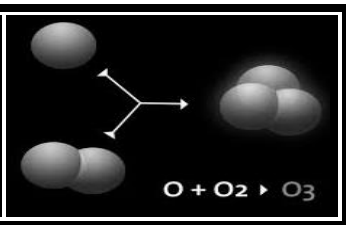
UNIT – 7
ATOMS AND MOLECULES



I. Choose the best answer

1. Which of the following has the smallest mass?

   a) 6.023×10^{23} atoms of He **b) 1 atom of He** c) 2 g of He d) 1 mole atoms of He

2. Which of the following is a triatomic molecule? **[MDL – 19, PTA – 1]**

   a) Glucose b) Helium **c) Carbon dioxide** d) Hydrogen

3. The volume occupied by 4.4 g of CO_2 at S.T.P

   a) 22.4 litre **b) 2.24 litre** c) 0.24 litre d) 0.1 litre

4. Mass of 1 mole of Nitrogen atom is

   a) 28 amu b) 14 amu c) 28 g **d) 14 g**

5. Which of the following represents 1 amu?

   a) Mass of a C – 12 atom b) Mass of a hydrogen atom

   c) $\frac{1}{12}$th of the mass of a C – 12 atom d) Mass of O – 16 atom

6. Which of the following statement is incorrect?

   a) One gram of C – 12 contains Avogadro's number of atoms.

   b) One mole of oxygen gas contains Avogadro's number of molecules.

   c) One mole of hydrogen gas contains Avogadro's number of atoms.

   d) One mole of electrons stands for 6.023×10^{23} electrons.

7. The volume occupied by 1 mole of a diatomic gas at S.T.P is

   a) 11.2 litre b) 5.6 litre **c) 22.4 litre** d) 44.8 litre

8. In the nucleus of $_{20}Ca^{40}$, there are

   a) 20 protons and 40 neutrons **b) 20 protons and 20 neutrons**

   c) 20 protons and 40 electrons d) 40 protons and 20 electrons

9. The gram molecular mass of oxygen molecule is **[AUG - 2022]**

   a) 16 g b) 18 g **c) 32 g** d) 17 g

10. 1 mole of any substance contains ____molecules.

    a) 6.023×10^{23} b) 6.023×10^{-23} c) 3.0115×10^{23} d) 12.046×10^{23}

II. Fill in the blanks

1. Atoms of different elements having **same** mass number, but **different** atomic numbers are called isobars.
2. Atoms of different elements having same number of **neutrons** are called isotones. **[PTA – 4]**
3. Atoms of one element can be transmuted into atoms of other element by **artificial transmutation**.
4. The sum of the numbers of protons and neutrons of an atom is called its **mass number**.
5. Relative atomic mass is otherwise known as **standard atomic weight**.
6. The average atomic mass of hydrogen is **1.008** amu.
7. If a molecule is made of similar kind of atoms, then it is called **homo** atomic molecule.
8. The number of atoms present in a molecule is called its **atomicity**. **[PTA – 4]**
9. One mole of any gas occupies **22400** ml at S.T.P.
10. Atomicity of phosphorous is **4**.

III. Match the following

Column I	Column II	Answer	*Hint :* No. of moles = $\frac{\text{Mass}}{\text{Atomic/molecular mass}}$
1. 8g of O_2	4 moles	1) 0.25 moles	1) 8g of $O_2 = \frac{8}{32} = 0.25$ moles
2. 4g of H_2	0.25 moles	2) 2 moles	2) 4g of $H_2 = \frac{4}{2} = 2$ moles
3. 52 g of He	2 moles	3) 13 moles	3) 52 g of He $= \frac{52}{4} = 13$ moles
4. 112 g of N_2	0.5 moles	4) 4 moles	4) 112 g of $N_2 = \frac{112}{28} = 4$ moles
5. 35.5 g of Cl_2	13 moles	5) 0.5 mole	5) 35.5 g of $Cl_2 = \frac{35.5}{71} = 0.5$ moles

IV. True or False: (if false give the correct statement)

1. Two elements sometimes can form more than one compound. **[True]**
2. Noble gases are diatomic. **[False]**
   Noble gases are **monoatomic.*
3. The gram atomic mass of an element has no unit. **[False]**
   ** The **relative** atomic mass of an element has no unit.*
4. 1 mole of Gold and Silver contain same number of atoms. **[True]**
5. Molar mass of CO_2 is 42g. **[False]**
   ** Molar mass of CO_2 = 12+(16 × 2) = **44 g**.*

V. Assertion & Reason

Answer the following questions using the data given below:

i) A and R are correct, R explains the A. ii) A is correct, R is wrong.
iii) A is wrong, R is correct. iv) A and R are correct, R does not explains A.

1. **Assertion:** The Relative Atomic mass of aluminium is 27.
   Reason : An atom of aluminium is 27 times heavier than $\frac{1}{12}$th of the mass of the C – 12 atom.
   Ans. (iv) ***A and R are correct, R does not explains A.***
2. **Assertion:** The Relative Molecular Mass of Chlorine is 35.5 a.m.u. **[PTA – 3]**
   Reason : The natural abundance of Chlorine isotopes are not equal.
   Ans. (iii) ***A is wrong, R is correct.***

VI. Short answer questions

1. Define: Relative Atomic Mass (or) Define Standard atomic weight. [AUG - 22, PTA – 3]

Relative Atomic mass of an element is the ratio between average mass of its isotope to $\frac{1}{12}^{th}$ part of the mass of a carbon-12 atom.

$$\textbf{Relative Atomic Mass, } A_r = \frac{\text{Average mass of the isotopes of the element}}{\frac{1}{12}\text{th of the mass of one carbon}-12 \text{ atom}}$$

2. Write the different types of isotopes of oxygen and its percentage abundance.

Isotope	Atomic Mass (amu)	% abundance
$_8O^{16}$	15.9949	99.757
$_8O^{17}$	16.9991	0.038
$_8O^{18}$	17.9992	0.205

3. Define: Atomicity. Give an example. [AUG – 2022, MAY-2022, SEP – 2021]

- Number of atoms present in molecule is called its atomicity.
- ***Ex :*** Atomicity of Phosphorous(P_4) is 4.

4. Give any two examples for hetero diatomic molecules. [AUG - 2022]

Hydrogen Chloride *(HCl)*, Hydrogen Fluoride *(HF)*

5. What is Molar volume of a gas?

It is the volume occupied by one mole of a gas at STP. Its value is 22.4 litre / 22400 ml

6. Find the percentage of nitrogen in ammonia. [PTA – 1]

$$\% \text{ of Nitrogen in } NH_3 = \frac{\text{Mass of element}}{\text{Molecular mass}} \times 100 = \frac{14}{17} \times 100 = 82.35\ \%$$

VII. Long answer questions

1. Calculate the number of water molecule present in one drop of water, which weighs 0.18 g.

Molecular mass of $H_2O = (1 \times 2) + 16 = 18$ g

$$\text{Number of molecules} = \frac{\text{Mass of water}}{\text{Molecular mass}} \times \text{Avogadro number}$$

$$= \frac{0.18}{18} \times 6.023 \times 10^{23}$$

$\therefore$ The No. of water molecules $= 6.023 \times 10^{21}$

2. $N_2 + 3\ H_2 \rightarrow 2\ NH_3$ (The atomic mass of nitrogen is 14, and that of hydrogen is 1)

1 mole of nitrogen (__g) + 3 moles of hydrogen (__ g) → 2 moles of ammonia (__ g)

$$\text{Mass} = \text{No. of moles} \times \text{Molecular mass}$$

$$\text{Mass of } N_2 = 1 \times (14 \times 2) = 28$$

$$\text{Mass of } H_2 = 3 \times (1 \times 2) = 6$$

$$\text{Mass of } NH_3 = 2 \times (14 + (3 \times 1)) = 34$$

1 mole of nitrogen (**28 g**) + 3 moles of hydrogen (**6 g**) → 2 moles of ammonia (**34 g**)

3. Calculate the number of moles in i) 27g of *Al* ii) 1.51×10^{23} molecules of NH_4Cl. [PTA – 5]

i) 27g of Al :

$$\text{Number of moles} = \frac{\text{Mass of } Molecule}{\text{Atomic mass of } Molecule}$$

$$= \frac{27}{27} = 1 \text{ mole}$$

ii) 1.51×10^{23} molecules of NH_4Cl :

$$\text{Number of moles} = \frac{\text{Number of Molecules}}{\text{Avogadro number}}$$

$$= \frac{1.51 \times 10^{23}}{6.023 \times 10^{23}} = 0.25 \text{ moles}$$

4. Give the salient features of "Modern atomic theory". [AUG – 2022, SEP – 2020, PTA – 5]

- Atom is no longer indivisible. It is divided into electron, proton and neutron.
- ***Isotope :*** Atoms of the same element having different atomic mass. ***Ex :*** $_{17}Cl^{35}$, $_{17}Cl^{37}$
- ***Isobars :*** Atoms of different elements having same atomic masses. ***Ex :*** $_{18}Ar^{40}$, $_{20}Ca^{40}$
- ***Artificial transmutation :*** Atom is no longer indestructible.
- Atoms may not always combine in a simple whole number ratio.

  Ex : Glucose $C_6H_{12}O_6$ C:H:O = 6:12:6 or 1:2:1
- Atom is the smallest particle that takes part in a chemical reaction.
- The mass of an atom can be converted into energy. **$E = mc^2$**

5. Derive the relationship between Relative molecular mass and Vapour density. [PTA-6, MDL-19]

***Relative Molecular Mass*(RMM)** $= \frac{\text{Mass of 1 molecule of gas (or) vapour at STP}}{\text{mass of 1 atom of hydrogen}}$ ……..(1)

Vapour Density (V.D) $= \frac{\text{Mass of a given volume of gas (or) Vapour at STP}}{\text{Mass of the same volume of Hydrogen}}$……..…(2)

According to Avogadro's law, Equal volumes of all gases contain equal number of molecules.

Let, number of molecules in the considered volume = n

$\therefore$ Vapour Density (at STP) $= \frac{\text{Mass of 'n' molecules of a gas (or) Vapour at STP}}{\text{mass of 'n' molecules of hydrogen}}$

Let n = 1, then VD $= \frac{\text{Mass of 1 molecule of a gas (or) Vapour at STP}}{\text{mass of 1 molecule of hydrogen}}$

Hydrogen is diatomic molecule so,

Vapour Density $= \frac{\text{Mass of 1 molecule of gas (or)Vapour at STP}}{2\times\text{Mass of 1 atom of hydrogen}}$

$2 \times$ Vapour density $= \frac{\text{Mass of 1 molecule of gas (or) Vapour at STP}}{\text{Mass of 1 atom of hydrogen}}$

$2 \times$ Vapour density = Relative Molecular Mass [$\because$ By Eqn (1)]

Relative Molecular Mass = 2 × Vapour Density

VIII. HOT Question

1. Calcium carbonate is decomposed on heating in the following reaction.

$CaCO_3 \rightarrow CaO + CO_2$

i) How many moles of Calcium carbonate are involved in this reaction?

One mole of $CaCO_3$.

ii) Calculate the gram molecular mass of calcium carbonate involved in this reaction.

Gram Molecular Mass of $CaCO_3 = (40 \times 1) + (12 \times 1) + (16 \times 3)$

$= 40 + 12 + 48 = 100$ g

iii) How many moles of CO_2 are there in this equation?

One mole of CO_2.

IX. Solve the following problems.

1. How many grams are there in the following? **[PTA – 4]**

i) 2 moles of hydrogen molecule, H_2

Molecular mass of $H_2 = 1 \times 2 = 2$

Mass = No. of moles $\times$ Molecular mass = $2 \times 2 = 4$ g

ii) 3 moles of chlorine molecule, Cl_2

Molecular mass of $Cl_2 = 35.5 \times 2 = 71$

Mass = No. of moles $\times$ Molecular mass = $3 \times 71 = 213$

iii) 5 moles of sulphur molecule, S_8

Molecular mass of $S_8 = 32 \times 8 = 256$

Mass = No. of moles $\times$ Molecular mass = $5 \times 256 = 1280$ g

iv) 4 moles of phosphorous molecule, P_4

Molecular mass of $P_4 = 30 \times 4 = 120$

Mass = No. of moles $\times$ Molecular mass = $4 \times 120 = 480$ g

2. Calculate the (mass) % of each element in calcium carbonate. (Atomic mass: C -12, O -16, Ca - 40)

Molecular mass of $CaCO_3 = 40 + 12 + (16 \times 3) = 100$ g **[PTA – 2]**

Elements	Mass of Individual element	$\frac{\text{Mass of element}}{\text{Molecular mass}} \times 100$	Mass percentage of each element
Ca	40	$\frac{40}{100} \times 100$	40%
C	12	$\frac{12}{100} \times 100$	12%
O	3×16 = 48	$\frac{48}{100} \times 100$	48%

3. Calculate the % of oxygen in $Al_2(SO_4)_3$. (Atomic mass: Al -27, O -16, S - 32). **[PTA – 2]**

Molecular mass of $Al_2(SO_4)_3$ = $(2 \times 27) + (3 \times (32 + (4 \times 16)))$ = 342 g

% of O in $Al_2(SO_4)_3$ = $\frac{3 \times 4 \times 16}{342} \times 100$ = $\frac{192}{342} \times 100$ = 56.14%

4. Calculate the % relative abundance of B -10 and B -11, if its average atomic mass is 10.804 amu.

Let a_1, a_2 be the % abundance of B-10 and B-11 respectively. $m_1 = 10$, $m_2 = 11$

$$a_1 + a_2 = 100 \quad \Rightarrow \quad a_1 = 100 - a_2$$

$$\text{Average Atomic Mass} = m_1 \times \frac{a_1}{100} + m_2 \times \frac{a_2}{100}$$

$$= 10 \times \frac{(100 - a_2)}{100} + 11 \times \frac{a_2}{100}$$

$$= 10 \times \left(1 - \frac{a_2}{100}\right) + \frac{11a_2}{100}$$

$$= 10 - \frac{10a_2}{100} + \frac{11a_2}{100}$$

$$10.804 = 10 + \frac{a_2}{100} \quad (\because \text{Average Atomic Mass of B} = 10.804 \text{ amu})$$

$$\frac{a_2}{100} = 10.804 - 10 = 0.804$$

$$a_2 = 0.804 \times 100 = 80.4\ \%$$

$$a_1 = 100 - 80.4 = 19.6\ \%$$

$\therefore$ % abundance of B-10 = 19.6 % & % abundance of B-11 = 80.4%