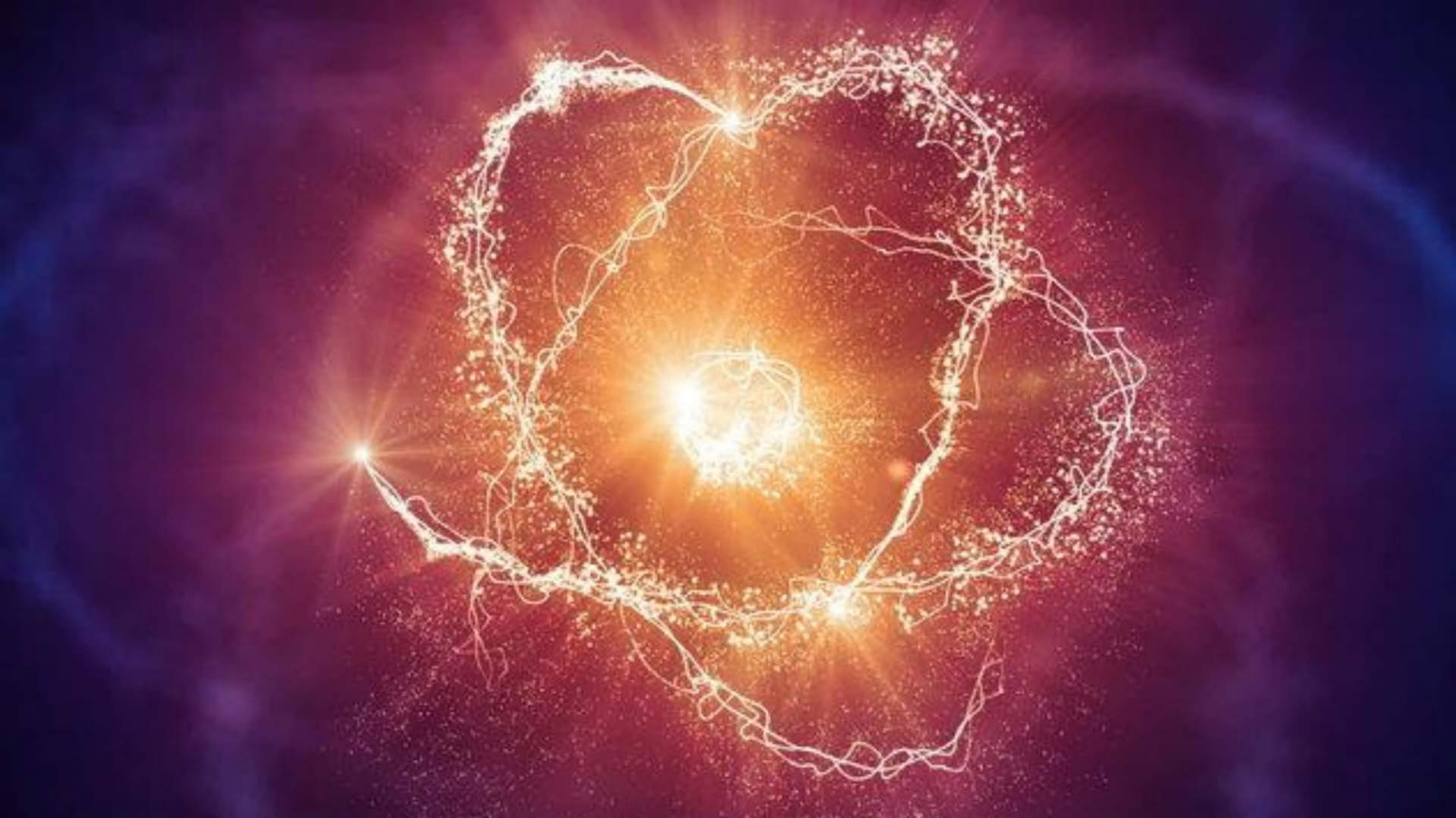


CONTENTS

we use the word formula unit for those substances whose constituent particles are ions. For example, sodium chloride as discussed above, has a formula unit NaCl. Its formula unit mass can be calculated as–

$$1 \times 23 + 1 \times 35.5 = 58.5 \text{ u}$$

Example 3.2 Calculate the formula unit mass of $CaCl_2$.

Solution:

Atomic mass of Ca
+ (2 × atomic mass of Cl)
= 40 + 2 × 35.5 = 40 + 71 = 111 u

Questions

1. *Calculate the molecular masses of H_2, O_2, Cl_2, CO_2, CH_4, C_2H_6, C_2H_4, NH_3, CH_3OH.*
2. *Calculate the formula unit masses of ZnO, Na_2O, K_2CO_3, given atomic masses of Zn = 65 u, Na = 23 u, K = 39 u, C = 12 u, and O = 16 u.*

3.5.3 Mole concept

imp Concept

Take an example of the reaction of hydrogen and oxygen to form water:

$$2H_2 + O_2 \rightarrow 2H_2O.$$

The above reaction indicates that

(i) two molecules of hydrogen combine with one molecule of oxygen to form two molecules of water, or

(ii) 4 u of hydrogen molecules combine with 32 u of oxygen molecules to form 36 u of water molecules.

We can infer from the above equation that the quantity of a substance can be characterised by its mass or the number of molecules. But, a chemical reaction equation indicates directly the number of atoms or molecules taking part in the reaction. Therefore, it is more convenient to refer to the quantity of a substance in terms of the number of its molecules or atoms, rather than their masses. So, a new unit "mole" was introduced. One mole of any species (atoms,

Molecular Mass आणविक द्रव्यमान

molecular mass = Molar mass = Formula mass

- The molecular mass of a substance is the sum of the **Atomic Masses Of All The Atoms In A Molecule** of that substance. It is expressed in **Atomic Mass Units (u)** किसी पदार्थ का आणविक द्रव्यमान उस पदार्थ के अणु में उपस्थित सभी परमाणुओं के परमाणु द्रव्यमानों का योग होता है। इसे परमाणु द्रव्यमान इकाइयों (u) में व्यक्त किया जाता है।

H = 1 gram

O = 16 gram

(1)

(a) Calculate the relative molecular mass of water (H_2O). $\Rightarrow (2\times1+16) = 2+16 = 18$ gram $\Rightarrow$ 18 u

(b) Calculate the molecular mass of HNO_3. $(1+14+3\times16) = (1+14+48) = 63$ gram (u) → a.m.u

63 u

Calculate the molar mass of the following substances.

(a) Ethyne, C_2H_2 —— $(12\times2+1\times2)=(24+2)=26\,g$

(b) Sulphur molecule, S_8 —— $(32\times8)=256\,g$

(c) Phosphorus molecule, P_4 (Atomic mass of phosphorus = 31) $=(31\times4)$

$\Rightarrow 124\,g$

(d) Hydrochloric acid, HCl —— $(1+35.5\,g)\Rightarrow$ 36.5 g

(e) Nitric acid, HNO_3 —— $(1+14+16\times3)$

$(1+14+48)\Rightarrow$ 63 gram

Molar mass of C = 12g

Molar mass of H = 1g

Molar mass of S = 32g

Molar mass of P = 31g

Molar mass of Cl = 35.5g

Molar mass of N = 14g

Molar mass of O = 16g

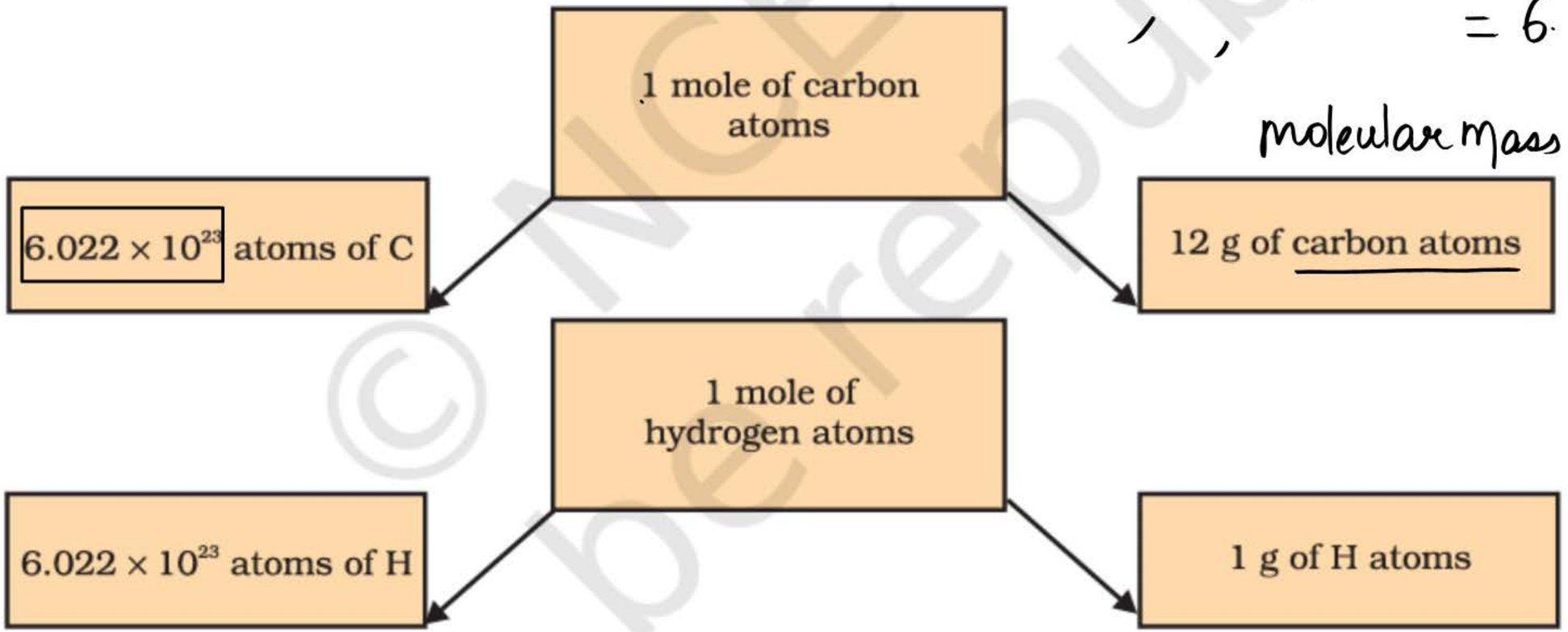
Mole Concept

One mole is the **amount of substance that contains the same number of particles** (atoms/ ions/ molecules/ formula units etc.) **as there are atoms in exactly 12 g of Carbon-12** . एक मोल पदार्थ की वह मात्रा है जिसमें कणों (परमाणु/आयन/अणु/सूत्र इकाइयाँ आदि) की संख्या उतनी ही होती है जितनी कार्बन-12 के ठीक 12 ग्राम में परमाणु होते हैं

$1C = 12\,gram = 1\,mole$

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

molecular mass



Lorenzo Romano Amedeo Carlo Avogadro (1776-1856)

He is known for the Avogadro's hypothesis. In honour of his contributions, the number of fundamental particles in a mole of substance was named as Avogadro number. Though Avogadro didn't predict the number of particles in equal volumes of gas, his hypothesis did lead to the eventual determination of the number as 6.022×10^{23} Rudolf Clausius, with his kinetic theory of gases, provided evidence for Avogadro's law.

One mole (1 mol) of a substance contains 6.02×10^{23} particles of the substance.

आवेगाद्रो नियंताक

The number 6.02×10^{23} is called the Avogadro Constant.

Number of moles	$\times 6.02 \times 10^{23}$ →	Number of particles
	← $\div 6.02 \times 10^{23}$	

$1\ mole = 6.022 \times 10^{23}$

Fix

- 1 mole of Carbon atoms = 6.022×10^{23} Carbon atoms
- 1 mole of Sodium atoms = 6.022×10^{23} Sodium atoms
- 1 mole of Hydrogen ions = 6.022×10^{23} Hydrogen ions (atom / molecule)
- 1 mole of molecules of Water = 6.022×10^{23} molecules of Water
- 0.5 mole of Carbon atoms = 3.011×10^{23} atoms of Carbon

important formula

η = Mole's Number
मोल संख्या

$1\eta = 6.022 \times 10^{23}$

$$\eta = \frac{\text{Mass (द्रव्यमान)} \quad m}{\text{molar Mass}\left(\begin{matrix}\text{आण्विक} \\ \text{द्रव्यमान}\end{matrix}\right) \quad M}$$

$$\eta = \frac{m}{M}$$

Which of the following correctly represents 360 g of water? निम्नलिखित में से कौन सा 360 ग्राम जल को सही ढंग से दर्शाता है?

(i) 2 moles of H_20 ✗

(ii) 20 moles of water (✓)

(iii) 6.022×10^{23} molecules of water ✗

(iv) 1.2044×10^{25} molecules of water (✓)

(a) (i)

(b) (i) and (iv)

(c) (ii) and (iii)

(d) (ii) and (iv) सही (✓)

$$n = \frac{m}{M} = \frac{360}{18}$$

$$n = 20 \text{ moles}$$

$m = 360$ gram

$M = (H_2O) = 1 \times 2 + 16$

$= 18$ gram.

1 mole $= 6.022 \times 10^{23}$ molecule

20 mole $= 20 \times 6.022 \times 10^{23}$ molecule

$= 1.2044 \times 10^{25}$ molecule

चमक

Which of the following would weigh the highest? निम्नलिखित में से किसका वजन सबसे अधिक होगा?

$\eta = \frac{m}{M}$ — द्रव्यमान

M → molecular Mass

$m = n \times M$

(a) 0.2 mole of sucrose ($C_{12}H_{22}O_{11}$) $(M) = (12\times12 + 1\times22 + 16\times11)$

$= 342$ gram

$m = \eta \times M$

$m = 0.2 \times 342 = 68.4$ gram

(b) 2 moles of CO_2 — $M = (12+16\times2) = 44$ gm

$m = n \times M = 2\times44$

$= 88$ gm

सत्य ✓

(c) 2 moles of $CaCO_3$

$M = (40+12+48) = 100$ gm, $m = n \times M = 2\times100$

$= 200$ gm

(d) 10 moles of H_2O

$M = H_2O = (2+16) = 18$ gm, $m = n \times M = 10\times18 = 180$ gram

NCERT- Exemplar

Which of the following has maximum number of atoms? निम्नलिखित में से किसमें परमाणुओं की संख्या अधिकतम है?

$$\text{No of atom} = \frac{m \times \text{No of atom}}{M}$$

(a) 18g of H_2O ⟶ $18 \times \frac{3}{18} = 3$

(b) 18g of O_2 ⟶ $18 \times \frac{2}{32} = 1.12$

(c) 18g of CO_2 ⟶ $18 \times \frac{3}{44} = 1.23$

(d) 18g of CH_4 ⟶ $18 \times \frac{5}{16} = 5.63$ सत्य

Concept

$$\eta = \frac{m}{M}$$

$$\eta = \frac{No}{NA}$$

$$\frac{m}{M} = \frac{No}{NA}$$

m = Mass

M = Molecular Mass

No = No of atom

NA = Avagadra No

η = Moles (मोल)

formula

$$No = \frac{m}{m} \times NA$$

Give the chemical formulae for the following compounds and compute the ratio by mass of the combining elements in each one of them. निम्नलिखित यौगिकों के रासायनिक सूत्र दीजिए तथा उनमें से प्रत्येक में संयोजन करने वाले तत्वों का द्रव्यमान अनुपात ज्ञात कीजिए।

(A) Ammonia / अमोनिया —— NH_3 —— 14 : 3

(B) Carbon Monoxide / कार्बन मोनोआक्साइड —— CO —— 12 : 16 ⇒ 3 : 4

(C) Hydrogen Chloride / हाइड्रोजन क्लोराइड —— HCl —— 1 : 35.5 ⇒ 2 : 71

(D) Aluminium Fluoride / एल्युमिनियम फ्लोराइड —— AlF_3 —— 27 : 57 ⇒ 9 : 19

(E) Magnesium Sulphide / मैग्नीशियम सल्फाइड —— MgS —— 24 : 32 ⇒ 3 : 4

निम्न में से किस यौगिक में सबसे अधिक परमाणु होते हैं?

Which of the following compounds contains the largest number of atoms?

(a) HNO_2 ——— 4

(b) H_2SO_4 ═══ 7

(c) CO_2 ——— 4

(d) $Ca(OH)_2$ ═══ 5

CaO_2H_2

NH_4NO_3 में नाइट्रोजन का प्रतिशत कितना होता है?

What is the percentage of nitrogen in NH_4NO_3?

(a) 35%

(b) 30%

(c) 40%

(d) 25%

NH_4NO_3

$(14+4+14+48)$

$\Rightarrow$ 80 gram

$$\% \text{ of } N = \frac{28}{80} \times 100$$

CO_2 में C और O_2, द्रव्यमान द्वारा अनुपात _____ में मौजूद हैं।

C and O_2 in CO_2 are present in the ratio _____ by mass.

C : O_2

12 : 32

3 : 8

(a) 3:8

(b) 8:3

(c) 14:3

(d) 3:14

ऑक्सीजन के एक अणु का द्रव्यमान है-

The mass of one molecule of oxygen is-

(a) 2.3×10^{-23} gm

(b) 3.3×10^{-23} gm

(c) 4.3×10^{-23} gm

(d) 5.3×10^{-23} gm

1 mole = O_2

1 mole = 32 gram = 6.022×10^{23} molecule

1 molecule = $\frac{32}{6.022 \times 10^{23}} = 5 \times 10^{-23}$

मैग्नीशियम के 144 ग्राम में, ... ग्राम परमाणु मौजूद होते हैं।

In 144 grams of magnesium, ... grams of atoms are present.

(a) 32

(b) 6

(c) 144

(d) 64

$$\eta = \frac{m}{M}$$

$$\eta = \frac{144}{24}$$

$$\eta = 6$$

कार्बन का परमाणु द्रव्यमान 12 है। कार्बन के 24 g में अणुओं की संख्या होगी-

The atomic mass of carbon is 12. The number of molecules in 24 g of carbon will be-

(a) 2

(b) 1

(c) 3

(d) 4

$$\eta = \frac{m}{M}$$

$$\eta = \frac{24}{12}$$

$$\eta = 2$$

topic खत्म

atomic structure