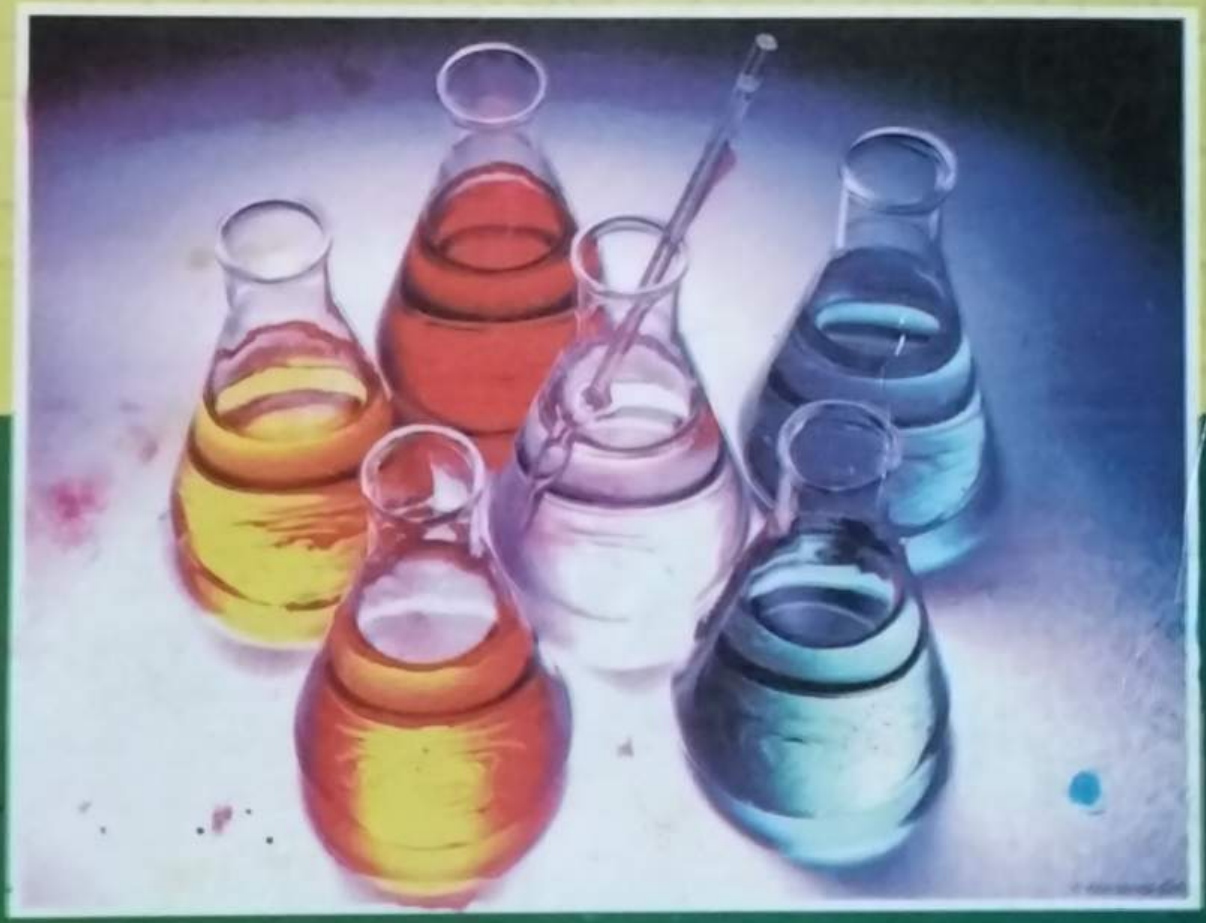
INORGANIC CHEMISTRY



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Preface

This book, Inorganic Chemistry for Tertiary Institution is intended to present Inorganic part of Chemistry to the students of tertiary institution.

The curriculum for Inorganic Chemistry especially in the Polytechnic was strictly followed.

In writing this book, we have tried to make it easier for the students to learn and understand inorganic chemistry by using simple language. We would appreciate comments and suggestions aimed at improving the quality of this book.

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Chapter One

1.1 THE MOLE

The Mole is defined as the amount of substance containing the same number of particles as on number of carbon atoms in exactly 12g of carbon 12.

The particles in substances are very small, thus it is impossible to count the numbers. For example, to obtain the smallest amount of carbon visible to the naked eye, billions of carbon atoms would be required.

Therefore, Chemist now use a unit called the Mole for counting particles as defined above and carbon atom was used as a reference.

Chemist have found that by experiment, 6.02×10^{23} atoms of an element have a mass in grams equivalent to the mass of one atom in atomic mass unit (a.m.u)

for example one atom of hydrogen has a mass of 1.0079 a.m.u., 6.02×10^{23} atoms of hydrogen have a mass of 1.0079g. This number, 6.02×10^{23} is called Avogadro's number in honour of a 19^{th} century Italian Scientist-Amadeo Avogadro.

One mole = 6.02×10^{23} particles. Thus we can say that:
1 mole of carbon (c) atoms = 6.02×10^{23} atoms
2 moles of Na^+ ion = $2 \times 6.02 \times 10^{23}$ Na^+ ion.
3 moles of CO^2 molecules = $3 \times 6.02 \times 10^{23}$ CO_2 molecules.
1 mole of NaCl formula unit = 6.02×10^{23} NaCl formula unit.

We can also speak of one mole of various amounts of chemical such as
1 mole of water containing 18.02g
1 mole of copper containing 63.55g
1 mole of sucrose containing 342.30g
1 mole of lead shot containing 207.21 g
1 mole of mercury containing 200.59g
1 mole of sodium chloride (salt) containing 58.44g

1 mole of sulphur containing 32.06g

- The mass of a mole or atoms is called a Gram-atomic mass
- The mass of a mole or molecules is called Gram-molecular mass.
- The mass of a mole of ions is called Gram-ion mass.
- The mass of a mole of formula unit is called the Gram-formula mass.

Calculations:

The number of moles of a substar.cc can be easily formed by simple calculation using the following relations.

(a) No. of moles = $\frac{\text{Mass of the substance}}{\text{Molar mass of the substance}}$

(B) Also, number of particles

$$= \frac{\text{Mass}}{\text{Molar mass}} \times \text{Avogadro Constant}$$

(c) No. of moles = $\frac{\text{No. of particles}}{\text{Avogadro Constant}}$

Example 1

What is the mass of 0.2 mole of Calcium trioxo Carbonate (IV) solution (Given: R.a.m =C= 12, 0 = 16, Ca = 40.1)

Calcium trioxo Carbonate (iv) = $CaCO_3$ = 100. 1gmol ^{1}. From (a) mass of $CaCO_3$ = No. of moles x molar mass = 0.2 x 100.1 = 20.02g.

Note: R.a.m. = relative atomic mass. Alternatively, we know that:

1 mole of $CaCO_3$ contains 100. 1 g/mole

0.2 mole $CaCO_3$ will contain $\frac{100.1g}{1 \text{ mole}} \times 0.2\text{mole}$

= 20.02g

Example 2:

Calculate the number of gold atoms ill a 20g gold coil (R.a.m Au = 197)

Solution

This is requesting for the number of particles. So we use formula (b),

e. No. of Particles = $\frac{\text{Mass}}{\text{Molar mass}}$ x Avogadro Constant

$$= \frac{20}{197} \times 6.02 \times 10^{23} = 6.11 \times 10^{22}$$

Example 3:

Given that the molar mass of water is 18g mol^{-1}

. What is the mass of 4 moles of water molecules?

i. How many molecules are there?

ii. How many atoms arc there?

(Take R.a.m. H= 1.0, O = 16.0)

Solution

i. From our equation (a);

No. of moles of substance = $\frac{\text{Mass of the substance}}{\text{Molar mass of the substance}}$

Mass of substance = No. of moles x molar mass of substance

M = 4 x 18 = 72.0g

Alternatively by reasoning:

1 mole of water is 18g

$$4 \text{ moles} = \frac{18}{1} \times \frac{4}{1} = 72.0\text{g}$$

ii. From (c):

$$\text{No. of moles} = \frac{\text{No. of particles}}{\text{Avogadro Constant}}$$

$$\Longrightarrow \frac{\text{No. of molecules}}{\text{Avogadro Constant}} = \frac{\text{No. of moles}}{1}$$

==> No of molecules = No. of moles x Avogadro Constant

$$= 4 \times 6.02 \times 10^{23}$$

$$= \underline{2.408 \times 10^{24}}$$

Alternatively; 1 mole of water = Avogadro Constant

$\therefore$ 4 moles of water = $6.02 \times 10^{23} \times 4$

$$= \underline{2.408 \times 10^{24}}$$

iii. 1 water molecule is written as H_2O = H,H,O = 3 atoms.

Remember we are talking of moles of water molecule.

1 mole of water molecules has 3 moles of atoms.

Thus, 4 moles of water molecules have 3 x 4 = 12 moles of atoms

No. of atom: we use equation (C) i.e.

No. or particle = No. of moles x Avogadro

$= 12 \times 6.02 \times 10^{23}$

$= \underline{7.224 \times 10^{24}}$

Example 4

A solution of magnesium chloride contains 109 of magnesium chloride.

(i) Find the number of moles of magnesium chloride in the solution.

(ii) Calculate the number or magnesium ions in the solution

(iii) Calculate the number of chloride ions in the solution

(iv) Calculate the total number of ions in the solution.

(R.a.m.: mg = 24.3, Cl = 35.5)

Solution:

(i) The chemical formula or magnesium chloride is $MgCl_2$ molar mass of $MgCl_2$ is 24.3 + 35.5 2 = 95.3g mol^{-1}

No of moles of magnesium chloride = Mass / Molar ma

= $\frac{10}{95.3}$ = 0.105mol

(ii) 1 mole of $MgCl_2$ written as $Mg^{2+}2Cl^-$

From (i)

0.1 05mole of MgCl contains 0.105mole of Mg^{2+}

No. of Mg^{2+}ions = No. of moles x Avogadro constant (from c)

= $0.105 \times 6.02 \times 10^{23}$

= 6.321×10^{22}

(iii) From the fact that 1 mole of $MgCl_2$ contains 1mole of Mg^{2+} and 2 moles of Cl

i.e 0.105 mole of $MgCl_2$ contains 2(0.105) mole of Cl^- 0.21 mole.

No. of Cl^- ion = Number of moles of Cl^- x 6.02×10^{23}

$= 0.21 \times 6.02 \times 10^{23}$

$= \underline{1.264 \times 10^{23}}$

(iv) Total No. of ions in the solution

This is the total ion of Mg^{2+} Cl-

i.e $0.632 \times 10^{23} + 1.264 \times 10^{23}$

$= 1.8961 \times 10^{23}$

$= \underline{1.896 \times 10^{23}}$

Examples 5

What is the mass of Carbon IV oxide molecule?

(R.a.m: C = 12, O = 6)

Solution:

Chemical formula of carbon IV oxide is CO_2

Molar mass of a carbon iv oxide = 12+16x2 = 44g mol

No. of mole = $\frac{\text{Mass}}{\text{Molar Mass}}$ $\frac{\text{No. of molecules}}{\text{Avogadro constant}}$

$$\Rightarrow \frac{\text{Mass of a molecule}}{\text{Molar mass of a molecule}} = \frac{1}{6.02 \times 10^{23}}$$

$$\text{Mass of a molecule} = \frac{44}{\frac{6.02 \times 10^{23}}{}}$$

$$= 7.31 \times 10^{23}$$

Practice problem U.G.C. / 37.

1. Calculate the mass in grams of 0.01 mole of zinc Sulphide (R.a.m: S = 32.1, Zn = 65.4)
2. Find the number of ions in 5.61g of calcium oxide. (R.a.m: O = 16, Ca = 40.1).
3. Find the number of atoms in 32.05g of surphodioxide (R.a.m O=16.0, s = 32.1
4. Given 4.80g of Amonium Carbonate, fine
   (i) Number of moles of the compound.
   (ii) Number of moles of Amonium ions
   (iii) Number of moles of carbonate ions.
   (iv) Number of hydrogen atoms
   (v) Number if hydrogen atoms.
   (R.a.m: H=1.0, C=12.0, N=14, O=16)

1.2 Molar Mass

This is the mass of one mole of a substance. It has the same numerical value as the relative atomic mass of the formula mass (which carry no units) of the substance but it is expressed in gram per mole.

The relationship between relative atomic mass/ formula mass and Molar mass is shown below:

Substance	Relative Atomic Mass (No Unit)	Mole Mass (g/mol)
C	12.0	12
O	16.0	16
S	32.1	32
Cl_2	71.0	71
NH_3	17.0	17
Al_2C_3	102.0	102
H_20	18.0	18