PETIT SEMINAIRE HIGHER SECONDARY SCHOOL – PUDUCHERRY

UNIT – 7 ATOMS AND MOLECULES

STD: X SELF – EVALUATION

I. Choose the best answer:

1. Which of the following has the smallest mass? (B) 1 atom of He
2. Which of the following is a triatomic molecule? (C) carbon dioxide
3. The volume occupied by 4.4 g of CO_2 at S.T.P - (B) 2.24 litre
4. Mass of 1 mole of Nitrogen atom is - (D) 14 g
5. Which of the following represents 1 amu? (C) $1/12^{th}$ of the mass of a C – 12 atom
6. Which of the following statement is incorrect?
   (C) One mole of hydrogen gas contains Avogadro's number of atoms.
7. The volume occupied by 1 mole of a diatomic gas at S.T.P is (C) 22.4 litre
8. In the nucleus of $_{20}Ca^{40}$, there are (B) 20 protons and 20 neutrons
9. The gram molecular mass of oxygen molecule is (C) 32 g
10. 1 mole of any substance contains ------ molecules. (A) 6.023×10^{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.
3. Atoms of one element can be transmuted into atoms of other elements 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 a.m.u.
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
9. One mole of any gas occupies 22400 ml at S.T.P
10. Atomicity of phosphorous is 4 (tetra atomic).

III. Match the following:

S.No	Column 1	Column 2

1	8 g of O_2	0.25 mole
2	4 g of H_2	2 moles
3	52 g of He	13 moles
4	112 g of N_2	4 moles
5	35.5 g of Cl_2	0.5 mole

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**

   Correct statement: Noble gases are monoatomic.
3. The gram atomic mass of an element has no unit - **False**

   Correct statement: The gram atomic mass of an element has unit expressed in grams.
4. 1 mole of gold and silver contain same number of atoms. - **True**
5. Molar mass of CO_2 is 42 g. - **False**

   Correct statement: Molar mass of CO_2 is 44 g.

V. Assertion & Reasoning:

1. **Assertion**: The Relative Atomic mass of aluminium is 27

   Reason: An atom of aluminium is 27 times heavier than $1/12^{th}$ of the mass of the C – 12 atom.

   (i) A and R are correct, R explains the A.
2. Assertion: The Relative Molecular Mass of Chlorine is 35.5 a.m.u.

   Reason: The natural abundance of Chlorine isotopes are not equal.

   (i) A and R are correct, R explains the A.

VI. Short answers questions:

1. Define: Relative atomic mass?

   Relative atomic mass of an element is the ratio between the average mass of its isotopes to $1/12^{th}$ part of the mass of a carbon – 12 atom. It is denoted as A_r. It is otherwise called "Standard Atomic Weight".

   Relative atomic mass (A_r) =

$$\frac{\text{Average mass of the isotopes of the element}}{\frac{1}{12^{th}} \text{ of the mass of one carbon-12 atom}}$$

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

Isotopes of Oxygen

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

3. Define: Atomicity:

The number of atoms present in one molecule of an element is called its 'atomicity'.

$$\text{Atomicity} = \frac{\text{molecular mass}}{\text{atomic mass}}$$

4. Give any two examples for heterodiatomic molecules.

HCl, HF, CO, NaBr are examples for hetero diatomic molecules.

5. What is Molar volume of a gas?

One mole of any gas occupies 22.4 litre or 22400 ml at S.T.P. This volume is called as molar volume.

Or

Volume occupied by one mole of any gas at S.T.P. Its value is 22.4 litre.

6. Find the percentage of nitrogen in ammonia.

Molecular mass of NH_3 = 14 + (3 x 1) = 17g

$$\text{Mass \% of an element} = \frac{\text{mass of that element in the compound}}{\text{molar mass of the compound}} \times 100$$

$$\text{Mass \% of nitrogen} = \frac{14}{17} \times 100$$

Mass % of nitrogen = 82.35%

VII. Long Answers Questions:

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

$$\text{No. of moles} = \frac{\text{given mass}}{\text{molecular mass}}$$

Molecular mass of H_2O = (2 x 1) + 16 = 18 g

No. of moles = $\frac{0.18}{18}$ = 0.01 mole.

No. of moles = $\frac{\text{no.of molecules}}{6.023 \times 10^{23}}$

No. of molecules = No. of moles x 6.023×10^{23}

= $0.01 \times 6.023 \times 10^{23} = 0.06023 \times 10^{23}$

No. of molecules = 6.023×10^{21} molecules.

2. $N_2 + 3H_2 \rightarrow 2\ NH_3$

(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).

(i) 1 mole of nitrogen:

No. of moles = $\frac{\text{given mass}}{\text{molecular mass}}$

Mass = No. of moles x molecular mass

Mass = 1 x (14 x 2) = 28 g

(ii) 3 moles of hydrogen:

No. of moles = $\frac{\text{given mass}}{\text{molecular mass}}$

Mass = No. of moles x molecular mass

Mass = 3 x (2 x 1) = 6 g

(iii) 2 moles of ammonia:

Molecular mass of NH_3 = 14 + (3 x 1) = 17g

No. of moles = $\frac{\text{given mass}}{\text{molecular mass}}$

Mass = No. of moles x molecular mass

Mass = 2x (17) = 34 g

3. Calculate the number of moles in

(i) 27 g of Al:

No. of moles = $\frac{\text{given mass}}{\text{Atomic mass}}$

No. of moles = $\frac{27}{27}$ = 1 mole

No. of moles of Al = 1 mole

(ii) 1.51×10^{23} molecules of NH_4Cl

No. of moles = $\frac{\text{no.of molecules}}{6.023 \times 10^{23}}$

$= \frac{1.51 \times 10^{23}}{6.023 \times 10^{23}} = 0.251$ mole.

No. of moles = 0.25 mole

4. Give the salient features of "Modern atomic theory"?

The main postulates of modern 'atomic theory' are as follows:

- An atom is no longer indivisible (after the discovery of the electron, proton and neutron).
- Atoms of the same element may have different atomic mass. (Discovery of isotopes $_{17}Cl^{35}$, $_{17}Cl^{37}$).
- Atoms of different elements may have same atomic masses (discovery of Isobars $_{18}Ar^{40}$, $_{20}Ca^{40}$).
- Atoms of one element can be transmuted into atoms of other elements. In other words, atom is no longer indestructible (discovery of artificial transmutation).
- Atoms may not always combine in a simple whole number ratio (Ex: Glucose $C_6H_{12}O_6$).
- 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?

(i) Relative molecular mass (Hydrogen scale):

It is the ratio between the mass of one molecule of the gas or vapour to mass of one atom of Hydrogen.

(ii) Vapour Density:

It is the ratio of the mass of a certain volume of a gas or vapour, to the mass of an equal volume of hydrogen, measured under the same conditions of temperature and pressure.

Vapour Density (V.D) =

$$\frac{\text{Mass of a given volume of gas or vapour at S.T.P}}{\text{Mass of the same volume of hydrogen}}$$

According to Avogadro's law, equal volume of all gases contain

equal number of molecules. Thus, let the number of molecules in one volume = n, then

Vapour Density (V.D) at S.T.P =

$$\frac{\text{Mass of 'n'molecules of gas or vapour at S.T.P}}{\text{Mass of 'n'molecules of hydrogen}}$$

Cancelling 'n' which is common, you get

$$\text{Vapour Density (V.D)} = \frac{\text{Mass of 1 molecule of gas or vapour at S.T.P}}{\text{Mass of 1 molecule of hydrogen}}$$

However, since hydrogen is diatomic

$$\text{Vapour Density (V.D)} = \frac{\text{Mass of 1 molecule of gas or vapour at S.T.P}}{\text{Mass of 2 atoms of hydrogen}}$$

When you compare the formula of vapour density with relative molecular mass, they can be represented as

$$\text{Vapour Density (V.D)} = \frac{\text{Mass of 1 molecule of gas or vapour at S.T.P}}{2 \times \text{Mass of 1 atom of hydrogen}}$$

---------- (1)

Relative molecular mass (Hydrogen scale) =

$$\frac{\text{Mass of 1 molecule of gas or vapour at S.T.P}}{\text{Mass of 1 atom of hydrogen}}$$

---------- (2)

You can therefore substitute the above equation to an Eqn 1 and arrive at the following formula.

$$\text{Vapour Density} = \frac{\text{Relative molecular mass}}{2}$$

2 x Vapour Density = Relative molecular mass of a gas

Or

Relative molecular mass = 2 x 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 calcium involved in this reaction.

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

GMM of $CaCO_3$ = 1 (Ca) + 1 (C) + 3 (O)

= 1 (40) + 1 (12) +3 (16)

= 40 + 12 + 48 = 100 g

Gram molecular mass of Calcium Carbonate = 100 g

(iii) How many moles of CO2 are there in this equation?

One mole of Carbon dioxide present in this equation.

IX. Solve the Following problems:

1. How many grams are there in the following?

(i) 2 moles of H_2:

Mass = No. of moles x Molecular mass

Mass = 2 x (2 x 1) = 4 g

Mass = 4 g.

(ii) 3 moles of Cl_2:

Mass = No. of moles x Molecular mass

Mass = 3 x (2 x 35.5) = 213 g

Mass = 213 g.

(iii) 5 moles of S_8:

Mass = No. of moles x Molecular mass

Mass = 5 x (8 x 32) = 1280 g

Mass = 1280 g.

(iv)4 moles of P_4:

Mass = No. of moles x Molecular mass

Mass = 4x (4 x 31) = 496 g

Mass = 496 g.

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

Molar mass of $CaCO_3$ = 1 (Ca) + 1 (C) + 3 (O)

= 1 (40) + 1 (12) +3 (16)

= 40 + 12 + 48 = 100 g

$$\% \text{ of Ca in } CaCO_3 = \frac{\text{Mass of Ca}}{\text{Molar mass of } CaCO_3} \times 100$$

$$= \frac{40}{100} \times 100 = 40\%$$

% of Ca in $CaCO_3$ = 40 %

$$\% \text{ of C in } CaCO_3 = \frac{\text{Mass of C}}{\text{Molar mass of } CaCO_3} \times 100$$

$$= \frac{12}{100} \times 100 = 12\%$$

% of C in $CaCO_3$ = 12 %

$$\% \text{ of O in } CaCO_3 = \frac{\text{Mass of O}}{\text{Molar mass of } CaCO_3} \times 100$$

$$= \frac{48}{100} \times 100 = 48\%$$

% of O in $CaCO_3$ = 48 %

3. Calculate the % of oxygen in $Al_2(SO_4)_3$. (Atomic mass: Al – 12, O – 16, S - 32)

Molar mass of $Al_2(SO_4)_3$ = 2 (Al) + 3 (S) + 12 (O)

= 2 (27) + 3(32) +12 (16)

= 54 +96 +192 = 342 g

$$\% \text{ of O in } Al_2(SO_4)_3 = \frac{\text{Mass of O}}{\text{Molar mass of Aluminium Sulphate}} \times 100$$

$$= \frac{192}{342} \times 100 = 56.1\%$$

% of O in $Al_2(SO_4)_3$ = 56.1 %

4. Calculate the % relative abundance of B – 10 and B – 11, if its average atomic mass is 10.804 a.m.u.

Let B – 10 = x %

B – 11 = (100 - x) %

$$\text{Average atomic mass} = \frac{10\,x}{100} + \frac{11\,(100-x)}{100}$$

$$10.804 = \frac{10\,x}{100} + \frac{11\,(100-x)}{100}$$

$$1080.4 = 10\,x + 11\,(100 - x)$$

$$10\,x + 1100 - 11\,x = 1080.4$$

$$-x = 1080.4 - 1100 = 19.6$$

$$x = 19.6$$

∴ (B – 10) = 19.6 %

B – 11 = (100 - x) %

= (100 – 19.6) %

$\therefore (B - 11) = 80.4\ \%$

$\therefore (B - 10) = 20\%; (B - 11) = 80.4\ \%$