ICSE Selina Solutions For Grade 10

Chemistry

Chapter 5. - Mole Concept and Stoichiometry

1. State:

(a) Gay-Lussac's Law of combining volumes.

Ans: Gay-Lussac's law states that when gases react, they do so in volumes which bear a simple ratio to one another, and to the volume of the gaseous product, provided that all the volumes are measured at the same temperature and pressure.

(b) Avogadro's law

Ans: Avogadro's law states that equal volumes of all gases under similar conditions of temperature and pressure contain the same number of molecules.

2. (a) What do you mean by stoichiometry?

Ans: Stoichiometry determines the amount of products/reactants produced/needed in a given reaction by measuring quantitative relationships.

(b) Define atomicity of a gas. State the atomicity of Hydrogen, Phosphorus and Sulphur.

Ans: Atomicity refers to the no of atoms present in a molecule. Atomicity of hydrogen is 2, phosphorus is 4 and sulphur is 8.

(c) Differentiate between N_2 and 2N.

Ans:

N_2	2N
It consists of one molecule of nitrogen.	It consists of two atoms of nitrogen.
Exist independently.	Cannot exist independently.

3. Explain Why?

(a) "The number of atoms in a certain volume of hydrogen is twice the number of atoms in the same volume of helium at the same temperature and pressure."

Ans: This is due to Avogadro's Law which states Equal volumes of all gases under similar conditions of temperature and pressure contain the same number of molecules.

Now volume of hydrogen gas = volume of helium gas

n molecules of hydrogen = n molecules of helium gas

$nH_2 = nHe$

1 mol. of hydrogen has 2 atoms of hydrogen and I molecule of helium has 1 atom of helium

Therefore 2H=He

Therefore atoms in hydrogen are double the atoms of helium.

(b) "When stating the volume of a gas, the pressure and temperature should also be given."

Ans: For a given volume of gas under given temperature and pressure, a change in any one of the variables i.e., pressure or temperature changes the volume.

(c) Inflating a balloon seems to violate Boyle's law.

Ans: Inflating a balloon seems violating Boyle's law as volume is increasing with increase in pressure. Since the mass of gas is also increasing.

4. (a) Calculate the volume of oxygen at S.T.P required for the complete combustion of 100 litres of carbon monoxide at the same temperature and pressure.

$2CO + O_2 \rightarrow 2CO_2$

Ans: $2CO + O_2 \rightarrow 2CO_2$

2V 1V 2V

2 V of CO requires = 1V of O_2

so, 100 litres of CO requires = 50 litres of O_2

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

$2H_2 + O_2 \rightarrow 2H_2O$

What volume of oxygen remains unreacted?

Ans: $2H_2 + O_2 \rightarrow 2H_2O$

2V 1V 2V

From the equation, 2V of hydrogen reacts with 1V of oxygen

so 200cm^3 of Hydrogen reacts with = $\frac{200}{2} = 100\ cm^3$

Hence, the unreacted oxygen is 150 - 100 = 50cm^3 of oxygen.

5. 24 cc Marsh gas (CH_4) was mixed with 106 cc oxygen and then exploded. On cooling the volume of the mixture became 82 cc, of which, 58 cc was unchanged oxygen. Which law does this experiment support? Explain with calculation.

Ans: This experiment supports Gay lussac's law of combining volumes.

Since the unchanged or remaining O_2 is 58 cc so, used oxygen 106 - 58 = 48cc

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

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

1V 2V

24cc 48 cc

i.e. methane and oxygen react in a 1:2 ratio.

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

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

Ans: $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$ (l)

2V 5V 4V

From equation, 2 V of C_2H_2 requires = 5 V of O_2

So, for 400ml C_2H_2, O_2 required = $400 \times \frac{5}{2}$ =1000 ml

Similarly, 2 V of C_2H_2 gives = 4 V of CO_2

So, 400ml of C_2H_2 gives CO_2 = $400 \times \frac{4}{2}$ = 800ml

7. 112 cm^3 of $H_2S(g)$ is mixed with 120 cm^3 of $Cl_2(g)$ at STP to produce HCl(g) and sulphur(s). Write a balanced equation for this reaction

Ans: $H_2S + Cl_2 \rightarrow 2HCl + S$

and calculate

(i) the volume of gaseous product formed

Ans: At STP, 1 mole gas occupies 22.4 L.

As 1 mole H_2S gas produces 2 moles HCl gas,

22.4 L H_2S gas produces 22.4 × 2 = 44.8 L HCl gas.

Hence, 112 cm^3 H_2S gas will produce 112 × 2 = 224 cm^3 HCl gas.

(ii) composition of the resulting mixture.

Ans: 1 mole H_2S gas consumes 1 mole Cl_2 gas.

This means 22.4 L H_2S gas consumes 22.4 L Cl_2 gas at STP.

Hence, 112 cm^3 H_2S gas consumes 112 cm^3 Cl_2 gas.

120 cm^3 - 112 cm^3 = 8 cm^3 Cl_2 gas remains unreacted.

Thus, the composition of the resulting mixture is 224 cm^3HCl gas + 8 cm^3 Cl_2 gas.

8. 1250cc of oxygen was burnt with 300cc of ethane [C_2H_6]. Calculate the volume of unused oxygen and the volume of carbon dioxide formed:

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

Ans: From the equation, 2V of ethane reacts with 7V oxygen.

So, 300 cc of ethane reacts with $\frac{300\times 7}{2}$ =1050cc

Hence, unused O_2 = 1250 - 1050 = 200 cc

From 2V of ethane, 4V of CO_2 is produced.

So, 300 cc of ethane will produce $\frac{300\times 4}{2}$ =600cc of CO_2

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

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

Ans:

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

1V 3V

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

V2= $\frac{P_1V_1T_2}{P_2T_1} = \frac{380\times 33\times 273}{549\times 760}$ =8.25 litres

10. Calculate the volume of HCl gas formed and chlorine gas required when 40 ml of methane reacts completely with chlorine at S.T.P.

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

Ans: $CH_4 + 2Cl_2\rightarrow CH_2Cl_2 + 2HCl$

1V 2V V 2V

From equation, 1V of CH_4 gives = 2 V HCl

so, 40 ml of methane gives = 80 ml HCl

For 1V of methane = 2V of Cl_2 required

So, for 40ml of methane = 40 x 2 = 80 ml of Cl_2

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

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

Ans: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

1V 5V 3V

From equation, 5V of O_2 required = 1V of propane

so, 100 cm^3 of O_2 will require = 20 cm^3 of propane

12. 450 cm^3 of nitrogen monoxide and 200 cm^3 of oxygen are mixed together and ignited. Calculate the composition of the resulting mixture.

$2NO + O_2 \rightarrow 2NO_2$

Ans: $2NO + O_2 \rightarrow 2NO_2$

2V V 2V

From equation, 1V of O_2 reacts with = 2V of NO

200cm^3 oxygen will react with = 200 $\times$2 =400 cm^3 NO

Hence, remaining NO is 450 - 400 = 50 cm^3

NO_2 produced = 400cm^3 because 1V oxygen gives 2V NO_2

Total mixture = 400 + 50 = 450 cm^3

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

Ans: 6 litres of hydrogen and 4 litres of chlorine when mixed, results in the formation of 8 litres of HCl gas.

When water is added to it, it results in the formation of hydrochloric acid. Chlorine acts as a limiting agent leaving behind only 2 litres of hydrogen gas.

Therefore, the volume of the residual gas will be 2 litres.

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

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

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

Ans: $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

4V 5V 4V

9 litres of reactants gives 4 litres of NO

So, 27 litres of reactants will give = $27 \times \frac{4}{9}$ = 12 litres of NO

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

Ans: $H_2 + Cl_2 \rightarrow 2HCl$

1V 1V 2V

Since 1V hydrogen requires 1V of oxygen and 4cm^3 of H_2 remained behind so the mixture had composition: 16 cm^3 hydrogen and 16 cm^3 chlorine.

Therefore Resulting mixture is H_2 = 4cm^3, HCl = 32cm^3

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

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

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

Ans: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

1V 2V 1V

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

2V 5V 4V

From the equations, we can see that

1V CH_4 requires oxygen = 2V O_2

So, 10cm^3 CH_4 will require =20 cm^3 O_2

Similarly 2V C_2H_2 requires = 5V O_2

So, 10 cm^3 C_2H_2 will require= 25 cm^3 O_2

Now, 20 V O_2 will be present in 100 V air and 25 V O_2 will be present in 125 V air ,so the volume of air required is 225cm^3

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

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

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

Ans: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

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

60 ml of propane (C_3H_8) gives $3 \times 60 = 180$ ml CO_2

40 ml of butane (C_4H_{10}) gives = $8 \times \frac{40}{2}$ = 160 ml of CO_2

Total carbon dioxide produced = 340 ml

So, when 10 litres of the mixture is burnt = 34 litres of CO_2 is produced.

18. 200 cm^3 of CO_2 is collected at S.T.P when a mixture of acetylene and oxygen is ignited. Calculate the volume of acetylene and oxygen at S.T.P. in the original mixture.

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

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

4 V CO_2 is collected with 2 V C_2H_2

So, 200cm^3 CO_2 will be collected with = 100cm^3 C_2H_2

Similarly, 4V of CO_2 is produced by 5 V of O_2

So, 200cm^3 CO^2 will be produced by = 250 ml of O_2

19. You have collected (a) 2 litres of CO_2 (b) 3 litres of chlorine (c) 5 litres of hydrogen (d) 4 litres of nitrogen and (e) 1 litres of SO_2, under similar conditions of temperature and pressure. Which gas sample will have:

(a) the greatest number of molecules, and

(b) The least number of molecules?

Justify your answers.

Ans: According to Avogadro's law, equal volumes of gases contain equal no. of molecules under similar conditions of temperature and pressure. This means more volume will contain more molecules and less volume will contain less molecules.

(a) 5 litres of hydrogen has the greatest no. of molecules with the maximum volume.

(b) 1 litre of SO_2 contains the least number of molecules since it has the smallest volume.

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

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

Ans:

Gas	**Volume (in litres)**	**Number of molecules**
Chlorine	10	$\frac{x}{2}$
Nitrogen	20	x
Ammonia	20	x
Sulphur dioxide	5	$\frac{x}{4}$

21. (i) If 150 cc of gas A contains X molecules, how many molecules of gas B will be present in 75 cc of B?

The gases A and B are under the same conditions of temperature and pressure.

Ans: According to Avogadro's law, under the same conditions of temperature and pressure, equal volumes of different gases have the same number of molecules.

As 150 cc of gas A contains X molecules, 150 cc of gas B also contains X molecules.

So, 75 cc of B will contain X/2 molecules.

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

Ans: The problem is based on Avogadro's law.

Exercise – 5B

1. (a) The relative atomic mass of Cl atom is 35.5 a.m.u. Explain this statement.

Ans: This statement states that one atom of chlorine is 35.5 times heavier than 1/12 times of the mass of an atom C-12.

(b) What is the value of Avogadro's number?

Ans: 6.023×10^{23}

(c) What is the value of molar volume of a gas at S.T.P?

Ans: The molar volume of a gas at STP is 22.4 dm^3 at STP.

2. Define or explain the terms

(a) Vapour density

Ans: The ratio between the masses of equal quantities of gas and hydrogen at normal temperature and pressure is known as the vapour density.

(b) Molar volume

Ans: Molar volume is the volume occupied by one mole of the gas at STP. It is equal to 22.4 dm^3.

(c) Relative atomic mass

Ans: The relative atomic mass of an element is the number of times one atom of the element is heavier than 1/12 times of the mass of an atom of carbon-12.

(d) Relative molecular mass

Ans: The relative molecular mass of a compound is the number that represents how many times one molecule of the substance is heavier than 1/12 of the mass of an atom of carbon-12.

(e) Avogadro's number

Ans: The number of atoms present in 12g (gram atomic mass) of C-12 isotope, i.e. 6.023 $x10^{23}$ atoms.

(f) Gram atom

Ans: The quantity of the element which weighs equal to its gram atomic mass is called one gram atom of that element.

(g) Mole

Ans: Mole is the amount of a substance containing elementary particles like atoms, molecules or ions in 12 g of carbon-12.

3. (a) What are the main applications of Avogadro's Law?

Ans: (a) Applications of Avogadro's Law:

(1) It explains Gay-Lussac's law.

(2) It determines the atomicity of the gases.

(3) It determines the molecular formula of a gas.

(4) It determines the relation between molecular mass and vapour density.

(5) It gives the relationship between gram molecular mass and gram molecular volume.

(b) How dose Avogadro's Law explain Gay-Lussac's Law of combining volumes?

Ans: According to Avogadro's law under the same conditions of temperature and pressure, equal volumes of different gases have the same number of molecules.

Since substances react in simple ratio by number of molecules, volumes of the gaseous reactants and products will also bear a simple ratio to one another.This what Gay Lussac's Law says.

$H_2 + Cl_2 \rightarrow 2HCl$

1V 1V 2V(By Gay-Lussacs law)

4. Calculate the relative molecular masses of:

(a) Ammonium chloroplatinate, $(NH_4)_2\ PtCl_6$

Ans: (2N)28 + (8H)8 + (Pt)195 + (6Cl)35.5 x 6 = 444

(b) Potassium chlorate

Ans: $KClO_3$

= (K)39 + (Cl)35.5 + (3O)48 = 122.5

(c) $CuSO_4.\ 5H_2O$

Ans: (Cu)63.5 + (S)32 + (4O)64 + (5H2O)5 x 18 = 249.5

(d) $(NH_4)_2SO_4$

Ans: (2N)28 + (8H)8 + (S)32 + (4O)64 = 132

(e) CH_3COONa

Ans: (C)12 + (3H)3 + (C)12 + (2O)32 + (Na)23 = 82

(f) $CHCl_3$

Ans: (C)12 + (H)1+ (3Cl)3 x 35.5 = 119.5

(g) $(NH_4)_2\ Cr_2O_7$

Ans: (2N)28 + (8H)8 + (2Cr)2 x 51.9+ (7O)7 x 16 = 252

5. Find the

(a) number of molecules in 73 g of HCl,

Ans: No. of molecules in 73 g HCl

= 6.023 $\times 10^{23} \times$ 73/36.5(mol. mass of HCl)

= 12.04 $\times$ 10^{23}

(b) weight of 0.5 mole of O_2,

Ans: Weight of 0.5 mole of O_2 is

= 32(mol. Mass of O_2) $\times$ 0.5

=16 g

(c) number of molecules in 1.8 g of H_2O

Ans: No. of molecules in 1.8 g H_2O

$$= 6.023 \times 10^{23} \times \frac{1.8}{18}$$

= 6.023 $\times$ 10^{22}

(d) number of moles in 10 g of $CaCO_3$

Ans: No. of moles in 10g of $CaCO_3$

$$= \frac{10}{100} (\text{mol. Mass } CaCO_3)$$

= 0.1 mole

(e) Weight of 0.2 mole of H_2 gas,

Ans: Weight of 0.2 mole H_2 gas

= 2(Mol. Mass) × 0.2

= 0.4 g

(f) Number of molecules in 3.2 g of SO_2.

Ans: No. of molecules in 3.2 g of SO_2

$= 6.023 \times 10^{23} \times \frac{3.2}{64}$

$= 3.023 \times 10^{22}$

6. Which of the following would weigh most?

(a) 1 mole of H_2O

(b) 1 mole of CO_2

(c) 1 mole of NH_3

(d) 1 mole of CO

Ans: (b) 1 mole of CO_2

Weight of H_2O= 2+16=18

Weight of CO_2= 12+32=44

Weight of NH_3= 14+3=17

Weight of CO= 12+16=28

7. Which of the following contains the maximum number of molecules?

(a) 4 g of O_2

(b) 4 g of NH_3

(c) 4 g of CO_2

(d) 4 g of SO_2

Ans: (b) 4 g of NH_3

4g of NH_3 having minimum molecular mass contains maximum molecules.

8. Calculate the number of

(a) Particles in 0.1 mole of any substance.

Ans: No. of particles in s1 mole = 6.023×10^{23}

So, particles in 0.1 mole = $6.023 \times 10^{23} \times 0.1$

$= 6.023 \times 10^{22}$

(b) Hydrogen atoms in 0.1 mole of H_2SO_4.

Ans: 1 mole of H_2SO_4 contains $=2 \times 6.023 \times 10^{23}$

So, 0.1 mole of H_2SO_4 contains $=2 \times 6.023 \times 10^{23} \times 0.1$

$= 1.2 \times 10^{23}$ atoms of hydrogen

(c) Molecules in one Kg of calcium chloride.

Ans: 111g $CaCl_2$ contains = 6.023×10^{23} molecules

So, 1000 g contains = 5.42×10^{24} molecules

9. How many grams of

(a) Al are present in 0.2 mole of it?

Ans: 1 mole of aluminium has mass = 27 g

So, 0.2 mole of aluminium has mass = $0.2 \times 27 = 5.4$ g

(b) HCl are present in 0.1 mole of it?

Ans: 0.1 mole of HCl has mass

$=0.1 \times 36.5$(mass of 1 mole)

= 3.65 g

(c) H_2O are present in 0.2 mole of it?

Ans: 0.2 mole of H_2O has mass = $0.2 \times 18 = 3.6$ g

(d) CO_2 is present in 0.1 mole of it?

Ans: 0.1 mole of CO_2 has mass = $0.1 \times 44 = 4.4$ g

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

Ans: 5.6 litres of gas at STP has mass = 12 g

So, 22.4 litre (molar volume) has mass $= 12 \times \frac{22.4}{5.6}$

= 48 g(molar mass)

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

Ans: 1 mole of SO_2 has volume = 22.4 litres

So, 2 moles will have = $22.4 \times 2 = 44.8$ litre

11. Calculate the number of moles of

(a) CO_2 which contain 8.00 g of O_2

Ans: 1 mole of CO_2 contains O_2 = 32g

So, CO_2 having 8 gm of O_2 has no. of moles = $\frac{8}{32}$

= 0.25 moles

(b) Methane in 0.80 g of methane.

Ans: 16 g of methane has no. of moles = 1

So, 0.80 g of methane has no. of moles = $\frac{0.8}{16}$

= 0.05 moles

12. Calculate the actual mass of

(a) An atom of oxygen

Ans: 6.023×10^{23} atoms of oxygen has mass = 16 g

So, 1 atom has mass = $\frac{16}{6.023} \times 10^{23}$

$= 2.656 \times 10^{-23}$ g

(b) an atom of hydrogen

Ans: 1 atom of Hydrogen has mass = $\frac{1.6}{6.023} \times 10^{23} = 1.666 \times 10^{-24}$

(c) a molecule of NH_3

Ans: 1 molecule of NH_3 has mass = $\frac{17}{6.023} \times 10^{23} = 2.82 \times 10^{-23}$ g

(d) the atom of silver

Ans: 1 atom of silver has mass = $\frac{108}{6.023} \times 10^{23} = 1.701 \times 10^{-22}$

(e) the molecule of oxygen

Ans: 1 molecule of O_2 has mass = $\frac{32}{6.023} \times 10^{23} = 5.314 \times 10^{-23}$ g

(f) 0.25 gram atom of calcium

Ans: 0.25 gram atom of calcium has mass = $0.25 \times 40 = 10$g

13. Calculate the mass of 0.1 mole of each of the following

(Ca = 40, Na=23, Mg =24, S=32, C = 12, Cl = 35.5, O=16, H=1)

(a) $CaCO_3$

Ans: 0.1 mole of $CaCO_3$ has mass =100(molar mass) $\times$ 0.1 = 10 g

(b) $Na_2SO_4.10H_2O$

Ans: 0.1 mole of $Na_2SO_4.10H_2O$ has mass = $322 \times 0.1 = 32.2$ g

(c) $CaCl_2$

Ans: 0.1 mole of $CaCl_2$ has mass = $111 \times 0.1 = 11.1$g

(d) Mg

Ans: 0.1 mole of Mg has mass = $24 \times 0.1 = 2.4$ g

14. Calculate the number of

(a) oxygen atoms in 0.10 mole of $Na_2CO_3.10H_2O$.

Ans: 1molecule of $Na_2CO_3.10H_2O$ contains oxygen atoms = 13

So, 6.023×10^{23} molecules (1mole) has atoms = $13 \times 6.023 \times 10^{23}$

So, 0.1 mole will have atoms = $0.1 \times 13 \times 6.023 \times 10^{23}$

$=7.8 \times 10^{23}$

(b) gram atoms in 4.6 gram of sodium

Ans: Given Na = 4.6 gm

Atomic mass= 23

$$\text{No. of gram atoms of Na} = \frac{\text{Mass of Na}}{\text{Atomic mass of Na}}$$

$$= \frac{4.6}{23} = 0.2$$

(c) moles in 12 g of oxygen gas

Ans: 32 g of oxygen gas = 1 mole

$$1 \text{ gram of oxygen gas} = \frac{1}{32} \text{ mole}$$

Given that 12 g of oxygen gas

$$\text{No: of moles} = \frac{\text{given mas}}{\text{molar mass}}$$

$$= \frac{12}{32} = 0.375 \text{ mole}$$

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

Ans: 3.2 g of S has number of atoms = $6.023 \times 10^{23} \times \frac{3.2}{32}$

$= 0.6023 \times 10^{23}$

So, 0.6023×10^{23} atoms of Ca has mass=$40 \times \frac{0.6023 \times 10^{23}}{6.023 \times 10^{23}}$

= 4g

16. Calculate the number of atoms in each of the following:

(a) 52 moles of He

Ans: No. of atoms = $52 \times 6.023 \times 10^{23} = 3.131 \times 10^{25}$

(b) 52 amu of He

Ans: 4 amu = 1 atom of He

so, 52 amu = 13 atoms of He

(c) 52 g of He

Ans: 4 g of He has atoms = 6.023×10^{23}

So, 52 g will have = $6.023 \times 10^{23} \times \frac{52}{4} = 7.828 \times 10^{24}$ atoms

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

Ans: Molecular mass of Na_2CO_3 = 106 g

106 g has $2 \times 6.023 \times 10^{23}$ atoms of Na

So, 5.3g will have = $2 \times 6.023 \times 10^{23} \times \frac{5.3}{106} = 6.022 \times 10^{22}$ atoms

Number of atoms of C = $6.023 \times 10^{23} \times \frac{5.3}{106} = 3.01 \times 10^{22}$ atoms

And atoms of O = $3 \times 6.023 \times 10^{23} \times \frac{5.3}{106} = 9.03 \times 10^{22}$ atoms

18. (a) Calculate the mass of nitrogen supplied to soil by 5 kg of urea [$CO(NH_2)_2$] [O = 16; N = 14; C = 12 ; H = 1]

Ans: 60 g urea has mass of nitrogen(N_2) = 28 g

So, 5000 g urea will have mass = $28 \times \frac{5000}{60} = 2.33$ kg

(b) Calculate the volume occupied by 320 g of sulphur dioxide at S.T.P. [S = 32; O = 16]

Ans: 64 g has volume = 22.4 litre

So, 320 g will have volume = $22.4 \times \frac{320}{64} = 112$ litres

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

Ans: Vapour density of carbon dioxide is 22, it means that 1 molecule of carbon dioxide is 22 heavier than 1 molecule of hydrogen.

(b) Atomic mass of Chlorine is 35.5.What is its vapour density?

Ans: Vapour density of Chlorine atom is 35.5.

20. What is the mass of 56 cm^3 of carbon monoxide at STP?

(C=12, O=16)

Ans: 22400 cm^3 of CO has mass = 28 g

So, 56 cm^3 will have mass = $56 \times \frac{28}{22400} = 0.07$ g

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

Ans: 18 g of water has number of molecules = 6.023×10^{23}

So, 0.09 g of water will have no. of molecules = $6.023 \times 10^{23} \times \frac{0.09}{18} = 3.01 \times 10^{21}$ molecules

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

(a) How many moles of sulphur are present?

Ans: No. of moles in 256 g S_8 = 1 mole

So, no. of moles in 5.12 g = $\frac{5.12}{256}$ = 0.02 moles

(b) How many molecules and atoms are present?

Ans: No. of molecules = $0.02 \times 6.023 \times 10^{23} = 1.2 \times 10^{22}$ molecules

No. of atoms in 1 molecule of S = 8

So, no. of atoms in 1.2×10^{22} molecules = $1.2 x \times 10^{22} \times 8$

= 9.635×10^{22} molecules

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

Ans: Atomic mass of phosphorus P = 30.97 g

Hence, molar mass of P_4 = 123.88 g

If phosphorus is considered as P_4 molecules,

then 1 mole $P_4 \equiv$ 123.88 g

Therefore, 100 g of P_4 = 0.807 g

24. Calculate:

(a) The gram molecular mass of chlorine if 308cm^3 of it at STP weighs 0.979 g

Ans: 308 cm^3 of chlorine weighs = 0.979 g

So, 22400 cm^3 will weigh = gram molecular mass

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

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

Ans: 2 g(molar mass) H_2 at 1 atm has volume = 22.4 litres

So, 4 g H_2 at 1 atm will have volume = 44.8 litres

Now, at 1 atm(P_1) 4 g H_2 has volume (V_1) = 44.8 litres

So, at 4 atm(P_2) the volume(V_2) will be = $\frac{P_1V_1}{P_2} = \frac{1 \times 44.8}{4} = 11.2$ litres

(c) The mass of oxygen in 2.2 litres of CO_2 at STP.

Ans: Mass of oxygen in 22.4 litres = 32 g(molar mass)

So, mass of oxygen in 2.2 litres = $2.2 \times \frac{32}{22.4} = 3.14$ g

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

Ans: No. of atoms in 12 g C = 6.023×10^{23}

So, no. of carbon atoms in 10^{-12} g = $10^{-12} \times \frac{6.023 \times 10^{23}}{12}$

$= 5.019 \times 10^{10}$ atoms

26. An unknown gas shows a density of 3 g per litre at 273^{0}C and 1140 mm Hg pressure. What is the gram molecular mass of this gas?

Ans: Given:

P = 1140 mm Hg

Density = D = 2.4 g / L

T = 273 ^{0}C = 273+273 = 546 K

M = ?

We know that, at STP, the volume of one mole of any gas is 22.4 L

Hence we have to find out the volume of the unknown gas at STP.

First, apply Charle's law.

We have to find out the volume of one litre of unknown gas at standard temperature 273 K.

V_1= 1 L

T_1 = 546 K

V_2=?

T_2 = 273 K

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

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

$$= \frac{1l \times 273}{546} = 0.5 \text{ L}$$

We have found out the volume at standard temperature. Now we have to find out the volume at standard pressure.

Apply Boyle's law.

P_1 = 1140 mm Hg

V_1 = 0.5 L

P_2 = 760 mm Hg

V_2 = ?

$P_1 \times V_1 = P_2 \times V_2$

$$V_2 = \frac{P_1 \times V_1}{P_2}$$

$$= \frac{1140\,mm\,hg \times 0.5\,L}{760 mm\,hg} = 0.75\ L$$

Now, 22.4 L is the volume of 1 mole of any gas at STP, then 0.75 L is the volume of X moles at STP

$$X\ moles = \frac{0.75}{22.4}$$

= 0.0335 moles

The original mass is 2.4 g

$$n = \frac{m}{M} = 0.0335\ moles$$

= 2.4 g / M

$$M = \frac{2.4}{0.0335}$$

M = 71.6 g / mole

Hence, the gram molecular mass of the unknown gas is 71.6 g

27. Cost of Sugar ($C_{12}H_{22}O_{11}$) is Rs 40 per kg; calculate its cost per mole.

Ans: 1000 g of sugar costs = Rs. 40

So, 342g(molar mass) of sugar will cost= $\frac{342 \times 40}{1000}$ =Rs. 13.68

28. Which of the following weighs the least?

(a) 2 g atom of N

(b) 3 x10^{25} atoms of carbon

(c) 1mole of sulphur

(d)7 g of silver

Ans: d) 7 g of silver

a. Weight of 1 g atom N = 14 g

So, weight of 2 g atom of N = 28 g

b. 6.023×10^{23} atoms of C weigh = 12 g

So, 3×10^{25} atoms will weigh = $\frac{12 \times 3 \times 10^{25}}{6.022 \times 10^{23}} = 597.7\text{g}$

c. 1 mole of sulphur weighs = 32 g

d. 7 g of silver

So, 7 grams of silver weighs the least.

29. Four grams of caustic soda contains:

(a) 6.02 x 10^{23} atoms of it

(b) 4 g atom of sodium

(c) 6.02 x10^{22} molecules

(d) 4 moles of NaOH

Ans: (c) 6.02×10^{22} molecule

40 g of NaOH contains 6.023×10^{23} molecules

So, 4 g of NaOH contains = $\frac{6.02 \times 10^{23} \times 4}{40}$ $6.02 \times 10^{23} \times \frac{4}{40}$

= 6.02×10^{22} molecules

30. The number of molecules in 4.25 g of ammonia is:

(a) 1.0 $\times$ 10^{23}

(b) 1.5 $\times$ 10^{23}

(c) 2.0 $\times$ 10^{23}

(d) 3.5×10^{23}

Ans: (b) 1.5×10^{23}

The number of molecules in 18 g of ammonia = 6.02×10^{23}

So, no. of molecules in 4.25 g of ammonia = $\frac{6.02 \times 10^{23} \times 4.25}{18}$

$= 1.5 \times 10^{23}$

31. Correct the statements, if required

(a) One mole of chlorine contains 6.023×10^{10} atoms of chlorine.

Ans: One mole of chlorine contains 6.023×10^{10} atoms of chlorine.

(b) Under similar conditions of temperature and pressure, two volumes of hydrogen combined with two volumes of oxygen will give two volumes of water vapour.

Ans: Under similar conditions of temperature and pressure, two volumes of hydrogen combined with two volumes of oxygen will give two volumes of water vapour.

(c) Relative atomic mass of an element is the number of times one molecule of an element is heavier than 1/12 the mass of an atom of carbon-12.

Ans: Relative atomic mass of an element is the number of times one molecule of an element is heavier than 1/12 the mass of an atom of carbon-12.

(d) Under similar conditions of temperature and pressure, equal volumes of all gases contain the same number of atoms.

Ans: Under similar conditions of temperature and pressure, equal volumes of all gases contain the same number of atoms.

Exercise – 5C

1. Give three kinds of information conveyed by the formula H_2O.

Ans: Information conveyed by H_2O

(1)That H_2O contains 2 volumes of hydrogen and 1 volume of oxygen.

(2)That ratio by weight of hydrogen and oxygen is 1:8.

(3)The molecular weight of H_2O is 18g.

2. Explain the terms empirical formula and molecular formula.

Ans: The empirical formula is the simplest formula, which gives the simplest ratio in whole numbers of atoms of different elements present in one molecule of the compound.

The molecular formula of a compound denotes the actual number of atoms of different elements present in one molecule of a compound.

3. Give the empirical formula of:

(a) C_6H_6

Ans: CH

(b) $C_6H_{12}O_6$

Ans: CH_2O

(c) C_2H_2

Ans: CH

(d) CH_3COOH

Ans: CH_2O

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

Ans: Relative molecular mass of $CuSO_4.\ 5H_2O$

$=64+32+4\times16+5(2+16)$

$=160+90=250$

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

$= \frac{90}{250} \times 100 = 36\%$

5. Calculate the percentage of phosphorus in

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

Ans: Molecular mass of $Ca(H_2PO_4)_2 = 234$

So, % of P = $2 \times 31 \times \frac{100}{234} = 26.5\%$

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

Ans: Molecular mass of $Ca_3(PO_4)_2 = 310$

% of P = $2 \times 31 \times \frac{100}{310} = 20\%$

6. Calculate the percent composition of Potassium chlorate $KClO_3$.

Ans: Molecular mass of $KClO_3 = 122.5$ g

% of K = $\frac{39}{122.5} = 31.8\%$

% of Cl = $\frac{35.5}{122.5} = 28.98\%$

% of O = $3 \times \frac{16}{122.5} = 39.18\%$

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

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

Ans:

Element	%	At. mass	Atomic ratio	Simple ratio

Pb	62.5%	207	$\frac{62.5}{207}$ =0.3019	$\frac{0.3019}{0.3019}$ =1
N	8.5%	15	$\frac{8.5}{15}$ = 0.6071	$\frac{0.6071}{0.3019}$ =2
O	29.0	16	$\frac{29}{16}$ = 1.81	$\frac{1.81}{0.3019}$ =6

So, $Pb(NO_3)_2$ is the empirical formula.

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

Ans: In Fe_2O_3, Fe = 56 and O = 16

Molecular mass of $Fe_2O_3 = 2 \times 56 + 3 \times 16 = 160$ g

Iron present in 80% of $Fe_2O_3 = \frac{112}{160} \times 80 = 56$g

So, mass of iron in 100 g of ore = 56 g

mass of Fe in 10000 g of ore = $56 \times \frac{10000}{100}$

= 5.6 kg

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

Ans: For acetylene, molecular mass = 2 ×V.D = 2 ×13 = 26 g

The empirical mass = 12(C) + 1(H) = 13 g

$$n = \frac{\text{Molecular formula mass}}{\text{Empirical formula weight}} = \frac{26}{13} = 2$$

Molecular formula of acetylene= $2 \times$Empirical formula $= C_2H_2$

Similarly, for benzene molecular mass= $2 \times$V.D $= 2 \times 39 = 78$

$$n = \frac{78}{13} = 6$$

So, the molecular formula = C_6H_6

10. Find the empirical formula of a compound containing 17.7% hydrogen and 82.3% nitrogen.

Ans: Element % At. mass Atomic ratio Simple ratio

Element	%	Atomic mass	Atomic ratio	Simple ratio
H	17.7	1	$\frac{17.7}{1} = 17.7$	$\frac{17.7}{5.87} = 3$
N	82.3	14	$\frac{82.3}{14} = 5.87$	$\frac{5.87}{5.87} = 1$

So, the empirical formula = NH_3

11. On analysis, a substance was found to contain

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

The vapour density of the substance is 44, calculate;

(a) its empirical formula, and

(b) its molecular formula

Ans:

Element	%	Atomic mass	Atomic ratio	Simple ratio

C	54.54	2	$\frac{54.54}{12}=4.55$	$\frac{4.55}{2.27}=2$
H	9.09	4	$\frac{9.09}{1}=9.09$	$\frac{9.09}{2.27}=4$
O	36.36	1	$\frac{36.36}{16}=2.27$	$\frac{2.27}{2.27}=1$

(a) So, its empirical formula = C_2H_4O

(b) empirical formula mass = 44

Since, vapour density = 44

So, molecular mass = $2 \times$V.D = 88

Or n = 2

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

12. An organic compound, whose vapour density is 45, has the following percentage composition

H=2.22%, O = 71.19% and remaining carbon.

Calculate,

(a) its empirical formula, and

(b) its molecular formula

Ans:

Elements	%	at. mass	atomic ratio	simple ratio
C	26.59	12	$\frac{26.59}{12}=2.21$	$\frac{2.21}{2.21}=1$
H	2.22	1	$\frac{2.22}{1}=2.22$	$\frac{2.22}{2.21}=1$
O	71.19	16	$\frac{71.19}{16}=$	$\frac{4.44}{2}=2$

			4.44	

(a) its empirical formula = CHO_2

(b) empirical formula mass = 45

Vapour density = 45

So, molecular mass = V.D $\times 2$ = 90

so, molecular formula = $C_2H_2O_4$

13. An organic compound contains H = 4.07%, Cl = 71.65% chlorine and remaining carbon. Its molar mass = 98.96. Find,

(a) Empirical formula, and

(b) Molecular formula

Ans:

Element	%	Atomic mass	Atomic ratio	Simple ratio
Cl	71.65	35.5	$\frac{71.65}{35.5}=2.01$	$\frac{2.01}{2.02}=1$
H	4.07	1	$\frac{4.07}{1}=4.07$	$\frac{4.07}{2.01}=2$
C	24.28	12	$\frac{24.28}{12}=2.02$	$\frac{24.28}{12}=1$

(a) its empirical formula = CH_2Cl

(b) empirical formula mass = 49.5

Since, molecular mass = 98.96

so, molecular formula = $(CH_2Cl)_2 = C_2H_4Cl_2$

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

(a) the g atom of each

Ans: The g atom of carbon = 4.8/12 = 0.4 and g atom of hydrogen = 1/1=1

(b) find the empirical formula

Ans:

Element	Given mass	At. mass	Atomic ratio	Simplest ratio
C	4.8	12	$\frac{4.8}{12}=0.4$	$\frac{0.4}{0.4}=1$
H	1	1	$\frac{1}{1}=1$	$\frac{1}{0.4}=\frac{5}{2}$

So, the empirical formula = C_2H_5

(c) Find molecular formula, if its vapour density is 29.

Ans: Empirical formula mass = 29

Molecular mass = V.D $\times 2 = 29 \times 2 = 58$

So, molecular formula = C_4H_{10}

15. 0.2 g atom of silicon Combine with 21.3 g of chlorine. Find the empirical formula of the compound formed.

Ans: 0.2g atom i.e 0.2 mole silicon

Moles of chlorine = $\frac{\text{given mass}}{\text{molar mass}} = \frac{21.3}{35.5} = 0.6\text{mol}$

Ratio of Si : Cl = $\frac{0.2}{0.2} : \frac{0.6}{0.2} = 1:3$

Empirical formula = $SiCl_3$

16. A gaseous hydrocarbon contains 82.76% of carbon. Given that its vapour density is 29, find its molecular formula.

Ans: % of carbon = 82.76%

% of hydrogen = 100 - 82.76 = 17.24%

Element	% Weight	Atomic Weight	Relative No. of Moles	Simplest Ratio
C	82.76	12	$\frac{82.76}{12} = 6.89$	$\frac{6.89}{6.89} = 1 \times 2 = 2$
H	17.24	1	$\frac{17.24}{17.24} = 1$	$\frac{17.24}{6.89} = 2.5 \times 2 = 5$

Empirical formula = C_2H_5

Empirical formula weight = $2 \times 12 + 1 \times 5 = 24 + 5 = 29$

Vapour Density = 29

Relative molecular mass = $29 \times 2 = 58$

$$N = \frac{\text{Relative molecular mass}}{\text{Empirical weight}} = \frac{58}{29} = 2$$

Molecular Formula = n x empirical formula

$= 2 \times C_2H_5$

$= C_4H_{10}$

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

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

Ans: G atoms of magnesium = $\frac{18}{24}$ = 0.75 or g- atom of Mg

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

Ans: G atoms of nitrogen = $\frac{7}{14}$ = 0.5 or 1/2 g- atoms of N

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

Ans: Ratio of gram-atoms of N and Mg = 1:1.5 or 2:3

So, the formula is Mg_3N_2

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

Ans: Barium chloride = $BaCl_2.\ x\ H_2O$

Ba + 2Cl + $x[H_2 + O]$

=137+ 235.5 + x(2+16)

= [208 + 18x] contains water = 14.8% water in $BaCl_2.x\ H_2O$

$= (208 + 18\ x) \times \frac{14.8}{100} = 18x$

= [104 + 9x] 2148=18000x

= [104+9x] 37=250x

= 3848 + 333x =2250x

1917x =3848

x = 2 molecules of water

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

Ans: Molar mass of urea; CON_2H_4 = 60 g

So, % of Nitrogen $= 28 \times \frac{100}{60} = 46.66\%$

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

Ans:

Element	%	Atomic mass	Atomic ratio	Simple ratio
C	42.1	12	$\frac{42.1}{12}=3.5$	$\frac{3.5}{3.2}=1$
H	6.48	1	$\frac{6.48}{1}=6.48$	$\frac{6.48}{3.2}=2$
O	51.42	16	$\frac{51.42}{16}=3.2$	$\frac{3.2}{3.2}=1$

The empirical formula is CH_2O

Since the compound has 12 atoms of carbon, so the formula is

$C_{12}\ H_{24}\ O_{12}$.

21. (a) A compound with empirical formula AB_2, has the vapour density equal to its empirical formula weight. Find its molecular formula.

Ans: Now since the empirical formula is equal to vapour density and we know that vapour density is half of the molecular mass i.e. we have n=2 so, the molecular formula is A_2B_4.

(b) A compound with empirical formula AB has vapour density 3 times its empirical formula weight. Find the molecular formula.

Ans: Since molecular mass is 2 times the vapour density, so Mol. Mass = 2 V.D

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

So, n = $\frac{\text{Molecular mass}}{\text{Empirical formula weight}}$ = 6

Hence, the molecular formula is A_6B_6

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

Ans: Wt. of the compound: 10.47g

Wt. of metal A: 6.25g

Wt. of non-metal B: 10.47 – 6.25 = 4.22g

Element	mass	At. Wt.	Relative no. of atoms	Simplest ratio
A	6.25g	207	$\frac{6.25}{207} = 0.03$	$\frac{0.03}{0.03} = 1$
B	4.22g	35.5	$\frac{4.26}{35.5} = 0.12$	$\frac{0.12}{0.03} = 4$

Empirical formula AB_4

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

Ans: Atomic ratio of N = $\frac{87.5}{14} = 6.25$

Atomic ratio of H = $\frac{12.5}{1} = 12.5$

This gives us the simplest ratio as 1:2

So, the molecular formula is NH_2

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

Ans:

Element	%	Atomic mass	Atomic ratio	Simple ratio
Zn	22.65	65	$\frac{22.65}{65}$	$\frac{0.348}{0.348} = 1$

			=0.348	
H	4.88	1	$\frac{4.88}{1}=4.88$	$\frac{4.88}{0.348}=14$
S	11.15	32	$\frac{11.15}{32}=0.348$	$\frac{0.348}{0.348}=1$
O	61.32	16	$\frac{61.32}{16}=3.83$	$\frac{3.83}{0.348}=11$

Empirical formula of the given compound $=ZnSH_{14}O_{11}$

Empirical formula mass = 65.37+32+141+11+16=287.37

Molecular mass = 287

$$n = \frac{\text{Molecular mass}}{\text{Empirical Formula}} = \frac{287}{287} = 1$$

Molecular formula = $ZnSO_{11}H_{14}$

$=ZnSO_4.7H_2O$

Exercise – 5D

1. Complete the following blanks in the equation as indicated.

CaH_2 (s) + $2H_2O$ (aq) $\rightarrow$ $Ca(OH)_2$ (s) + $2H_2$ (g)

(a) Moles: 1 mol + ------- $\rightarrow$ -------- + ----------

Ans: (a) Moles:1 mole + 2 mole $\rightarrow$ 1 mole + 2 mole

(b) Grams: 42g + ------- $\rightarrow$ -------- + ----------

Ans: Grams: 42g + 36g $\rightarrow$ 74g + 4 g

(c) Molecules: 6.02 x 10^{23} + ------- → -------- + ----------

Ans: Molecules = 6.02 $\times 10^{23}$ + 12.046 $\times 10^{23}$ → 6.02 $\times 10^{23}$ + 12.046 $\times 10^{23}$

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

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

Calculate:

(a) the mass of anhydrous calcium nitrate formed

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

So, 15 g $CaCO_3$ will produce = 164 $\times$ 15/100 = 24.6 g $Ca(NO_3)_2$

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

Ans: 1 V of $CaCO_3$ produces 1 V of CO_2

100 g of $CaCO_3$ has volume = 22.4 litres

So, 15 g will have volume = 22.4 $\times$ 15/100 = 3.36 litres CO_2

3. 66g of ammonium sulphate is produced by the action of ammonia on sulphuric acid.

Write a balanced equation and calculate:

$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

(a) Mass of ammonia required.

Ans: $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

34g 98g 132g

For 132 g $(NH_4)_2SO_4$ = 34 g of NH_3 is required

So, for 66 g $(NH_4)_2SO_4$ = 66 $\times$ 32/132 = 17 g of NH_3 is required

(b) The volume of the gas used at the S.T.P.

Ans: 17g of NH_3 requires volume = 22.4 litres

(c) The mass of acid required.

Ans: Mass of acid required, for producing 132g $(NH_4)_2SO_4$ = 98g

So, Mass of acid required, for 66g $(NH_4)_2SO_4$ = 66 × 98/132 = 49g

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

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

Calculate

(a) the mass of lead chloride formed by the action of the 6.85 g of red lead,

Ans: Molecular mass of Pb_3O_4 = 3 × 207.2 + 4 ×16 = 685 g

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

Hence, 6.85 g of Pb_3O_4 will give = 6.85 ×834/685 = 8.34 g

(b) the mass of the chlorine

Ans: 685g of Pb_3O_4 gives = 71g of Cl_2

Hence, 6.85 g of Pb_3O_4 will give = $6.85 \times \frac{71}{685}$ = 0.71 g Cl_2

(c) the volume of the chlorine evolved at S.T.P.

Ans: 1 V Pb_3O_4 produces 1 V Cl_2

685g of Pb_3O_4has volume = 22.4 litres = volume of Cl_2 produced

So, 6.85 Pb_3O_4 will produce = $6.85 \times \frac{22.4}{685}$ = 0.224 litres of Cl_2

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

$KNO_3 + H_2SO_4 \rightarrow KHSO_4 + HNO_3$

$NaNO_3 + H_2SO_4 \rightarrow NaHSO_4 + HNO_3$

Ans: Molecular mass of KNO_3 = 101 g

63 g of HNO_3 is formed by = 101 g of KNO_3

So, 126000 g of HNO_3 is formed by = $126000 \times \frac{101}{63}$ = 202 kg

Similarly,126 g of HNO_3 is formed by 170 kg of $NaNO_3$

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

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

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

Calculate:

(a) The mass of salt required.

Ans: $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

100g 73g 22.4L

According to given reaction

2L of $O_2 = \frac{2}{22.4}$ of $CaCO_3$

Mass of salt required= $100 \times \frac{2}{22.4}$ = 8.93g

(b) The mass of the acid required to prepare the 2 litres of CO_2 at 27 C and normal pressure.

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

Ans: 2L CO_2 given by = $2 \times \frac{2}{22.4}$ mole HCl

Mass of HCl = $36.5 \times \frac{4}{22.4}$ = 6.52g

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

Ans: $2H_2O \rightarrow 2H_2 + O_2$

2 moles of H_2O gives = 1 mole of O_2

So, 1 mole of H_2O will give = 0.5 moles of O_2

so, mass of O_2 = no. of moles x molecular mass

$= 0.5 \times 32 = 16$ g of O_2

and 1 mole of O_2 occupies volume =22.4 litre

so, 0.5 moles will occupy = $22.4 \times 0.5 = 11.2$ litres at S.T.P.

8. 1.56 g of sodium peroxide reacts with water according to the following equation:

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

Calculate:

(a) mass of sodium hydroxide formed,

Ans: Mol. Mass of $Na_2O_2 = 2 \times 23 + 2 \times 16 = 78$ g

Mass of $2Na_2O_2 = 156$ g

156 g Na_2O_2 gives = 160 g of NaOH (4×40 g)

So, 1.56 Na_2O_2 will give = $160 \times \frac{1.56}{156} = 1.6$ g

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

Ans: 156 g Na_2O_2 gives = 22.4 litres of oxygen

So, 1.56 g will give = $22.4 \times 1.56/156 = 0.224$ litres

$= 224\ cm^3$

(c) Mass of oxygen liberated.

Ans: 156 g Na_2O_2 gives = 32 g O_2

So, 1.56 g Na_2O_2 will give = 32 $\times$1.56/156

= 32/100 = 0.32 g

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

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

Ans: $2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3$

Mol. Mass of $2NH_4Cl$ = 2[14 + (1 $\times$4) + 35.5] = 2[53.5] = 107 g

107 g NH_4Cl gives = 34 g NH_3

So, 21.4 g NH_4Cl will give = 21.4 $\times$34/107 = 6.8 g NH_3

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

The molar volume of a gas = 22.4 litres at STP.

Ans: The volume of 17 g NH_3 is 22.4 litre

So, volume of 6.8 g will be = 6.8 $\times$22.4/17 = 8.96 litre

10. Aluminium carbide reacts with water according to the following equation.

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

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

Ans: $Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3CH_4$

1V 3V

144g 3×22.4 Vol

Since 144g of Al_4C_3 gives 312g of $Al(OH)_3$

So, 12g of Al_4C_3 will give = $\frac{312\times12}{144}$ = 26g $Al(OH)_3$

(b) What volume of methane s.t.p. is obtained from 12g of aluminium carbide?

Ans: 144g of Al_4C_3 gives 3×22.4 litre of CH_4

So 12g of Al_4C_3 will give = $\frac{3\times22.4\times12}{144}$ = 5.6 litre CH_4

11. MnO_2 + 4HCl $\rightarrow$ $MnCl_2$ + $2H_2O$ + Cl_2

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

(a) mass of MnO_2 used

Ans: 1 mole of MnO_2 weighs = 87 g (mol. Mass)

So, 0.02 mole will weigh = 87 × 0.02 = 1.74 g MnO_2

(b) moles of salt formed,

Ans: 1 mole MnO_2 gives = 1 mole of $MnCl_2$

So, 0.02 mole MnO_2 will give = 0.02 mole of $MnCl_2$

(c) mass of salt formed,

Ans: 1 mole $MnCl_2$ weighs = 126 g(mol mass)

So, 0.02 mole $MnCl_2$ will weigh = 126 × 0.02 g = 2.52 g

(d) moles of chlorine gas formed,

Ans: 0.02 mole MnO_2 will form =0.02 mol of Cl_2

(e) mass of chlorine gas formed,

Ans: 1 mole of Cl_2 weighs = 35.5 g

So, 0.02 mole will weigh = 71 × 0.02 = 1.42 g of Cl_2

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

Ans: 1 mole of chlorine gas has volume = 22.4 litres

So, 0.02 mole will have volume = 22.4 × 0.02 = 0.448 litre

(g) moles of acid required,

Ans: 1 mole MnO_2 requires HCl = 4 mole

So, 0.02 mole MnO_2 will require = $4 \times 0.02 = 0.08$ mole

(h) Mass of acid required.

Ans: For 1 mole MnO_2, acid required = 4 mole of HCl

So, for 0.02 mole, acid required = $4 \times 0.02 = 0.08$ mole

Mass of HCl = $0.08 \times 36.5 = 2.92$ g

12. Nitrogen and hydrogen react to form ammonia.

N_2 (g) + $3H_2$ (g) $\rightarrow$ $2NH_3$ (g)

If 1000g H_2 react with 2000g of N_2:

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

Ans: $N_2 + 3H_2 \rightarrow 2NH_3$

28g 6g 34g

28g of nitrogen requires hydrogen = 6g

2000g of nitrogen requires hydrogen = $6/28 \times 2000 = 3000/7$g

So mass of hydrogen left unreacted = $1000 - \frac{3000}{7} = 571.4$g of H_2

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

Ans: 28g of nitrogen forms NH_3 = 34g

2000g of N_2 forms NH_3

$= \frac{34}{28} \times 2000$

= 2428.6g

Miscellaneous exercise

1. From the equation for burning of hydrogen and oxygen

$2H_2 + O_2 \rightarrow 2H_2O$ (Steam)

Write down the number of mole (or moles) of steam obtained from 0.5 moles of oxygen.

Ans: As per the given equation

1 mole of Oxygen gives = 2 moles of steam

so, 0.5 mole oxygen will give = 2×0.5 = 1mole of steam

2. From the equation

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

(At. mass Cu=64, H=1, N=14, O=16)

Calculate:

(a) Mass of copper needed to react with 63g of HNO_3

Ans: Mol. Mass of $8HNO_3 = 8 \times 63 = 504$ g

For 504 g HNO_3, Cu required is = 192 g

So, for 63g HNO_3Cu required = $192 \times \frac{63}{504} = 24$g

(b) Volume of nitric oxide at S.T.P. that can be collected.

Ans:504 g of HNO_3 gives = 2×22.4 litre volume of NO

So, 63g of HNO_3 gives =$2 \times 22.4 \times \frac{63}{504} = 5.6$ litre of NO

3. (a) Calculate the number of moles in 7g of nitrogen.

Ans: 28g of nitrogen = 1mole

So, 7g of nitrogen = $\frac{1}{28} \times 7 = 0.25$ moles

(b) What is the volume at S.T.P. of 7.1 g of chlorine?

Ans: Volume of 71 g of Cl_2 at STP = 22.4 litres

Volume of 7.1 g chlorine = $22.4 \times \frac{7.1}{71}$ = 2.24 litre

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

Ans: 22400cm^3 volume have mass = 28 g of CO(molar mass)

So, 56cm^3 volume will have mass = $28 \times \frac{56}{22400}$ = 0.07 g

4. Some of the fertilizers are sodium nitrate $NaNO_3$, ammonium sulphate $(NH_4)_2SO_4$ and urea $CO(NH_2)_2$. Which of these contains the highest percentage of nitrogen?

Ans:

% of N in $NaNO_3 = \frac{14}{85} \times 100 = 16.47\%$

% of N in $(NH_4)_2SO_4 = \frac{14}{132} \times 100 = 21.21\%$

% of N in $CO(NH_2)_2 = \frac{14}{60} \times 100 = 46.66\%$

So, the highest percentage of N is in urea.

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

$2H_2O \rightarrow 2H_2 + O_2$

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

Ans: $2H_2O \rightarrow 2H_2 + O_2$

2V 2V 1V

From equation, 2 V of water gives 2 V of H_2 and 1 V of O_2

where 2 V = 2500 cm^3

so, volume of O_2 liberated = $\frac{2V}{V}$ = 1250 cm^3

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

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

$$\frac{P_1V_1}{T_1} = \frac{7P_1 \times V_2}{2 \times T_1}$$

$$V_2 = \frac{2500 \times 2}{7}$$

$$V_2 = \frac{5000}{7} cm^3$$

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

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

$$\frac{5000}{7 \times 2500} = \frac{T_1}{T_2}$$

$T_2 = 3.5\ T_1$

i.e. temperature should be increased by 3.5 times.

6. Urea [$CO(NH_2)_2$] is an important nitrogenous fertilizer. Urea is sold in 50 kg sacks. What mass of nitrogen is in one sack of urea?

Ans: Molecular mass of urea=12 + 16+2(14+2) =60g

60g of urea contains nitrogen =28g

So, in 50g of urea, nitrogen present =23.33 g

50 kg of urea contains nitrogen=23.33kg

7. Find the molecular formula of a hydrocarbon having vapour density 15, which contains 20% of Hydrogen.

Ans:

% of hydrogen = 20%

% of carbon = 100 - 20 = 80%

	% Weight	Atomic Weight	Relative No. of Moles	Simplest Ratio
C	80	12	$\frac{80}{12} = 6.667$	$\frac{6.667}{6.667} = 1$
H	20	1	$\frac{20}{1} = 20$	$\frac{20}{6.667} = 2.99 \approx 3$

Empirical formula = CH_3

Empirical formula weight = $1 \times 12 + 1 \times 3 = 12 + 3 = 15$

Vapour Density = 15

Relative molecular mass = $15 \times 2 = 30$

$$N = \frac{\text{Relative molecular massRelative molecular mass}}{\text{Empirical weight}} = \frac{30}{15} = 2$$

Molecular formula = n x empirical formula

$= 2 \times CH_3$

$= C_2H_6$

8. The following experiment was performed in order to determine the formula of a hydrocarbon. The hydrocarbon X is purified by fractional distillation.

0.145 g of X was heated with dry copper (II) oxide and 224 cm^3 of carbon dioxide was collected at S.T.P.

Ans: 22400cm^3 CO_2 has mass = 44g

so, 224 cm^3 CO_2 will have mass= 0.44 g

Now since CO_2 is being formed and X is a hydrocarbon so it contains C and H.

In 0.44g CO_2, mass of carbon=0.44-0.32=0.12g=0.01g atom

So, mass of Hydrogen in X = 0.145-0.12 = 0.025g

= 0.025g atom

Now the ratio of C:H is C=1: H=2.5 or C=2 : H=5

i.e. the formula of hydrocarbon is C_2H_5

(a) Which elements does X contain?

Ans: C and H

(b) What was the purpose of copper (II) oxide?

Ans: Copper (II) oxide was used for reduction of the hydrocarbon.

(c) Calculate the empirical formula of X by the following steps:

(i) Calculate the number of moles of carbon dioxide gas.

Ans: no. of moles of CO_2= 0.44/44 = 0.01 moles

(ii) Calculate the mass of carbon contained in this quantity of carbon dioxide and thus the mass of carbon in sample X.

Ans: mass of C = 0.12 g

(iii) Calculate the mass of hydrogen in sample X.

(iii) mass of H = 0.025 g

(iv) Deduce the ratio of atoms of each element in X (empirical formula).

(iv) The empirical formula of X = C_2H_5

9. A compound is formed by 24g of X and 64g of oxygen. If atomic mass of X=12 and O=16, calculate the simplest formula of compound.

Ans: Mass of X in the given compound =24g

Mass of oxygen in the given compound =64g

So total mass of the compound =24+64=88g

% of X in the compound = 24/88 100 = 27.3%

% of oxygen in the compound=64/88 100 =72.7%

Element	**%**	**Atomic mass**	**Atomic ratio**	**Simplest ratio**
X	27.3	12	$\frac{27.3}{12}=2.27$	$\frac{2.27}{2.27}=1$
O	72.7	16	$\frac{72.2}{16}=4.54$	$\frac{4.54}{2.27}=2$

So simplest formula = XO_2

10. A gas cylinder filled with hydrogen holds 5g of the gas. The same cylinder holds 85 g of gas X under the same temperature and pressure. Calculate:

(a) Vapour density of gas X.

Ans:

$$\text{V.D} = \frac{\text{mass of gas at STP}}{\text{mass of equal volume of } H_2} = \frac{85}{5} = 17$$

(b) Molecular weight of gas X.

Ans: Molecular mass = 17(V.D) × 2= 34g

11. (a) When carbon dioxide is passed over red hot carbon, carbon monoxide is produced according to the equation :

$CO_2 + C \rightarrow 2CO$

What volume of carbon monoxide at S.T.P. can be obtained from 3 g of carbon?

Ans: $CO_2 + C \rightarrow 2CO$

1V 1V 2V

12 g of C gives = 44.8 litre volume of CO

So, 3 g of C will give = 11.2 litre of CO

(b) 60 cm^3 of oxygen was added to 24 cm^3 of carbon monoxide and mixture ignited. Calculate:

(i) volume of oxygen used up and

(ii) Volume of carbon dioxide formed.

Ans: $2CO + O_2 \rightarrow 2CO_2$

2V 1V 2V

(i) 2 V CO requires oxygen = 1 V

so, 24 cm^3 CO will require = 24/2 =12 cm^3

(ii) 2 x 22400 cm^3 CO gives = 2 × 22400 cm^3 CO_2

so, 24cm^3 CO will give = 24 cm^3 CO_2

12. How much calcium oxide is obtained by heating 82 g of calcium nitrate? Also find the volume of NO_2 evolved:

$2Ca(NO_3)_2 \rightarrow 2CaO+4NO_2+O_2$

Ans: Molecular weight of $2Ca(NO_3)_2$= 2[40+2(14+48)]

=328g

Molecular weight of CaO =2(40+16)

=112g

a. 328g of $Ca(NO_3)_2$ liberates 4 moles of NO_2

Ans: 328g of $Ca(NO_3)_2$ liberates 4×22.4L of NO_2, 82g will liberate

$$\frac{4 \times 22.4 \times 82}{328}$$

$=22.4dm^3$ of NO_2

b. 328 g of calcium nitrate gives 112g of CaO

82 g will give $\frac{112 \times 82}{328}$

=28 g of CaO

13.The equation for the burning of octane is:

$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$

2V 25V 16V 18V

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

Ans: 2 moles of octane gives = 16 moles of CO_2

so, 1 mole octane will give = 8 moles of CO_2

(ii) What volume at S.T.P. is occupied by the number of moles determined in (i)?

Ans: 1 mole CO_2 occupies volume = 22.4 litre

so, 8 moles will occupy volume = $8 \times 22.4 = 179.2$ litre

(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?

Ans: 1 mole CO_2 has mass = 44 g

so, 16 moles will have mass = $44 \times 16 = 704$ g

(iv) What is the empirical formula of octane?

Ans: Empirical formula is C_4H_9.

14. Ordinary chlorine gas has two isotopes $^{35}_{17}Cl$ and $^{37}_{17}Cl$ in the ratio of 3:1. Calculate the relative atomic mass of chlorine.

Ans: The relative atomic mass of Cl $= \frac{(35\times 3+1\times 37)}{4} = 35.5$ amu

15. Silicon (Si = 28) forms a compound with chlorine (Cl = 35.5) in which 5.6 g of silicon combines with 21.3 g of chlorine. Calculate the empirical formula of the compound.

Ans: Mass of silicon in the given compound =5.6g

Mass of the chlorine in the given compound=21.3g

Total mass of the compound=5.6g+21.3g=26.9g

% of silicon in the compound = 56/26.9 ×100 = 20.82%

% of chlorine in the compound = 21.2/26.9 ×100 = 79.18%

Element	**%**	**Atomic mass**	**Atomic ratio**	**Simplest ratio**
Si	20.82	28	$\frac{20.82}{28}=0.74$	$\frac{0.74}{0.74}=1$
Cl	79.18	35	$\frac{79.18}{35.5}=2.23$	$\frac{2.23}{0.74}=3$

So the empirical formula of the given compound =$SiCl_3$

16. An acid of phosphorus has the following percentage composition; Phosphorus = 38.27%; hydrogen = 2.47 %; oxygen = 59.26 %. Find the empirical formula of the acid and its molecular formula, given that its relative molecular mass is 162.

Ans:

Element	**%**	**Atomic mass**	**Atomic ratio**	**Simplest ratio**
P	38.72	31	$\frac{38.72}{31}=1.23$	$\frac{1.23}{1.23}=1$

H	2.47	1	$\frac{2.47}{1}=2.47$	$\frac{2.47}{1.23}=2$
O	59.26	16	$\frac{59.26}{16}=3.70$	$\frac{3.70}{1.23}=3$

So, empirical formula is PH_2O_3 or H_2PO_3

Empirical formula mass = $31+2\times1+3\times16=81$

The molecular formula is = $H_4P_2O_6$, because n = 162/81=2

17. a) Calculate the mass of substance 'A' which in gaseous form occupies 10 litres at 27 ºC and 700 mm pressure. The molecular mass of 'A' is 60.

Ans: V_1 = 10 litres V_2=?

T_1= 27+ 273 = 300KT_2=273K

P_1=700 mmP_2 = 760 mm

Using the gas equation

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

$$V2=\frac{P_1V_1T_2}{T_1P_2}=\frac{700\times10\times273}{300\times760}$$

Molecular weight A= 60

So weight of 22.4 litres of A at STP=60g

$$\text{Weight of A at STP}=\frac{700\times10\times273}{300\times760}\times\frac{60}{22.4}=22.45\text{g}$$

b) A gas occupied 360 cm^3 at 87^0C and 380 mm Hg pressure. If the mass of gas is 0.546 g, find its relative molecular mass.

Ans:

$$V \times \frac{760}{273} = \frac{360 \times 380}{360}$$

$$V = \frac{360 \times 380 \times 273}{760 \times} = 136.5 cm^3$$

$136.5 cm^3$ of gas weigh= 0.546

$22400 cm^3$ of gas weight= $\frac{0.546}{136.5} \times 22400 = 89.6$ amu

Relative molecular mass= 89.6 amu

18. A gas cylinder can hold 1 kg of hydrogen at room temperature and pressure.

(a) What mass of carbon dioxide can it hold under similar conditions of temperature and pressure?

Ans: Molecular mass of CO_2 = 12+ 2×16 = 44 g

So, vapour density (V.D) = mol. Mass/2 = 44/2 = 22

$$V.D = \frac{\text{mass of certain amount of } CO_2}{\text{mass of equal volume of hydrogen}} = \frac{m}{1}$$

$$22 = \frac{m}{1}$$

So, mass of CO_2 = 22 kg

(b) If the number of molecules of hydrogen in the cylinder is X, calculate the number of carbon dioxide molecules in the cylinder. State the law that helped you to arrive at the above result

Ans: According to Avogadro's law, equal volumes of all gases under similar conditions of temperature and pressure contain equal numbers of molecules.

So, number of molecules of carbon dioxide in the cylinder =number of molecules of hydrogen in the cylinder = X

19. Following questions refer to one mole of chlorine gas.

(a) What is the volume occupied by this gas at S.T.P.?

Ans: The volume occupied by 1 mole of chlorine = 22.4 litre

(b) What will happen to the volume of gas, if pressure is doubled?

Ans: Since PV=constant so, if pressure is doubled; the volume will become half i.e. 11.2 litres.

(c) What volume will it occupy at 273°C?

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

$$\frac{22.4}{V_2} = \frac{273}{546}$$

V_2 = 44.8 litres

(d) If the relative atomic mass of chlorine is 35.5, what will be the mass of 1 mole of chlorine gas?

Ans: Mass of 1 mole Cl_2 gas =35.5 × 2 =71 g

20. (a) A hydrate of calcium sulphate $CaSO_4.xH_2O$ contains 21% water of crystallisation. Find the value of x.

Ans: Total molar mass of hydrated $CaSO_4.xH_2O$ = 136+18x

Since 21% is water of crystallization, so

$$\frac{18x}{136+18x} = \frac{21}{100}$$

So, x = 2 i.e. water of crystallization is 2.

(b) What volume of hydrogen and oxygen measured at S.T.P. will be required to prepare 1.8 g of water.

Ans: For 18 g water, vol. of hydrogen needed = 22.4 litre

So, for 1.8 g, vol. of H_2 needed = $1.8 \times \frac{22.4}{18}$ = 2.24 litre

Now 2 vols. of water = 1 vol. of oxygen

1 vol. of water =1/2 vol. of O_2 = $\frac{22.4}{2}$ = 11.2 lit.

18 g of water = 11.2 lit. of O_2

1.8 g of water = $\frac{11.2}{18} = \frac{18}{10}$ = 1.12 lit.

(c) How much volume will be occupied by 2g of dry oxygen at 27^0C and 740 mm pressure?

Ans: 32g of dry oxygen at STP = 22400cc

2g will occupy = $\frac{224002}{32}$ = 1400cc

P_1 = 760 mm P_2 = 740mm

V_1 = 1400cc V_2 =?

T_1 = 273 K, T_2 = 27 +73 = 300K

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

$$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{760 \times 1400 \times 300}{273 \times 740} = 1580\text{cc}$$

$\frac{1580}{1000}$ = 1.58 litres

(d) What would be the mass of CO_2 occupying a volume of 44 litres at 25^0 C and 750 mm pressure?

Ans: P_1= 750 mm P_2=760 mm

V_1= 44lit. V_2=?

T_1= 298K T_2=273K

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

$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{750 \times 44 \times 273}{298 \times 760} = 39.78\text{litre}$

22.4 litre of CO_2 at STP has mass = 44g

39.78 litre of CO_2 at STP has mass = $\frac{44 \times 39.78}{22.4}$ = 78.14g

(e) 1 g of a mixture of sodium chloride and sodium nitrate is dissolved in water. On adding silver nitrate solution, 1.435 g of AgCl is precipitated.

$AgNO_3$ (aq) + NaCl (aq) $\rightarrow$ AgCl (s) + $NaNO_3$

Calculate the percentage of NaCl in the mixture.

Ans: Since 143.5g of AgCl is produced from =58.5 g of NaCl

so, 1.435 g of AgCl is formed by =0.585 g of NaCl

% of NaCl =0.585 $\times$100 = 58.5%

21. a. From the equation:

$C + 2H_2SO_4 \rightarrow CO_2 + 2H_2O + 2SO_2$

Calculate:

i. The mass of carbon oxidized by 49 g of sulphuric acid.

Ans: Molecular mass of sulphuric acid = 2(2+32+64)

= 196

196 g of sulphuric acid oxidized 12g of Carbon

49 g of sulphuric acid will $\frac{12 \times 49}{196}$

=3 g

ii. The volume of sulphur dioxide measured at STP, liberated at the same time.

Ans: 196 g of sulphuric acid gives 2(22.4)

= 44.8L

= 49 g of sulphuric acid will give $\frac{44.8 \times 49}{196}$

= 11.2 L of SO_2

b. i. 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. (H = 1; C = 12; Cl = 35.5)

Ans:

Element	**% Weight**	**Atomic Weight**	**Atomic Ratio**	**Simplest Ratio**
C	14.4	12	$\frac{14.4}{12} = 1.2$	$\frac{1.2}{1.2} = 1$
H	1.2	1	$\frac{1.2}{1} = 1.2$	$\frac{1.2}{1.2} = 1$
Cl	84.5	35.5	$\frac{84.5}{35.5} = 2.3$	$\frac{2.3}{1.2} = 1.9 = 2$

Empirical formula = $CHCl_2$

ii. The relative molecular mass of this compound is 168, so what is its molecular formula?

Ans: Empirical formula = $CHCl_2$

Empirical formula weight = $1 \times 12 + 1 \times 1 + (2 \times 35.5)$

= 12 + 1+70

= 83

Relative molecular mass = 168

$N = \frac{\text{Relative molecular mass}}{\text{Empirical weight}} = \frac{168}{83} = 2.02 \approx 2$

Molecular formula = n x empirical formula

= $2 \times CHCl_2$

= $C_2H_2Cl_4$

22. Find the percentage of

a. oxygen in magnesium nitrate crystals [Mg (NO_3) $6H_2O$].

Ans: Relative molecular mass of [Mg (NO_3) $6H_2O$]

= 24+14+(3 ×16)+(6 ×18)=194

Since, 194g of [Mg (NO_3) $6H_2O$] contains 144g of oxygen

100g of [Mg (NO_3) $6H_2O$] contains $\frac{144\times100}{194}$ of oxygen = 74.22%

b. boron in $Na_2B_4O_7.10H_2O$. [H = 1, B = 11, O =16, Na = 23].

Ans: Relative molecular mass of $Na_2B_4O_7.10H_2O$

(23 × 2) + (4 × 11) + (7 × 16) + 10(18) = 382

Since 382g of $Na_2B_4O_7.10H_2O$ contains 44g of boron

100g $Na_2B_4O_7.10H_2O$ of contains $\frac{100\times44}{382}$ of boron

=11.5%

c. phosphorus in the fertilizer superphosphate $Ca(H_2PO_4)_2$

Ans: Relative molecular mass of $Ca(H_2PO_4)_2$

= 40 + 2(2 + 31 + 64) = 234

Since, 234g of $Ca(H_2PO_4)_2$ contains 62g of phosphorus

100g of $Ca(H_2PO_4)_2$ contains $\frac{100\times62}{234}$

= 26.5%

23. What mass of copper hydroxide is precipitated by using 200g of sodium hydroxide?

$NaOH+CuSO_4 \rightarrow Na_2SO_4+Cu(OH)_2$

[Cu=64, Na=23, S=32,H=1]

Ans:

98g of $Cu(OH)_2$ is precipitated by using 80g of NaOH

Xg of $Cu(OH)_2$ is precipitated by using 200g of NaOH

$x= \frac{90}{80} \times 200 = 245g$ of $Cu(OH)_2$

24. Solid ammonium dichromate decomposes as:

$(NH_4)_2Cr_2O_7 \rightarrow N_2+Cr_2O_3+4H_2O$

If 63 g of ammonium dichromate decomposes. Calculate

a. the quantity in moles of $(NH_4)_2Cr_2O_7$

Ans: Molecular mass of ammonium dichromate

$= 2(14+4)+104+112$

$= 252$ g

$$\text{Number of moles} = \frac{\text{Given mass}}{\text{Molecular mass}} = \frac{63}{252} = 0.25 \text{ moles}$$

b. the quantity in moles of nitrogen formed

Ans: 252 g of ammonium dichromate gives 22.4 dm^3 of N_2

63 g of ammonium dichromate gives $\frac{63 \times 22.4}{252}$

$= 5.6$ L

$$\text{Number of moles} = \frac{\text{Given mass}}{\text{Molecular mass}} = \frac{5.6}{22.4} = 0.25 \text{ moles}$$

c. the volume of N_2 evolved at STP.

Ans: 252 g of ammonium dichromate gives 22.4 dm^3 of N_2

63 g of ammonium dichromate gives $\frac{63\times 22.4}{252}$

= 5.6 L

d. What will be the loss of mass?

Ans: Number of moles = $\frac{\text{Given mass}}{\text{Molecular mass}} = \frac{63}{252}$

= 0.25moles

$(NH_4)_2Cr_2O_7 \rightarrow N_2+Cr_2O_3+4H_2O$

0.25 moles of ammonium dichromate gives

0.25 moles of N_2 = 7 g

1 mole of H_2O =18 g

Therefore, total loss of mass = 7+18

= 25 g

e. calculate the mass of chromium (III) oxide formed at the same time.

Ans: 252 g of ammonium dichromate gives 152 g of CrO_3

63 g of ammonium dichromate gives $\frac{63\times 152}{252}$

= 38 g

25. Hydrogen sulphide gas burns in oxygen to yield 12.8 g of sulphur dioxide gas as under:

$2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$

Calculate the volume of hydrogen sulphide at S.T.P. Also, calculate the volume of oxygen required at S.T.P. which will complete the combustion of hydrogen sulphide determined in (litres).

Ans: $2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$

2V 3V 2V

128 g of SO_2 gives = 2 × 22.4 litres volume

So, 12.8 g of SO_2 gives = 2 × 22.4 × 12.8/128

= 4.48 litre volume

Or one can say 4.48 litres of hydrogen sulphide.

2 × 22.4 litre H_2S requires oxygen = 3 ×22.4 litre

So, 4.48 litres H_2S will require = 6.72 litre of oxygen

26. Ammonia burns in oxygen and combustion, in the presence of a catalyst. May be represented by $2NH_3 + 2O_2 \rightarrow 2NO + 3H_2O$

[H= 1, N= 14, O=16]

What mass of steam is produced when 1.5 g of nitrogen monoxide is formed?

Ans: From equation, $2NH_3 + 2\ O_2 \rightarrow 2NO + 3H_2O$

When 60 g NO is formed, mass of steam produced = 54 g

So, 1.5 g NO is formed, mass of steam produced = 54 ×1.5/60

=1.35 g

27. If a crop of wheat removes 20 kg of nitrogen per hectare of soil, what mass of the fertilizer, calcium nitrate $Ca(NO_3)_2$ would be required to replace the nitrogen in a 10 hectare field ?

Ans: In 1 hectare of soil, N_2 removed = 20 kg

So, in 10 hectare N_2 removed = 200 kg

The molecular mass of $Ca(NO_3)_2$ =164

Now, 28 g N_2 present in fertilizer = 164 g $Ca(NO_3)_2$

So, 200000 g of N_2 is present in = 164 ×200000/28

= 1171.42 kg

28. Concentrated nitric acid oxidises phosphorus to phosphoric acid according to the following equation:

$P + 5HNO_3 \rightarrow H_3PO_4 + 5NO_2 + H_2O$

If 6.2g of phosphorus was used in the reaction calculate:

(a) Number of moles of phosphorus taken and mass of phosphoric acid formed.

Ans: 1 mole of phosphorus atom = 31 g of phosphorus

31 g of P =1 mole of P

6.2g of P = $\frac{6.2 \times 1}{31}$ = 0.2 mole of P

(b) mass of nitric acid will be consumed at the same time?

Ans: 31 g P reacts with HNO_3 = 315 g

so, 6.2 g P will react with $HNO_3 = 315 \times \frac{6.2}{31}$ = 63 g

(c) The volume of steam produced at the same time if measured at 760 mm Hg pressure and 273^0C?

Ans: Moles of steam formed from 31g phosphorus = $\frac{18g}{18g}$ = 1mol

Moles of steam formed from 6.2 g phosphorus = $\frac{1\ \text{mol}}{31\ \text{g} \times 6.2} = 0.2\,\text{mol}$

Volume of steam produced at STP = 0.2×22.4 = 4.48 litre

Since the pressure (760mm) remains constant, but the temperature (273+273) = 546 is double, the volume of the steam also gets doubled

So, Volume of steam produced at 760 mm Hg and 273^0C = 4.48 × 2 = 8.96 litre

29. 112 cm^3 of a gaseous fluoride of phosphorus has a mass of 0.63 g. Calculate the relative molecular mass of the fluoride. If the molecule of the fluoride contains only one atom of phosphorus, then determine the formula of the phosphorus fluoride. [F=19, P=31].

Ans: 112cm^3 of gaseous fluoride has mass = 0.63 g

so, 22400cm^3 will have mass = $0.63 \times \frac{22400}{112}$

= 126 g

The molecular mass = At mass P + At. mass of F

126 = 31 + At. Mass of F

So, At. Mass of F = 95 g

But, at. mass of F = 19

so $\frac{95}{19} = 5$

Hence, there are 5 atoms of F so the molecular formula = PF_5

30. Washing soda has 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?

Ans: $Na_2CO_3.10H_2O \rightarrow Na_2CO_3 + 10H_2O$

286 g 106 g

So, for 57.2 g $Na_2CO_3.10H_2O = 106 \times \frac{57.2}{286}$ = 21.2 g Na_2CO_3

31. A metal M forms a volatile chloride containing 65.5% chlorine. If the density of the chloride relative to hydrogen is 162.5, find the molecular formula of the chloride (M = 56).

Ans: Simple ratio of M = $\frac{34.5}{56} = 0.616 = 1$

Simple ratio of Cl = $\frac{65.5}{35.5} = 1.845 = 3$

Empirical formula = MCl_3

Empirical formula mass = 162.5, Molecular mass = 2 ×V.D = 325

So, n = 2

So, molecular formula = M_2Cl_6

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

(i) Determine the empirical formula of this compound working correct to one decimal place (C = 12; Br = 80)

Ans:

Element	%	Atomic mass	Atomic ratio	Simplest ratio
C	4.812	12	$\frac{4.8}{12}=0.4$	$\frac{0.4}{0.4}=1$
Br	95.28	80	$\frac{95.2}{80}=1.2$	$\frac{1.2}{0.4}=3$

So, empirical formula is CBr_3

(ii) If the vapour density of the compound is 252, what is the molecular formula of the compound?

Ans: Empirical formula mass = 12 + 3 ×80 = 252 g

molecular formula mass = 2 ×252(V.D) = 504 g

$n = \frac{504}{252} = 2$

so, molecular formula = C_2Br_6

33. The reaction: $4N_2O + CH_4 \rightarrow CO_2 + 2H_2O + 4N_2$ takes place in the gaseous state. If all volumes are measured at the same temperature and pressure, calculate the volume of dinitrogen oxide (N_2O) required to give 150 cm^3 of steam.

Ans: $4N_2O + CH_4 \rightarrow CO_2 + 2H_2O + 4N_2$

4V 1V 1V 2V 4V

2 x 22400 litre steam is produced by $N_2O = 4 \times 22400\ cm^3$

So, 150 cm^3 steam will be produced by= $4 \times 22400 \times 150/2 \times 22400$

= 300 cm^3 N_2O

34. Samples of the gases O_2, N_2, CO_2 and CO under the same conditions of temperature and pressure contain the same number of molecules x. The molecules of oxygen occupy V litres and have a mass of 8 g under the same of temperature and pressure

What is the volume occupied by:

(a) x molecules of N_2

Ans: Volume of O_2 = V

Since O_2 and N_2 have same no. of molecules = x

so, the volume of N_2 = V

(b) 3x molecules of CO

Ans: 3x molecules means 3V volume of CO

(c) What is the mass of CO_2 in grams?

Ans: 32 g oxygen is contained in = 44 g of CO_2

So, 8 g oxygen is contained in = $44 \times 8/32 = 11$ g

(d) In answering the above questions, which law have you used?

Ans: Avogadro's law is used in the above questions.

35. 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?

Ans: simple ratio of Na = 42.1/23 = 1.83 = 3

simple ratio of P = 18.9/31 = 0.609 = 1

simple ratio of O = 39/16 = 2.43 = 4

So, the empirical formula is Na_3PO_4

36. What volume of oxygen is required to burn completely a mixture of 22.4 dm^3 of methane and 11.2 dm^3 of hydrogen into carbon dioxide and steam?

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

$2H_2 + O_2 \rightarrow 2H_2O$

Ans: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

1V 2V 1V 2V

From equation:

22.4 litres of methane requires oxygen = 44.8 litres O_2

$2H_2 + O_2 \rightarrow 2H_2O$

2V 1V 2 V

From equation,

44.8 litres hydrogen requires oxygen = 22.4 litres O_2

So, 11.2 litres will require = $22.4 \times \frac{11.2}{44.8}$ = 5.6 litres

Total volume = 44.8 + 5.6 = 50.4 litres

37. The gases hydrogen, oxygen, carbon dioxide, sulphur dioxide and chlorine are arranged in order of their increasing relative molecular masses. Given 8 g of each gas at S.T.P., which gas will contain the least number of molecules and which gas the most?

Ans: According to Avogadro's law:

Equal volumes of all gases, under similar conditions of temperature and pressure, contain equal numbers of molecules.

So, 1 mole of each gas contains = 6.02×10^{23} molecules

Mol. Mass of $H_2(2)$, $O_2(32)$, $CO_2(44)$, $SO_2(64)$, $Cl_2(71)$

(1) Now 2 g of hydrogen contains molecules = 6.02×10^{23}

So, 8g of hydrogen contains molecules = $8/2 \times 6.02 \times 10^{23}$

$= 4 \times 6.02 \times 10^{23} = 4M$ molecules

(2) 32g of oxygen contains molecules = $\frac{8}{32} \times 6.02 \times 10^{23} = \frac{M}{4}$

(3) 44g of carbon dioxide contains molecules = $\frac{8}{44} \times 6.02 \times 10^{23} = \frac{2M}{11}$

(4) 64g of sulphur dioxide contains molecules = 6.02×10^{23}

So, 8g of sulphur dioxide molecules = $\frac{8}{64} \times 6.02 \times 10^{23} = \frac{M}{8}$

(5)71 g of chlorine contains molecules = 6.02×10^{23}

So, 8g of chlorine molecules = $\frac{8}{72} \times 6.02 \times 10^{23} = \frac{8M}{71}$

Since $\frac{8M}{71} < \frac{M}{8} < \frac{2M}{11} < \frac{M}{4} < 4M$

Thus $Cl_2 < SO_2 < CO_2 < O_2 < H_2$

(i)Least number of molecules in Cl_2

(ii)Most number of molecules in H_2

38. 10 g of a mixture of sodium chloride and anhydrous sodium sulphate is dissolved in water. An excess of barium chloride solution is added and 6.99 g of barium sulphate is precipitated according to the equation given below:

$Na_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2NaCl$

Calculate the percentage of sodium sulphate in the original mixture.

Ans: $Na_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2NaCl$

Molecular mass of $BaSO_4 = 233$ g

Now, 233 g of $BaSO_4$ is produced by $Na_2SO_4 = 142$ g

So, 6.99 g $BaSO_4$ will be produced by $= 6.99 \times 142/233 = 4.26$

The percentage of Na_2SO_4 in original mixture $= 4.26 \times 100/10$

= 42.6%

39. When heated, potassium permanganate decomposes according to the following equation:

$2K_2MnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$

(a) Some potassium permanganate was heated in the test tube. After collecting one litre of oxygen at room temperature, it was found that the test tube had undergone a loss in 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.

Ans: 1 litre of oxygen has mass = 1.32 g

So, 24 litres (molar vol. at room temp.) will have mass = 1.32 x 24

= 31.6 or 32 g

(b) Given that the molecular mass of potassium permanganate 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)

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

316 g of $KMnO_4$ gives oxygen = 24 litres

So, 15.8 g of $KMnO_4$ will give = $24 \times 316/15.8 = 1.2$ litres

40. (a) A flask contains 3.2 g of sulphur dioxide. Calculate the following:

(i) The moles of sulphur dioxide present in the flask.

Ans: The no. of moles of $SO_2 = 3.2/64 = 0.05$ moles

(ii) The number of molecules of sulphur dioxide present in the flask.

Ans: In 1 mole of SO_2, no. of molecules present = 6.02×10^{23}

So, in 0.05 moles, no. of molecules = $6.02 \times 10^{23} \times 0.05$

= 3.0×10^{22}

(iii) The volume occupied by 3.2 g of sulphur dioxide at S.T.P.

(S= 32, O= 16)

Ans: The volume occupied by 64 g of SO_2 = 22.4 dm^3

3.2 g of SO_2 will be occupied by volume = 22.4 $\times$3.2/64 =1.12 dm^3

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

Ans: Gram atoms of Pb = 6.21/207=0.03 = 1

Gram atoms of Cl = 4.26/35.5 = 0.12 = 4

So, the empirical formula = $PbCl_4$

41. The volume of gases A, B, C and D are in the ratio, 1 : 2 : 2 : 4 under the same conditions of temperature and pressure .

(i) Which sample of gas contains the maximum number of molecules?

Ans: D contains the maximum number of molecules because volume is directly proportional to the number of molecules.

(ii) If the temperature and pressure of gas A are kept constant, then what will happen to the volume of A when the number of molecules is doubled?

Ans: The volume will become double because volume is directly proportional to the no. of molecules at constant temperature and pressure.

$V_1/V_2 = n_1/n_2$

$V_1/V_2 = n_1/2n_1$

So, $V_2 = 2V_1$

(iii)If this ratio of gas volume refers to the reactants and products of a reaction, which gas law is being observed?

Ans: (iii) Gay lussac's law of combining volume is being observed.

(iv)If the volume of A is actually 5.6 dm^3 at S.T.P., calculate the number of molecules in the actual Volume of D at S.T.P. (Avogadro's number is 6 $\times 10^{23}$).

Ans: (iv) The volume of D = 5.6 $\times$4 = 22.4 dm^3, so the number of molecules = 6 $\times$ 10^{23} because according to mole concept 22.4 litre volume at STP has = 6 $\times 10^{23}$ molecules

(v) Using your answer from (iv), state the mass of D if the gas is dinitrogen oxide (N_2O)

Ans: (v) No. of moles of D = 1 because volume is 22.4 litre

so, mass of N_2O = 1 $\times$44 = 44 g

42. The equation given below relates the manufacture of sodium carbonate (molecular weight of Na_2CO_3 = 106).

1. $NaCl+NH_3+ CO_2 + H_2O \rightarrow NaHCO_3+NH_4Cl$

2. $2NaHCO_3 \rightarrow Na_2CO_3+H_2O + CO_2$

Equations (1) and (2) 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?

Ans: $NaCl+NH_3+ CO_2 + H_2O \rightarrow NaHCO_3+NH_4Cl$

$2NaHCO_3 \rightarrow Na_2CO_3+H_2O + CO_2$

From equation:

106 g of Na_2CO_3 is produced by = 168 g of $NaHCO_3$

So, 21.2 g of Na_2CO_3 will be produced by = 168 $\times$21.2/106

= 33.6 g of $NaHCO_3$

(b) To produce the mass of sodium hydrogen carbonate calculate in (a), what volume of carbon dioxide, measured at S.T.P. would be required?

Ans: For 84 g of $NaHCO_3$, required volume of CO_2 = 22.4 litre

So, for 33.6 g of $NaHCO_3$, required volume of CO_2 = 22.4 $\times$ 33.6/84

= 8.96 litre

43. A sample of ammonium nitrate when heated yields 8.96 litres of steam (measured at S.T.P.)

$NH_4NO_3 \rightarrow N_2O + 2H_2O$

(i) What volume of dinitrogen oxide is produced at the same time as 8.96 litres of steam?

Ans: $NH_4NO_3 \rightarrow N_2O+2H_2O$

1mole 1mole 2mole

1V 1V 2V

44.8 litres of water produced by = 22.4 litres of NH_4NO_3

So, 8.96 litres will be produced by = $22.4 \times 8.96/44.8$

= 4.48 litres of NH_4NO_3

So, 4.48 litres of N_2O is produced.

(ii) What mass of ammonium nitrate should be heated to produce 8.96 litres of steam? (Relative molecular mass of ammonium nitrate is 80)

Ans: 44.8 litre H_2O is produced by = 80 g of NH_4NO_3

So, 8.96 litre H_2O will be produced by = $80 \times 8.96/44.8$

= 16g NH_4NO_3

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

Ans: % of O in $NH_4NO_3 = 3 \times 16/80 = 60\%$

44. Given that the relative molecular mass of copper oxide is 80, what volume of ammonia (measured at STP) is required to completely reduce 120g of copper oxide? The equation for the reaction is:

$3CuO+2NH_3 \rightarrow 3Cu+H_2O+N_2$

Ans: Molecular mass of 3CuO = (240) g

Molecular mass of $2NH_3 = 2 \times 22.4 = 44.8dm^3$

Molecular mass of 3Cu = (192)g

240 g of CuO requires 44.8 dm^3 of NH_3

$\therefore$ 120g of CuO will require $\frac{120 \times 44.8}{240}$

$= 22.4dm^3$

45. (a) Calculate the number of moles and the number of molecules present in 1.4 g of ethylene gas. What is the volume occupied by the same amount of ethylene?

Ans: The molecular mass of ethylene (C_2H_4) is 28 g

No. of moles = 1.4/28 = 0.05 moles

No. of molecules = $6.023 \times 10^{23} \times 0.05 = 3 \times 10^{22}$ molecules

Volume = $22.4 \times 0.05 = 1.12$ litres

(b) What is the vapour density of ethylene?

Ans: Molecular mass = 2 × V.D

S0, V.D = 28/2 = 14

46. (a) Calculate the percentage of sodium in sodium aluminium fluoride (Na_3AlF_6) correct to the nearest whole number.

(F = 19; Na =23; Al = 27)

Ans: Molecular mass of $Na_3AlF_6 = 210$

So, Percentage of Na = $3 \times 23 \times 100/210 = 32.85\%$

(b) 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.

Ans: $2CO + O_2 \rightarrow 2CO_2$

2V 1V 2V

1 mole of O_2 has volume = 22400 ml

Volume of oxygen used by 2 × 22400 ml CO = 22400 ml

So, Vol. of O_2 used by 560 ml CO =22400 × 560/(2 × 22400)

= 280 ml

So, Volume of CO_2 formed is 560 ml.

2009

47. a. 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 2 g, hence the relative molecular mass of the gas is:

i. 5

ii. 10

iii. 15

iv. 20

Ans: ii. 10

Mass of gas X =10g

Mass of hydrogen gas= 2

$$\text{Relative vapour density} = \frac{\text{Mass of volume of gas X under similar conditions}}{\text{Mass of volume of hydrogen gas under similar conditions}}$$

$$= \frac{10}{2} = 5$$

Relative molecular mass of the gas = 2 × relative vapour

Density = 2×5

= 10

b. i. Calcium carbide is used for the artificial ripening of fruits. Actually the fruit ripens because of the heat evolved while calcium carbide reacts with moisture. During this reaction calcium hydroxide and acetylene gas is formed. If 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.

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

Ans: i. According to Gay-Lussac's law,

2 volume of acetylene requires 5 volume of oxygen to burn it

1 volume of acetylene requires 2.5 volume of oxygen to burn it

200cm^3 requires 2.5×200=500 cm^3 of oxygen

2 volume of acetylene on combustion gives $4CO_2$

1 volume of acetylene on combustion gives $2CO_2$

200cc of acetylene on combustion will give 200×2=400cc of CO_2

ii. 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].

Ans: Hydrogen = 12.5%

∴ Nitrogen= 100-12.5= 87.5%

Element	% Weight	Atomic Weight	Atomic Ratio	Simplest Ratio
N	87.5	14	$\frac{87.5}{14}=6.25$	$\frac{6.25}{6.25}=1$
H	12.5	1	$\frac{12.5}{1}=12.5$	$\frac{12.5}{6.25}=2$

The Empirical formula of the compound is NH_2

Empirical formula weight =14+2=16

Relative molecular mass =37

$$N = \frac{\text{Relative molecular mass}}{\text{Empirical weight}} = \frac{37}{16} 2.3 \approx 2$$

Molecular formula = n x empirical formula = $2 \times NH_2$

$= N_2H_4$

c. i. A gas cylinder contains 24 x 10^{24} molecules of nitrogen gas. If Avogadro's number is 6 x 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.

Ans: i. Molecules of nitrogen gas in a cylinder = 24×10^{24}

Avogadro's number = 6×10^{23}

1. Mass of nitrogen in a cylinder = $\frac{24 \times 10^{24} \times 28}{6 \times 10^{23}}$

= 1120g

2. Volume of nitrogen at STP

Volume of 28 g of N_2 = $22.4 dm^3$

Volume of 1120g of $N_2 = \frac{1120 \times 22.4}{28}$ dm^3

= 896 dm^3

(ii) Commercial sodium hydroxide weighing 30g has some sodium chloride in it. The Mixture on dissolving in water and subsequent treatment with excess silver nitrate solution formed a precipitate weighing 14.3 g. What is the percentage of sodium chloride in the commercial sample of sodium hydroxide? The equation for the reaction is

$NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

[Relative molecular mass of NaCl = 58; AgCl = 143]

Ans: 143g of AgCl is formed from 58g of NaCl

1g of AgCl will be formed from $\frac{58}{143}$ g of NaCl

143g of AgCl will be formed from $\frac{58}{143} \times 14.3 = 5.8$g of NaCl

Percentage of sodium chloride = $\frac{5.8}{30} \times 100 = 19.33\%$

(iii) A certain gas 'X' occupies a volume of 100 cm^3 at S.T.P. and weighs 0.5 g. Find its relative molecular mass

Ans: 100 cc of gas X at STP weighs = 0.5g

22400cc of gas X at STP weighs= $\frac{0.5 \times 22400}{100}$ =112g

2010

48. a. i. LPG stands for liquefied petroleum gas. Varieties of LPG are marketed including a mixture of propane (60%) and butane (40%). If 10 litre of this mixture is burnt, find the total volume of carbon dioxide gas added to the atmosphere. Combustion reactions can be represented as:

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

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

Ans: 10 litres of LPG contains

Propane= $\frac{60}{100} \times$ 10= 6 litres

Butane = $\frac{40}{100} \times 10$= 4 litres

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

1 vol 3 vol

6L 18L

$2C_4H_{10}+5O_2 \rightarrow 3CO_2+4H_2O$

2 vol 3 vol

4L 16L

18+16=34 L

ii. Calculate the percentage of nitrogen and oxygen in ammonium nitrate. [Relative molecular mass of ammonium nitrate is 80, H = 1, N = 14, O = 16].

Ans: Molecular mass of $NH_4(NO_3)$ = 80

H = 1, N = 14, O = 16

% of Nitrogen

As 80 g of $NH_4(NO_3)$ contains 28 g of nitrogen

100 g of of $NH_4(NO_3)$ will contain $\frac{28\times100}{80}$

= 35%

% of Oxygen

As, 80 g of $NH_4(NO_3)$ contains 48 g of oxygen

100 g of of $NH_4(NO_3)$ will contain $\frac{100\times48}{80}$

= 60%

b. 4.5 moles of calcium carbonate are reacted with dilute hydrochloric acid.

i. Write the equation for the reaction.

Ans: Equation for reaction of calcium carbonate with dilute hydrochloric acid:

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

ii. What is the mass of 4.5 moles of calcium carbonate? (Relative molecular mass of calcium carbonate is 100)

Ans: Relative molecular mass of calcium carbonate=100

Mass of 4.5 moles of calcium carbonate

= No. of moles× Relative molecular mass

= 4.5×100

= 450g

iii. What is the volume of carbon dioxide liberated at STP?

Ans: $CaCO_3+2HCl \rightarrow CaCl_2+H_2O+CO_2$

As, 100g of calcium carbonate gives 22.4dm^3 of CO_2

$\therefore$ 450 g of calcium carbonate will give $\frac{450\times 22.4}{100}$

= 100.8 L

iv. What mass of calcium chloride is formed? (Relative molecular mass of calcium chloride is 111).

Ans:

iii. Molecular mass of calcium carbonate =100

Relative molecular mass of calcium chloride =111

As 100 g of calcium carbonate gives 111g of calcium chloride

$\therefore$ 450 g of calcium carbonate will give $\frac{450\times 111}{100}$

= 499.5 g

Molecular mass of HCl=36.5

Molecular mass of calcium carbonate =100

As 100 g of calcium carbonate gives (2×36.5)= 73g of HCl

$\therefore$ 450 g of calcium carbonate will give $\frac{450 \times 73}{100}$

= 328.5g

v. How many moles of HCl are used in this reaction?

Ans: Number of moles of HCl = $\frac{\text{Weight of HCl}}{\text{Molecular weight of HCl}}$

= $\frac{328.5}{36.5}$

= 9 moles

2011

49. a. i. Calculate the volume of 320 g of SO_2 at STP. (Atomic mass: S = 32 and O = 16).

Ans: Atomic mass: S = 32 and O = 16

Molecular mass of SO_2 = 32 + (2 × 16)

= 64g

As 64 g of SO_2 = 22.4dm^3

Then, 320 g of SO_2 = $\frac{320 \times 22.4}{64}$

= 112 L

ii. State Gay-Lussac's Law of combining volumes.

Ans: Gay-Lussac's law Gay-Lussac's Law states "When gases react, they do so in volumes which bear a simple ratio to one another and to the volume of the gaseous product, if all the volumes are measured at the same temperature and pressure."

iii. Calculate the volume of oxygen required for the complete combustion of 8.8 g of propane (C_3H_8). (Atomic mass: C = 12, O = 16, H = I, Molar Volume = 22.4 dm^3 at stp.)

Ans: iii. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Molar mass of propane = 44

44 g of propane requires 5 × 22.4 litres of oxygen at STP.

8.8 g of propane requires $\frac{5 \times 22.4 \times 8.8}{44}$ = 22.4 litres

b. i. An organic compound with vapour density = 94 contains C = 12.67%, H = 2.13%, and Br = 85.11%. Find the molecular formula. [Atomic mass : C = 12, H = 1, Br = 80]

Ans: i.

Element	Relative atomic mass	% Compound	Atomic ratio	Simplest ratio
H	1	2.13	$\frac{2.13}{1}$ =2.13	2
C	12	12.67	$\frac{12.67}{12}$ =1.055	2
Br	80	85.11	$\frac{85.11}{80}$ =1	1

Empirical formula = CH_2Br

n (Empirical formula mass of CH_2Br) = Molecular mass (2 × VD)

n (12 + 2 + 80) = 94 × 2

n = 2

Molecular formula = Empirical formula × 2

= $(CH_2Br) \times 2$

= $C_2H_4Br_2$

ii. Calculate the mass of:

1. 10^{22} atoms of sulphur.

Ans: 10^{22} atoms of sulphur

6.022×10^{23} atoms of sulphur will have mass = 32 g

10^{22} atoms of sulphur will have mass = $\frac{32 \times 10^{22}}{6.022 \times 10^{23}}$

= 0.533 g

2. 0.1 mole of carbon dioxide.

[Atomic mass: S = 32, C = 12 and O = 16 and

Avogadro's Number = 6 x 10^{23}]

Ans: 0.1 mole of carbon dioxide

1 mole of carbon dioxide will have mass = 44 g

0.1 mole of carbon dioxide will have mass = 4.4 g

2012

50. a. Concentrated nitric acid oxidises phosphorus to phosphoric acid according to the following equation:

$P + 5HNO_3 \rightarrow H_3PO_4 + H_2O + 5NO_2$

If 9.3 g of phosphorus was used in the reaction, calculate:

i. Number of moles of phosphorus taken.

Ans: Number of moles of phosphorus taken = $\frac{9.3}{31}$

= 0.3 mol

ii. The mass of phosphoric acid formed.

Ans: 1 mole of phosphorus gives 98 gm of phosphoric acid.

So, 0.3 mole of phosphorus gives (0.3 × 98) gm of phosphoric acid

= 29.4 gm of phosphoric acid

iii. The volume of nitrogen dioxide produced at STP.

Ans: 1 mole of phosphorus gives 112 L of NO_2 gas at STP.

So, 0.3 mole of phosphorus gives (112 × 0.3) L of

NO_2 gas at STP.

= 33.6 L of NO_2 gas at STP

b. i. 67.2 litres of hydrogen combines with 44.8 litres of nitrogen to form ammonia under specific conditions as:

$N_2 + 3H_2 \rightarrow 2NH_3$

Calculate the volume of ammonia produced. What is the other substance, if any, that remains in the resultant mixture?

Ans: According to the equation

$N_2 + 3H_2 \rightarrow 2NH_3$

3 volumes of hydrogen produce 2 volumes of ammonia

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

3 volumes of hydrogen combine with 1 volume of ammonia.

67.2 litres of hydrogen combine with $\frac{1 \times 67.2}{3}$ =22.4L Nitrogen left = 44.8 - 22.4 = 22.4 litres

ii. The mass of 5.6 dm3 of a certain gas at STP is 12.0 g. Calculate the relative molecular mass of the gas.

Ans: 5.6 dm^3 of gas weighs 12 g

1 dm^3 of gas weighs = (12/56) gm

22.4 dm^3 of gas weighs = (12/56 × 22.2) gm = 48g

Therefore, the relative molecular mass of gas = 48 gm.

iii. Find the total percentage of Magnesium in magnesium nitrate crystals, $Mg(NO_3)_2$-$6H_2O$.

[Mg = 24, N = 14, 0 = 16 and H = 1]

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

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

Mass percent of magnesium = $\frac{24 \times 100}{256}$ =9.37%

2013

51. a. i. What volume of oxygen is required to burn completely 90 dm^3 of butane under similar conditions of temperature and pressure?

Ans: $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

2V 13V

2 vols. of butane requires O_2 = 13 vols

90 dm^3 of butane will require O_2 = $\frac{13}{2} \times 90$

= 585 dm^3

ii. The vapour density of a gas is 8. What would be the volume occupied by 24.0 g of the gas at STP?

Ans: Molecular mass = 2 × Vapour density

So, molecular mass of gas = 2 × 8 = 16 g

As we know, molecular mass or molar mass occupies 22.4 litres.

That is,

16 g of gas occupies volume = 22.4 litres

So, 24 g of gas will occupy volume

$= \frac{22.4}{16} \times 24 = 33.6 \text{litres}$

iii. A vessel contains X number of molecules of hydrogen gas at a certain temperature and pressure. How many molecules of nitrogen gas would be present in the same vessel under the same conditions of temperature and pressure?

Ans: According to Avogadro's law, equal volumes of all gases under similar conditions of temperature and pressure contain the same number of molecules.

So, molecules of nitrogen gas present in the same vessel = X

b. O_2 is evolved by heating $KClO_3$ using MnO_2 as a catalyst.

$2KClO_3 \rightarrow 2KCl + 3O_2$

i. Calculate the mass of $KClO_3$ required to produce 6.72 litre of O_2 at STP.

[atomic masses of K = 39, Cl = 35.5, 0 = 16].

Ans: 3 vols. of oxygen require $KClO_3$ = 2 vols.

So, 1 vol. of oxygen will require $KClO_3 = \frac{2}{3}$ vol

So, 6.72 litres of oxygen will require $KClO_3$

$= \frac{2}{3} \times 6.72 = 44.8 \text{litres}$

22.4 litres of $KClO_3$ has mass = 122.5 g

So, 4.48 litres of $KClO_3$ will have mass

$= \frac{122.5}{22.4} \times 4.48 = 24.5 \text{g}$

ii. Calculate the number of moles of oxygen present in the above volume and also the number of molecules.

Ans: Molecular mass = 2 × Vapour density

So, molecular mass of gas = 2 × 8 = 16 g

As we know, molecular mass or molar mass occupies 22.4 litres.

That is,

16 g of gas occupies volume = 22.4 litres

So, 24 g of gas will occupy volume

$= \frac{22.4}{16} \times 24 = 33.6$ litres

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

Ans: Volume occupied by 1 mole of CO_2 at STP = 22.4 litres

So, volume occupied by 0.01 mole of CO_2 at STP = 22.4 × 0.01= 0.224 litres

2014

52. a. i. Oxygen oxidises ethyne to carbon dioxide and water as shown by the equation:

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

What volume of ethyne gas at s.t.p. is required to produce 8.4 dm^3 of carbon dioxide at STP [H = 1, C = 12, 0 = 16].

Ans: $2C_2H_2+5O_2 \rightarrow 4CO_2+2H_2O$

2 moles of C_2H_2=4moles of CO_2

x dm^3 of C_2H_2 =8.4 dm^3 of CO_2

$x = \frac{2 \times 8.4}{4}$

= 4.2 dm^3 of C_2H_2

ii. A compound made up of two elements X and Y has an empirical formula X_2Y. If the atomic weight of X is 10 and that of Y is 5 and the compound has a vapour density (V.D.) 25, find its molecular formula.

Ans: Empirical formula= X_2Y

Atomic weight (X) = 10

Atomic weight (Y) = 5

Empirical formula weight = (2 × 10) + 5

= 25

$$n = \frac{\text{molecular weight}}{\text{empirical formula weight}}$$

$$= \frac{2\times\text{vapour density}}{\text{empirical formula weight}} = \frac{2\times 25}{25} = 2$$

So, molecular formula = $X_2Y \times 2$

= X_4Y_2

b. A cylinder contains 68 g of Ammonia gas at STP

i. What is the volume occupied by this gas?

Ans: A cylinder contains 68 g of ammonia gas at STP.

Molecular weight of ammonia = 17 g/mole

68 g of ammonia gas at STP =?

1 mole = 22.4 dm^3

∴ 4 mole = 22.4 × 4 = 89.6 dm^3

ii. How many moles of ammonia are present in the cylinder?

Ans: 4 moles of ammonia gas are present in the cylinder.

iii. How many molecules of ammonia are present in the cylinder?

Ans:

1 mole = 6.023×10^{23} molecules

4 moles = 24.092×10^{23} molecules