

## 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

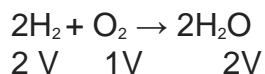
Therefore  $2H = He$

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.

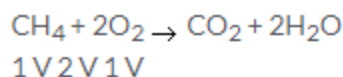
(c) Inflating a balloon seems violating Boyle's law as volume is increasing with increase in pressure. Since the mass of gas is also increasing.

#### Solution 4.



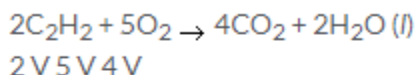
From the equation, 2V of hydrogen reacts with 1V of oxygen  
so 200cm<sup>3</sup> of Hydrogen reacts with = 200/2 = 100 cm<sup>3</sup>  
Hence, the unreacted oxygen is 150 – 100 = 50cm<sup>3</sup> of oxygen.

#### Solution 5.



From equation, 1V of CH<sub>4</sub> reacts with = 2 V of O<sub>2</sub>  
so, 80 cm<sup>3</sup> CH<sub>4</sub> reacts with = 80 × 2 = 160cm<sup>3</sup> O<sub>2</sub>  
Remaining O<sub>2</sub> is 200-160 = 40cm<sup>3</sup>  
From equation, 1V of methane gives 1 V of CO<sub>2</sub>  
So, 80 cm<sup>3</sup> gives 80cm<sup>3</sup> CO<sub>2</sub> and H<sub>2</sub>O is negligible.

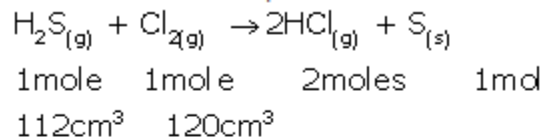
#### Solution 6.



From equation, 2 V of C<sub>2</sub>H<sub>2</sub> requires = 5 V of O<sub>2</sub>  
So, for 400ml C<sub>2</sub>H<sub>2</sub>, O<sub>2</sub> required = 400 × 5/2 = 1000 ml  
Similarly, 2 V of C<sub>2</sub>H<sub>2</sub> gives = 4 V of CO<sub>2</sub>  
So, 400ml of C<sub>2</sub>H<sub>2</sub> gives CO<sub>2</sub> = 400 × 4/2 = 800ml

#### Solution 7.

Balanced chemical equation:



(i) At STP, 1 mole gas occupies 22.4 L.  
As 1 mole H<sub>2</sub>S gas produces 2 moles HCl gas,  
22.4 L H<sub>2</sub>S gas produces 22.4 × 2 = 44.8 L HCl gas.

Hence, 112 cm<sup>3</sup> H<sub>2</sub>S gas will produce 112 × 2 = 224 cm<sup>3</sup> HCl gas.

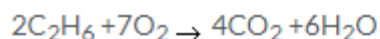
(ii) 1 mole H<sub>2</sub>S gas consumes 1 mole Cl<sub>2</sub> gas.  
This means 22.4 L H<sub>2</sub>S gas consumes 22.4 L Cl<sub>2</sub> gas at STP.

Hence, 112 cm<sup>3</sup> H<sub>2</sub>S gas consumes 112 cm<sup>3</sup> Cl<sub>2</sub> gas.

120 cm<sup>3</sup> - 112 cm<sup>3</sup> = 8 cm<sup>3</sup> Cl<sub>2</sub> gas remains unreacted.

Thus, the composition of the resulting mixture is 224 cm<sup>3</sup> HCl gas + 8 cm<sup>3</sup> Cl<sub>2</sub> gas.

### Solution 8.



2 V 7 V 4 V

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

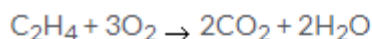
So, 600cc of ethane reacts with =  $600 \times \frac{7}{2} = 2100\text{cc}$

Hence, unused  $\text{O}_2$  is =  $2500 - 2100 = 400\text{ cc}$

From 2V of ethane = 4 V of  $\text{CO}_2$  is produced

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

### Solution 9.



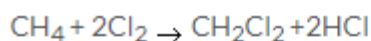
1V 3V

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.



1 V 2 V 1 V 2 V

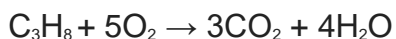
From equation, 1V of  $\text{CH}_4$  gives = 2 V HCl

so, 40 ml of methane gives = 80 ml HCl

For 1V of methane = 2V of  $\text{Cl}_2$  required

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

### Solution 11.

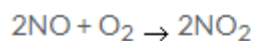


1 V 5 V 3 V

From equation, 5 V of  $\text{O}_2$  required = 1V of propane

so, 100  $\text{cm}^3$  of  $\text{O}_2$  will require = 20  $\text{cm}^3$  of propane

### Solution 12.



From equation, 1V of  $\text{O}_2$  reacts with = 2 V of NO

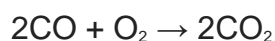
$200\text{cm}^3$  oxygen will react with =  $200 \times 2 = 400\text{cm}^3$  NO

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

$\text{NO}_2$  produced =  $400\text{cm}^3$  because 1V oxygen gives 2 V  $\text{NO}_2$

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

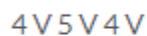
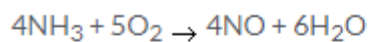
### Solution 13.



2 V of CO requires = 1V of  $\text{O}_2$

so, 100 litres of CO requires = 50 litre of  $\text{O}_2$

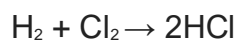
### Solution 14.



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

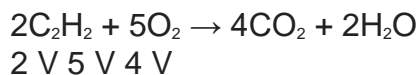
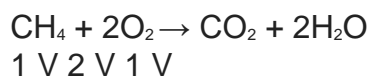
### Solution 15.



Since 1 V hydrogen requires 1 V of oxygen and  $4\text{cm}^3$  of  $\text{H}_2$  remained behind so the mixture had  $16\text{cm}^3$  hydrogen and  $16\text{cm}^3$  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 CH<sub>4</sub> requires oxygen = 2 V O<sub>2</sub>

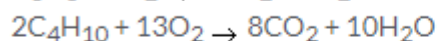
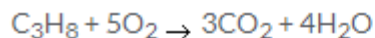
So, 10cm<sup>3</sup> CH<sub>4</sub> will require =20 cm<sup>3</sup> O<sub>2</sub>

Similarly 2 V C<sub>2</sub>H<sub>2</sub> requires = 5 V O<sub>2</sub>

So, 10 cm<sup>3</sup> C<sub>2</sub>H<sub>2</sub> will require = 25 cm<sup>3</sup> O<sub>2</sub>

Now, 20 V O<sub>2</sub> will be present in 100 V air and 25 V O<sub>2</sub> will be present in 125 V air ,so the volume of air required is 225cm<sup>3</sup>

### Solution 17.



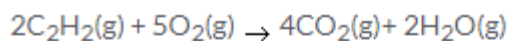
60 ml of propane (C<sub>3</sub>H<sub>8</sub>) gives 3 × 60 = 180 ml CO<sub>2</sub>

40 ml of butane (C<sub>4</sub>H<sub>10</sub>) gives = 8 × 40/2 = 160 ml of CO<sub>2</sub>

Total carbon dioxide produced = 340 ml

So, when 10 litres of the mixture is burnt = 34 litres of CO<sub>2</sub> is produced.

### Solution 18.



4 V CO<sub>2</sub> is collected with 2 V C<sub>2</sub>H<sub>2</sub>

So, 200cm<sup>3</sup> CO<sub>2</sub> will be collected with = 100cm<sup>3</sup> C<sub>2</sub>H<sub>2</sub>

Similarly, 4V of CO<sub>2</sub> is produced by 5 V of O<sub>2</sub>

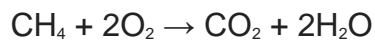
So, 200cm<sup>3</sup> CO<sub>2</sub> will be produced by = 250 ml of O<sub>2</sub>

### 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  $106 - 58 = 48$ 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  $6.023 \times 10^{23}$
- c) The molar volume of a gas at STP is  $22.4 \text{ dm}^3$  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  $22.4 \text{ dm}^3$ .
- (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.  $6.023 \times 10^{23}$  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.

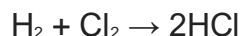
### Solution 3.

(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)  
=  $12.04 \times 10^{23}$

(b) Weight of 0.5 mole of O<sub>2</sub> is =  $32$  (mol. Mass of O<sub>2</sub>)  $\times 0.5 = 16$  g

(c) No. of molecules in 1.8 g H<sub>2</sub>O =  $6.023 \times 10^{23} \times 1.8/18$   
=  $6.023 \times 10^{22}$



(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  $\text{H}_2$  gas =  $2(\text{Mol. Mass}) \times 0.2 = 0.4 \text{ g}$

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

### Solution 6.

Molecular mass of  $\text{H}_2\text{O}$  is 18,  $\text{CO}_2$  is 44,  $\text{NH}_3$  is 17 and  $\text{CO}$  is 28  
So, the weight of 1 mole of  $\text{CO}_2$  is more than the other three.

### Solution 7.

4g of  $\text{NH}_3$  having minimum molecular mass contain maximum molecules.

### Solution 8.

a) No. of particles in 1 mole =  $6.023 \times 10^{23}$   
So, particles in 0.1 mole =  $6.023 \times 10^{23} \times 0.1 = 6.023 \times 10^{22}$

b) 1 mole of  $\text{H}_2\text{SO}_4$  contains =  $2 \times 6.023 \times 10^{23}$   
So, 0.1 mole of  $\text{H}_2\text{SO}_4$  contains =  $2 \times 6.023 \times 10^{23} \times 0.1$   
=  $1.2 \times 10^{23}$  atoms of hydrogen

c) 111g  $\text{CaCl}_2$  contains =  $6.023 \times 10^{23}$  molecules  
So, 1000 g contains =  $5.42 \times 10^{24}$  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  $\text{HCl}$  has mass =  $0.1 \times 36.5$  (mass of 1 mole)  
= 3.65 g
- (c) 0.2 mole of  $\text{H}_2\text{O}$  has mass =  $0.2 \times 18 = 3.6 \text{ g}$
- (d) 0.1 mole of  $\text{CO}_2$  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  $\text{SO}_2$  has volume = 22.4 litres  
So, 2 moles will have =  $22.4 \times 2 = 44.8$  litre

### Solution 11.

- (a) 1 mole of  $\text{CO}_2$  contains  $\text{O}_2 = 32\text{g}$   
So,  $\text{CO}_2$  having 8 gm of  $\text{O}_2$  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)  $6.023 \times 10^{23}$  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 =  $1/6.023 \times 10^{23} = 1.666 \times 10^{-24}$
- (c) 1 molecule of  $\text{NH}_3$  has mass =  $17/6.023 \times 10^{23} = 2.82 \times 10^{-23}$  g
- (d) 1 atom of silver has mass =  $108/6.023 \times 10^{23} = 1.701 \times 10^{-22}$
- (e) 1 molecule of  $\text{O}_2$  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  $\text{CaCO}_3$  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  $\text{CaCl}_2$  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,  $6.023 \times 10^{23}$  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 =  $6.023 \times 10^{23} \times 3.2 / 32$   
=  $0.6023 \times 10^{23}$

So,  $0.6023 \times 10^{23}$  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 =  $6.023 \times 10^{23}$

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 ( $\text{N}_2$ ) = 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  $\text{cm}^3$  of CO has mass = 28 g

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

### Solution 21.

18 g of water has number of molecules =  $6.023 \times 10^{23}$

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  $1.2 \times 10^{22}$  molecules =  $1.2 \times 10^{22} \times 8$

=  $9.635 \times 10^{22}$  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)  $308 \text{ cm}^3$  of chlorine weighs = 0.979 g

So,  $22400 \text{ cm}^3$  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 =  $6.023 \times 10^{23}$

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

=  $5.019 \times 10^{10}$  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)  $6.023 \times 10^{23}$  atoms of C weigh = 12 g

So,  $3 \times 10^{25}$  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  $6.023 \times 10^{23}$  molecules

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

=  $6.02 \times 10^{22}$  molecules

### Solution 30.

The number of molecules in 18 g of ammonia =  $6.02 \times 10^{23}$

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

=  $1.5 \times 10^{23}$

### Solution 31.

(a) One mole of chlorine contains  $6.023 \times 10^{23}$  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  $\text{H}_2\text{O}$

1. That  $\text{H}_2\text{O}$  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  $\text{H}_2\text{O}$  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) CH<sub>2</sub>O (c) CH (d) CH<sub>2</sub>O

### Solution 4.

Relative mol. mass of CuSO<sub>4</sub>·5H<sub>2</sub>O = 63.5 + 32 + (16 × 4) + 5(1 × 2 + 16)  
= 249.5 g

249.5 g of CuSO<sub>4</sub>·5H<sub>2</sub>O contains water of crystallization = 90 g

So, 100 g will contain =  $\frac{90 \times 100}{249.5} = 36.07$  g

So, % of H<sub>2</sub>O = 36.07 × 100 = 36.07 %

### Solution 5.

(a) Molecular mass of Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub> = 234

So, % of P =  $2 \times 31 \times 100 / 234 = 26.5\%$

(b) Molecular mass of Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> = 310

% of P =  $2 \times 31 \times 100 / 310 = 20\%$

### Solution 6.

Molecular mass of KClO<sub>3</sub> = 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  $\text{Fe}_2\text{O}_3$ , Fe = 56 and O = 16

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

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

$\therefore$  mass of Fe in 10000 g of ore =  $56 \times 10000/100$

= 5.6 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 =  $\text{C}_6\text{H}_6$

### 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 =  $\text{NH}_3$



### 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 =  $\text{CHO}_2$

(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 =  $\text{CH}_2\text{Cl}$

(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 =  $28 \times 100/60 = 46.66\%$

### 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  $\text{CH}_2\text{O}$   
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  $\text{A}_2\text{B}_4$ .

(b) Since molecular mass is 2 times the vapour density, so Mol. Mass =  $2 \text{ V.D}$   
Empirical formula weight =  $\text{V.D}/3$   
So,  $n = \text{molecular mass} / \text{Empirical formula weight} = 6$   
Hence, the molecular formula is  $\text{A}_6\text{B}_6$

### 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  $\text{NH}_2$

### 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 =  $65.37 + 32 + 141 + 11 + 16 = 287.37$

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

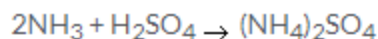
So, 15 g  $\text{CaCO}_3$  will produce =  $164 \times 15/100 = 24.6$  g  $\text{Ca(NO}_3)_2$

(b) 1 V of  $\text{CaCO}_3$  produces 1 V of  $\text{CO}_2$

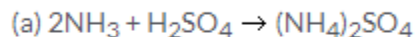
100 g of  $\text{CaCO}_3$  has volume = 22.4 litres

So, 15 g will have volume =  $22.4 \times 15/100 = 3.36$  litres  $\text{CO}_2$

### Solution 3.



66 g



34 g 98 g 132 g

For 132 g  $(\text{NH}_4)_2\text{SO}_4 = 34$  g of  $\text{NH}_3$  is required

So, for 66 g  $(\text{NH}_4)_2\text{SO}_4 = 66 \times 32/132 = 17$  g of  $\text{NH}_3$  is required

(b) 17 g of  $\text{NH}_3$  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  $\text{Pb}_3\text{O}_4$  gives = 834 g of  $\text{PbCl}_2$

Hence, 6.85 g of  $\text{Pb}_3\text{O}_4$  will give =  $6.85 \times 834/685 = 8.34$  g

(b) 685g of  $\text{Pb}_3\text{O}_4$  gives = 71g of  $\text{Cl}_2$

Hence, 6.85 g of  $\text{Pb}_3\text{O}_4$  will give =  $6.85 \times 71/685 = 0.71$  g  $\text{Cl}_2$

(c) 1 V  $\text{Pb}_3\text{O}_4$  produces 1 V  $\text{Cl}_2$

685g of  $\text{Pb}_3\text{O}_4$  has volume = 22.4 litres = volume of  $\text{Cl}_2$  produced

So, 6.85  $\text{Pb}_3\text{O}_4$  will produce =  $6.85 \times 22.4/685 = 0.224$  litres of  $\text{Cl}_2$

### Solution 5.

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

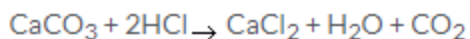
63 g of  $\text{HNO}_3$  is formed by = 101 g of  $\text{KNO}_3$

So, 126000 g of  $\text{HNO}_3$  is formed by =  $126000 \times 101/63 = 202$  kg

Similarly, 126 g of  $\text{HNO}_3$  is formed by 170 kg of  $\text{NaNO}_3$

So, smaller mass of  $\text{NaNO}_3$  is required.

### Solution 6.



100g 73g 22.4L

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

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

$$V_1/T_1 = V_2/T_2$$

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

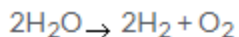
Now at STP 22.4 litres of  $\text{CO}_2$  are produced using  $\text{CaCO}_3 = 100\text{g}$

So,  $\left[ \frac{2 \times 273}{300} \right]$  litres are produced by  $= 100 / 22.4 \times 2274 / 300 = 1.25\text{g}$

(b) 22.4 litres of  $\text{CO}_2$  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  $\text{H}_2\text{O}$  gives = 1 mole of  $\text{O}_2$

So, 1 mole of  $\text{H}_2\text{O}$  will give = 0.5 moles of  $\text{O}_2$

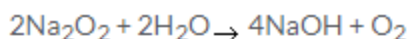
so, mass of  $\text{O}_2$  = no. of moles  $\times$  molecular mass

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

and 1 mole of  $\text{O}_2$  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  $\text{Na}_2\text{O}_2$  gives = 160 g of NaOH ( $4 \times 40 \text{ g}$ )

So, 1.56 g  $\text{Na}_2\text{O}_2$  will give  $= 160 \times 1.56 / 156 = 1.6 \text{ g}$

(b) 156 g  $\text{Na}_2\text{O}_2$  gives = 22.4 litres of oxygen

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

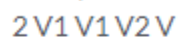
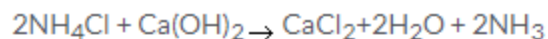
$$= 224 \text{ cm}^3$$

(c) 156 g  $\text{Na}_2\text{O}_2$  gives = 32 g  $\text{O}_2$

So, 1.56 g  $\text{Na}_2\text{O}_2$  will give  $= 32 \times 1.56 / 156$

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

### Solution 9.



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

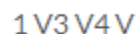
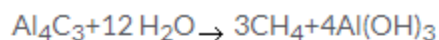
(a)  $107 \text{ g NH}_4\text{Cl}$  gives =  $34 \text{ g NH}_3$

So,  $21.4 \text{ g NH}_4\text{Cl}$  will give =  $21.4 \times 34/107 = 6.8 \text{ g NH}_3$

(b) The volume of  $17 \text{ g NH}_3$  is  $22.4 \text{ litre}$

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

### Solution 10.

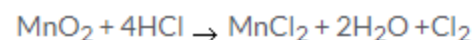


$144 \text{ g} \times 22.4 \text{ l/volume}$

Now, since  $144 \text{ g}$  of  $\text{Al}_4\text{C}_3$  gives =  $3 \times 22.4 \text{ litre}$  of  $\text{CH}_4$

So,  $14.4 \text{ g}$  of  $\text{Al}_4\text{C}_3$  will give =  $3 \times 22.4 \times 14.4 / 144 = 6.72 \text{ litres CH}_4$

### Solution 11.



(a) 1 mole of  $\text{MnO}_2$  weighs =  $87 \text{ g}$  (mol. Mass)

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

(b) 1 mole  $\text{MnO}_2$  gives = 1 mole of  $\text{MnCl}_2$

So,  $0.02 \text{ mole MnO}_2$  will give =  $0.02 \text{ mole of MnCl}_2$

(c) 1 mole  $\text{MnCl}_2$  weighs =  $126 \text{ g}$  (mol mass)

So,  $0.02 \text{ mole MnCl}_2$  will weigh =  $126 \times 0.02 \text{ g} = 2.52 \text{ g}$

(d)  $0.02 \text{ mole MnO}_2$  will form =  $0.02 \text{ mole of Cl}_2$

(e) 1 mole of  $\text{Cl}_2$  weighs =  $71 \text{ g}$

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

(f) 1 mole of chlorine gas has volume =  $22.4 \text{ litres}$

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

(g) 1 mole  $\text{MnO}_2$  requires  $\text{HCl} = 4 \text{ mole}$

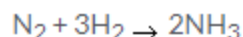
So,  $0.02 \text{ mole MnO}_2$  will require =  $4 \times 0.02 = 0.08 \text{ mole}$

(h) For 1 mole  $\text{MnO}_2$ , acid required = 4 mole of  $\text{HCl}$

So, for  $0.02 \text{ mole}$ , 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  $\text{H}_2$

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

2000g of  $\text{N}_2$  forms  $\text{NH}_3$

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

= 2428.6g

### Miscellaneous Exercise

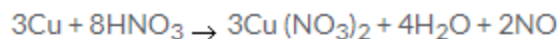
#### Solution 1.

From equation:  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

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  $\text{HNO}_3$ , Cu required is = 192 g

So, for 63g  $\text{HNO}_3$  Cu required =  $192 \times \frac{63}{504} = 24\text{g}$

(b) 504 g of  $\text{HNO}_3$  gives =  $2 \times 22.4$  litre volume of NO

So, 63g of  $\text{HNO}_3$  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  $\text{Cl}_2$  at STP = 22.4 litres

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

(c)  $22400\text{cm}^3$  volume have mass = 28 g of CO (molar mass)

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



#### Solution 4.

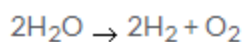
$$\% \text{ of N in NaNO}_3 = \frac{14}{85} \times 100 = 16.47\%$$

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

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

So, highest percentage of N is in urea.

#### Solution 5.



(a) From equation, 2 V of water gives 2 V of H<sub>2</sub> and 1 V of O<sub>2</sub>

where 2 V = 2500 cm<sup>3</sup>

so, volume of O<sub>2</sub> liberated = 2V/V = 1250 cm<sup>3</sup>

(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 = 23.33kg

### 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 =  $15(V.D) \times 2 = 30$  g

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

### Solution 8.

$22400\text{cm}^3$   $CO_2$  has mass = 44g

so,  $224\text{cm}^3$   $CO_2$  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 =  $0.44 - 0.32 = 0.12\text{g} = 0.01\text{g atom}$

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  $CO_2 = 0.44/44 = 0.01$  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 =  $\frac{24}{88} \times 100 = 27.3\%$

% of oxygen in the compound =  $\frac{64}{88} \times 100 = 72.7\%$

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

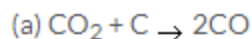
So simplest formula =  $XO_2$

### Solution 10.

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

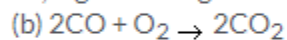
$$(b) \text{Molecular mass} = 17(\text{V.D}) \times 2 = 34\text{g}$$

### Solution 11.



12 g of C gives = 44.8 litre volume of CO

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



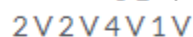
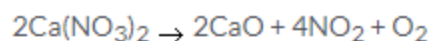
(i) 2 V CO requires oxygen = 1 V

so, 24 cm<sup>3</sup> CO will require = 24/2 = 12 cm<sup>3</sup>

(ii) 2 x 22400 cm<sup>3</sup> CO gives = 2 x 22400 cm<sup>3</sup> CO<sub>2</sub>

so, 24cm<sup>3</sup> CO will give = 24 cm<sup>3</sup> CO<sub>2</sub>

### Solution 12.



(a) 56 g of CaO is obtained with NO<sub>2</sub> = 2 x 22.4 litre of NO<sub>2</sub>

So, 5.6g of CaO is obtained with NO<sub>2</sub> = 2 x 22.4 x 5.6/56

= 4.48 litre

(b) 56 g of CaO is obtained by = 164 g Ca(NO<sub>3</sub>)<sub>2</sub>

So, 5.6 g CaO is obtained by = 5.6 x 56/164 g Ca(NO<sub>3</sub>)<sub>2</sub>

= 16.4 g of Ca(NO<sub>3</sub>)<sub>2</sub> is heated.

### Solution 13.

(a) Number of molecules in 100cm<sup>3</sup> 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 cm<sup>3</sup> of nitrogen under the same conditions of temperature and pressure = Y

So, number of molecules in 50 cm<sup>3</sup> 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  $\text{CH}_3$

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

V.D = 30

Molecular formula mass = V.D  $\times$  2 = 60

Hence, n = mol. Formula mass/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 = 5.6g + 21.3g = 26.9g

% of silicon in the compound =  $5.6/26.9 \times 100 = 20.82\%$

% of chlorine in the compound =  $21.3/26.9 \times 100 = 79.18\%$

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 =  $\text{SiCl}_3$

#### 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  $\text{PH}_2\text{O}_3$  or  $\text{H}_2\text{PO}_3$

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  $\text{Cl}_2$  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  $\text{H}_2$  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  $\text{O}_2$

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  $\text{CO}_2$  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  $\text{AgCl}$  is produced from = 58.5 g of  $\text{NaCl}$

so, 1.435 g of  $\text{AgCl}$  is formed by = 0.585 g of  $\text{NaCl}$

% 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.

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

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

$136.5 \text{ cm}^3$  of the gas weigh = 0.546

$$22400 \text{ cm}^3 \text{ of the gas weight} = \frac{0.546 \times 22400}{136.5} = 89.6 \text{ a.m.u}$$

Relative molecular mass = 89.6 a.m.u

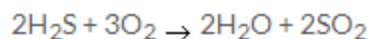
### Solution 24.

(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 =  $100 \times \frac{63}{252} = 25 \text{ g}$

(b) If 252 g of ammonium dichromate produces  $\text{Cr}_2\text{O}_3 = 152 \text{ g}$

So, 63 g ammonium dichromate will produce =  $63 \times \frac{152}{252} = 38 \text{ g}$

**Solution 25.**

128 g of  $\text{SO}_2$  gives =  $2 \times 22.4$  litres volume

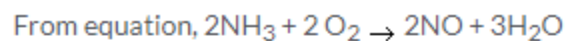
So, 12.8 g of  $\text{SO}_2$  gives =  $2 \times 22.4 \times 12.8/128$

= 4.48 litre volume

Or one can say 4.48 litres of hydrogen sulphide.

$2 \times 22.4$  litre  $\text{H}_2\text{S}$  requires oxygen =  $3 \times 22.4$  litre

So, 4.48 litres  $\text{H}_2\text{S}$  will require = 6.72 litre of oxygen

**Solution 26.**

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,  $\text{N}_2$  removed = 20 kg

So, in 10 hectare  $\text{N}_2$  removed = 200 kg

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

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

So, 200000 g of  $\text{N}_2$  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 g

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

(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)  $112\text{cm}^3$  of gaseous fluoride has mass = 0.63 g

so,  $22400\text{cm}^3$  will have mass =  $0.63 \times 22400/112$   
= 126 g

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

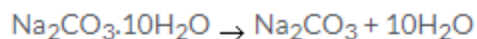
$$126 = 31 + \text{At. Mass of F}$$

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 =  $\text{PF}_5$

### 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 =  $\text{MCl}_3$

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

So,  $n = 2$

So, molecular formula =  $\text{M}_2\text{Cl}_6$

### 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  $\text{SO}_2 = x/4$

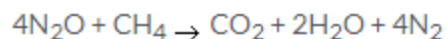
This is because of Avogadro's law which states Equal volumes of all gases, under similar conditions of temperature and pressure, contain equal number of molecules.

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  $\text{cm}^3$  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  $\text{O}_2$  and  $\text{N}_2$  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  $\text{CO}_2$

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  $(\text{NH}_4)_2\text{PtCl}_6$

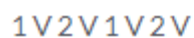
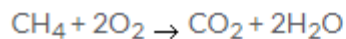
% of Pt =  $(195/444) \times 100 = 43.91\%$  or 44%

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

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

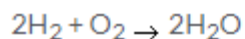
simple ratio of O =  $39/16 = 2.43 = 4$

So, the empirical formula is  $\text{Na}_3\text{PO}_4$

**Solution 36.**

From equation:

22.4 litres of methane requires oxygen = 44.8 litres  $\text{O}_2$



From equation,

44.8 litres hydrogen requires oxygen = 22.4 litres  $\text{O}_2$

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 =  $6.02 \times 10^{23}$  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 =  $6.02 \times 10^{23}$

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 =  $6.02 \times 10^{23}$

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

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

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

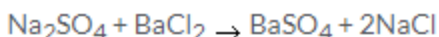
Since  $8M/71 < M/8 < 2M/11 < M/4 < 4M$

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  $\text{BaSO}_4$  is produced by  $\text{Na}_2\text{SO}_4 = 142 \text{ g}$

So, 6.99 g  $\text{BaSO}_4$  will be produced by  $= 6.99 \times 142/233 = 4.26$

The percentage of  $\text{Na}_2\text{SO}_4$  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 =  $1.32 \times 24$

$= 31.6$  or 32 g



316 g of  $\text{KMnO}_4$  gives oxygen = 24 litres

So, 15.8 g of  $\text{KMnO}_4$  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  $\text{SO}_2$ , 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  $\text{SO}_2$  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.

$$V_1/V_2 = n_1/n_2$$

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

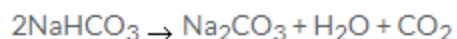
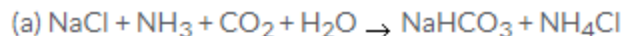
$$\text{So, } V_2 = 2V_1$$

(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 =  $6 \times 10^{23}$  because according to mole concept 22.4 litre volume at STP has =  $6 \times 10^{23}$  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  $\text{Na}_2\text{CO}_3$  is produced by = 168 g of  $\text{NaHCO}_3$

So, 21.2 g of  $\text{Na}_2\text{CO}_3$  will be produced by =  $168 \times 21.2/106$

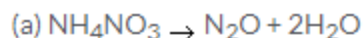
= 33.6 g of  $\text{NaHCO}_3$

(b) For 84 g of  $\text{NaHCO}_3$ , required volume of  $\text{CO}_2 = 22.4 \text{ litre}$

So, for 33.6 g of  $\text{NaHCO}_3$ , 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  $\text{NH}_4\text{NO}_3$

So, 8.96 litres will be produced by =  $22.4 \times 8.96/44.8$

= 4.48 litres of  $\text{NH}_4\text{NO}_3$

So, 4.48 litres of  $\text{N}_2\text{O}$  is produced.

(i) 44.8 litre  $\text{H}_2\text{O}$  is produced by = 80 g of  $\text{NH}_4\text{NO}_3$

So, 8.96 litre  $\text{H}_2\text{O}$  will be produced by =  $80 \times 8.96/44.8$

= 16g  $\text{NH}_4\text{NO}_3$

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

### Solution 44.

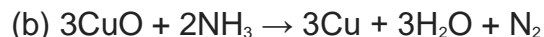
(a) Element % Atomic mass Atomic ratio Simple ratio

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  $\text{K}_2\text{BeF}_4$



3 V 2 V 3 V 1V

3 x 80 g of CuO reacts with = 2 x 22.4 litre of  $\text{NH}_3$

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

2 V 1 V 2 V

1 mole of  $\text{O}_2$  has volume = 22400 ml

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

So, Vol. of  $\text{O}_2$  used by 560 ml CO =  $22400 \times 560 / (2 \times 22400)$

= 280 ml

So, Volume of  $\text{CO}_2$  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 × 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

∴ 1 volume of acetylene requires 2.5 volume of oxygen to burn it

∴ 200 cm<sup>3</sup> requires 2.5 × 200 = 500 cm<sup>3</sup> of oxygen

2 volume of acetylene on combustion gives 4 CO<sub>2</sub>

∴ 1 volume of acetylene on combustion gives 2 CO<sub>2</sub>

∴ 200 cc of acetylene on combustion will give 200 × 2 = 400 cc of CO<sub>2</sub>

ii. Hydrogen = 12.5%

∴ 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<sub>2</sub>

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 NH<sub>2</sub>  
= N<sub>2</sub>H<sub>4</sub>

c.

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

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

2. Volume of nitrogen at stp

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

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

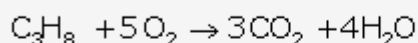
### Solution 48.

a.

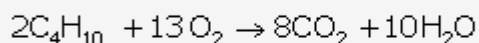
i. 10 litres of LPG contains

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

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



$$\begin{array}{ccc} 1 \text{ vol.} & & 3 \text{ vol.} \\ 6 \text{ L} & & 18 \text{ L} \end{array}$$



$$\begin{array}{ccc} 2 \text{ vol.} & & 8 \text{ vol.} \\ 4 \text{ L} & & 16 \text{ L} \end{array}$$

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

ii. Molecular mass of NH<sub>4</sub>(NO<sub>3</sub>) = 80

H=1, N=14, O=16

% of Nitrogen

As 80 g of NH<sub>4</sub>(NO<sub>3</sub>) contains 28 g of nitrogen

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

% of Oxygen

As, 80 g of NH<sub>4</sub>(NO<sub>3</sub>) contains 48 g of oxygen

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

b.

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



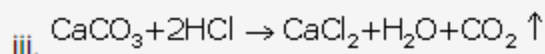
ii. Relative molecular mass of calcium carbonate = 100

Mass of 4.5 moles of calcium carbonate

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

$$= 4.5 \times 100$$

$$= 450\text{g}$$



As, 100g of calcium carbonate gives  $22.4\text{dm}^3$  of  $\text{CO}_2$

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

$$= 100.8\text{ L}$$

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

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

$$= 328.5\text{g}$$

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

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

$$= 9$$

$$= 9\text{ moles}$$

### 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  $\text{SO}_2 = 22.4 \text{ dm}^3$

Then, 320 g of  $\text{SO}_2 = \frac{320 \times 22.4}{64}$   
= 112 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  $5 \times 22.4$  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.

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 =  $\text{CH}_2\text{Br}$

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

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

$n = 2$

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

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

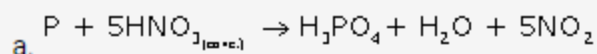
$10^{22}$  atoms of sulphur will have mass =  $\frac{32 \times 10^{22}}{6.022 \times 10^{23}}$   
= 0.533 g

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  $(0.3 \times 98)$  gm of phosphoric acid  
= 29.4 gm of phosphoric acid

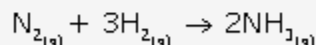
iii. 1 mole of phosphorus gives 112 L of  $\text{NO}_2$  gas at STP.  
So, 0.3 mole of phosphorus gives  $(112 \times 0.3)$  L of

$\text{NO}_2$  gas at STP.

= 33.6 L of  $\text{NO}_2$  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.  $5.6 \text{ dm}^3$  of gas weighs 12 g

1  $\text{dm}^3$  of gas weighs =  $(12/56)$  gm

$22.4 \text{ dm}^3$  of gas weighs =  $(12/56 \times 22.4)$  gm = 48g

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

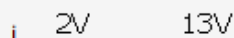
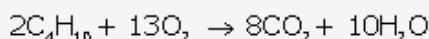
iii. Molar mass of  $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$

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

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

### Solution 51.

a.



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

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

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

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

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

That is,

16 g of gas occupies volume = 22.4 litres

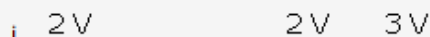
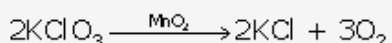
So, 24 g of gas will occupy volume

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

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.



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

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

So, 6.72 litres of oxygen will require  $KClO_3$

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

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

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

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  $O_2$

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

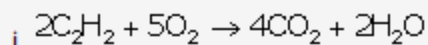
$$= 1.806 \times 10^{23}$$

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

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

$= 4.2 \text{ dm}^3$  of  $\text{C}_2\text{H}_2$

ii. Empirical formula =  $\text{X}_2\text{Y}$

Atomic weight (X) = 10

Atomic weight (Y) = 5

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

$= 25$

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

$= 2$

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

$= \text{X}_4\text{Y}_2$

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 =  $22.4 \text{ dm}^3$

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

4 moles =  $24.092 \times 10^{23}$  molecules

### Solution 42.

The formula of aluminium nitride is  $\text{AlN}$ .

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

$$\text{C } 4.8 \quad 12 \quad \frac{4.8}{12} = 0.41$$

$$\text{Br } 95.2 \quad 80 \quad \frac{95.2}{80} = 1.23$$

So, empirical formula is  $\text{CBr}_3$

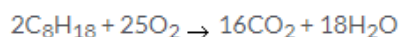
(ii) Empirical formula mass =  $12 + 3 \times 80 = 252 \text{ g}$

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

$$n = 504/252 = 2$$

so, molecular formula =  $\text{C}_2\text{Br}_6$

### Solution 49.



$$2 \text{ V } 25 \text{ V } 16 \text{ V } 18 \text{ V}$$

(i) 2 moles of octane gives = 16 moles of  $\text{CO}_2$

so, 1 mole octane will give = 8 moles of  $\text{CO}_2$

(ii) 1 mole  $\text{CO}_2$  occupies volume = 22.4 litre

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

(iii) 1 mole  $\text{CO}_2$  has mass = 44 g

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

(iv) Empirical formula is  $\text{C}_4\text{H}_9$ .

### 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 =  $\text{CHCl}_2$

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

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

196 g of  $\text{H}_2\text{SO}_4$  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  $\text{H}_2\text{SO}_4$  occupies volume =  $2 \times 22.4 \text{ litres}$

So, 49 g  $\text{H}_2\text{SO}_4$  will occupy =  $2 \times 22.4 \times 49/196 = 11.2 \text{ litre}$

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