

Chapter 5 - Mole Concept and Stoichiometry

Exercise 5(A)

Solution 1.

(a) 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 states that equal volumes of all gases under similar conditions of temperature and pressure contain the same number of molecules.

Solution 2.

a) The number of atoms in a molecule of an element is called its atomicity. Atomicity of Hydrogen is 2, phosphorus is 4 and sulphur is 8.

b) N_2 means 1 molecule of nitrogen and $2N$ means two atoms of nitrogen. N_2 can exist independently but $2N$ cannot exist independently.

Solution 3.

(a) 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 1 molecule of helium has 1 atom of helium

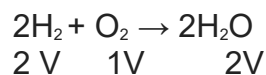
Therefore $2H = He$

Therefore atoms in hydrogen is double the atoms of helium.

(b) For a given volume of gas under given temperature and pressure, a change in any one of the variable i.e., pressure or temperature changes the volume.

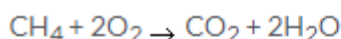
(c) Inflating a balloon seems violating Boyle's law as volume is increasing with increase in pressure. Since the mass of gas is also increasing.

Solution 4.



From the equation, 2V of hydrogen reacts with 1V of oxygen
so 200cm³ of Hydrogen reacts with = 200/2 = 100 cm³
Hence, the unreacted oxygen is 150 – 100 = 50cm³ of oxygen.

Solution 5.



From equation, 1V of CH₄ reacts with = 2 V of O₂

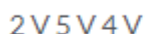
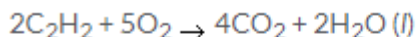
so, 80 cm³ CH₄ reacts with = 80 × 2 = 160cm³ O₂

Remaining O₂ is 200-160 = 40cm³

From equation, 1V of methane gives 1 V of CO₂

So, 80 cm³ gives 80cm³ CO₂ and H₂O is negligible.

Solution 6.



From equation, 2V of C₂H₂ requires = 5 V of O₂

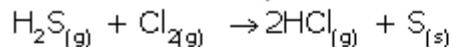
So, for 400ml C₂H₂, O₂ required = 400 × 5/2 = 1000 ml

Similarly, 2 V of C₂H₂ gives = 4 V of CO₂

So, 400ml of C₂H₂ gives CO₂ = 400 × 4/2 = 800ml

Solution 7.

Balanced chemical equation:



1mole 1mole 2moles 1mol

112cm³ 120cm³

(i) At STP, 1 mole gas occupies 22.4 L.

As 1 mole H₂S gas produces 2 moles HCl gas,

22.4 L H₂S gas produces 22.4 × 2 = 44.8 L HCl gas.

Hence, 112 cm³ H₂S gas will produce 112 × 2 = 224 cm³ HCl gas.

(ii) 1 mole H₂S gas consumes 1 mole Cl₂ gas.

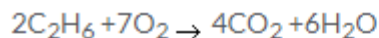
This means 22.4 L H₂S gas consumes 22.4 L Cl₂ gas at STP.

Hence, 112 cm³ H₂S gas consumes 112 cm³ Cl₂ gas.

120 cm³ - 112 cm³ = 8 cm³ Cl₂ gas remains unreacted.

Thus, the composition of the resulting mixture is 224 cm³ HCl gas + 8 cm³ Cl₂ gas.

Solution 8.



Now from equation, 2V of ethane reacts with = 7 V of oxygen

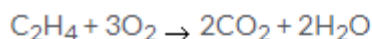
So, 600cc of ethane reacts with = $600 \times \frac{7}{2} = 2100\text{cc}$

Hence, unused O_2 is = $2500 - 2100 = 400\text{ cc}$

From 2V of ethane = 4 V of CO_2 is produced

So, 600cc of ethane will produce = $4 \times \frac{600}{2} = 1200\text{cc CO}_2$

Solution 9.

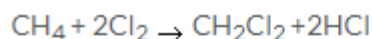


11litre 33 litre

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$V_2 = \frac{P_1 V_1 T_2}{P_2 T_1} = \frac{380 \times 33 \times 273}{549 \times 760} = 8.25 \text{ litres}$$

Solution 10.



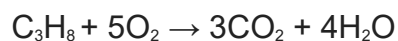
From equation, 1V of CH_4 gives = 2 V HCl

so, 40 ml of methane gives = 80 ml HCl

For 1V of methane = 2V of Cl_2 required

So, for 40ml of methane = $40 \times 2 = 80\text{ ml of Cl}_2$

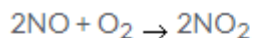
Solution 11.



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

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

Solution 12.



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

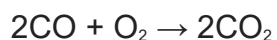
200cm^3 oxygen will react with = $200 \times 2 = 400\text{cm}^3$ NO

Hence, remaining NO is $450 - 400 = 50\text{cm}^3$

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

Total mixture = $400 + 50 = 450\text{cm}^3$

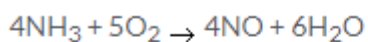
Solution 13.



2 V of CO requires = 1V of O_2

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

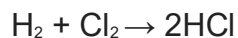
Solution 14.



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

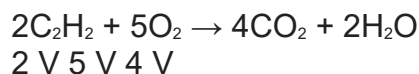
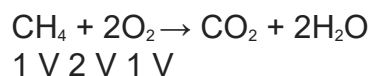
Solution 15.



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

Therefore Resulting mixture is $\text{H}_2 = 4\text{cm}^3$, $\text{HCl} = 32\text{cm}^3$

Solution 16.



From the equations, we can see that

1V CH₄ requires oxygen = 2 V O₂

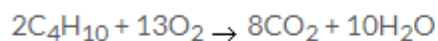
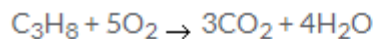
So, 10cm³ CH₄ will require =20 cm³ O₂

Similarly 2 V C₂H₂ requires = 5 V O₂

So, 10 cm³ C₂H₂ will require = 25 cm³ O₂

Now, 20 V O₂ will be present in 100 V air and 25 V O₂ will be present in 125 V air ,so the volume of air required is 225cm³

Solution 17.



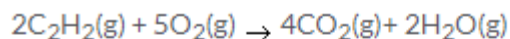
60 ml of propane (C₃H₈) gives 3 × 60 = 180 ml CO₂

40 ml of butane (C₄H₁₀) gives = 8 × 40/2 = 160 ml of CO₂

Total carbon dioxide produced = 340 ml

So, when 10 litres of the mixture is burnt = 34 litres of CO₂ is produced.

Solution 18.



4 V CO₂ is collected with 2 V C₂H₂

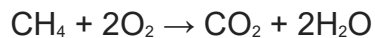
So, 200cm³ CO₂ will be collected with = 100cm³ C₂H₂

Similarly, 4V of CO₂ is produced by 5 V of O₂

So, 200cm³ CO₂ will be produced by = 250 ml of O₂

Solution 19.

This experiment supports Gay lussac's law of combining volumes.
Since the unchanged or remaining O_2 is 58 cc so, used oxygen $106 - 58 = 48\text{cc}$
According to Gay lussac's law, the volumes of gases reacting should be in a simple ratio.



1 V 2 V

24 cc 48 cc

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

Solution 19.

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 least volume will contain least molecules.

So,

(a) 5 litres of hydrogen has 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.

Solution 20.

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

Solution 21.

100 cm^3 of oxygen contains = Y molecules

Applying Avogadro's law,

$$50 \text{ cm}^3 \text{ of nitrogen contains} = \frac{50 Y}{100} = \frac{Y}{2}$$

Exercise 5(B)

Solution 1.

- a) This statement means one atom of chlorine is 35.5 times heavier than $1/12$ time of the mass of an atom C-12.
- b) The value of avogadro's number is 6.023×10^{23}
- c) The molar volume of a gas at STP is 22.4 dm^3 at STP

Solution 2.

- (a) The vapour density is the ratio between the masses of equal volumes of gas and hydrogen under the conditions of standard temperature and pressure.
- (b) Molar volume is the volume occupied by one mole of the gas at STP. It is equal to 22.4 dm^3 .
- (c) 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) 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) The number of atoms present in 12g (gram atomic mass) of C-12 isotope, i.e. 6.023×10^{23} atoms.
- (f) The quantity of the element which weighs equal to its gram atomic mass is called one gram atom of that element.
- (g) Mole is the amount of a substance containing elementary particles like atoms, molecules or ions in 12 g of carbon-12.

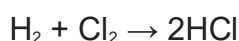
Solution 3.

(a) Applications of Avogadro's Law :

1. It explains **Gay-Lussac's law**.
2. It determines 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) 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.



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

n molecules n molecules 2n molecules (By Avogadros law)

Solution 4.

(a) $(2\text{N})28 + (8\text{H})8 + (\text{Pt})195 + (6\text{Cl})35.5 \times 6 = 444$

(b) $\text{KClO}_3 = (\text{K})39 + (\text{Cl})35.5 + (3\text{O})48 = 122.5$

(c) $(\text{Cu})63.5 + (\text{S})32 + (4\text{O})64 + (5\text{H}_2\text{O})5 \times 18 = 249.5$

(d) $(2\text{N})28 + (8\text{H})8 + (\text{S})32 + (4\text{O})64 = 132$

(e) $(\text{C})12 + (3\text{H})3 + (\text{C})12 + (2\text{O})32 + (\text{Na})23 = 82$

(f) $(\text{C})12 + (\text{H})1 + (3\text{Cl})3 \times 35.5 = 119.5$

(g) $(2\text{N})28 + (8\text{H})8 + (2\text{Cr})2 \times 51.9 + (7\text{O})7 \times 16 = 252$

Solution 5.

(a) No. of molecules in 73 g HCl = $6.023 \times 10^{23} \times 73/36.5$ (mol. mass of HCl)
= 12.04×10^{23}

(b) Weight of 0.5 mole of O_2 is = 32 (mol. Mass of O_2) $\times 0.5 = 16$ g

(c) No. of molecules in 1.8 g H_2O = $6.023 \times 10^{23} \times 1.8/18$
= 6.023×10^{22}

(d) No. of moles in 10g of $\text{CaCO}_3 = 10/100(\text{mol. Mass CaCO}_3)$
= 0.1 mole

(e) Weight of 0.2 mole H_2 gas = $2(\text{Mol. Mass}) \times 0.2 = 0.4 \text{ g}$

(f) No. of molecules in 3.2 g of $\text{SO}_2 = 6.023 \times 10^{23} \times 3.2/64$
= 3.023×10^{22}

Solution 6.

Molecular mass of H_2O is 18, CO_2 is 44, NH_3 is 17 and CO is 28
So, the weight of 1 mole of CO_2 is more than the other three.

Solution 7.

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

Solution 8.

a) No. of particles in 1 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) 1 mole of H_2SO_4 contains = $2 \times 6.023 \times 10^{23}$
So, 0.1 mole of H_2SO_4 contains = $2 \times 6.023 \times 10^{23} \times 0.1$
= 1.2×10^{23} atoms of hydrogen

c) 111g CaCl_2 contains = 6.023×10^{23} molecules
So, 1000 g contains = 5.42×10^{24} molecules

Solution 9.

- (a) 1 mole of aluminium has mass = 27 g
So, 0.2 mole of aluminium has mass = $0.2 \times 27 = 5.4 \text{ g}$
- (b) 0.1 mole of HCl has mass = 0.1×36.5 (mass of 1 mole)
= 3.65 g
- (c) 0.2 mole of H_2O has mass = $0.2 \times 18 = 3.6 \text{ g}$
- (d) 0.1 mole of CO_2 has mass = $0.1 \times 44 = 4.4 \text{ g}$

Solution 10.

- (a) 5.6 litres of gas at STP has mass = 12 g
So, 22.4 litre (molar volume) has mass = $12 \times 22.4 / 5.6$
= 48g(molar mass)
(b) 1 mole of SO_2 has volume = 22.4 litres
So, 2 moles will have = $22.4 \times 2 = 44.8$ litre

Solution 11.

- (a) 1 mole of CO_2 contains $\text{O}_2 = 32\text{g}$
So, CO_2 having 8 gm of O_2 has no. of moles = $8/32 = 0.25$ moles
(b) 16 g of methane has no. of moles = 1
So, 0.80 g of methane has no. of moles = $0.8/16 = 0.05$ moles

Solution 12.

- (a) 6.023×10^{23} atoms of oxygen has mass = 16 g
So, 1 atom has mass = $16 / 6.023 \times 10^{23} = 2.656 \times 10^{-23}$ g
(b) 1 atom of Hydrogen has mass = $1 / 6.023 \times 10^{23} = 1.666 \times 10^{-24}$ g
(c) 1 molecule of NH_3 has mass = $17 / 6.023 \times 10^{23} = 2.82 \times 10^{-23}$ g
(d) 1 atom of silver has mass = $108 / 6.023 \times 10^{23} = 1.701 \times 10^{-22}$ g
(e) 1 molecule of O_2 has mass = $32 / 6.023 \times 10^{23} = 5.314 \times 10^{-23}$ g
(f) 0.25 gram atom of calcium has mass = $0.25 \times 40 = 10\text{g}$

Solution 13.

- (a) 0.1 mole of CaCO_3 has mass = $100(\text{molar mass}) \times 0.1 = 10\text{ g}$
(b) 0.1 mole of $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ has mass = $322 \times 0.1 = 32.2\text{ g}$
(c) 0.1 mole of CaCl_2 has mass = $111 \times 0.1 = 11.1\text{g}$
(d) 0.1 mole of Mg has mass = $24 \times 0.1 = 2.4\text{ g}$

Solution 14.

1 molecule of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ 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 = $0.1 \times 13 \times 6.023 \times 10^{23} = 7.8 \times 10^{23}$

Solution 15.

3.2 g of S has number of atoms = $6.023 \times 10^{23} \times 3.2 / 32$
= 0.6023×10^{23}

So, 0.6023×10^{23} atoms of Ca has mass = $40 \times 0.6023 \times 10^{23} / 6.023 \times 10^{23}$
= 4g

Solution 16.

(a) No. of atoms = $52 \times 6.023 \times 10^{23} = 3.131 \times 10^{25}$

(b) 4 amu = 1 atom of He

so, 52 amu = 13 atoms of He

(c) 4 g of He has atoms = 6.023×10^{23}

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

Solution 17.

Molecular mass of $\text{Na}_2\text{CO}_3 = 106$ g

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

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

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

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

Solution 18.

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

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

(b) 64 g has volume = 22.4 litre

So, 320 g will have volume = $22.4 \times 320/64 = 112$ litres

Solution 19.

(a) Vapour density of carbon dioxide is 22, it means that 1 molecule of carbon dioxide is 22 heavier than 1 molecule of hydrogen.

(b) Vapour density of Chlorine atom is 35.5.

Solution 20.

22400 cm^3 of CO has mass = 28 g

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

Solution 21.

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

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

Solution 22.

(a) No. of moles in 256 g $S_8 = 1$ mole
So, no. of moles in 5.12 g = $5.12/256 = 0.02$ moles

(b) 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 = $1.2 \times 10^{22} \times 8$
= 9.635×10^{22} molecules

Solution 23.

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

Solution 24.

(a) 308 cm^3 of chlorine weighs = 0.979 g
So, 22400 cm^3 will weigh = gram molecular mass
= $0.979 \times 22400/308 = 71.2$ g
(b) 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 = $\frac{P_1 V_1}{P_2} = \frac{1 \times 44.8}{4} = 11.2$ litres
(c) Mass of oxygen in 22.4 litres = 32 g (molar mass)
So, mass of oxygen in 2.2 litres = $2.2 \times 32/22.4 = 3.14$ g

Solution 25.

No. of atoms in 12 g C = 6.023×10^{23}
So, no. of carbon atoms in 10^{-12} g = $10^{-12} \times 6.023 \times 10^{23}/12$
= 5.019×10^{10} atoms

Solution 26.

Given:
P = 1140 mm Hg
Density = D = 2.4 g / L

$$T = 273\text{ }^{\circ}\text{C} = 273 + 273 = 546\text{ K}$$

$$M = ?$$

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 Charles's law.

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

$$V_1 = 1\text{ L} \quad T_1 = 546\text{ K}$$

$$V_2 = ? \quad T_2 = 273\text{ K}$$

$$V_1/T_1 = V_2/T_2$$

$$V_2 = (V_1 \times T_2)/T_1 \\ = (1\text{ L} \times 273\text{ K})/546\text{ K}$$

$$= 0.5\text{ L}$$

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

Apply Boyle's law.

$$P_1 = 1140\text{ mm Hg} \quad V_1 = 0.5\text{ L}$$

$$P_2 = 760\text{ mm Hg} \quad V_2 = ?$$

$$P_1 \times V_1 = P_2 \times V_2$$

$$V_2 = (P_1 \times V_1)/P_2 \\ = (1140\text{ mm Hg} \times 0.5\text{ L})/760\text{ mm Hg}$$

$$= 0.75\text{ L}$$

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

$$X\text{ moles} = 0.75\text{ L} / 22.4\text{ L}$$

$$= 0.0335\text{ moles}$$

The original mass is 2.4 g

$$n = m / M$$

$$0.0335\text{ moles} = 2.4\text{ g} / M$$

$$M = 2.4\text{ g} / 0.0335\text{ moles}$$

$$M = 71.6\text{ g} / \text{mole}$$

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

Solution 27.

1000 g of sugar costs = Rs. 40

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

Solution 28.

(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 = $\frac{12 \times 3 \times 10^{25}}{6.023 \times 10^{23}} = 597.7 \text{ g}$

(c) 1 mole of sulphur weighs = 32 g

(d) 7 g of silver

So, 7 grams of silver weighs least.

Solution 29.

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

So, 4 g of NaOH contains = $6.02 \times 10^{23} \times 4/40$
= 6.02×10^{22} molecules

Solution 30.

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

So, no. of molecules in 4.25 g of ammonia = $6.02 \times 10^{23} \times 4.25/18$
= 1.5×10^{23}

Solution 31.

(a) One mole of chlorine contains 6.023×10^{23} atoms of chlorine.

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

(c) Relative atomic mass of an element is the number of times one atom 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 molecules.

Exercise 5(C)

Solution 1.

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. That molecular weight of H_2O is 18g.

Solution 2.

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.

Solution 3.

(a) CH (b) CH₂O (c) CH (d) CH₂O

Solution 4.

Relative mol. mass of CuSO₄·5H₂O = 63.5 + 32 + (16 × 4) + 5(1 × 2 + 16)
= 249.5 g
249.5 g of CuSO₄·5H₂O contains water of crystallization = 90 g
So, 100 g will contain = $\frac{90 \times 100}{249.5} = 36.07$ g
So, % of H₂O = 36.07 × 100 = 36.07 %

Solution 5.

(a) Molecular mass of Ca(H₂PO₄)₂ = 234
So, % of P = $2 \times 31 \times 100 / 234 = 26.5\%$
(b) Molecular mass of Ca₃(PO₄)₂ = 310
% of P = $2 \times 31 \times 100 / 310 = 20\%$

Solution 6.

Molecular mass of KClO₃ = 122.5 g
% of K = 39 / 122.5 = 31.8%
% of Cl = 35.5 / 122.5 = 28.98%
% of O = 3 × 16 / 122.5 = 39.18%

Solution 7.

Element % At. mass Atomic ratio Simple ratio

$$\text{Pb } 62.5 \quad 207 \quad \frac{62.5}{207} = 0.3019 \quad 1$$

$$\text{N } 8.5 \quad 14 \quad \frac{8.5}{14} = 0.6071 \quad 2$$

$$\text{O } 29.0 \quad 16 \quad \frac{29.0}{16} = 1.81 \quad 6$$

So, $\text{Pb}(\text{NO}_3)_2$ is the empirical formula.

Solution 8.

In Fe_2O_3 , Fe = 56 and O = 16

Molecular mass of $\text{Fe}_2\text{O}_3 = 2 \times 56 + 3 \times 16 = 160 \text{ g}$

$$\text{Iron present in 80\% of } \text{Fe}_2\text{O}_3 = \frac{112}{160} \times 80 = 56 \text{ g}$$

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

$$\therefore \text{ mass of Fe in 10000 g of ore} = 56 \times 10000/100 \\ = 5.6 \text{ kg}$$

Solution 9.

For acetylene, molecular mass = $2 \times \text{V.D} = 2 \times 13 = 26 \text{ g}$

The empirical mass = $12(\text{C}) + 1(\text{H}) = 13 \text{ g}$

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

Molecular formula of acetylene = $2 \times \text{Empirical formula} = \text{C}_2\text{H}_2$

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

$$n = 78/13 = 6$$

So, the molecular formula = C_6H_6

Solution 10.

Element % At. mass Atomic ratio Simple ratio

$$\text{H } 17.7 \quad 1 \quad \frac{17.7}{1} = 17.7 \quad \frac{17.7}{5.87} = 3$$

$$\text{N } 82.3 \quad 14 \quad \frac{82.3}{14} = 5.87 \quad \frac{5.87}{5.87} = 1$$

So, the empirical formula = NH_3

Solution 11.

Element % at. mass atomic ratio simple ratio

$$\text{C } 54.54 \text{ } 12 \frac{54.54}{12} = 4.55 \text{ } 2$$

$$\text{H } 9.09 \text{ } 1 \frac{9.09}{1} = 9.09 \text{ } 4$$

$$\text{O } 36.36 \text{ } 16 \frac{36.36}{16} = 2.27 \text{ } 1$$

(a) So, its empirical formula = $\text{C}_2\text{H}_4\text{O}$

(b) empirical formula mass = 44

Since, vapour density = 44

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

Or $n = 2$

so, molecular formula = $(\text{C}_2\text{H}_4\text{O})_2 = \text{C}_4\text{H}_8\text{O}_2$

Solution 12.

Element % at. mass atomic ratio simple ratio

$$\text{C } 26.59 \text{ } 12 \frac{26.59}{12} = 2.21 \text{ } 1$$

$$\text{H } 2.22 \text{ } 1 \frac{2.22}{1} = 2.22 \text{ } 1$$

$$\text{O } 71.19 \text{ } 16 \frac{71.19}{16} = 4.44 \text{ } 2$$

(a) its empirical formula = CHO_2

(b) empirical formula mass = 45

Vapour density = 45

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

so, molecular formula = $\text{C}_2\text{H}_2\text{O}_4$

Solution 13.

Element % at. mass atomic ratio simple ratio

$$\text{Cl } 71.65 \text{ } 35.5 \frac{71.65}{35.5} = 2.01 \text{ } 1$$

$$\text{H } 4.07 \text{ } 1 \frac{4.07}{1} = 4.07 \text{ } 2$$

$$\text{C } 24.28 \text{ } 12 \frac{24.28}{12} = 2.02 \text{ } 1$$

(a) its empirical formula = CH_2Cl

(b) empirical formula mass = 49.5

Since, molecular mass = 98.96

so, molecular formula = $(\text{CH}_2\text{Cl})_2 = \text{C}_2\text{H}_4\text{Cl}_2$

Solution 14.

(a) The g atom of carbon = $4.8/12 = 0.4$ and g atom of hydrogen = $1/1=1$

(b) Element Given mass At. mass Gram atom Ratio

C 4.8 12 0.4 1 2

H 1 1 1 2.5 5

So, the empirical formula = C_2H_5

(c) Empirical formula mass = 29

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

So, molecular formula = C_4H_{10}

Solution 15.

Since, g atom of Si = given mass/mol. Mass

so, given mass = $0.2 \times 28 = 5.6$ g

Element mass At. mass Gram atom Ratio

Si 5.6 28 0.2 1

Cl 21.3 35.5 $\frac{21.3}{35.5} = 0.6$ 3

Empirical formula = $SiCl_3$

Solution 16.

Element % at. mass atomic ratio simple ratio

C 92.3 12 $\frac{92.3}{12} = 7.7$ 1

H 7.7 1 $\frac{7.7}{1} = 7.7$ 1

So, empirical formula is CH

Empirical formula mass = 13

Since molecular mass = 78

So, $n = 6$

\therefore molecular formula is C_6H_6

Solution 17.

(a) G atoms of magnesium = $18/24 = 0.75$ or g- atom of Mg

(b) G atoms of nitrogen = $7/14 = 0.5$ or $1/2$ g- atoms of N

(c) Ratio of gram-atoms of N and Mg = 1:1.5 or 2:3

So, the formula is Mg_3N_2

Solution 18.

Barium chloride = $\text{BaCl}_2 \cdot x \text{H}_2\text{O}$

$\text{Ba} + 2\text{Cl} + x[\text{H}_2 + \text{O}]$

$= 137 + 235.5 + x[2 + 16]$

$= [208 + 18x]$ contains water = 14.8% water in $\text{BaCl}_2 \cdot x \text{H}_2\text{O}$

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

$= [104 + 9x] \frac{2148}{18000} = x$

$= [104 + 9x] \frac{37}{250} = x$

$= 3848 + 333x = 2250x$

$1917x = 3848$

$x = 2$ molecules of water

Solution 19.

Molar mass of urea; $\text{CON}_2\text{H}_4 = 60 \text{ g}$

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

Solution 20.

Element % At. mass Atomic ratio Simple ratio

C 42.1 12 3.5 1

H 6.48 1 6.48 2

O 51.42 16 3.2 1

The empirical formula is CH_2O

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

$\text{C}_{12} \text{H}_{24} \text{O}_{12}$.

Solution 21.

(a) 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, molecular formula is A_2B_4 .

(b) Since molecular mass is 2 times the vapour density, so Mol. Mass = 2 V.D

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

So, $n = \text{molecular mass} / \text{Empirical formula weight} = 6$

Hence, the molecular formula is A_6B_6

Solution 22.

Atomic ratio of N = $87.5/14 = 6.25$

Atomic ratio of H = $12.5/1 = 12.5$

This gives us the simplest ratio as 1:2
So, the molecular formula is NH_2

Solution 23.

Element % at. mass atomic ratio simple ratio

Zn 22.65 65 0.348 1

H 4.88 1 4.88 14

S 11.15 32 0.348 1

O 61.32 16 3.83 11

Empirical formula of the given compound = $\text{ZnSH}_{14}\text{O}_{11}$

Empirical formula mass = $65.37 + 32 + 14 \times 1 + 11 \times 16 = 287.37$

Molecular mass = 287

$n = \text{Molecular mass} / \text{Empirical formula mass} = 287 / 287 = 1$

Molecular formula = $\text{ZnSO}_{11}\text{H}_{14}$

= $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$

Exercise 5(D)

Solution 1.

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

(b) Grams: 42g + 36g \rightarrow 74g + 4g

(c) Molecules = $6.02 \times 10^{23} + 12.046 \times 10^{23} \rightarrow 6.02 \times 10^{23} + 12.046 \times 10^{23}$

Solution 2.

(a) 100 g of CaCO_3 produces = 164 g of $\text{Ca(NO}_3)_2$

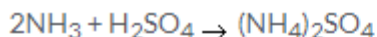
So, 15 g CaCO_3 will produce = $164 \times 15 / 100 = 24.6$ g $\text{Ca(NO}_3)_2$

(b) 1 V of CaCO_3 produces 1 V of CO_2

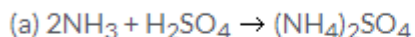
100 g of CaCO_3 has volume = 22.4 litres

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

Solution 3.



66 g



34 g 98 g 132 g

For 132 g $(\text{NH}_4)_2\text{SO}_4 = 34$ g of NH_3 is required

So, for 66 g $(\text{NH}_4)_2\text{SO}_4 = 66 \times 32/132 = 17$ g of NH_3 is required

(b) 17g of NH_3 requires volume = 22.4 litres

(c) Mass of acid required, for producing 132g $(\text{NH}_4)_2\text{SO}_4 = 98$ g

So, Mass of acid required, for 66g $(\text{NH}_4)_2\text{SO}_4 = 66 \times 98/132 = 49$ g

Solution 4.

(a) Molecular mass of $\text{Pb}_3\text{O}_4 = 3 \times 207.2 + 4 \times 16 = 685$ g

685 g of Pb_3O_4 gives = 834 g of PbCl_2

Hence, 6.85 g of Pb_3O_4 will give = $6.85 \times 834/685 = 8.34$ g

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

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

(c) 1 V Pb_3O_4 produces 1 V Cl_2

685g of Pb_3O_4 has volume = 22.4 litres = volume of Cl_2 produced

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

Solution 5.

Molecular mass of $\text{KNO}_3 = 101$ g

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

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

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

So, smaller mass of NaNO_3 is required.

Solution 6.



100g 73g 22.4L

(a) $V_1 = 2$ litres $V_2 = ?$

$$T_1 = (273 + 27) = 300\text{K} \quad T_2 = 273\text{K}$$

$$V_1/T_1 = V_2/T_2$$

$$V_2 = V_1 T_2 / T_1 = \left[\frac{2 \times 273}{300} \right] \text{L}$$

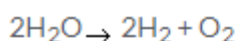
Now at STP 22.4 litres of CO_2 are produced using $\text{CaCO}_3 = 100\text{g}$

So, $\left[\frac{2 \times 273}{300} \right]$ litres are produced by $= 100 / 22.4 \times 2274 / 300 = 5.125\text{g}$

(b) 22.4 litres are CO_2 are prepared from acid = 73g

$\left[\frac{2 \times 273}{300} \right]$ litres are prepared from $= 73 / 22.4 \times 2273 / 300 = 5.9\text{g}$

Solution 7.



2 V 2 V 1 V

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

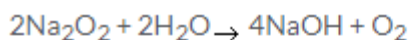
so, mass of $\text{O}_2 = \text{no. of moles} \times \text{molecular mass}$

$$= 0.5 \times 32 = 16 \text{ g of } \text{O}_2$$

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.

Solution 8.



2 V 4 V 1 V

(a) Mol. Mass of $\text{Na}_2\text{O}_2 = 2 \times 23 + 2 \times 16 = 78 \text{ g}$

Mass of $2\text{Na}_2\text{O}_2 = 156 \text{ g}$

156 g Na_2O_2 gives = 160 g of NaOH ($4 \times 40 \text{ g}$)

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

(b) 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

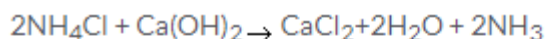
$$= 224 \text{ cm}^3$$

(c) 156 g Na_2O_2 gives = 32 g O_2

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

$$= 32 / 100 = 0.32 \text{ g}$$

Solution 9.



2 V1 V1 V2 V

Mol. Mass of $2\text{NH}_4\text{Cl} = 2[14 + (1 \times 4) + 35.5] = 2[53.5] = 107 \text{ g}$

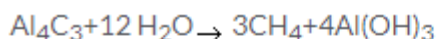
(a) 107 g NH_4Cl gives = 34 g NH_3

So, 21.4 g NH_4Cl will give = $21.4 \times 34/107 = 6.8 \text{ g NH}_3$

(b) The volume of 17 g NH_3 is 22.4 litre

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

Solution 10.



1 V3 V4 V

144g3 \times 22.4 / volume

Now, since 144 g of Al_4C_3 gives = 3 \times 22.4 litre of CH_4

So, 14.4 g of Al_4C_3 will give = $3 \times 22.4 \times 14.4/144 = 6.72 \text{ litres CH}_4$

Solution 11.



1 V4 V1 V1 V

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

So, 0.02 mole will weigh = $87 \times 0.02 = 1.74 \text{ g MnO}_2$

(b) 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) 1 mole MnCl_2 weighs = 126 g (mol mass)

So, 0.02 mole MnCl_2 will weigh = $126 \times 0.02 \text{ g} = 2.52 \text{ g}$

(d) 0.02 mole MnO_2 will form = 0.02 mole of Cl_2

(e) 1 mole of Cl_2 weighs = 71 g

So, 0.02 mole will weigh = $71 \times 0.02 = 1.42 \text{ g of Cl}_2$

(f) 1 mole of chlorine gas has volume = 22.4 litres

So, 0.02 mole will have volume = $22.4 \times 0.02 = 0.448 \text{ litre}$

(g) 1 mole MnO_2 requires $\text{HCl} = 4 \text{ mole}$

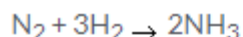
So, 0.02 mole MnO_2 will require = $4 \times 0.02 = 0.08 \text{ mole}$

(h) For 1 mole MnO_2 , acid required = 4 mole of HCl

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

Mass of $\text{HCl} = 0.08 \times 36.5 = 2.92 \text{ g}$

Solution 12.



28g 6g 34g

28g of nitrogen requires hydrogen = 6g

2000g of nitrogen requires hydrogen = $\frac{6}{28} \times 2000 = 3000/7\text{g}$

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

(b) 28g of nitrogen forms $\text{NH}_3 = 34\text{g}$

2000g of N_2 forms NH_3

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

= 2428.6g

Miscellaneous Exercise

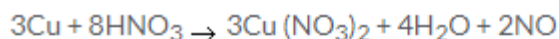
Solution 1.



1 mole of Oxygen gives = 2 moles of steam

so, 0.5 mole oxygen will give = $2 \times 0.5 = 1$ mole of steam

Solution 2.



1 V 8 V 3 V 2 V

Mol. Mass of $8\text{HNO}_3 = 8 \times 63 = 504\text{g}$

(a) For 504 g HNO_3 , Cu required is = 192 g

So, for 63g HNO_3 Cu required = $192 \times \frac{63}{504} = 24\text{g}$

(b) 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

Solution 3.

(a) 28g of nitrogen = 1mole

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

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

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

Solution 4.

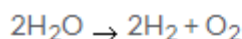
$$\% \text{ of N in NaNO}_3 = \frac{14}{85} \times 100 = 16.47\%$$

$$\% \text{ of N in (NH}_4)_2\text{SO}_4 = \frac{14}{132} \times 100 = 21.21\%$$

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

So, highest percentage of N is in urea.

Solution 5.



(a) From equation, 2 V of water gives 2 V of H₂ and 1 V of O₂

where 2 V = 2500 cm³

so, volume of O₂ liberated = 2V/V = 1250 cm³

(b)

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{P_1 V_1}{T_1} = \frac{7P_1 \times V_2}{2 \times T_1}$$

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

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

(c)

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

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

$$T_2 = 3.5 T_1$$

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

Solution 6.

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 = 23.33 kg

Solution 7.

(a) 80% C and 20% H

So, atomic ratio of C and H are: $C = \frac{80}{12} = 6.66$; $H = \frac{20}{1} = 20$

Simple ratio of C:H = 1 : 3

So, empirical formula is CH_3

(b) Empirical formula mass = $12 + (3 \times 1) = 15$ g

Vapour density = 15

So, the molecular mass = $15(\text{V.D}) \times 2 = 30$ g

Hence, $n = 2$ so the molecular formula is C_2H_6

Solution 8.

22400cm^3 CO_2 has mass = 44g

so, 224cm^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 = $0.44 - 0.32 = 0.12\text{g} = 0.01\text{g atom}$

So, mass of Hydrogen in X = $0.145 - 0.12 = 0.025\text{g}$
= 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) C and H

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

(c)

(i) no. of moles of $\text{CO}_2 = 0.44/44 = 0.01$ moles

(ii) mass of C = 0.12 g

(iii) mass of H = 0.025 g

(iv) The empirical formula of X = C_2H_5

Solution 9.

Mass of X in the given compound = 24g

Mass of oxygen in the given compound = 64g

So total mass of the compound = $24 + 64 = 88\text{g}$

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

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

Element % At. Mass Atomic ratio Simplest ratio

X 27.3 12 $27.3/12 = 2.27$ 1

O 72.7 16 $72.7/16 = 4.54$ 2

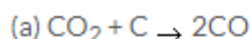
So simplest formula = XO_2

Solution 10.

$$(a) \text{V.D} = \frac{\text{mass of gas at STP}}{\text{mass of equal volume of H}_2} = \frac{85}{5} = 17$$

$$(b) \text{Molecular mass} = 17(\text{V.D}) \times 2 = 34\text{g}$$

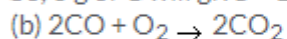
Solution 11.



$$1 \text{ V } 1 \text{ V } 2 \text{ V}$$

12 g of C gives = 44.8 litre volume of CO

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



$$2 \text{ V } 1 \text{ V } 2 \text{ V}$$

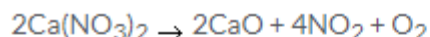
(i) 2 V CO requires oxygen = 1 V

so, 24 cm³ CO will require = 24/2 = 12 cm³

(ii) 2 x 22400 cm³ CO gives = 2 x 22400 cm³ CO₂

so, 24cm³ CO will give = 24 cm³ CO₂

Solution 12.



$$2 \text{ V } 2 \text{ V } 4 \text{ V } 1 \text{ V}$$

(a) 56 g of CaO is obtained with NO₂ = 2 x 22.4 litre of NO₂

So, 5.6g of CaO is obtained with NO₂ = 2 x 22.4 x 5.6/56

= 4.48 litre

(b) 56 g of CaO is obtained by = 164 g Ca(NO₃)₂

So, 5.6 g CaO is obtained by = 5.6 x 56/164 g Ca(NO₃)₂

= 16.4 g of Ca(NO₃)₂ is heated.

Solution 13.

(a) Number of molecules in 100cm³ of oxygen=Y

According to Avogadro's law, Equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules. Therefore, number of molecules in 100 cm³ of nitrogen under the same conditions of temperature and pressure = Y

So, number of molecules in 50 cm³ of nitrogen under the same conditions of temperature and pressure = Y/100 50=Y/2

(b) (i) Empirical formula is the formula which tells about the simplest ratio of combining capacity of elements present in a compound.

(ii) The empirical formula is CH_3

(iii) The empirical formula mass for $\text{CH}_2\text{O} = 30$

V.D = 30

Molecular formula mass = V.D 2 = 60

Hence, $n = \text{mol. Formula mass} / \text{empirical formula mass} = 2$

So, molecular formula = $(\text{CH}_2\text{O})_2 = \text{C}_2\text{H}_4\text{O}_2$

Solution 14.

The relative atomic mass of Cl = $(35 \times 3 + 1 \times 37) / 4 = 35.5$ amu

Solution 15.

Mass of silicon in the given compound = 5.6g

Mass of the chlorine in the given compound = 21.3g

Total mass of the compound = $5.6\text{g} + 21.3\text{g} = 26.9\text{g}$

% of silicon in the compound = $56 / 26.9 \times 100 = 20.82\%$

% of chlorine in the compound = $21.2 / 26.9 \times 100 = 79.18\%$

Element % At. Mass At. Ratio Simplest ratio

Si 20.82 28 $20.82 / 28 = 0.74$ 1

Cl 79.18 35.5 $79.18 / 35.5 = 2.23$ 3

So the empirical formula of the given compound = SiCl_3

Solution 16.

% composition Atomic ratio Simple ratio

P = 38.27% $38.27 / 31 = 1.23$ 1

H = 2.47% $2.47 / 1 = 2.47$ 2

O = 59.26% $59.26 / 16 = 3.70$ 3

So, empirical formula is PH_2O_3 or H_2PO_3

Empirical formula mass = $31 + 2 \times 1 + 3 \times 16 = 81$

The molecular formula is = $\text{H}_4\text{P}_2\text{O}_6$, because $n = 162 / 81 = 2$

Solution 17.

$$V_1 = 10 \text{ litres } V_2 = ?$$

$$T_1 = 27 + 273 = 300\text{K } T_2 = 273\text{K}$$

$$P_1 = 700 \text{ mm } P_2 = 760 \text{ mm}$$

Using the gas equation

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{700 \times 10 \times 273}{300 \times 760}$$

Molecular weight A = 60

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

$$\text{Weight of } = \frac{700 \times 10 \times 273}{300 \times 760} \text{ litres of A at STP}$$

$$= \frac{60}{22.4} \times \frac{700 \times 10 \times 273}{300 \times 760} \text{ g or } 22.45\text{g}$$

Solution 18.

(a) Molecular mass of $\text{CO}_2 = 12 + 2 \times 16 = 44 \text{ g}$

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

$$\text{V.D} = \frac{\text{mass of certain amount of } \text{CO}_2}{\text{mass of equal volume of hydrogen}} = \frac{m}{1}$$

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

So, mass of $\text{CO}_2 = 22 \text{ kg}$

(b) According to Avogadro's law, equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules.

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

Solution 19.

(a) The volume occupied by 1 mole of chlorine = 22.4 litre

(b) Since $PV = \text{constant}$ so, if pressure is doubled; the volume will become half i.e. 11.2 litres.

$$(c) V_1/V_2 = T_1/T_2$$

$$22.4/V_2 = 273/546$$

$$V_2 = 44.8 \text{ litres}$$

(d) Mass of 1 mole Cl_2 gas = $35.5 \times 2 = 71 \text{ g}$

Solution 20.

(a) Total molar mass of hydrated $\text{CaSO}_4 \cdot x\text{H}_2\text{O} = 136 + 18x$

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

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

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

1 vol. of water = $1/2$ vol. of $\text{O}_2 = 22.4/2 = 11.2$ lit.

18 g of water = 11.2 lit. of O_2

1.8 g of water = $11.2/18 \times 1.8 = 1.12$ lit.

(c) 32g of dry oxygen at STP = 22400cc

2g will occupy = $22400/32 = 1400$ cc

$P_1 = 760$ mm $P_2 = 740$ mm

$V_1 = 1400$ cc $V_2 = ?$

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

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \quad \times$$

$$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{760 \times 1400 \times 300}{273 \times 740} = 1580 \text{ cc}$$

$$= 1580/1000 = 1.58 \text{ l}$$

(d) $P_1 = 750$ mm $P_2 = 760$ mm

$V_1 = 44$ lit. $V_2 = ?$

$T_1 = 298$ K $T_2 = 273$ K

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \quad \times$$

$$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{750 \times 44 \times 273}{298 \times 760} = 39.78 \text{ lit.}$$

22.4 lit. of CO_2 at STP has mass = 44g

$$39.78 \text{ lit. of } \text{CO}_2 \text{ at STP has mass} = 44 \times \frac{39.78}{22.4} = 78.14 \text{ g}$$

(e) 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 $\text{NaCl} = 0.585 \times 100 = 58.5\%$

Solution 21.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$
$$\frac{P_1 \times 22.4}{273} = \frac{2P_2 V_2}{546}$$
$$V_2 = 22.4 \text{ litre}$$

Solution 22.

(a) The molecular mass of $(\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}) = 256.4 \text{ g}$
% of Oxygen = $12 \times 16/256$
= 75%

(b) The molecular mass of boron in $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O} = 382 \text{ g}$
% of B = $4 \times 11/382 = 11.5\%$

Solution 23.

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

136.5 cm³ of the gas weigh = 0.546

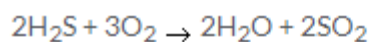
22400 cm³ of the gas weight = $\frac{0.546 \times 22400}{136.5} = 89.6 \text{ a.m.u}$

Relative molecular mass = 89.6 a.m.u

Solution 24.

(a) 252 g of solid ammonium dichromate decomposes to give 152 g of solid chromium oxide, so the loss in mass in terms of solid formed = 100 g
Now, if 63 g ammonium dichromate is decomposed, the loss in mass would be = $100 \times 63/252 = 25 \text{ g}$

(b) If 252 g of ammonium dichromate produces $\text{Cr}_2\text{O}_3 = 152 \text{ g}$
So, 63 g ammonium dichromate will produce = $63 \times 152/252$
= 38 g

Solution 25.

$$2 \text{ V } 3 \text{ V } 2 \text{ V}$$

128 g of SO_2 gives = 2×22.4 litres volume

So, 12.8 g of SO_2 gives = $2 \times 22.4 \times 12.8/128$

= 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

Solution 26.

From equation, $2\text{NH}_3 + 2\text{O}_2 \rightarrow 2\text{NO} + 3\text{H}_2\text{O}$

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

So, 1.5 g NO is formed, mass of steam produced = $54 \times 1.5/60$

= 1.35 g

Solution 27.

In 1 hectare of soil, N_2 removed = 20 kg

So, in 10 hectare N_2 removed = 200 kg

The molecular mass of $\text{Ca}(\text{NO}_3)_2$ = 164

Now, 28 g N_2 present in fertilizer = 164 g $\text{Ca}(\text{NO}_3)_2$

So, 200000 g of N_2 is present in = $164 \times 200000/28$

= 1171.42 kg

Solution 28.

(a) 1 mole of phosphorus atom = 31 g of phosphorus
31 g of P = 1 mole of P

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

(b) 31 g P reacts with $\text{HNO}_3 = 315 \text{ g}$

so, 6.2 g P will react with $\text{HNO}_3 = 315 \times 6.2/31 = 63 \text{ g}$

(c)

Moles of steam formed from 31g phosphorus = $18\text{g}/18\text{g} = 1\text{mol}$

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

Volume of steam produced at STP = $0.2 \times 22.4 \text{ l/MOL} = 4.48 \text{ litre}$

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 760mm Hg and $273^\circ\text{C} = 4.48 \times 2 = 8.96 \text{ litre}$

Solution 29.

(a) 1 mole of gas occupies volume = 22.4 litre

(b) 112cm^3 of gaseous fluoride has mass = 0.63 g

so, 22400cm^3 will have mass = $0.63 \times 22400/112$

$$= 126 \text{ g}$$

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

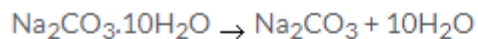
$$126 = 31 + \text{At. Mass of F}$$

So, At. Mass of F = 95 g

But, at. mass of F = 19 so $95/19 = 5$

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

Solution 30.



286 g 106 g

So, for 57.2 g $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} = 106 \times 57.2/286 = 21.2 \text{ g Na}_2\text{CO}_3$

Solution 31.

(a) The molecular mass of $\text{Ca}(\text{H}_2\text{PO}_4)_2 = 234$

The % of P = $2 \times 31/234 = 26.49 \%$

(b) Simple ratio of M = $34.5/56 = 0.616 = 1$

Simple ratio of Cl = $65.5/35.5 = 1.845 = 3$

Empirical formula = MCl_3

Empirical formula mass = 162.5, Molecular mass = $2 \times \text{V.D} = 325$

So, $n = 2$

So, molecular formula = M_2Cl_6

Solution 32.

$$V_1/V_2 = n_1/n_2$$

So, no. of moles of Cl = $x/2$ (since V is directly proportional to n)

No. of moles of $\text{NH}_3 = x$

No. of moles of $\text{SO}_2 = x/4$

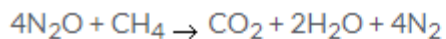
This is because of Avogadro's law which states Equal volumes of all gases, under similar conditions of temperature and pressure, contain equal number of molecules.

So, 20 litre nitrogen contains x molecules

So, 10 litre of chlorine will contain = $x \times 10/20 = x/2$ mols.

And 20 litre of ammonia will also contain = x molecules

And 5 litre of sulphur dioxide will contain = $x \times 5/20 = x/4$ mols.

Solution 33.

2 x 22400 litre steam is produced by $\text{N}_2\text{O} = 4 \times 22400 \text{ cm}^3$

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

$$= 300 \text{ cm}^3 \text{N}_2\text{O}$$

Solution 34.

(a) Volume of $\text{O}_2 = V$

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

so, the volume of $\text{N}_2 = V$

(b) 3x molecules means 3V volume of CO

(c) 32 g oxygen is contained in = 44 g of CO_2

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

(d) Avogadro's law is used in the above questions.

Solution 35.

(a) 444 g is the molecular formula of $(\text{NH}_4)_2\text{PtCl}_6$

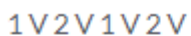
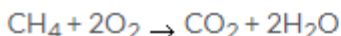
% of Pt = $(195/444) \times 100 = 43.91\%$ or 44%

(b) simple ratio of Na = $42.1/23 = 1.83 = 3$

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

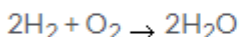
simple ratio of O = $39/16 = 2.43 = 4$

So, the empirical formula is Na_3PO_4

Solution 36.

From equation:

22.4 litres of methane requires oxygen = 44.8 litres O_2



From equation,

44.8 litres hydrogen requires oxygen = 22.4 litres O_2

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

Total volume = $44.8 + 5.6 = 50.4 \text{ litres}$

Solution 37.

According to Avogadro's law:

Equal volumes of all gases, under similar conditions of temperature and pressure, contain equal number 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 = $8/32 \times 6.02 \times 10^{23} = M/4$

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

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

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

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

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

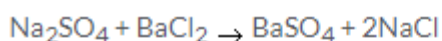
Since $8M/71 < M/8 < 2M/11 < M/4 < 4M$

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

Solution 38.



Molecular mass of $\text{BaSO}_4 = 233 \text{ g}$

Now, 233 g of BaSO_4 is produced by $\text{Na}_2\text{SO}_4 = 142 \text{ g}$

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 $= 4.26 \times 100/10$
 $= 42.6\%$

Solution 39.

(a) 1 litre of oxygen has mass = 1.32 g

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

= 31.6 or 32 g



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

Solution 40.

(a)

(i) The no. of moles of $\text{SO}_2 = 3.2/64 = 0.05$ moles

(ii) In 1 mole of SO_2 , no. of molecules present $= 6.02 \times 10^{23}$

So, in 0.05 moles, no. of molecules $= 6.02 \times 10^{23} \times 0.05$

$= 3.0 \times 10^{22}$

(iii) The volume occupied by 64 g of $\text{SO}_2 = 22.4 \text{ dm}^3$

3.2 g of SO_2 will be occupied by volume $= 22.4 \times 3.2/64 = 1.12 \text{ dm}^3$

(b) 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 $= \text{PbCl}_4$

Solution 41.

(i) D contains the maximum number of molecules because volume is directly proportional to the number of molecules.

(ii) The volume will become double because volume is directly proportional to the no. of molecules at constant temperature and pressure.

$$V_1/V_2 = n_1/n_2$$

$$V_1/V_2 = n_1/2n_1$$

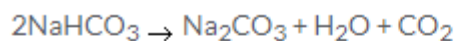
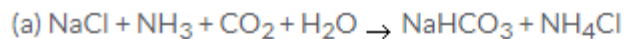
$$\text{So, } V_2 = 2V_1$$

(iii) Gay lussac's law of combining volume is being observed.

(iv) The volume of D = $5.6 \times 4 = 22.4 \text{ dm}^3$, so the number of molecules = 6×10^{23} because according to mole concept 22.4 litre volume at STP has = 6×10^{23} molecules

(v) No. of moles of D = 1 because volume is 22.4 litre
so, mass of $\text{N}_2\text{O} = 1 \times 44 = 44 \text{ g}$

Solution 42.



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 = $168 \times 21.2/106$

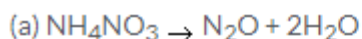
= 33.6 g of NaHCO_3

(b) For 84 g of NaHCO_3 , required volume of $\text{CO}_2 = 22.4 \text{ litre}$

So, for 33.6 g of NaHCO_3 , required volume of $\text{CO}_2 = 22.4 \times 33.6/84$

= 8.96 litre

Solution 43.



1mole 1mole 2mole

1 V 1 V 2 V

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.

(i) 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) % of O in $\text{NH}_4\text{NO}_3 = 3 \times 16/80 = 60\%$

Solution 44.

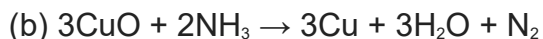
(a) Element % Atomic mass Atomic ratio Simple ratio

K 47.9 39 1.22 2

Be 5.5 9 0.6 1

F 46.6 19 2.45 4

so, empirical formula is K_2BeF_4



3 V 2 V 3 V 1V

3 x 80 g of CuO reacts with = 2 x 22.4 litre of NH_3

so, 120 g of CuO will react with = $2 \times 22.4 \times 120/80 \times 3$

= 22.4 litres

Solution 45.

(a) 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) Molecular mass = 2 X V.D

So, V.D = $28/2 = 14$

Solution 46.

(a) Molecular mass of $\text{Na}_3\text{AlF}_6 = 210$

So, Percentage of Na = $3 \times 23 \times 100 / 210 = 32.85\%$

(b) $2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$

2V 1V 2V

1 mole of O_2 has volume = 22400 ml

Volume of oxygen used by 2 x 22400 ml CO = 22400 ml

So, Vol. of O_2 used by 560 ml CO = $22400 \times 560 / (2 \times 22400)$

= 280 ml

So, Volume of CO_2 formed is 560 ml.

Solution 47.

a. Mass of gas X = 10g

Mass of hydrogen gas = 2

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 = $2 \times$ relative vapour

density = 2×5

= 10

b.

i. The combustion reaction $2\text{C}_2\text{H}_2(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 4\text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$

According to Gay-Lussac's law,

2 volume of acetylene requires 5 volume of oxygen to burn it

\therefore 1 volume of acetylene requires 2.5 volume of oxygen to burn it

\therefore 200cm^3 requires $2.5 \times 200 = 500\text{cm}^3$ of oxygen

2 volume of acetylene on combustion gives 4CO_2

\therefore 1 volume of acetylene on combustion gives 2CO_2

\therefore 200cc of acetylene on combustion will give $200 \times 2 = 400\text{cc}$ of CO_2

ii. Hydrogen = 12.5%

\therefore Nitrogen = $100 - 12.5 = 87.5\%$

Element	% Weight	Atomic Weight	Atomic Ratio	Simplest Ratio
N	87.5	14	$87.5/14 = 6.25$	$6.25/6.25 = 1$
H	12.5	1	$12.5/1 = 12.5$	$12.5/6.25 = 2$

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 x NH₂
= N₂H₄

c.

i. Molecules of nitrogen gas in a cylinder = 24×10^{24}
Avogadro's number = 6×10^{23}

$$1. \text{ Mass of nitrogen in a cylinder} = \frac{24 \times 10^{24} \times 28}{6 \times 10^{23}} = 1120 \text{g}$$

2. Volume of nitrogen at stp

$$\text{Volume of 28 g of N}_2 = 22.4 \text{dm}^3$$

$$\text{Volume of 1120g of N}_2 = \frac{1120 \times 22.4}{28} \text{ dm}^3 = 896 \text{ dm}^3$$

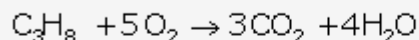
Solution 48.

a.

i. 10 litres of LPG contains

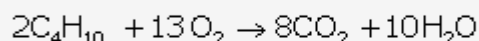
$$\text{Propane} = \frac{60}{100} \times 10 = 6 \text{ litres}$$

$$\text{Butane} = \frac{40}{100} \times 10 = 4 \text{ litres}$$



1 vol. 3 vol.

6L 18L



2 vol. 8 vol.

4L 16L

$$18 + 16 = 34 \text{ L}$$

ii. Molecular mass of NH₄(NO₃) = 80

H=1, N=14, O=16

% of Nitrogen

As 80 g of NH₄(NO₃) contains 28 g of nitrogen

$$\therefore 100 \text{ g of of NH}_4(\text{NO}_3) \text{ will contain } \frac{28 \times 100}{80} = 35\%$$

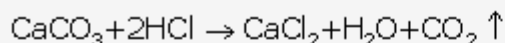
% of Oxygen

As, 80 g of NH₄(NO₃) contains 48 g of oxygen

$$\therefore 100 \text{ g of of NH}_4(\text{NO}_3) \text{ will contain } \frac{100 \times 48}{80} = 60\%$$

b.

i. Equation for reaction of calcium carbonate with dilute hydrochloric acid:



ii. Relative molecular mass of calcium carbonate = 100

Mass of 4.5 moles of calcium carbonate

$$= \text{No. of moles} \times \text{Relative molecular mass}$$

$$= 4.5 \times 100$$

$$= 450\text{g}$$

iii. $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2 \uparrow$

As, 100g of calcium carbonate gives 22.4dm^3 of CO_2

$$\therefore 450 \text{ g of calcium carbonate will give } \frac{450 \times 22.4}{100}$$

$$= 100.8 \text{ L}$$

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

$$\therefore 450 \text{ g of calcium carbonate will give } \frac{450 \times 111}{100}$$

$$= 499.5 \text{ g}$$

iv.

Molecular mass of HCl = 36.5

Molecular mass of calcium carbonate = 100

As 100 g of calcium carbonate gives $(2 \times 36.5) = 73\text{g}$ of HCl

$$\therefore 450 \text{ g of calcium carbonate will give } \frac{450 \times 73}{100}$$

$$= 328.5\text{g}$$

$$\text{Number of moles of HCl} = \frac{\text{Weight of HCl}}{\text{Molecular weight of HCl}}$$

$$= \frac{328.5}{36.5}$$

$$= 9 \text{ moles}$$

Solution 49.

a.

- i. Atomic mass: S = 32 and O = 16
Molecular mass of $\text{SO}_2 = 32 + (2 \times 16)$
= 64g
As 64 g of $\text{SO}_2 = 22.4 \text{ dm}^3$

$$\text{Then, } 320 \text{ g of } \text{SO}_2 = \frac{320 \times 22.4}{64} \\ = 112 \text{ L}$$

ii. 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. $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$
Molar mass of propane = 44

44 g of propane requires 5×22.4 litres of oxygen at STP.

$$8.8 \text{ g of propane requires } \frac{5 \times 22.4 \times 8.8}{44} = 22.4 \text{ litres}$$

b.

i.

Element	Relative atomic mass	%Compound	Atomic ratio	Simplest ratio
H	1	2.13	$2.13/1=2.13$	2
C	12	12.67	$12.67/12=1.055$	2
Br	80	85.11	$85.11/80=1$	1

Empirical formula = CH_2Br

$n(\text{Empirical formula mass of } \text{CH}_2\text{Br}) = \text{Molecular mass } (2 \times \text{VD})$

$$n(12 + 2 + 80) = 94 \times 2$$

$$n = 2$$

Molecular formula = Empirical formula $\times 2$

$$= (\text{CH}_2\text{Br}) \times 2$$

$$= \text{C}_2\text{H}_4\text{Br}_2$$

ii. 10^{22} atoms of sulphur

6.022×10^{23} atoms of sulphur will have mass = 32 g

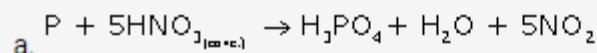
$$10^{22} \text{ atoms of sulphur will have mass} = \frac{32 \times 10^{22}}{6.022 \times 10^{23}} \\ = 0.533 \text{ g}$$

iii. 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

Solution 50.



i. Number of moles of phosphorus taken = $\frac{9.3}{31}$
= 0.3 mol

ii. 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

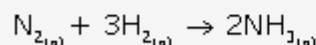
iii. 1 mole of phosphorus gives 112 L of NO_2 gas at STP.
So, 0.3 mole of phosphorus gives (112×0.3) L of

NO_2 gas at STP.

= 33.6 L of NO_2 gas at STP

b.

i. According to the equation



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 $\frac{1 \times 67.2}{3} = 22.4$ L Nitrogen left = $44.8 - 22.4 = 22.4$ litres

ii. 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 = $(12/56 \times 22.2)$ gm = 48g

Therefore, the relative molecular mass of gas = 48 gm.

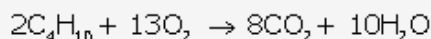
iii. Molar mass of $Mg(NO_3)_2 \cdot 6H_2O$

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

$$\text{Mass percent of magnesium} = \frac{24 \times 100}{256} = 9.37\%$$

Solution 51.

a.



i. $2V$ $13V$

2 vols. of butane requires $O_2 = 13$ vols

90 dm^3 of butane will require $O_2 = \frac{13}{2} \times 90$
 $= 585 \text{ dm}^3$

ii. Molecular mass = $2 \times$ Vapour density

So, molecular mass of gas = $2 \times 8 = 16 \text{ g}$

As we know, molecular mass or molar mass occupies 22.4 litres.

That is,

16 g of gas occupies volume = 22.4 litres

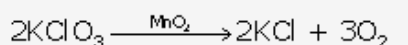
So, 24 g of gas will occupy volume

$$= \frac{22.4}{16} \times 24 = 33.6 \text{ litres}$$

iii. 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.



i. $2V$ $2V$ $3V$

3 vols. of oxygen require $KClO_3 = 2$ vols.

So, 1 vol. of oxygen will require $KClO_3 = \frac{2}{3}$ vols.
So, 6.72 litres of oxygen will require $KClO_3$

So, 1 vol. of oxygen will require $KClO_3 = \frac{2}{3}$ vols.
So, 6.72 litres of oxygen will require $KClO_3$

$$= \frac{2}{3} \times 6.72 = 4.48 \text{ litres}$$

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. 22.4 litres of oxygen = 1 mole

So, 6.72 litres of oxygen = $\frac{6.72}{22.4} = 0.3$ moles

No. of molecules present in 1 mole of O_2

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

So, no. of molecules present in 0.3 mole of O_2

$$= 6.023 \times 10^{23} \times 0.3$$

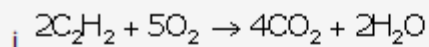
$$= 1.806 \times 10^{23}$$

iii. 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 = $22.4 \times 0.01 = 0.224$ litres

Solution 52.

a.



2 moles of $\text{C}_2\text{H}_2 = 4$ moles of CO_2

$x \text{ dm}^3$ of $\text{C}_2\text{H}_2 = 8.4 \text{ dm}^3$ of CO_2

$$x = \frac{2 \times 8.4}{4}$$

$x = 4.2 \text{ dm}^3$ of C_2H_2

ii. Empirical formula = X_2Y

Atomic weight (X) = 10

Atomic weight (Y) = 5

Empirical formula weight = $(2 \times 10) + 5$

= 25

$$\begin{aligned} n &= \frac{\text{Molecular weight}}{\text{Empirical formula weight}} \\ &= \frac{2 \times \text{V.D}}{\text{Empirical formula weight}} \\ &= \frac{2 \times 25}{25} \\ &= 2 \end{aligned}$$

= 2

So, molecular formula = $\text{X}_2\text{Y} \times 2$

= X_4Y_2

b.

i. 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

\therefore 4 mole = $22.4 \times 4 = 89.6 \text{ dm}^3$

ii. 4 moles of ammonia gas is present in the cylinder.

iii. 1 mole = 6.023×10^{23} molecules

4 moles = 24.092×10^{23} molecules

Solution 42.

The formula of aluminium nitride is AlN .

The molecular mass = 41

So, the percentage of N = $14 \times 100/41 = 34.146\%$

Solution 48.

(i) Element % atomic mass atomic ratio simple ratio

$$\text{C } 4.8 \quad 12 \quad \frac{4.8}{12} = 0.4 \quad 1$$

$$\text{Br } 95.2 \quad 80 \quad \frac{95.2}{80} = 1.2 \quad 3$$

So, empirical formula is CBr_3

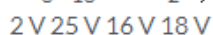
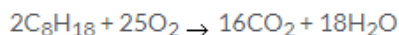
(ii) Empirical formula mass = $12 + 3 \times 80 = 252 \text{ g}$

molecular formula mass = $2 \times 252(\text{V.D}) = 504 \text{ g}$

$$n = 504/252 = 2$$

so, molecular formula = C_2Br_6

Solution 49.



(i) 2 moles of octane gives = 16 moles of CO_2

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

(ii) 1 mole CO_2 occupies volume = 22.4 litre

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

(iii) 1 mole CO_2 has mass = 44 g

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

(iv) Empirical formula is C_4H_9 .

Solution 50.

(a) (i) element % atomic mass at. ratio simple ratio

C 14.4 12 1.2 1

H 1.2 1 1.2 1

Cl 84.5 35.5 2.38 2

Empirical formula = CHCl_2

(ii) Empirical formula mass = $12+1+71=84 \text{ g}$

Since molecular mass = 168 so, $n = 2$

so, molecular formula = $(\text{CHCl}_2)_2 = \text{C}_2\text{H}_2\text{Cl}_4$

(b) (i) $\text{C} + 2\text{H}_2\text{SO}_4 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} + 2\text{SO}_2$



196 g of H_2SO_4 is required to oxidized = 12 g C

So, 49 g will be required to oxidise = $49 \times 12/196 = 3 \text{ g}$

(ii) 196 g of H_2SO_4 occupies volume = $2 \times 22.4 \text{ litres}$

So, 49 g H_2SO_4 will occupy = $2 \times 22.4 \times 49/196 = 11.2 \text{ litre}$

i.e. volume of $\text{SO}_2 = 11.2 \text{ litre}$