10 = 20 \text{ g}$$

Question 3.
Calculate the relative molecular mass [molecular weight] of 290 ml. of a gas 'A' at 17°C and 1520 mm pressure which weighs 2.73 g at s.t.p. [1 litre of hydrogen at s.t.p. weighs 0.09 g.]

Answer:

To convert the vol. 290 ml. of gas at s.t.p.

$V_1 = 290$ ml $\qquad V_2 = ?$

$P_1 = 1520$ mm $\qquad P_2 = 760$ mm

$T_1 = 273 + 17 = 290$ K $\qquad T_2 = 273$ K

Applying gas equation, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$.

$$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{290 \times 1520 \times 273}{290 \times 760} = 546 \text{ ml}$$

To calculate V.D. of gas 'X'

546 ml of gas at s.t.p. weighs 273 g

$\therefore$ 1000 ml (1 lit.) of gas weighs $= \frac{273 \times 1000}{546} = 500$ g

Now V.D. of gas 'X' $= \frac{\text{wt. of 1 lit. of gas 'X'}}{\text{wt. of 1 lit. of } H_2}$

$$= \frac{500}{0.09} = 55.55$$

Molecular mass of gas = 2 × V.D.

= 2 × 55.55 = 111.10 g

Question 4.
State the volume occupied by 40 g of a hydrocarbon – CH_4 at s.t.p. if its V.D. is 8.

Answer:
V.D. of hydrocarbon = 8

$\therefore$ Molecular weight = 2 × V.D. = 2 × 8 = 16 g

16 g of hydrocarbon occupy at S.T.P. = 22.4 lit

$\therefore$ 40 g of hydrocarbon occupy at S.T.P. $= \frac{22.4 \times 40}{16} = 56$ lits.

Question 5.
Calculate the atomcity of a gas X [at. no. 35.5] whose vapour density is equal to its relative atomic mass.

Answer:

V.D. = At. mass

V.D. = 35.5

Molecular weight = 2 × V.D.

$= 2 \times 35.5 = 71$ g

$$\text{Number of atoms} = \frac{\text{Molecular weight}}{\text{Atomic weight}}$$

$$n = \frac{71}{35.5} = 2 \text{ atoms}$$

∴ Atomicity of gas 'X' = 2

Question 6.
Calculate the relative molcular mass and vapour density of methyl alcohol [CH_3OH] if 160 g. of the alcohol on vaporization has a volume of 112 litres at s.t.p.

Answer:

Mass of 112 L of alcohol vapour at STP = 160 g

$$\therefore \text{ Mass of 1 L of alcohol vapour at STP hass mass} = \frac{160}{112} \text{ g}$$

$= 1.4286$ g

Mass of 1 L of H_2 at STP = 0.09 g

∴ Vapour density

$$= \frac{\text{Mass of given vol. of gas or vapour}}{\text{Mass of same vol. of } H_2 \text{ under similar T and P}}$$

$$= \frac{1.4286}{0.09} = 15.87 \approx 16$$

Mol. mass = 2 × V.D. = 2 × 15.87 = 31.75 ≈ 32

Percentage Composition – Empirical & Molecular Formula Calculations Based on Chemical

Additional Problems

Q.1. Percentage Composition

Question 1.

Calculate the percentage by weight of :
(a) C in carbon dioxide
(b) Na in sodium carbonate
(c) Al in aluminium nitride.
[C = 12, O = 16, H = 1, Na = 23, Al = 27, N = 14]

Answer:

(a) Weight of C = 12

Weight of $CO_2 = 12 + 2(16) = 44$

$$\% \text{ age of C in } CO_2 = \frac{\text{wt. of carbon}}{\text{wt. of } CO_2} \times 100$$

$$= \frac{12}{44} \times 100 = \frac{300}{11} = 27.27\%$$

$\Rightarrow$ Percentage of C in $CO_2 = 27.3\%$

(b) Wt. of sodium carbonate Na_2CO_3

$= 2(Na) + C + 3(O)$

$= 2\,(23) + 12 + 3\,(16)$
$= 46 + 12 + 48 = 106$

$$\text{Percentage of sodium in } Na_2CO_3 = \frac{\text{wt. of Na}}{\text{wt. of } Na_2CO_3} \times 100$$

$$= \frac{46}{106} \times 100 = 43.4\%$$

(c) Weight of Aluminium nitride AlN
Molecular weight of AlN = 27 + 14 = 41g

$$\text{Percentage of Aluminium} = \frac{\text{wt. of Al}}{\text{wt. of AlN}} \times 100$$

$$= \frac{27}{41} \times 100 = 65.85\%$$

Question 2.
Calculate the percentage of iron in $K_3Fe(CN)_6$. [K = 39,Fe = 56, C = 12, N = 14]

Answer:
Molecular mass of $K_3Fe(CN)_6$
$= 3\,(K) + Fe + 6\,[C + N]$
$= 3\,(39) + 56 + 6\,[12 + 14] = 329g$

$$\text{Percentage of iron in } K_3Fe(CN)_6 = \frac{\text{wt. of iron} \times 100}{\text{wt. of } K_3Fe(CN)_6}$$

$$= \frac{56 \times 100}{329} = 17.03\%$$

Question 3.
Calculate which of the following – calcium nitrate or ammonium sulphate has a higher % of nitrogen.[Ca = 40, S = 32, N = 14, O = 16]

Answer:

Gram-molecular mass of $Ca(NO_3)_2$

$= Ca + 2\,[N + 3(O)]$

$= 40 + 2\,[14 + 3(16)] = 40 + 2\,[14 + 48] = 164g$

Gram-molecular mass of $[NH_4]_2\,SO_4$

$= 2\,[N + 2(H)] + S + 4\,(O)^2$

$= 2\,[14 + 4(1)] + 32 + 4\,(16) = 132g$

$$\% \text{ of nitrogen in } Ca[NO_3] = \frac{28}{164} \times 100 = \frac{700}{41} = 17.07\%$$

$$\% \text{ of nitrogen in } [NH_4]_2\,SO_4 = \frac{28}{132} \times 100 = 21.2\%$$

$$\because \frac{700}{33} > \frac{700}{41} \text{ or } 21.2\% > 17.07\%$$

$\therefore$ % N_2 is higher in Ammonium sulphate

Question 4.
Calculate the percentage of pure aluminium in 10kg. of aluminium oxide $[Al_2O_3]$ of 90% purity. [Al = 27, O = 16]

Answer:

Molecular weight of Al_2O_3

$= 2\,(Al) + 3\,(O)$

$= 2\,(27) + 3\,(16) = 54 + 48 = 102g$

Wt. of aluminium in aluminium oxide = 54g

$$\% \text{ of Al in ore} = \frac{54 \times 100}{102} = \frac{27 \times 100}{51} = \frac{900}{17}$$

Pure aluminium is of 90% purity

$\therefore$ % of 90% pure Aluminium in ore (Al_2O_3)

$$= \frac{900}{17} \times \frac{90}{100} = \frac{810}{17} = 47.64\%$$

% purity of Al in ore my be 10kg or else

Question 5.
State which of the following are better fertilizers —

1. Potassium phosphate [K_3PO_4] or potassium nitrate [KNO_3]
2. Urea [NH_2CONH_2] or ammonium phosphate [$(NH_4)_3PO_4$]
   [K = 39, P = 31, O = 16, N = 14, H = 1]

Answer:

(*i*) Out of K_3PO_4 and KNO_3

Molecular weight of $K_3PO_4 = 3\ (K) + P + 4\ (O)$

$= 3\ (39) + 31 + 4\ (16) = 212\ g$

$$\% \text{ of potassium in } K_3PO_4 = \frac{117}{212} \times 100 \Rightarrow 55.2\%$$

Molecular wt. of $KNO_3 = K + N + 3\ (O)$

$= 39 + 14 + 48 = 101g$

$$\% \text{ of potassium in } KNO_3 = \frac{39}{101} \times 100 = 38.6\%$$

$\because$ % of potassium in K_3PO_4 is higher

$\therefore$ Potassium phosphate is better than potassium nitrate

(*ii*) Molecular weight of NH_2CONH_2

$= 2(N) + 4(H) + C + O$

$= 2(14) + 4(1) + 12 + 16 = 60g$

$$\% \text{ of nitrogen in urea} = \frac{28}{60} \times 100 = 46.67\%$$

Molecular weight of $[NH_4]_3\ PO_4$

$= 3(N) + 12(H) + P + 4(O)$

$= 3(14) + 12(1) + 31 + 4(16)$

$= 42 + 12 + 31 + 64 = 149g$

$$\% \text{ of } N_2 \text{ in } (NH_4)_3\ PO_4 = \frac{42}{149} \times 100 = 28.19\%$$

$\because$ % of N_2 in urea is higher than $(NH_4)_3\ PO_4$

$\therefore$ Urea is better

Question 6.
Calculate the percentage of carbon in a 55% pure sample of carbon carbonate.
[Ca = 40, C = 12, O = 16]

Answer:

$$= Ca + C + 3(O)$$
$$= 40 + 12 + 3\ (16) = 100g$$

Weight of carbon in 100 g of $CaCO_3$ = 12g

But purity is 55%

$\therefore$ Percentage of carbon in $CaCO_3$

$$= \frac{12 \times 55}{100} = 6.60\%$$

Question 7.
Calculate the percentage of water of crystallisation in hydrated copper sulphate [$CuSO_4.5H_2O$].
[Cu = 63.5, S = 32, O = 16, H = 1]

Answer:

Molecular weight of $CuSO_4.5H_2O$

$$= Cu + S + 4\ (O) + 5\ [(2H) + O]$$
$$= 63.5 + 32 + 4\ (16) + 5\ [2 \times (1) + 16] = 249.5g$$

$$\%\text{ of water of crystallisation} = \frac{\text{wt. of water}}{\text{wt. of } CuSO_4.5H_2O}$$

$$= \frac{90}{249.5} \times 100 = 36.07\%$$

Question 8.
Hydrated calcium sulphate [$CaSO_4xH_2O$] contains 21% of water of crystallisation. Calculate the number of molecules of water of crystallisation Le. 'X' in the hydrated compound.
[Ca = 40, S = 32, O = 16, H = 1]

Answer:

Molecular weight of $CaSO_4$

$= Ca + S + 4\,(O)$

$= 40 + 32 + 4\,(16) = 136$ g

136 g of $CaSO_4$ is = (100 – 21%) = 79% of total mass of $CaSO_4.xH_2O$ = A (say)

$\therefore$ 79% of A = 136

$$= \frac{79}{100} \text{ of } A = 136$$

$$\therefore\ A = \frac{136 \times 100}{79}$$

$$\text{X molecules of water} = 21\% \text{ of } A \left(\frac{136 \times 100}{79}\right)$$

$$= \frac{21}{100} \times \frac{136 \times 100}{79} = \frac{21 \times 136}{79}$$

$$\therefore\ \text{Number of molecules of water } n\,(18) = \frac{21 \times 136}{79}$$

$$n = \frac{21 \times 136}{79 \times 18} \Rightarrow 2 \text{ molecules}$$

$\therefore$ $CaSO_4.2H_2O$

Q.2. Empirical And Molecular Formula

Question 1.
A compound gave the following data : C = 57.82%, O = 38.58% and the rest hydrogen. Its vapour density is 83. Find its empirical and molecular formula. [C = 12, O = 16, H = 1]

Answer:

Element	% composition	At. wt.	R.N. of atoms	Simple ratio
C	57.82	12	$\frac{57.82}{12} = 4.8$	$\frac{4.8}{2.4} = 2$
O	38.58	16	$\frac{38.58}{16} = 2.41$	$\frac{2.4}{2.4} = 1$
H	3.60	1	$\frac{3.60}{1} = 3.6$	$\frac{3.6}{2.4} = \frac{3}{2}$

$$C : O : H = 2 : 1 : \frac{3}{2} = 4 : 2 : 3$$

Simplest ratio of whole numbers = 4 : 2 : 3

$\therefore$ Empirical formula is $C_4O_2H_3$ or $C_4H_3O_2$

$\therefore$ E.F. weight = 4(12) + 2(16) + 3(1)

= 48 + 32 + 3 = 83

Vapour density, V.D. = 83

Molecular formula weight = 2 × V.D.

= 2 × 83 (given) = 166

$$\therefore n = \frac{\text{Molecular formula wt.}}{\text{Empirical formula wt.}} = \frac{166}{83} = 2$$

$\therefore$ Molecular formula = n [E.F.]

$= 2\ [C_4O_2H_3] = C_8O_4H_6$

$\therefore$ Molecular formula $C_8H_6O_4$

Question 2.

Four g of a metallic chloride contains 1.89 g of the metal ‘X’. Calculate the empirical formula of the metallic chloride. [At. wt. of ‘X’ = 64, Cl = 35.5]

Answer:

Wt. of metallic chloride = 4g

Wt. of metal = 1.89g

$\therefore$ Wt. of chloride = 4 – 1.89 = 2.11g

Metal X chloride Cl

Symbol	Composite	At. wt.	R.N. of atoms	Simple ratio
X	1.89	64	$\frac{1.89}{64} = 0.03$	$\frac{0.03}{0.03} = 1$
Cl	2.11	35.5	$\frac{2.11}{35.5} = 0.06$	$\frac{0.06}{0.03} = 2$

Empirical formula = $X_1Cl_2 = XCl_2$

Question 3.
Calculate the molecular formula of a compound whose empirical formula is CH_2O and vapour density is 30.

Answer:

Empirical formula weight = C + 2H + O

V.D. = 30 (given)

$\therefore$ Molecular weight = 2 × V.D. = 2 × 30 = 60

$$n = \frac{\text{molecular wt.}}{\text{E.F. weight}} = \frac{60}{30} = 2$$

$\therefore$ Molecular formula = n [Empirical formula]

$= 2\,[CH_2O] = C_2H_4O_2 \Rightarrow CH_3COOH$

Question 4.
A compound has the following percentage composition. Al = 0.2675g.; P = 0.3505g.; O = 0.682g. If the molecular weight of the compound is 122 and its original weight on analysis gave the above results 1.30 g. Calculate the molecular formula of the compounds
[Al = 27, P = 31, O = 16]

Answer:

Element %	composition	Atomic ratio	Simplest ratio of whole numbers
Al	0.2675	$\frac{0.2675}{27} = 0.0099 = 99$	$\frac{99}{99} = 1 = 1$
P	0.3505	$\frac{0.3505}{31} = 0.0113 = 113$	$\frac{113}{99} = 1.14 = 1$
O	0.6820	$\frac{0.6820}{16} = 0.0426 = 426$	$\frac{429}{99} = 4.3 = 4$

$Al : P : O = 1 : 1 : 4$

$\therefore$ Empirical formula $= AlPO_4$

Question 5.
Two organic compounds 'X' and 'Y' containing carbon and hydrogen only have vapour densities 13 and 39 respectively. State the molecular formula of 'X' and 'Y' [C = 12, H = 1]

Answer:

Vapour density of X = 13

$\therefore$ Mol. mass of X = 2 × V.D. = 2 × 13 = 26

Vapour density of Y = 39

$\therefore$ Mol. mass of Y = 2 × V.D. = 2 × 39 = 78

Let formula of X = C_mH_n

Where m and n are simple whole numbers.

$\therefore$ Mol. mass of X = $12m + n = 26$

The only simple whole number values of n and n which satisfies this equation are,

$m = 2$, and $n = 2$

$\therefore$ Molecular formula of X = C_2H_2

Let formula of Y = C_xH_y

Where x and y are simple whole numbers.

$\therefore$ Mol. mass of Y = $12x + y = 78$

The only simple whole number values of x and y which satisfies this equation are ;

$x = 6, y = 6$

$\therefore$ Molecular formula of Y = C_6H_6

Question 6.

A compound has the following % composition. Zn = 22.65%; S = 11.15%; O = 61.32% and H = 4.88%. Its relative molecular mass is 287 g. Calculate its molecular formula assuming that all the hydrogen in the compound is present in combination with oxygen as water of crystallization.
[Zn = 65, S — 32, O = 16, H = 1]

Answer:

Element	% composition	At. ratio	Simplest ratio of whole numbers
Zn	22.65	$\frac{22.65}{65} = 0.35$	$\frac{0.35}{0.35} = 1$
S	11.15	$\frac{11.15}{32} = 0.35$	$\frac{0.35}{0.35} = 1$
O	61.32	$\frac{61.32}{16} = 3.83$	$\frac{3.83}{0.35} = 11$
H	4.88	$\frac{4.88}{1} = 4.88$	$\frac{4.88}{0.35} = 14$

But all the hydrogen in the compound is present in combination with oxygen as water of crystallization

$\therefore$ $H_2 : O$

$14 : 11 \Rightarrow 14 : 11$

7 molecules of H_2 need 7 atoms of oxygen to form

$\therefore$ $11 - 7 = 4$ atoms of oxygen are left

$1 : 1 : 4 : 7$

Formula of compound is $Zn : S : O : H_2O$

$ZnSO_4.7H_2O$

Question 7.
A hydrocarbon contains 82.8% of carbon. Find its molecular formula if its vapour density is 29 [H = 1, C = 12]

Answer:

Element At. wt.	% composition	At. ratio	Simplest ratio of whole numbers
C 12	82.8	$\frac{82.8}{12} = 6.9$	$\frac{6.9}{6.9} = 1$
H 1	100 – 82.8 = 17.2	$\frac{17.2}{1} = 17.2$	$\frac{17.2}{6.9} = 2.5$

$\therefore$ C : H $= 1 : \frac{5}{2} = 2 : 5$

$\therefore$ E. formula $= C_2H_5$

E.F. wt. $= (12 \times 2) + 5\,(1) = 29$ g

M. wt. $= 2 \times$ V.D.

$= 2 \times 29$ (given) $= 58$ g

$$n = \frac{\text{M.F. wt.}}{\text{E.F. wt.}} = \frac{58}{29} = 2$$

$\therefore$ Molecular formula $= n\,[C_2H_5] = 2\,[C_2H_5] = C_4H_{10}$

Question 8.
An organic compound on analysis gave H = 6.48% and O = 51.42%. Determine its empirical formula if the compound contains 12 atoms of carbon.
[C = 12, H = 1, O = 16]

Answer:

Element	At. no. %	composition	At. ratio	Simplest ratio of whole numbers
H	1	6.48	$\frac{6.48}{1} = 6.48$	$\frac{6.48}{3.21} = 2$
O	16	51.42	$\frac{51.42}{16} = 3.21$	$\frac{3.21}{3.21} = 1$
C	12	42.10	$\frac{42.10}{12} = 3.51$	$\frac{3.51}{3.21} = 1.1$

This shows H : O : C = 2 : 1 : 1

That is empirical formula no. of oxygen atoms = no. of carbon atoms and number of hydrogen atoms is twice the number of oxygen atoms

∴ 2 × oxygen atoms = hydrogen atoms

H = 2 × 12 = 24

Oxygen atoms = carbon atoms = 12 (given)

∴ Empirical formula = $C_{12}H_{24}O_{12}$

Question 9.
A hydrated salt contains Cu = 25.50%, S = 12.90%, O = 25.60% and the remaining % is water of crystallization. Calculate the empirical formula of the salt.
[Cu = 64, S = 32, O = 16, H = 1]

Answer:

Element	At. no. %	composition	At. ratio	Simplest ratio of whole numbers
Cu	64	25.5	$\frac{25.5}{64} = 0.4$	$\frac{0.4}{0.4} = 1$
S	32	12.9	$\frac{12.9}{32} = 0.4$	$\frac{0.4}{0.4} = 1$
O	16	25.6	$\frac{25.6}{16} = 1.6$	$\frac{1.6}{0.4} = 4$
H_2O	18	36	$\frac{36}{18} = 2.0$	$\frac{2.0}{0.4} = 5$

Ratio of Cu : S : O : H_2O = 1 : 1 : 4 : 5

∴ Empirical formula of compound = $CuSO_4.5H_2O$

Question 10.
A gaseous hydrocarbon weights 0.70 g. and contains 0.60 g. of carbon. Find the molecular formula of the compound if its molecular weight is 70.
[C = 12, H = 1]

Answer:

Element	At. no. %	composition	At. ratio	Simplest ratio of whole numbers
C	12	0.6	$\frac{0.6}{12} = .05$	$\frac{0.05}{0.05} = 1$
H	1	$0.7 - 0.6 = 0.1$	$\frac{0.1}{1} = 0.1$	$\frac{0.1}{0.05} = 2$

Ratio of C : H = 1 : 2 = CH_2

E.F. wt. = 12 + 2 (1) = 14

$$n = \frac{\text{Mol. wt.}}{\text{E.F. wt.}} = \frac{70}{14} = 5$$

$\therefore$ Molecular formula = 5 $[CH_2]$ = C_5H_{10}

Question 11.

A salt has the following % composition Al = 10.50%, K = 15.1%, S = 24.8% and the remaining oxygen. Calculate the empirical formula of the salt.
[Al = 27, K = 39, S = 32, O = 16]

Answer:

$$\text{Percentage of oxygen} = 100 - (\text{Al\%} + \text{K\%} + \text{S\%})$$
$$= 100 - (10.50 + 15.10 + 24.80)$$
$$= 100 - 50.40 = 49.50\%$$

Element	At. no. %	composition	At. ratio	Simplest ratio of whole numbers
Al	27	10.5	$\frac{10.5}{27} = 0.39$	$\frac{0.39}{0.38} = 1$
K	39	15.1	$\frac{15.1}{39} = 0.39$	$\frac{0.38}{0.38} = 1$
S	32	24.8	$\frac{24.8}{32} = 0.78$	$\frac{0.78}{0.38} = 2$
O	16	49.6	$\frac{49.6}{16} = 3.09$	$\frac{3.09}{0.38} = 8$

Al : K : S : O = 1 : 1 : 2 : 8

$\therefore$ Empirical formula of salt $= AlKS_2O_8$

$= AlK\,[SO_4]_2$

Q.3. Chemical Equations

Question 1.
What mass of silver chloride will be obtained by adding an excess of hydrochloric acid to a solution of 0.34 g of silver nitrate.
[Cl = 35.5, Ag = 108, N = 14, O = 16, H = 1]

Answer:

$$\underset{\substack{108 + 14 + 48 \\ 170\text{ g}}}{AgNO_3} + HCl \longrightarrow \underset{\substack{108 + 35.5 \\ 143.5\text{ g}}}{AgCl} + HNO_3$$

170 g of $AgNO_3$ produces AgCl = 143.5 g

$\therefore$ 0.34 g of $AgNO_3$ will produce AgCl $= \frac{143.5 \times 0.34}{170} = 0.287$ g

Question 2.
What volume of oxygen at s.t.p. will be obtained by the action of heat on 20 g KClO3 [K = 39, Cl = 35.5, O = 16]

Answer:

$$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$$

2 [39 + 35.5 + 48] 3 molar vol.

245

2 moles of $KClO_3$ at s.t.p. evolve O_2 = 3 molar vol.

= 3 × 22.4 lits.

or 245 g of $KClO_2$ produce O_2 = 3 × 22.4 lits.

$$\therefore \text{ 20 g } KClO_3 \text{ produce } O_2 = \frac{3 \times 22.4 \times 20}{245} = 5.48 \text{ lits.}$$

Question 3.
From the equation : $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$. Calculate

1. the mass of copper needed to react with 63 g of nitric acid
2. the volume of nitric oxide collected at the same time. [Cu = 64, H = 1, O = 16, N = 14]

Answer:

(*i*) $3Cu + 8HNO_3 \rightarrow 3Cu[NO_3]_2 + 4H_2O + 2NO$

3 (64) 8 [1+14+48]

192 8 × 63 = 504

504 g of HNO_3 needs Cu = 192g

$$\therefore \text{ 63 g of } HNO_3 \text{ needs Cu} = \frac{192 \times 63}{504} = \frac{192}{8} = 24g$$

(*ii*) $3Cu + 8HNO_3 \rightarrow 3Cu[NO_3] + 4H_2O + 2NO$

8 vol. 2 vol.

8 volumes of HNO_3 produces NO = 2 vol.

= (2 × 22.4) lit.

or (8 × 63) g produces NO = (2 × 22.4) lit.

$$\therefore \text{ 63g } (HNO_3) \text{ produces NO} = \frac{2 \times 22.4 \times 63}{(8 \times 63)} = 5.6 \text{ lits.}$$

Question 4.
Zinc blende [ZnS] is roated in air. Calculate :

(a) The number of moles of sulphur dioxide liberated by 776 g of ZnS and
(b) The weight of ZnS required to produce 22.4 lits. of SO_2 at s.t.p. [S = 32, O = 16, Zn = 65]

Answer:

(a) $ZnS + O_2 \longrightarrow SO_2$

(65 + 32) 1 mole

97g

97g of ZnS produces SO_2 = 1 mole

$$\therefore \text{ 776g of ZnS produces } SO_2 = \frac{1 \times 776}{97} = 8 \text{ moles}$$

(b) $ZnS + O_2 \longrightarrow SO_2$

(65 + 32) (1 mole) 22.4 lits.

97g

22.4 lits of SO_2 is produce by 97 g of ZnS

Question 5.
Ammonia reacts with sulphuric acid to give the fertilizer ammonium sulphate. Calculate the volume of ammonia [at s.t.p.] used to form 59 g of ammonium sulphate.
[N = 14, H = 1, S = 32, O = 16]

Answer:

$2NH_3 + H_2SO_4 \longrightarrow [NH_4] SO_4$

2 [22.4] lits. 2 [14 + 4] + 32 + 64

36 + 96 = 132g

Vol. of ammonia needed = 2 vols.

= (2 × 22.4) lits.

132g of $[NH_4]_2 SO_4$ require Ammonia = (2 × 22.4) lits.

$$\therefore \text{ 59g of } [NH_4]_2 \text{ require Ammonia} = \frac{2 \times 22.4 \times 49}{132} = 20.02 \text{ lits.}$$

Question 6.
Heat on lead nitrate gives yellow lead [II] oxide, nitrogen dioxide and oxygen. Calculate the total volume of NO_2 and O_2 produced on heating 8.5 of lead

nitrate.
[Pb = 207, N = 14, O = 16]

Answer:

$$2Pb[NO_3]_2 \xrightarrow{\Delta} 2PbO + 4NO_2 + O_2$$

2 [207+2(14+48] $4 \times (22.4)$ lits.   22.4 lits

2 [207+124]

2×331g

(2×331)g of lead nitrate gives $NO_2 = (4 \times 22.4)$ lits.

$$\therefore \ 8.5\text{g of lead nitrate gives } NO_2 = \frac{4 \times 22.4 \times 8.5}{2 \times 331}$$

$$= 1.15 \text{ lits. of } NO_2$$

(2×331) g of lead nitrate gives $O_2 = 22.4$ lits

$$\therefore \ 8.5 \text{ g of lead nitrate gives } O_2 = \frac{22.4 \times 8.5}{2 \times 331} = 0.287 \text{ lits}$$

$$= 0.287 \text{ lits of } O_2$$

$$\therefore \ \text{Total vol. produced} = 1.15 + .287 = 1.437 \text{ lits.}$$

Question 7.
Calculate the amount of $KClO_3$ which on thermal decomposition gives 'X' vol. of O_2, which is the volume required for combustion of 24 g. of carbon.

$$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2; \ C + O_2 \xrightarrow{\Delta} CO_2.$$

[K = 39, Cl = 35.5, O = 16, C = 12].

Answer:

$$C + O_2 \xrightarrow{\Delta} CO_2$$

12g 22.4 lits.

12g carbon on combustion produces $CO_2 = 22.4$ lits.

$$\therefore \text{ 24g carbon produces} = \frac{22.4 \times 24}{12} = (2 \times 22.4) \text{ lits.}$$

$$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$$

2 [39+35.5+48] (3×22.4) lits

245g

For (3 × 22.4) lits. O_2 wt. of $KClO_3 = 245g$

$$\therefore \text{ For } (2 \times 22.4) \text{ lits } O_2 \text{ wt. of } KClO_3 = \frac{245 \times (2 \times 22.4)}{(3 \times 22.4)}$$

$$= \frac{490}{3} = 163.33g$$

Question 8.
Calculate the weight of ammonia gas.
(a) Required for reacting with sulphuric acid to give 78g. of fertilizer ammonium sulphate.
(b) Obtained when 32.6g. of ammonium chloride reacts with calcium hydroxide during the laboratory preparation of ammonia.
[$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3$] [N = 14, H = 1, O = 16, S = 32, Cl = 35.5].

Answer:

(a) $2NH_3 + H_2SO_4 \longrightarrow [NH_4]_2SO_4$

$2[14+3\times1]$ $\qquad$ $2[14+4]+32+64$

$34g$ $\qquad$ $= 132g$

132g of ammonium sulphate is produced from $NH_3 = 34g$

$\therefore$ 78g of $(NH_4)_2SO_4$ is produced from $= \dfrac{34\times78}{132} = 20.09g$

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

$2[14+4+35.5$ $\qquad$ $2[14+3]$

2×53.5 $\qquad$ $34g$

$107.0g$

107g of ammonium chloride produces $NH_3 = 34g$

$\therefore$ 32.6g of ammonium chloride produces ammonia $= \dfrac{34\times32.6}{107}$

$= 10.36g$

Question 9.
Sodium carbonate reacts with dil. H_2SO_4 to give the respective salt, water and carbon dioxide. Calculate the mass of pure salt formed when 300 g. of Na_2CO_3 of 80% purity reacts with dil. H_2SO_4.
[Na = 23, C = 12, O = 16, H = 1, S = 32].

Answer:

$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$

$2(23)+12+3(16)$ $\quad$ (dil.) $\qquad$ $2(23)+32+4(16)$

$106g$ $\qquad$ $142g$

80% of 300 $(Na_2CO_3) = \dfrac{80}{100}\times300 = 240g$ of Na_2CO_3

106g of Na_2CO_3 produce $Na_2SO_4 = 142g$

$\therefore$ 240g of Na_2CO_3 produce $Na_2SO_4 = \dfrac{142\times240}{106} = 321.51g$

Question 10.
Sulphur burns in oxygen to give sulphur dioxide. If 16 g. of sulphur burns in 'x' cc. of oxygen, calculate the amount of potassium nitrate which must be heated

to produce V cc. of oxygen. [S = 32, K = 39, N = 14, O = 16].

Answer:

$$2KNO_3 \longrightarrow 2KNO_2 + O_2$$
$$S + O_2 \longrightarrow SO_2$$

2 mol KNO_3 $\equiv 1$ mol $O_2 \equiv 1$ mol S

$= 2 \times (39 + 14 + 16 \times 3$ $= 32$ g

$= 2 \times 101 = 202$ g

32 g of sulphur require O_2 obtained from $KNO_3 = 202$ g

16 g of sulphur will require O_2 produced from KNO_3

$$= \frac{202}{32} \times 16 = 101 \text{ g}$$

Question 11.
Sample of impure magnesium is reacted with dilute sulphuric acid to give the respective salt and hydrogen. If 1 g. of the impure sample gave 298.6 cc. of hydrogen at s.t.p. Calculate the % purity of the sample. [Mg = 24, H = 1].

Answer:

$$\underset{24g}{Mg} + \underset{(dil.)}{H_2SO_4} \longrightarrow MgSO_4 + H_2\uparrow$$

22400 cc of H_2 is produced from 24 g pure magnesium

$$\therefore \text{ 298.6 cc } H_2 \text{ is produced from } \frac{24 \times 298.6}{22400} = \frac{4479}{14000} \text{ g}$$

$$\frac{4479}{14000} \text{ g of pure Mg is in 1 g impure Mg sample}$$

$$\therefore \text{ \% purity} = \frac{4479}{14000} \times \frac{100}{1} = \frac{4479}{140}$$

$$= \frac{447.9}{14} = 31.99 = 31.99\%$$

Questions

A. Lussac'S Law – Problems based on them

2006

Question 1.
560 ml. of carbon monoxide is mixed with 500 ml of oxygen and ignited. The chemical equation for the reaction is as follows : $2CO + O_2 \rightarrow 2CO_2$. Calculate the volume of oxygen used and carbon dioxide formed in the above reaction.

Answer:

$$\underbrace{2CO}_{2\text{ vol.}} + \underbrace{O_2}_{1\text{ vol.}} \longrightarrow \underbrace{2H_2O}_{2\text{ vol.}}$$

2 vol. of CO use oxygen = 1 vol.

$$560 \text{ ml of CO use oxygen} = \frac{1}{2} \times 560 = 280 \text{ ml.}$$

2 vol. of CO produces = 2 vol. of CO_2

$$560 \text{ ml of CO produces} = \frac{2}{2} \times 560 = 560 \text{ ml}$$

2009

Question 1.
200 cm^3 of acetylene is formed from a certain mass of calcium carbide, find the volume of oxygen required and carbon dioxide formed during the complete combustion. The combustion reaction can be represented as below.
$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$

Answer:

$$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$$

2 volumes of acetylene requires 5 volumes of oxygen

1 volume of acetylene requires $\frac{5}{2}$ volumes of oxygen

200 cm^3 of acetylene requires $= \frac{5}{2} \times 200\ cm^3$

$= 500\ cm^3$ of oxygen

2 volumes of acetylene is required to form

$= 4$ volumes of CO_2

1 volume of acetylene is required to form

$= \frac{4}{2}$ volumes of CO_2

200 cm^3 of acetylene is required to form $= \frac{4}{2} \times 200\ cm^3$

$= 400\ cm^3$ of CO_2

Thus 500 cm^3 of oxygen is required and 400 cm^3 of CO_2 is formed.

2010

Question 1.

10 litre of this mixture is burnt, And the total volume of carbon dioxide gas added to the atmosphere. Combustion reaction can be represented as :

$$C_3H_{8(g)} + 50_{2(g)} \longrightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

$$2C_4H_{10(g)} + 13O_{2(g)} \longrightarrow 8CO_{2(g)} + 10H_2O_{(g)}$$

Answer:

$$C_3H_{8(g)} + 5O_{2(g)} \longrightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

1 vol 3 vol

6 litres ?

1 vol of propane releases = 3 vol of CO_2

6 litres of propane releases = $\frac{3}{1} \times 6$ litres

Combustion of butane :

$$2C_4H_{10(g)} + 13O_{2(g)} \longrightarrow 8CO_{2(g)} + 10H_2O_{(g)}$$

2 vol 8 vol

1 vol 4 vol

4 litres ?

2 vol of butane releases = 8 vol of CO_2

4 litres of butane releases = $\frac{8}{2} \times 4 = 16\ l$

Total CO_2 released O_2 = $18\ l + 16\ l$

= 34 litres of CO_2 gas is added to atmosphere

2012

Question 1.
67.2 litres of H_2 combines with 44.8 litres of N_2 to form NH_3 :
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$. Calculate the vol. of NH_3 produced. What is the substance, if any, that remains in the resultant mixture ?

Answer:

3 volume of hydrogen produces 2 volume of ammonia

67.2 litres of hydrogen produces = $\frac{2}{3} \times 67.2 = 44.8$ litres

3 volume of hydrogen reacts with 1 volumes of nitrogen

67.2 litres of hydrogen reacts with = $\frac{1}{3} \times 67.2 = 22.4$ litres

Nitrogen left = 44.8 – 22.4 = 22.4 litres

2013

Question 1.
What volume of oxygen is required to burn completely 90 dm^3 of butane under similar conditions of temperature and pressure?
$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

Answer:

$$\begin{array}{lllll} 2C_4H_{10}(g) + 13O_2 & \longrightarrow & 8CO_2 & + & 10H_2O \\ \text{2Vols.} \quad \text{13Vols.} & & \text{8 Vols.} & & \text{Nil} \end{array}$$

(Under similar T and P)

2 volume of butane require O_2 for complete combustion

$= 13$ vol.

90 dm^3 of butane will require O_2 for complete combustion

$$= \frac{13}{2} \times 90 = 585 \text{ dm}^3$$

2014

Question 1.
What volume of ethyne gas at s.t.p. is required to produce 8.4 dm^3 of carbon dioxide at s.t.p.?
$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$ [H = 1, C = 12, O = 16]

Answer:

$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$ [by Gay Lussac's Law]

2 vol. 5 vol. 4 vol.

4 vol. of CO_2 required ethyne = 2 vol.

$\therefore$ 4 dm^3 of vol. of CO_2 required ethyne $= \frac{2}{4}$ dm^3

8.4 dm^3 vol. of CO_2 required ethyne $= \frac{2 \times 8.4}{4} = 4.2$ dm^3

2015

Question 1.
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:

$$H_2 + Cl_2 \longrightarrow 2HCl$$

1 volume of chlorine reacts with 1 volume of hydrogen

$\therefore$ 4 litres of chlorine reacts with $\frac{1}{1} \times 4\ l$ of hydrogen

$\therefore$ Hydrogen used is 4 litres

Remaining hydrogen = 6 – 4 = 2 litres

1 volume of chlorine forms 2 volume of HCl

4 litres of chlorine forms $= \frac{2}{1} \times 4 = 8\ l$ of HCl

Hence gases after reaction, 8 *l* HCl and 2 *l* hydrogen *i.e.*, 10 litres

When water is added to the gases formed HCl dissolves and residual gas is 2 litres of hydrogen.

2016

Question 1.
The equations $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$, represents the catalytic oxidation of ammonia. If 100 cm3 of ammonia is used calculate the volume of oxygen required to oxidise the ammonia completely.
Answer:

$4NH_3$	+	$5O_2$	$\rightarrow$	$4NO$	+	$6H_2O$
4 Vol		5 Vol		5 Vol		

If 4 volumes of NH_3 requires 5 vol. of O_2.

Then 100 cm³ of NH_3 requires $= \frac{5}{4} \times 100 = 125\ cm^3$ oxygen

2017

Question 1.
Propane burns in air according to the following equation :
$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$. What volume of propane is consumed on using 1000 cm3 of air, considering only 20% of air contains oxygen.

Answer:

$$\text{Amount of oxygen in } 1000 \text{ cm}^3 \text{ of air} = 1000 = \frac{20}{100} = 200 \text{ cm}^3$$

$$\begin{array}{llllllll} C_3H_8 & + & 5O_2 & \rightarrow & 3CO_2 & + & 4H_2O \\ 1 \text{ vol} & : & 5 \text{ vol} & & 3 \text{ vol} & : & \text{Nil} \end{array}$$

For 5 volumes of oxygen, the propane consumption = 1 Vol

$$\therefore \; 200 \text{ cm}^3 \text{ of oxygen, the propane consumption} = \frac{200}{5} = 40 \text{ cm}^3$$

B. Mole Concept – Avogadro'S Number – Problems based on them

2004

Question 1.
A flask contains 3.2 g of SO_2. Calculate :

1. The moles of SO_2 and the no. of molecules of SO_2 present in the flask.
2. The volume occupied by 3.2 g. of SO_2 at s.t.p. (S = 32, O = 16)

Answer:

(i) $\underbrace{SO_2}_{1 \text{ mol.}}$

Molecular mass = (32 + 2 × 16) = 64 g

64 g of SO_2 is equal to 1 mole

$$\therefore \quad 3.2 \text{ of } SO_2 \text{ is} = \frac{1}{64} \times 3.2 = 0.05 \text{ mole}$$

1 mole of SO_2 has = 6.02×10^{23} molecules

0.05 mole of SO_2 has = $0.05 \times 6.02 \times 10^{23} = 3.01 \times 10^{22}$ molecules

(ii) 64 g of SO_2 at S.T.P. occupies = 22.4 *l*

$$3.2 \text{ g of } SO_2 \text{ at S.T.P. occupies} = \frac{22.4}{64} \times 32 = 1.12 \, l$$

Question 2.
$2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$ Given that the molecular mass KMn04 is 158, what volume of oxygen (measured at room temperature) would be obtained by the complete decomposition of 15.8 g. of potassium permanganate. (Molar

volume at room temperature is 24 litres.)

Answer:

$$2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$$

2 (39 + 55 + 64) 24 lit.

$2 \times 158 = 316$ g

vol. of O_2 produced by 316 g of $KMnO_4$ = 24 lit.

$$\therefore \text{ vol. of } O_2 \text{ produced by 15.8 g of } KMnO_4 = \frac{24 \times 15.8}{316} = 1.2 \text{ lit.}$$

2005

1. The volumes of gases A, B, C and D are in the ratio, 1 : 2 : 2 : 4 under the same conditions of temp, and press.

(i) Which sample contains the maximum number of molecules. If the temp, and pressure of gas A are kept constant, then what will happen to the volume of A when the no. of molecules is doubled.

Answer:
The sample D and volume of A will get Doubled.

(ii) If this ratio of gas vols. refers to reactants and products of reaction – gas law observed is ….
Answer:
Gay Lussac's law of combining volumes.

(iii) If the volume of 'A' is 5.6 dm^3 at s.t.p., calculate the no. of molecules in the actual vol. of 'D' at s.t.p. (Avog no. is 6 × 10^{23}). Using your answer, state the mass of 'D' if the gas is "N2O" (N = 14, O = 16). [6 x 1023, 44g.]

Answer:
Vol. of D will be 4 × 5.6 = 22.4 lit. and 22.4 lit. of D contain molecules = 6 × 10^{23} (AV. number)
Mass of N_2 O (i.e. D) = (14 × 2 + 16 × 1) = 44g

2006

Question 1.
Calculate the no. of moles and the no. of molecules present in 1.4 g of ethylene gas (C_2H_4). What is the vol. occupied by the same amount of C_2H_4. State the vapour density of C_2H_4.

(Avog. No. = 6 × 10^{23} ; C = 12, H = 1]
(0.05 moles ; 3 × 10^{22} molecules ; 1.12 lit. ; 14)

Answer:

(a) Mass of ethylene gas = 1.4 g

$$\text{Number of moles of ethylene} = C_2H_4 = \frac{\text{mass}}{\text{molar mass}} = \frac{1.4}{28} = 0.5$$

Number of molecules in 0.05 mole ethylene = $0.05 \times 6 \times 10^{23}$
$= 3 \times 10^{22}$ molecules

1 mole of ethylene has volume at s.t.p. = 22.4 lit.
Volume occupied by 0.05 moles of ethylene gas at s.t.p.
$= 0.05 \times 22.4 = 1.12$ lit.

(b) $$\text{Vapour density of ethylene} = \frac{\text{mol. wt}}{2} = \frac{28}{2} = 14$$

2008

1. The equation for the burning of octane is : $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$

(i) How many moles of carbon dioxide are produced when one mole of octane burns ?

Answer:
2 moles of octane produce 16 moles of $C0_2$
1 mole of octane will produce 16/2 moles of $C0_2$ = 8 moles of carbon dioxide.

(ii) What volume, at s.t.p., is occupied by the number of moles determined in (1) (i) ?

Answer:
1 moles occupy a volume of 22.4 litres.
8 mole will occupy a volume of = 22.4 × 8 = 179.2 litres

(iii) If the relative molecular mass of carbon dioxide is 44, what is the mass of carbon dioxide produced by burning two moles of octane ?
Answer:
From equation, we know that 2moles of octane produces 16 moles of CO_2.
Mass of CO_2 produced = 16 × 44 = 704

2009

Question 1.
Define the term – Mole. A gas cylinder contains 24×10^{24} molecules of nitrogen gas. If Avogadro's number is 6×10^{23} and the relative atomic mass of nitrogen is 14, calculate :

1. Mass of nitrogen gas in the cylinder.
2. Volume of nitrogen at STP in dm^3

Answer:

Definition -A mole is the amount of substance which contains particles (atoms/molecules ions) equal to 6.023×10^{23} i.e. Avogadro's no."

(i) Nitrogen exist as N_2.

Hence its molecular mass = $14 \times 2 = 28$g

6×10^{23} molecules of nitrogen weigh = 28 g

1 molecule of nitrogen will weigh = $\frac{28}{6 \times 10^{23}}$

= 1119.9 g or 1.119 kg

(ii) 6×10^{23} molecules will occupy a volume of 22.4 dm^3

1 molecule will occupy a volume of $\frac{22.4}{6 \times 10^{23}}$ dm^3

24×10^{24} molecules will occupy a volume of

$$= \frac{22.4}{6 \times 10^{23}} \times 24 \times 10^{24} = 895.9 \text{ dm}^3$$

Question 2.
Gas 'X' occupies a volume of 100 cm^3 at S.T.P and weighs 0.5 g. find its relative molecular mass.

Answer:

100 cm^3 of a gas weighs = 0.5g

1 cm^3 of a gas will weigh = $\frac{0.5}{100}$ g

22400 cm^3 of a gas will weigh = $\frac{0.5}{100} \times 22400 = 112$g

2010

Question 1.
Dilute hydrochloric acid (HCl) is reacted with 4.5 moles of calcium carbonate. Give the equation for the said reaction. Calculate :

1. The mass of 4.5 moles of $CaCO_3$.
2. The volume of CO_2 liberated at stp.
3. The mass of $CaCl_2$ formed ?
4. The number of moles of the acid HCl used in the reaction (relative molecular mass of $CaCO_3$ is 100 and of $CaCl_2$ is 111].

Answer:

(i) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Molar mass of $CaCO_3$ = 100 g = 1 mole

$\therefore$ 4.5 mole of $CaCO_3 = 4.5 \times 100 = 450$ g

(ii) 1 mole of $CaCO_3$ produces 1 mole of CO_2

4.5 moles of $CaCO_3$ will produce 4.5 moles of CO_2

$\because$ 1 mole of CO_2 occupies 22.4 l at at S.T.P.

$\therefore$ 4.5 moles of CO_2 will $= 4.5 \times 22.4\ l = 100.80 l$

(iii) 1 mole = 22.4

1 mole of $CaCO_3$ gives 111 g of $CaCl_2$

4.5 mole of $CaCO_3$ gives $111 \times 4.5 = 499.5$g

(iv) 1 mole uses 2 moles of HCl

4.5 mole uses $4.5 \times 2 = 9$ moles

2011

Question 1.
Calculate the mass of :

1. 10^{22} atoms of sulphur.
2. 0.1 mole of carbon dioxide.
   [S = 32, C = 12 and O = 16 and Avogadro's Number 6×10^{23}]

Answer:

(i) 6.022×10^{23} atoms of sulphur weight = 32

$$1 \text{ atom of sulphur weigh} = \frac{32}{6.022 \times 10^{23}}$$

$$10^{22} \text{ atoms of sulphur weigh} = \frac{32}{6.022 \times 10^{23}} \times 10^{22} = 0.531 \text{ g}$$

(ii) 1 mole of CO_2 weigh = 44 g

0.1 mole of CO_2 weigh = $44 \times 0.1 = 4.4$ g

Question 2.
Calculate the volume of 320 g of SO_2 at stp. [S = 32 and O = 16]

Answer:

SO_2

M.W. = $32 + 16 \times 2 = 64$

64 g of SO_2 occupy 22.4 litres

$$1 \text{ g of } SO_2 \text{ will occupy} = \frac{22.4}{64} \text{ litres}$$

$$320 \text{ g of } SO_2 \text{ will occupy} = \frac{22.4}{64} \times 320 = 22.4 \times 5 = 112 \text{ litres}$$

2012

Question 1.
The mass of 5.6 dm^3 of a certain gas at STP is 12.0 g. Calculate the relative molecular mass of the gas.

Answer:

5.6 dm^3 of gas weighs = 12 g

$$22.4 \text{ dm}^3 \text{ of gas weighs} = \left(\frac{12.0}{5.6} \times 22.4\right) \text{ gm} = 48 \text{ gm}$$

2013

Question 1.
The vapour density of a gas is 8. What would be the volume occupied by 24.0 g

of the gas at STP ?

Answer:

V.D. of gas = 8

$\therefore$ Molecular mass of gas = $2 \times$ V.D. = $2 \times 8 = 16$

$\therefore$ Gram molecular mass of gas = 16 g

16 g of gas at STP occupies = 22.4 l at S.T.P.

$$\therefore \text{24 g of gas at STP occupies} = \frac{22.4 \times 24}{16} = 33.6\ l$$

Question 2.
Calculate the volume occupied by 0.01 mole of CO_2 at STP.

Answer:

1 mole of carbon dioxide gas at STP occupies = 22.4 l

$\therefore$ 0.01 mole of carbon dioxide gas at STP occupies

$$= \frac{22.4 \times 0.01}{1} = 0.224 l$$

2014

Question 1.
State Avogadro’s Law. A cylinder contains 68g of ammonia gas at s.t.p.

1. What is the volume occupied by this gas?
2. How many moles and how many molecules ammonia are present in the cylinder? [N = 14, H = 1]

Answer:

Avogadro's Law states that "equal vol. of all gases under similar conditions of temperature and pressure contain the same no. of molecules."

(i) Molecular gram atom wt. of NH_3 = 17 gm

17 gm of NH_3 has vol. at s.t.p. = 22.4 lt.

$\therefore$ 68 gm of NH_3 has vol. at s.t.p. = $\frac{22.4 \times 68}{17}$ = 89.6 lt.

(ii) No. of moles in 68 gm of NH_3 = $\frac{68}{17}$ = 4 moles.

$\Rightarrow$ 1 mole of ammonia = 6.023×10^{23} molecules

$\Rightarrow$ 4 moles of ammonia = $4 \times 6.023 \times 10^{23}$

= 24.092×10^{23} molecules

2015

Question 1.
From A, B, C, D, which weighs the least —
A : 2 g. atoms of Nitrogen
B : 1 mole of Silver
C : 22.4 litres of oxygen gas at 1 atmospheric pressure and 273K
D : $6.02 \times 1o^{23}$ atoms of carbon.
[Ag = 108, N=14, 0=16, C=12]

Answer:
D : 6.02×10^{23} atoms of carbon.

Question 2.
Calculate the mass of Calcium that will contain the same number of atoms as are present in 3.2 gm of sulphur. [S = 32, Ca = 40]

Answer:

Atomic weight of element contains Avogadro number of atoms

$\therefore$ 32 g of sulphur contains 6.02×10^{23} atoms

$$3.2 \text{ g of sulphur contain} = \frac{6.02 \times 10^{23}}{32} \times 3.2 = 6.02 \times 10^{22} \text{ atoms}$$

6.02×10^{23} atoms of calcium weighs 40 g

6.02×10^{22} atoms of calcium weigh

$$= \frac{40}{6.02 \times 10^{23}} \times 6.02 \times 10^{22} = 4 \text{ g}$$

2016

Question 1.
Select the correct answer from A, B, C and D : The ratio between the number of molecules in 2g of hydrogen and 32g of oxygen is: k

(A) 1 : 2
(B) 1 : 0.01
(C) 1:1
(D) 0.01 : 1
[H = 1, O = 16]

Answer:

(C) 1 : 1

Question 2.
A gas of mass 32 gms has a volume of 20 litres at S.T.P. Calculate the gram mol. weight of the gas.

Answer:

The mass of 22.4 *l* of gas at S.T.P. is equal to its gram molecular mass.

20 litres of gas at S.T.P. weighs = 32 g

$$1 \text{ litre of gas at S.T.P. weighs} = \frac{32}{20} \text{ g}$$

$$\therefore \ 22.4 \text{ litres of gas will weigh} = \frac{32}{20} \times 22.4 = 35.84 \text{ g}$$

Question 3.
A gas cylinder contains 12 x 1024 molecules of oxygen gas. Calculate :

1. the mass of 02 present in the cylinder.
2. the volume of O_2 at S.T.P. present in the cylinder.[0 = 16] Avog. no. is 6 × 10^{23} [640g. ; 448 l]

Answer:
(i) Let mass of molecules

$$= \frac{\text{No. of molecues}}{N_A} \times \text{Molecular mass}$$

$$= \frac{12 \times 12^{24}}{6 \times 10^{23}} \times (2 \times 16)$$

$$= 2 \times 10 \times 32 = 640 \text{ g}$$

(ii) $\text{Volume of molecule} = \frac{\text{No. of molecules}}{N_A} \times \text{Molar volume}$

$$= \frac{12 \times 10^{24}}{6 \times 10^{23}} \times 22.4$$

$$= 2 \times 10 \times 22.4 = 448 \text{ litres}$$

2017

Question 1.
Calculate the number of gram atoms in 4.6 grams of sodium [Na = 23]

Answer:
23 g of sodium = 1 g-atom

$$\therefore \; 4.6 \text{ g of sodium} = \frac{4.6}{23} = 0.2 \text{ g-atom}$$

Question 2.
The mass of 11.2 litres of a certain gas at s.t.p. is 24 g. Find the gram molecular mass of the gas.

Answer:

1 gram molecular mass = mass of 22.4 litres of gas at s.t.p.

Now, 11.2 litres of gas weighs = 24 g

$\therefore$ 22.4 litres of gas weighs = $\frac{22.4 \times 24}{11.2} = 48$ g

$\therefore$ Gram molecular weight of gas = 48 g

C. Mole Concept – Avogadro'S Law – problmes based on them

2001

Question 1.
The gases chlorine, nitrogen, ammonia and sulphur dioxide are collected under the same conditions of temperature and pressure. If 20 litres of nitrogen contain 'X' no. of molecules state the no. of molecules in 10 litres of chlorine, 20 litres of ammonia and 5 litres of sulphur dioxide, (x/2, x, x/4)

Gas	Volume milliliters	Number of molecules
Chlorine	10	0x/2
Nitrogen	20	x
Ammonia	20	x
Sulphur dioxide	5	x/4

Answer:

This is because of Avogadro's laws which states "Equal volumes of all gases, under similar conditions of temperature and pressure, contain equal number of molecules.

$\therefore$ 20 lit. nitrogen contains x molecules

$\therefore$ 10 lit. of chlorine will contain $\frac{x \times 10}{20} = \frac{x}{2}$ mol.

and 20 lit. of Ammonia will also contain = x molecules

and 5 lit. of SO_2 will contain = $\frac{x \times 5}{20} = \frac{x}{4}$ = mol.

2002

Question 1.
Samples of gases O_2, N_2, CO and CO_2 under the same conditions of temperature and pressure contain the same number of molecules represented by X. The molecules of oxygen occupy V litres and have a mass of 8 g. Under the same conditions of temperature and pressure, what is the volume occupied by :

1. X molecules of N_2.
2. 3X molecules of CO.
3. What is the mass of CO_2 in grams.
4. In answering the above questions, whose law has been used.
   (C = 12, N = 14, O = 16)

Answer:

(i) According to Avogadro's law

Volume of X molecules of N_2 = Volume of X molecules of O_2 = V litres

(Under similar T and P)

(ii) Volume of X molecules of CO = Volume of X molecules of O_2 = V litres

$\therefore$ Volume of 3 X molecules of CO = 3 V litres

(Under similar T and P)

(iii) Molar mass of $O_2 = 32 \text{ g mol}^{-1}$

$\therefore$ 8 g of O_2 occupy volume = V litres

$\therefore$ 32 g of O_2 will occupy $= \frac{V}{8} \times 32 = 4$ V litres

$\therefore$ Molar volume = 4 V litres

Molar mass = $CO_2 = 12 + 16 \times 2 = 12 + 32 = 44 \text{ g mol}^{-1}$

$\therefore$ 4 V litres of CO_2 have mass = 44 g

V litres of CO_2 will have mass $= \frac{44}{4V} \times V = 11$ g

(iv) Avogadro's Law has been used in answering the above problems.

2005

Question 1.
Define the term atomic weight :

Answer:
Atomic weight : is the number of times one atom of an element is heavier than 1/2 the mass of an atom of carbon (C^{12})

2008

Question 1.
The gas law which relates the volume of a gas to the number of molecules of the gas is :

A Avogadro’s Law
B Gay-Lussac’s Law
C Boyle’s Law
D Charle’s Law

Answer:

A Avogadro’s Law

2009

Question 1.
Correct the following – Equal masses of all gases under identical conditions contain the same number of molecules.

Answer:
Equal volumes of all gases under identical conditions contain the same number of molecules.

2013

Question 1.
A vessel contains X number of molecules of hydrogen gas at a certain temperature & pressure. Under the same conditions of temperature & pressure, how many molecules of nitrogen gas would be present in the same vessel.

Answer:
According to Avogadro’s law, equal volume of all gases under similar conditions of temperature and pressure contain equal number of molecules.
Hence, number of molecules of N_2 = Number of molecules of H_2 = X

2017

Question 1.
A gas cylinder can hold 1 kg. of H_2 at room temp. & press.:

1. Find the number of moles of hydrogen present

2. What weight of CO_2 can the cylinder hold under similar conditions to temp. & press
3. If the number of molecules of hydrogen in the cylinder is X, calculate the number of CO_2 molecules in the cylinder under the same conditions of temp. & press
4. State the law that helped you to arrive at the above result.

Answer:

1. 2 g of hydrogen gas = 1 mole.
   ∴ 1000 g of hydrogen gas 1000/2 = 500 moles.
2. 1 mole of carbon dioxide = 44 g
   ∴ 500 moles of carbon dioxide = 44 x 500 = 22000 g = 22 kg Weight of carbon dioxide in cylinder = 22 kg
3. Equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules.
   ∴ Molecules in the cylinder of carbon dioxide = X.
4. Avogadro’s law.

D. Vapour Density & Molecular Weight – Problems based on them

1996

Question 1.
Find the relative molecular mass of a gas, 0.546 g of which occupies 360 cm3 at 87°C and 380 mm Hg pressure. (1 litre of hydrogen at s.t.p. weighs 0.09 g)

Answer:

$V_1 = 360\ cm^3$ | $V_2 = ?$

$P_1 = 380\ mm$ | $P_2 = 760\ mm$

$T_1 = 87°C = 87 + 273 = 360\ K$ | $T_2 = 273\ K$

$\left.\begin{matrix} P_2 = 760\ mm \\ T_2 = 273\ K \end{matrix}\right\}$ S.T.P.

Applying gas equation,

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

$$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{380 \times 360 \times 273}{360 \times 760} = 136.5\ cm^3 = 0.1365\ L$$

0.1365 L of the gas at STP have mass = 0.546 g

$\therefore$ 1 L of the gas at S.T.P will have mass $= \frac{0.546 \times 1}{0.1365} = 4\ g$

$$\text{Vapour density} = \frac{\text{Mass of given volume of gas}}{\text{Mass of same volume of } H_2}$$

(Under similar T and P)

$$\text{Vapour density, V.D.} = \frac{4\ g}{0.09\ g} = 44.444$$

$\therefore$ Mol. wt. = 2 × V.D. = 2 × 44.444 = 88.888 = 88.89

2001

Question 1.
Mention the term defined by the following : The mass of a given volume of gas compared to the mass of an equal volume of hydrogen.
Answer:
Vapour Density.

2004

Question 1.
Some potassium permanganate was heated in a test tube. After collecting one litre of oxygen at room temperature, it was found that the test tube had undergone a loss in a mass of 1.32 g. If one litre of hydrogen under the same conditions of temperature and pressure has a mass of 0.0825 g. Calculate the relative molecular mass of oxygen.

$2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$ ($K_2MnO_4 + MnO_2$ is the solid residue)

Answer:

$$\underset{\text{Potassium permanganate}}{2KMnO_4} \xrightarrow{\Delta} \underbrace{K_2MnO_4 + MnO_2}_{\text{Solid residue}} + O_2$$

Loss in mass is due to the evolution of O_2 gas = 1.32 g

Volume of O_2 produced = 1 L

$\therefore$ Mass of 1 L of O_2 produced = 1.32 g

$$V.D. = \frac{\text{Mass of given volume of the gas}}{\text{Mass of same volume of } H_2}$$

(Under Similar T and P)

$$= \frac{\text{Mass of 1 L of the gas}}{\text{Mass of 1 L of } H_2}$$

$$= \frac{1.32g}{0.0825g}$$

$$= \frac{13200}{825} = 16$$

Mol. mass = 2 × V.D. = 2 × 16 = 32

2009

Question 1.
A gas cylinder of capacity of 20 dm^3 is filled with gas X the mass of which is 10 g. When the same cylinder is filled with hydrogen gas at the same temperature and pressure the mass of the hydrogen is 2g, hence the relative molecular mass of the gas is :

(A) 5
(B) 10
(C) 15
(D) 20

Answer:

(B) 10

2012

Question 1.
The vapour density of carbon dioxide [C = 12, O = 16] is

(A) 32
(B) 16
(C) 44
(D) 22

Answer:

(D) 22

2014

Question 1.
Give one word or phrase for : The ratio of the mass of a certain volume of gas to the mass of an equal volume of hydrogen under the same conditions of temperature and pressure.

Answer:
Vapour density.

E. Percentage Composition – Problems based on them

1996

Question 1.
Find the total percentage of oxygen in magnesium nitrate crystals : $Mg(NO_3)_2$. $6H_2O$
(H = 1, N = 14, O = 16, Mg = 24)

Answer:
Molecular mass of $Mg(NO_3)_2 . 6H_2O$

$$= 24 + (2 \times 62) + 6 \times 18 = 24 + 124 + 108 = 256$$

Mass due to oxygen = $(2 \times 48) + 16 \times 16) = 192$

$$\% \text{ of oxygen} = \frac{192}{256} \times 100 = 75\%$$

1997

Question 1.
What is the mass of nitrogen in 1000 kg of urea $[CO(NH_2)_2]$.[C = 12] (Answer to

the nearest kg.)

Answer:

Molecular mass of area $[CO(NH_2)_2]$

$$= 12 + 16 + (14 \times 2)_2 = 60g$$

60 g of urea contains nitrogen = 28 g

$$1000 \text{ kg. area contains nitrogen} = \frac{28}{60} \times \frac{1000 \times 1000}{1000} = 467 \text{ kg}$$

1998

Question 1.
Calculate the % of boron (B) in borax $Na_2 B_4 O_7 . 10H_2O$. (H = 1, B = 11, O = 16, Na = 23)

Answer:

Molecular wt. of borax = $(Na_2B_4O_7 : 10H_2O)$

$$= 2(Na) + 4(B) + 7(O) + 10(2H + O)$$

$$= 2 \times 23 + 4 \times 11 + 7 \times 16 + 10(2 \times 1) + 16$$

$$= 46 + 44 + 112 + 180 = 382 \text{ g}$$

Amount of Boron in $(Na_2B_4O_7 . 10H_2O) = 4(B) = 4 \times 11 = 44g$

$$\% \text{ of Boron} = \frac{44}{328} \times 100 = 11.51 = 11.51\%$$

1999

Question 1.
If a crop of wheat removes 20 kg of nitrogen per hectare of soil, what mass in kg. of the fertilizer calcium nitrate would be required to replace the nitrogen in a 10 hectare field. (N = 14 ; O = 16 ; Ca = 40)

Answer:

Total area of the field = 10 hectare

Total nitrogen that has to be replaced = $20 \times 10 = 200$ kg

Molecular mass of $Ca(NO_3)_2 = 40 + 2 \times 62 = 164$

164 kg of $Ca(NO_3)_2$ contain 28 kg of nitrogen

Now 28 kg of nitrogen are present in 164 kg of $Ca(NO_3)_2$

$\therefore$ 200 kg of nitrogen are present in $= \dfrac{164 \times 200}{28} = 1171$ kg (app.)

2001

Question 1.
Calculate the percentage of phosphorus in the fertilizer superphosphate $Ca(H_2PO_4)_2$. (correct to 1dp) (H = 1 ; O = 16 ; P = 31 ; Ca = 40)

Answer:

Molecular mass of $Ca(H_2PO_4)_2$

$= 40 + 2\,(1 \times 2 + 31 + 16 \times 4) = 234$ g

Mass of phosphorus in 234 g superphosphate = 62 kg

$\therefore$ Percentage of phosphorus $= \dfrac{62}{234} \times 100 = 26.5\%$

2002

Question 1.
Calculate the percentage of platinum in ammonium chloroplatinate $(NH_4)_2\ PtCl_6$ (Give your answer correct to the nearest whole number). (N = 14, H = 1, Cl = 35.5, Pt = 195)

Answer:

Molecular mass of $(NH_4)_2\ Pt\ Cl_6$

$= 2(14 + 1 \times 4) + 195 + 35.5 \times 6$

$= 36 + 195 + 213 = 444$

$= 444$ g of $(NH_4)\ Pt\ Cl_6$ contains Pt = 195 g

Percentage of pt $= \dfrac{195}{444} \times 100 = 43.92\% \approx 44\%$

2005

Question 1.
Calculate the percentage of nitrogen in aluminium nitride. (Al = 27, N = 14)

Answer:

Molecular mass of Aluminium nitride

$AlN = 27 + 14 = 41$

41 g of Al N contains nitrogen = 14 g

$$\therefore \ \% \text{ of nitrogen in AlN} = \frac{14}{41} \times 100 = 34.146\%$$

2006

Question 1.
Calculate the percentage of sodium in sodium aluminium fluoride (Na_3AlF_6) correct to the nearest whole number. (F = 19 ; Na = 23 ; A1 = 27)

Answer:

Molecular mass of $Na_3(AlF_6)$

$= 3 \times 23 + 27 + 6 \times 19$

$= 69 + 27 + 114 = 210$ g

% of Sodium in $Na_3(AlF_6)$

$$= \frac{\text{mass of sodium}}{\text{mass of } Na_3AlF_6} \times 100 = \frac{69}{210} \times 100 = 329\%$$

2007

Question 1.
Determine the percentage of oxygen in ammonium nitrate (O = 16)

Answer:

Molar mass of NH_4NO_3 (or $N_2H_4O_3$)

$= 14 \times 2 + 4 + 16 \times 3 = 80 \text{ g mol}^{-1}$

$\therefore$ Mass of 1 mole of $NH_4NO_3 = 80$ g

Mass of oxygen in 1 mole of $NH_4NO_3 = 16 \times 3 = 48$ g

Percentage of oxygen in amm. nitrate $= \frac{48}{80} \times 100 = 60\%$

2010

Question 1.
If the relative molecular mass of ammonium nitrate is 80, calculate the percentage of nitrogen and oxygen in ammonium nitrate. (N = 14, H = 1, O = 16).

Answer:

Molar mass of NH_4NO_3 (or $N_2H_4O_3$)

$= 2 \times 14 + 4 + 16 \times 3$

$= 28 + 4 + 48 = 80 \text{ g mol}^{-1}$

Mass of nitrogen in 1 mole of $NH_4NO_3 = 2 \times 14 = 28$ g

Mass of oxygen in 1 mole of $NH_4NO_3 = 16 \times 3 = 48$ g

Mass of 1 mole of $NH_4NO_4 = 80$ g

Percentage of nitrogen in $NH_4NO_3 = \frac{28}{80} \times 100 = 35\%$

2012

Question 1.
Find the total percentage of Magnesium in magnesium nitrate crystals, $Mg(NO_3)_2.6H_2O$/ [Mg = 24; N = 14; O = 16 and H = 1]

Answer:

Molar mass of $Mg(NO_3)_2.6H_2O$

$$= 24 + (14 \times 2) + (16 \times 12) + (1 \times 12) = 256 \text{ g}$$

$$\text{Mass percent of Magnesium nitrate crystals} = \frac{24}{256} \times 100$$

$$= 9.375\%$$

2017

Question 1.
Calculate the percentage of water of crystallization in $CUSO_4.5H_2O$. [H = 1, O = 16, S = 32, Cu = 64]

Answer:

Molecular weight of $CuSO_4.5H_2O = 64 + 32 + 64 + 5\ (18)$

$= 250$ amu

Molecular weight of $5H_2O = 5 \times 18 = 90$ amu.

$$\therefore \ \% \text{ of water of crystallisation} = \frac{90}{250} \times 100 = 36\%$$

F. Empirical Formula And Molecular Formula – Problems based on then

2000

Question 1.
Determine the empirical formula of the compound whose composition by mass is : 42% nitrogen 48% oxygen and 9% hydrogen.
(H = 1 ; N = 14 ; O 16).

Answer:

Element	% composition	At. wt. Ratio	Atomic ratio Ratio	Simplest
N	42	14	$\frac{42}{14} = 3$	$\frac{3}{3} = 1$
O	48	16	$\frac{48}{16} = 3$	$\frac{3}{3} = 1$
H	9	1	$\frac{9}{1} = 9$	9/3 = 3

The ratio of N : O : H = 1 : 1 : 3

Empirical formula of compound = NOH_3

2001

Question 1.
A metal M forms a voltaic chloride containing 65.5% chlorine. If the density of the chloride relative to hydrogen (i.e. V.D.) is 162.5, find the molecular formula of the chloride. (M = 56, Cl = 35.5)

Answer:

Percentage of M in the chloride = 110 – 65.5 = 34.5

Element	Mass % age	Atomic mass	Rel. number of atoms	Simplest ratio
M	34.5	56	$\frac{34.5}{56} = 0.62$	$\frac{0.62}{0.62} = 1$
Cl	65.5	35.5	$\frac{65.5}{35.5} = 1.84$	$\frac{18.4}{0.62} = 3$

Empirical formula of chloride = MCl_3

Empirical formula mass = 56 + 35.5 × 3 = 162.5 g

Vapour density = 162.5

Molecular mass = 2 × vapour density = 2 × 162.5 = 325.0 g

Molecular formula = (Empirical formula)

$$\text{and } n = \frac{\text{Molecular Mass}}{\text{Empirical formula mass}} = \frac{325.0}{162.5} = 2$$

$\therefore$ Molecular formula = $(MCl_3)_2$ or M_2Cl_6

2002

Question 1.
The percentage composition of sodium phosphate as determined by analysis is 42.1% sodium, 18.9% phosphorus and 39% oxygen. Find the empirical formula of the compound (work to two decimal places). (Na = 23, P = 31, O = 16)

Answer:

Element	% composition	Atomic wt.	Rel. number of atoms	Simplest
Na	42.1%	23	$\frac{42.1}{23} = 1.8$	$\frac{1.8}{0.6} = 3$
P	18.9%	31	$\frac{18.9}{31} = 0.6$	$\frac{0.6}{0.6} = 1$
O	39	16	$\frac{39}{16} = 2.4$	$\frac{2.4}{0.6} = 4$

The ratio Na : P : O ; 3 : 1 : 4

Empirical formula = Na_3PO_4

2004

Question 1.
An experiment showed that in a lead chloride solution, 6.21 g of lead combined with 4.26 g. of chlorine. What is the empirical formula of this chloride. (Pb = 207 ; Cl = 35.5)

Answer:

In lead chloride

Mass of lead = 6.21 g

Mass of chlorine = 4.26 g

Total mass of lead chloride = 6.21 + 4.16 = 10.47 g

$$\text{Percentage of lead in lead chloride} = \frac{6.21}{10.47} \times 100 = 59.31\%$$

$$\text{Percentage of chlorine in lead chloride} = \frac{4.26}{10.47} \times 100 = 40.69\%$$

To calculate empirical formula of lead chloride

Element	Percentage	Atomic mass	Atomic ratio	Simplest atomic ratio	Simplest whole no. ratio
Lead	59.31	207	$\frac{59.31}{207} = 0.287$	$\frac{0.287}{0.287} = 1$	1
Chlorine	40.69	35.5	$\frac{40.69}{35.5} = 1.146$	$\frac{1.146}{0.287} = 3.99$	4

2006

Question 1.
Determine the empirical formula of a compound containing 47.9% potassium, 5.5% beryllium and 46.6% fluorine by mass.
(At. weight of Be = 9 ; F = 19 ; K = 39) Work to one decimal place.

Answer:

K = 47.9%, Be 5.5 %, F = 46.6%

Element	% age	Atomic wt.	Atomic ratio	Simplest ratio
K	47.9	39	$\frac{47.9}{39} = 1.22$	$\frac{1.22}{0.61} = 2$
Be	55	9	$\frac{55}{9} = 0.61$	$\frac{0.61}{0.61} = 1$
F	46.6	19	$\frac{46.6}{19} = 2.45$	$\frac{2.45}{0.61} = 4$

Empirical formula $K_2Be_1F_4 = K_2BeF_4$

2007

Question 1.
A compound X consists of 4.8% carbon and 95.2% bromine by mass

1. Determine the empirical formula of this compound working correct to one decimal place
2. If the vapour density of the compound is 252, what is the molecular formula of the compound. (C = 12 ; Br = 80) (CBr_3, C_2Br_6).

Answer:

Element	% age	Atomic wt.	Atomic ratio	Simplest ratio
C	4.8	12	$\frac{4.8}{12} = 0.4$	$\frac{0.4}{0.4} = 1$
Br	95.2	80	$\frac{95.2}{80} = 1.2$	$\frac{1.2}{0.4} = 3$

Empirical formula = CBr_3

V.D = 252

Empirical formula = CBr_3

Empirical molecular mass = $12 + 80 \times 3 = 252$

$$n = \frac{\text{mol. wt}}{\text{Emp. formula wt.}} = \frac{2 \times \text{V.D.}}{252}$$

$$= \frac{2 \times 252}{252} = 2$$

Molecular formula = 2 × Emp. formula = $2(CBr_3)$

Molecular formula = 2 × Emp. formula = $2(CBr_3) = C_2Br_6$.

2008

Question 1.
What is the empirical formula of octane (C_8H_{18}) ?

Answer:
M.F. of octane = C_8H_{18} = $(c_4H_9)_2$
∴ E.F. of octane = C_4H_9

Question 2.
A compound has the following percentage composition by mass, Carbon 14.4%, hydrogen 1.2% and chlorine 84.5%. Determine the empirical formula of this compound. Work correct to 1 decimal place. The relative molecular mass of this compound is 168, so what is its molecular formula?
(H = 1 ; C = 12 ; Cl = 35.5)

Answer:

Element	% age	At mass	%age/ At mass	Simplest ratio	Simplest whole no. ratio
Carbon	14.4	12	$\frac{14.4}{12} = 1.2$	$\frac{1.2}{1.2} = 1$	1
Hydrogen	1.2	1	$\frac{1.2}{1} = 1.2$	$\frac{1.2}{1.2} = 1$	1
Chlorine	84.5	35.5	$\frac{84.5}{35.5} = 2.38$	$\frac{2.38}{1.2} = 1.98$	2

Empirical formula $= CHCl_2$

Empirical formula mass

$$= 12 \times 1 + 1 \times 1 + 35.5 \times 2 = 12 + 1 + 71 = 84$$

Relative molecular mass (given) $= 168$

$$n = \frac{\text{M.F.M.}}{\text{E.F.M.}} = \frac{168}{84}$$

$n = 2$

Molecular formula $= (CHCl_2)_2 = C_2H_2Cl_4$

2009

Question 1.
A gaseous compound of nitrogen and hydrogen contains 12.5% hydrogen by mass. Find the molecular formula of the compound if its relative molecular mass is 37.
[N =14, H = 1].

Answer:

Elements	%	At wt	Simplest ratio	Simplest whole no ratio
Nitrogen	87.5	14	$\frac{87.5}{14} = 6.25$	$\frac{6.25}{6.25} = 1$
Hydrogen	12.5	1	$\frac{12.5}{1} = 12.5$	$\frac{12.5}{6.25} = 2$

Empirical Formula = NH_2

Empirical formula mass = 14 + 2 = 16

$n = \frac{\text{Molecular mass}}{\text{Empirical mass}} = \frac{37}{16}$, $\qquad n = 2.31 = 2$

Hence M.F. = $(NH_2)_2 = N_2H_4$

2011

Question 1.
An organic compound with vapour density 94. It contains C = 12.67%, H = 2.13%, and Br = 85.11%. Find the molecular formula of the organic compound. [C = 12, H = 1, Br = 80]

Answer:

Element	Symbol	Atomic No.	Percentage	Relative no. of Atoms	Simplest ratio
Carbon	C	12	12.67	$\frac{12.67}{12} = 1.055$	$\frac{1.055}{1.055} = 1$
Hydrogen	H	1	2.13	$\frac{2.13}{1} = 2.13$	$\frac{2.13}{1.055} = 2$
Bromine	Br	80	85.11	$\frac{85.11}{80} = 1.0638$	$\frac{1.0638}{1.055} = 1$

E. F. = CH_2 Br

Given V.D. = 94

Molecular mass = 2 × V.D. = 2 × 94 = 188

$$M.F.M = (E.F.M)n \Rightarrow 188 = (94)n \Rightarrow n = \frac{188}{94} = 2$$

Molecular formula = (Empirical formula) × n = $(CH_2Br) \times 2$

= $C_2H_4Br_2$

2014

Question 1.

A compound having empirical formula X_2Y is made of two elements X and Y. Find its molecular formula. If the atomic weight of X is 10 and that of Y is 5 and the compound has a vapour density 25.

Answer:

Empirical formula = X_2Y, Empirical mass = 2 × 10 + 5 = 25

Vapour density of X_2Y = 25

∴ Molecular weight of X_2Y = 2 × vapour density = 2 × 25 = 50

Now Molecular weight = n × empirical weight = 50 = n × 25

$$\Rightarrow n = \frac{50}{25} = 2$$

∴ Molecular formula = n × Empirical formula = 2 × X_2Y = X_4Y_2

2015

Question 1.
If the empirical formula of a compound is CH and it has a vapour density of 13, find the molecular formula of the compound. [C = 12, H = 1]

Answer:

Given : Empirical formula = CH, Vapour density = 13

Molecular weight = 2 × Vapour density = 2 × 13 = 26

∴ Empirical formula of a compound with molecular mass 26 is CH.

$$n = \frac{\text{Molecular mass}}{\text{Empirical formula}} = \frac{26}{(12+1)} = \frac{26}{13} = 2$$

∴ Molecular formula of the given compound is $2\times(CH) = (CH)_2 = C_2H_2$.

2016

Question 1.
A gaseous hydrocarbon contains 82.76% of carbon. Given that its vapours density is 29, find its molecular formula. [C=12,H=1]

Answer:

Symbol	Percentage	Atomic mass	No. of atoms	Simplest ratio	Rounding of ratio
C	82.76	12	$\frac{82.76}{12} = 6.89$	6.89/6.89 = 1	2
H	17.24	1	$\frac{17.24}{1} = 17.24$	17.24/6.89 = 2.5	5

Empirical formula = C_2H_5

Empirical formula mass = 12 × 2 + 5 × 1 = 24 + 5 = 29

V.D. = 29

Molecular mass = 2 × V.D. = 2 × 29 = 58

$$n = \frac{\text{M.M}}{\text{E.F.M}} = \frac{58}{29} = 2$$

Molecular formula = $(C_2H_5)_2 = C_4H_{10}$

2017

Question 1.
A compound of X and Y has the empirical formula XY_2. Its vapou density is equal to its empirical formula weight. Determine its Molecular formla.

Answer:

Molecular f rmula = 2 × V.D.

∴ Molecr lar formula = 2 × Empirical formula

$= 2 \times XY_2 = X_2X_4$

G Chemical Equations – Problems based on them

2000

Question 1.
Washing soda has the formula $Na_2CO_3.10H_2O$. What mass of anhydrous sodium carbonate is left when all the water of crystallization is expelled by heating 57.2 g of washing soda.

Answer:

$Na_2CO_3.10H_2O \xrightarrow{Heat} Na_2CO_3 + 10H_2O$

Molecular weight of $Na_2CO_3.10H_2O$

$= 23 \times 2 + 12 + 16 \times 3 + 10 (1 \times 2 + 16)$

$= 46 + 12 + 48 + 10 (18) = 106 + 180 = 286$

Molecular weight of $Na_2CO_3 = 106$

∴ 286 g $Na_2CO_3.10H_2O$ left 106 g Na_2CO_3

∴ 57.2 g $Na_2CO_3.10H_2O$ left 106 g $Na_2CO_3 = \frac{57.2 \times 106}{286}$

$= 21.2$ g Na_2CO_3

Mass of anhydrous sodium carbonate is 21.2 g

Question 2.
$Na_2SO_4 + Pb(N0_3)_2 \rightarrow PbSO_4 + 2NaNO_3$ When excess » lead nitrate solution was added to a solution of sodium sulphate, 15.15 g of lead sulphate were precipitated. What mass of sodium sulphate was present in the original solution. (H = 1 ; C = 12 ; O = 16 ; Na = 23; S = 32 ; Pb = 207)

Answer:

$$Na_2SO_4 + Pb(NO_3)_2 \rightarrow PbSO_4 + 2NaNO_3.$$

Mol. mass of $Na_2SO_4 = 2 \times 23 + 32 + 16 \times 4$

$= 46 + 32 + 64 = 142$ g

Mol. mass of lead sulphate $= 207 + 32 \times 4 \times 16$

$= 270 + 32 + 64 = 366$ g

Now 366 g of $PbSO_4$ is obtained from 142 g of Na_2SO_4

15.15 g of $PbSO_4$ obtained from $= \frac{142}{366} \times 15.15 = 7$ g (app.)

2001

Question 1.
From the equation : $(NH_4)_2 Cr_2O_7 \rightarrow Cr_2O_3 + 4H_2O + N_2$ Calculate :

1. the vol. of nitrogen at STP, evolved when 63g. of ammonium dichromate is heated. (5.6 lits.)
2. the mass of Cr_2O_3 formed at the same time. (N = 14, H = 1, Cr = 52, O = 16) (38 g.)

Answer:

$$\underset{\substack{1\text{ mol} \\ = 2 \times (14+4) + 2 \times 52 + 7 \times 16 \\ = 252\text{ g}}}{(NH_4)_2Cr_2O_7\,(s)} \xrightarrow{\text{Heat}} \underset{\substack{1\text{ mol} \\ = 2 \times 52 + 16 \times 3 \\ = 152\text{ g}}}{Cr_2O_3\,(s)} + 4H_2O\,(g) + \underset{\substack{1\text{ mol} \\ = 22.4\text{ L}}}{N_2\,(g)}$$

(i) 252 g of ammonium dichromate on decomposition give N_2 at S.T.P. = 22.4 L

63 g of ammonium dichromate on decomposition will give

N_2 at S.T.P. $= \frac{22.4}{252} \times 63$ L $= 5.6$ L

(ii) 252 g of ammonium dichromate on thermal decomposition give $Cr_2O_3 = 152$ g

63 g of ammonium dichromate or thermal decomposition

will give $Cr_2O_3 = \frac{152}{252} \times 63 = 38$ g

2003

Question 1.
10g. of a mixture of NaCI and anhydrous Na_2SO_4 is dissolved in water. An excess of $BaCl_2$ soln. is added and 6.99 g. of BaSO is precipitated according to the equation :
$Na_2SO_4 + BaCl_2 \rightarrow BaSO_4 \downarrow + 2NaCl$. Calculate the percentage of sodium sulphate in the original mixture.
(O = 16 ; Na = 23 ; S = 32; Ba = 137)

Answer:

$$\underset{\substack{[(2\times 23)+32+4\times 16] \\ 142\text{ g}}}{Na_2SO_4} + BaCl_2 \rightarrow \underset{\substack{(137+32+64) \\ 233\text{ g}}}{BaSO_4} + 2NaCl$$

Now 223 g of $BaSO_4$ is obtained from 142 g Na_2SO_4

$$6.99 \text{ g of } BaSO_4 \text{ is obtained from} = \frac{142\times 6.99}{233}$$

$$= 4.26 \text{ g. of } Na_2SO_4$$

$$\therefore\ NaSO_4 \text{ in 10 g of mixture} = \frac{4.26\times 100}{10} = 42.6\%$$

2004

Question 1.
The reaction of potassium permanganate with acidified iron (II) sulphate is given below :
$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5\ Fe_2(SO_4)_3 + 8H_2O$.
If 15.8 g. of potassium permanganate was used in the reaction, calculate the mass of iron (II) sulphate used in the above reaction.
(K = 39, Mn = 55, Fe = 56, S = 32, O = 16)

Answer:

$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5 Fe_2(SO_4)_3 + 8H_2O$

Molecular mass of $2KMnO_4$

$= 2(39 + 55 + 4 \times 16) = 2 (39 + 35 + 64) = 2 (158) = 316$ g

Molecular mass of $10FeSO_4 = 10(56 + 32 + 4 \times 16)$

$= 10(56 + 32 + 64) = 10(152) = 1520$ g

316 g of $KMnO_4$ used iron (III) sulphate = 1520 g

15.8 g of $KMnO_4$ used $= \frac{1520}{316} \times 15.8 = 71$ g

2005

Question 1.
The equation given below relate to the manufacture of sodium carbonate (Mol), wt. of Na_2CO_3 = 106

1. $NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$
2. $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$

Questions (a) and (b) are based on the production of 21.2 g. of sodium carbonate.
(a) What mass of sodium hydrogen carbonate must be heated to give 21.2 g. of sodium carbonate (Molecular weight of $NaHCO_3$ = 84).
(b) To produce the mass of sodium hydrogen carbonate calculated in (a), what volume of carbon dioxide, measured at s.t.p., would be required.

Answer:

$$\text{(a)}\quad \underset{\substack{2\text{ mol}\\ =2\times 84=168\text{ g}}}{2NaHCO_3} \longrightarrow \underset{\substack{1\text{ mol}\\ =106\text{ g}}}{Na_2CO} + H_2O + CO_2$$

106 g of Na_2CO_3 is obtained from $NaHCO_3$ = 168 g

21.2 g of Na_2CO_3 is obtained from $NaHCO_3$

$$= \frac{168}{106} \times 21.2 = 33.6 \text{ g}$$

$$\text{(b)}\quad NaCl + NH_3 + \underset{\substack{1\text{ mol}\\ =22.4\text{ L at S.T.P.}}}{CO_2} + H_2O \longrightarrow \underset{\substack{1\text{ mol}\\ =84\text{ g}}}{NaHCO_3} + NH_4Cl$$

84 g of $NaHCO_3$ is obtained from CO_2 at STP = 22.4 L

33.6 g of $NaHCO_3$ is obtained from CO_2 at STP

$$= \frac{22.4}{84} = 33.6 = 8.96 \text{ L}$$

2006

Question 1.
The relative molecular mass (mol. wt.) of copper oxide is 80. What vol. of HN_3 (measured at s.t.p.) is required to completely reduce 120 g of cuO. ($3CuO + 2NH_3 \rightarrow 3Cu + 3H_2O + N_2$].

Answer:

$$\underset{\substack{3\text{ moles}\\ 3\times 80\text{ g}}}{3CuO} + \underset{\substack{2\text{ moles}\\ =2\times 22.4\text{ litres at S.T.P.}}}{2NH_3} \longrightarrow 3Cu + 3H_2O + N_2$$

240 g of CuO requires NH_3 for reduction = 2 × 22.4 litres

$$\therefore\ 120 \text{ g of CuO requires } NH_3 \text{ for reduction} = \frac{2\times 22.4}{240} \times 120$$

$$= 22.4 \text{ L}$$

$\therefore$ Volume of NH_4 required at S.T.P. = 22.4 L

2007

Question 1.
A sample of ammonium nitrate when heated yields 8.96 litres of steam

(measured at stp.)
$NH_4 NO_3 \rightarrow N_2O + 2H_2O$

1. What volume of dinitrogen oxide is produced at the same time as 8.96 litres of steam.
2. What mass of ammonium nitrate should be heated to produce 8.96 litres of steam (Relative molecular mass of NH_4NO_3 is 80)

Answer:

$$\underset{1 \text{ mol} = 80 \text{ g}}{NH_4NO_3\,(s)} \xrightarrow{\text{Heat}} \underset{1 \text{ vol}}{N_2O\,(g)} + \underset{2 \text{ vol}}{2H_2O\,(g)}$$

(i) $\text{Volume } N_2O = \dfrac{8.96}{2} = 4.48 \text{ L}$

[$\because$ 1 vol of N_2O is produced at the same time as 2 vol. of steam]

(ii) 2×22.4 L steam at S.T.P. is produced from NH_4NO_3
$= 80$ g

8.96 L of steam at S.T.P. is produced from NH_4NO_3

$$= \frac{80}{2 \times 22.4} \times 8.96 = 16 \text{ g}$$

(iii) Percentage of oxygen in $NH_4NO_3 = \dfrac{16 \times 3}{80} \times 100 = 60\%$

2008

Question 1.
From the equation :
$C + 2H_2SO_4 \rightarrow CO_2 + 2H_2O + 2SO_2$
Calculate :

1. The mass of carbon oxidised by 49 g of sulphuric acid (C = 12 ; relative molecular mass of sulphuric acid = 98).
2. The volume of SO_2 measured at s.t.p., liberated at the same time.

Answer:

$$\underset{12g}{C} + \underset{2(98)}{2H_2SO_4} \longrightarrow CO_2 + 2H_2O + 2SO_2$$

(i) 196 g of sulphuric acid is required to oxidise

= 12g of carbon

1 g of sulphuric acid is required to oxidise $= \frac{12}{196}$ g of carbon

49g of sulphuric acid is required to oxidise $= \frac{12}{196} \times 49$ g of carbon = 3 g of carbon

(ii) 12 g of carbon will liberate (22.4×2) litres of SO_2

1 g of carbon will liberate $\frac{22.4 \times 2}{12}$ litres of SO_2

3 g of carbon will liberate $\frac{22.4 \times 2}{12} \times 3 = 11.2$ litres of SO_2

2009

Question 1.
Commercial NaOH weighing 30 g. has some NaCl in it. The mixture on dissolving in water and treatment with excess $AgNO_3$ soln. formed a precipitate weighing 14.3 g. What is the percentage of NaCl in the commercial sample of NaOH.
$NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$
[Relative molecular mass of NaCl = 58 ; AgCl = 143]

Answer:

$NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$

J43g of AgCl is formed from = 58g of NaCl

1g of AgCl is formed from = $\frac{58}{143}$ of NaCl

14.3 g of AgCl is formed from = $\frac{58}{143} \times 14.3 = 5.8$ g

% of sodium chloride = $\frac{5.8}{30} \times 100 = 19.3\%$

2011

Question 1.
Calculate the volume of oxygen required for the complete combustion of 8.8g of propane ($C_3 H_8$). (C = 12, O = 16, H = 1, Molar Volume = 22.4 dm^3 at stp)

Answer:

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

M.W. of C_3 1 12 × 3 + = 44

Volume of $5O_2$ = . 2.4 = 1 ? litres

44 g of propane requires = 112 litres of oxygen

1 g of propane requires = $\frac{112}{44}$ litres

8.8 g of propane requires = $\frac{112}{44} \times 8.8 = 112 \times .2 = 22.4$ litres

2013

Question 1.

$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$

(i) **Calculate the mass of $KClO_3$ required to produce 6.72 litre of O_2 at S.T.P. [K = 39, Cl = 35.5, O = 16]**

(ii) **Calculate the no. of moles of O_2 in the above volume and also the no. of molecules.**

Answer:

$$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$$

$2[39+35.5+48]$ g $2[39+35.5]$g $3[22.4]$ lt

245 g 67.2 lt

(i) 67.2 lt of oxygen at STP is librated from $KClO_3$ = 245 g

$\therefore$ 6.72 lt of oxygen is liberated from $KClO_3$

$$= \frac{245 \times 6.72}{67.2} = 24.5g$$

(ii) 22.4 lt of oxygen and STP = 1 mole.

$$\therefore \quad 6.72 \text{ lt of oxygen at STP} = \frac{6.72}{22.4} = 0.3 \text{ moles}$$

1 mole of oxygen contains number of molecules

$= 6 \times 10^{23}$

$\therefore$ 0.3 mole of oxygen contain number of molecules

$= 6.02 \times 10^{23} \times 0.3 = 1.806 \times 10^{23}$ molecules

2015

Question 1.
From the equation :

$$(NH_4)_2Cr_2O_7 \xrightarrow{heat} N_2(g) + 4H_2O(g) + Cr_2O_3$$

Calculate:

1. the quantity in moles of $(NH_4)_2Cr_2O_7$ if 63gm oft$[NH_4)_2Cr_2O_7$ is heated.
2. the quantity in moles of nitrogen formed.
3. the volume in litres or dm^3 of N_2 evolved at s.t.p.
4. the mass in grams of Cr_2O_3 formed at the same time. [H=l, Cr= 52, N=14]

Answer:

The given reaction is as follows:

$$(NH_4)_2Cr_2O_7 \xrightarrow{\text{heat}} N_2(g) + 4H_2O(g) + Cr_2O_3$$

(i) Given : Weight of $(NH_4)_2Cr_2O_7$ = 63 gm

Molar mass of $(NH_4)_2Cr_2O_7$

$$= (2 \times 14) + (8 \times 1) + (2 \times 52) + (7 \times 16)$$

$$= 28 + 8 + 104 + 112 = 252 \text{ gm}$$

1 mole $(NH_4)_2Cr_2O_7$ = 252 gm

Hence, 63 gm of $(NH_4)_2Cr_2O_7 = \frac{63}{252} = 0.25$ moles

The quantity of moles of $(NH_4)_2Cr_2O_7$ if 63 gm of $(NH_4)_2Cr_2O_7$ is heated is **0.25** moles.

(ii) From the given chemical equation, 1 mole of $(NH_4)_2Cr_2O_7$ produces 1 mole of nitrogen gas.

Hence, 0.25 moles of $(NH_4)_2Cr_2O_7$ can produce 0.25 moles of nitrogen gas.

The quantity in moles of nitrogen formed is **0.25** moles.

(iii) One mole of an ideal gas at S.T.P. occupies 22.4 litres or dm^3.

Hence, 0.25 moles of $(NH_4)_2Cr_2O_7$ will occupy $0.25 \times 22.4 = 5.6$ litres or dm^3.

The volume in litres or dm^3 of N_2 evolved at S.T.P. is **5.6** litres or dm^3.

(iv) From the given chemical equation, 1 mole of $(NH_4)_2Cr_2O_7$ produces 1 mole of Cr_2O_3.

Hence, 0.25 moles of $(NH_4)_2Cr_2O_7$ will produce 0.25 moles of Cr_2O_3.

Molar mass of $Cr_2O_3 = (2 \times 52) + (3 \times 16) = 104 + 48 = 152$ gm

1 mole $Cr_2O_3 = 152$ gm

Hence, 0.25 moles of $Cr_2O_3 = 0.25 \times 152 = 38$ gm

The mass in grams of Cr_2O_3 formed at the same time is **38** gm.

2016

Question 1.

How much calcium oxide is formed when 82g. of calcium nitrate is heated. Also find the volume of nitrogen dioxide evolved :

$2Ca(NO_3)2 \rightarrow 2CaO + 4NO_2 + O_2$ (Ca = 40, N = 14, O = 16)

Answer:

$$\begin{array}{ccccccc} 2Ca(NO_3)_2 & \longrightarrow & 2CaO & + & 4NO_2 & + & O_2 \\ 2[40 + 2(14 + 48)] & & 2(40 + 16) & & 4(22.4\ lt) & & \\ 328 & & 112 & & 89.6\ lt & & \end{array}$$

(i) When calcium nitrate is 328 g, the calcium oxide formed $= 112$ g

When calcium nitrate is 82 g the calcium oxide formed

$$= \frac{112 \times 82}{328} = 28 \text{ g}$$

(ii) When calcium nitrate is 328 g, the volume of NO_2 formed $= 89.6\ l$

When calcium nitrate is 82 g the volume of NO_2 formed

$$= \frac{89.6 \times 82}{328} = 22.4\ lt \text{ at S.T.P.}$$