3. Hrs

UNIT-IBRIDGE COURSE- CHEMISTRY

I. BASIC CONCEPTS

Chemistry is a branch of science which deals with the composition, structure and properties of matter.

According to Dalton's atomic theory, an atom is the smallest particle of an element, which may or may not have free existence. Moreover it is the smallest particle that take parts in a chemical reaction.The size of anatom is extremely small. Just imagine that one gram of a metal contains millions and millions of atoms. Recent photograph of an atom taken by a special microscope called the scanning tunnelling microscope (STM) supports these facts.

Atoms are considered to be spherical in shape. The radius of hydrogen atom is 10^{-10}m. The mass of hydrogen atom is 1.6 x 10^{-27}kg.In 1964 for the sake of convenience and to avoid fraction, value of atomic mass recommended Carbon-12 isotope as standard.

Atomic Mass = $\frac{\text{Average mass of atom of an element}}{1/12^{th} \text{ the mass of an atom of C-12 Isotope.}}$

Thus atomic mass is defined as the mass of $1/12^{th}$ of the mass of carbon-12isotope andis considered as one atomic unit (amu)

Atomic mass is defined as ratio of average mass of an atom of an element to $1/12^{th}$mass of carbon-12 isotope. One atomic mass unit (a.m.u) is equal to $1/12^{th}$ mass of an atom of carbon-12 isotope.

Atomic mass of element expressed in grams iscalled gram atomic mass

e.g 1. Atomic mass of oxygen is 16. It means that average mass of oxygen atom is 16 times heavier than the $1/12^{th}$ the mass of carbon-12 isotope

e.g.2. Atomic mass of nitrogen atom is 14. That is average mass of nitrogen atom is 14 times heavier than $1/12^{th}$ the carbon isotope-12

Atomic Numbers:

Atomic number (Z) is defined as the number of protons present in the nucleus of an atom (which is also equal to number of electrons in the neutral atom.)

Mass Number

Mass number (A) of an atom is the sum of the number of protons and neutrons present in the nucleus. Mass number is also equal to total number of nucleons present in the nucleus. (Number of protons and neutrons present in the nucleus are collectively known as nucleons.)

e.g., Mass number of carbon is 12

[Number of protons (Z) 6+ N0. of neutrons (n) 6 = 12.]

Similarly mass number of Sodium is 23

[No.of protons (Z) + No. of neutrons (n)]= 11 + 12 = 23

An element X with mass number A and Atomic number Z is represented as ${}_{Z}X^{A}$

Isotopes and Isobars:

Isotopes are atoms of the same element with different mass number and same atomic numbers. This is due to the presence of different numbers of neutrons present in the nucleus e.g. Carbon ${}_{6}C^{12}$[6 proton + 6 Neutrons]

${}_{6}C^{14}$[6 protons + 8 neutrons]

Isobars are the atoms with same mass numbers but different atomic numbers e.g., $_6C^{14}$, $_7N^{14}$.

Molecule:

The smallest particle of a substance made up of two or more atoms, which can exists freely is called molecule.
The molecules may be classified as:
monoatomic – eg.-Helium (He)
diatomic – eg.-oxygen (O_2)
triatomic – eg.- ozone (O_3)
Molecules may also Homoatomic (Made up of one kind of atoms) or Heteroatomic (Made up of different elements)
e.g. Homoatomic : Hydrogen (H_2), Oxygen (O_2) etc.
Heteroatomic: HF, HCl, H_2O NH_3 etc.

Molecular Mass

Molecular mass is defined as the ratio of the mass of one molecule of the substance to $1/12^{th}$ the mass of Carbon-12 isotope.

$$\text{Molecular mass} = \frac{\text{mass of one molecule of a substance}}{1/12\text{th mass of carbon} - 12 \text{ isotope}}$$

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Molecular mass can be calculated by adding atomic masses of all the atoms present in one molecule of a substance
e.g. i) Molecular mass of H_2O is 18

= 2 x At.mass of H + At mass of O = 2 x 1.0 + 16.0 = 18

Molecular mass of glucose is 180

= 6 x At.mass of C +12 x At.mass of H_2+
6 x At.mass of O_2 = 6x12 + 12x1 x 6x16 = 180

Molecular mass of substance expressed in grams is called Gram molecular mass.
e.g., Molecular mass of Glucose ($C_6H_{12}O_6$) = 180
Gram molecular mass of Glucose = 180 g

Equivalent massof an Element.

Equivalent mass of an element is defined the number of parts by mass of the element which combine with or displaces 1.008 parts by mass of hydrogen or 8 parts by mass of oxygen or 35.5 parts by mass chlorine.

Equivalent mass is simply a number it is related to atomic mass.
Atomic mass = Valency x equivalent mass.

e.g., Equivalent mass of magnesium is 12. It means 12 parts by mass of magnesium displaces 1.008 parts by mass of hydrogen when it reacts with dil.hydrochloric acid

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2. THE LAWS OF CHEMICAL COMBINATION.

In a chemical reaction, the reactants react together to form product. They follow certain laws known as'laws of chemical combination'.

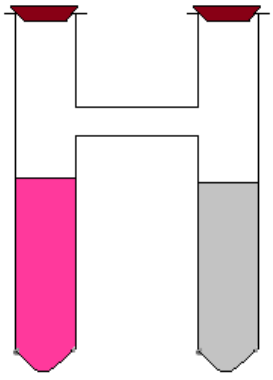
Some important chemical combinations are:
1. The law of conservation of mass.
2. The law of constant proportion.
3. The law of multiple proportions

<u>The law of Conservation of mass</u>.

The law of conservation of mass states that in a chemical change the matter can neither be created nor destroyed.
The law was established byFrench Chemist Lavoisier in 1789 and is stated as: In all physical changes and chemical changes, the total mass of the products is the same as the total mass of reactants.

With the help of experiment Landolt verified the law. Landolt took solutions of silver nitrate and sodium chloride separately in two limbs of tube and made to react. The tube was weighed before and after the experiment and found no change in mass.This justifies the law of conservation of mass.

$NaCl\ (aq) + AgNO_3\ (aq) \qquad AgCl\ (s) + NaNO_3\ (aq)$



Silver Nitrate Solution

Sodium Chloride Solution

<u>Landolt's tube</u>

Problem

In a reaction it is found 17 g of silver nitrate reacts with 5.85 g of sodium chloride to produce 14.35 g silver chloride and 8.5 g of sodium nitrate. show that the data agree with the lawa of conservation of mass.

Solution: Mass of reactants = (17g + 5.85)g = 22.85 g

Mass of product = (14.35 + 8.5)g = 22.85 g

Total mass of the reactants = Total mass of the products,. The result illustrate the law of conservation of mass.

The law of constant proportion.

This law was prop[osed by french chemist J.L Proust in 1799. It states that a chemical compound is always found to be made up of the same elements combined together in the fixed proportion by mass.

e.g., Pure water obtained by any source will always contains hydrogen and oxygen combinead together in the same fixed ratio 1:8 by mass.

Problem

3.16 g of copper metal was converted to metal oxide. 3.14g of copper oxide was obtained. Inanother experiment 2.04 g of copper metal was convearated its oxide. 2.56 g of copper oxide was obtaianed. On calculataion it is found that % of copper in both the experiment remains same(i.e 80.00%)

The law of Multiple proporation.

This law was proposed by Dalton in 1803.It states that when two elements combine to form two or more compounds, then the masses of one of the elements which combine with a fixed mass of the other, bear a simple waholenumber ratio to one other.

e.g., 1. The compounds of Carbon and oxygen.

The element carbon and oxygen combined to form two different compounds carbon monoxide (CO)and carbon dioxide (CO_2).The different mas of oxygen that combine with a fixed mass of carbon are in a simple ratio i.e 16 : 32 . or 1:2.

e.g.2. Compounds of Nitrogen and Oxygen.

The element nitrogen and oxygen combine to produce five oxides of nitrogen. viz., Nitrous oxide, Nitric oxide,Nitrogen trioxide, Nitrogen tetroxide and Nitrogen pentoxide.

The mass of Nitrogen and oxygen which combines with one another are :-

Compound	N_2O,	NO,	N_2O_3,	N_2O_4	N_2O_5
Nitrogen	28	14	28	28	28
Oxygen	16	16	48	64	80

Fixing the mass of nitrogen as 14 and the different mass of oxygen are in simple ratio of 1:2:3:4:5

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3. MOLE CONCEPT.

In our day to day life, we use quantities such as dozen (12 numbers) pair (2 numbers) one kilogram of rice, 1 gross (144 numbers) etc.

A mole is a unit which is used to express the amount of substance. It is destined as the amount of substance which contains Avogadro number of particles (i.e., 6.022×10^{23}), is called Avogadro's number.(represented by N_A) named in the honour of Italian scientist Amedeo Avogadro

Mole in terms of mass:

The mole is the amount of substance (Elements or compounds) which has a mass equal to its gram atomic mass or gram molecular mass.

e.g., 1.One mole of oxygen atoms = 16 g (0ne gm. atomic mass).

2. One mole of oxygen molecule = 32 g.(One gm. molecular mass)

Mole in terms number.

One mole of substance contain one Avogadro's number

e.g. 1 gm mole of hydrogen atom contain 6.022×10^{23} hydrogen atoms.

1gm mole of Hydrogen molecule contains 6.023×10^{23} hydrogen molecule..

Molecular mass of water (H_2O) is 16 .One mole of water (H_2O) contain

6.022×10^{23} molecules of water .

Mole in terms of volume.

One mole of gasunder standard temperature(273K) and Pressure

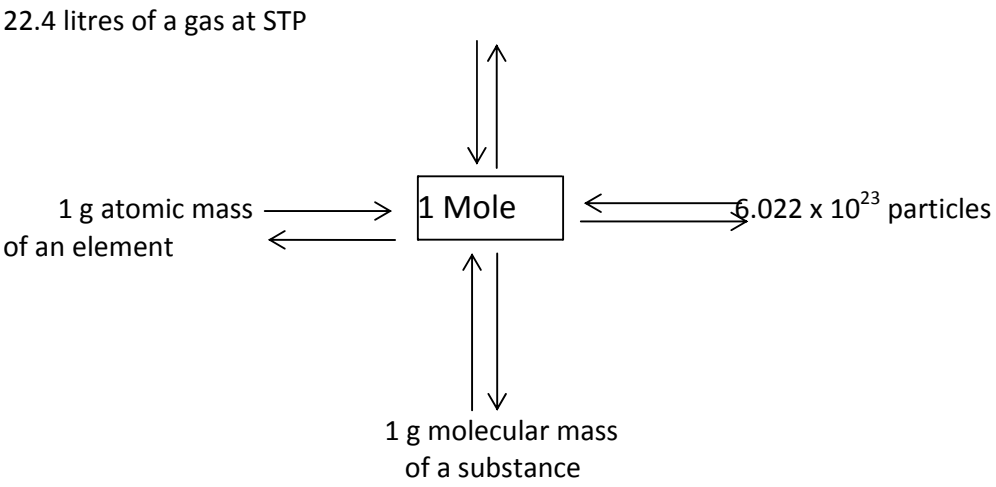
(1 atm.)contains 22.4 dm^3 of gas.

A mole of gaseous substance can alsobe defined the amount of substance that occupy 22.4dm^3 at STP or 0.0224 m^3

Numerical problems.(Hints)

No.of moles= given mass in gm or =given mass in gm
gram molecular mass gram atomic mass

1 mole = 6.023×10^{23} particles; Molecular mass in g.= 22.4 dm^3 at STP



1. A sample of nitrogen contains 5.6×10^{19} atoms of Nitrogen. Find the mass of atoms.

   Ans.

   Mass of 5.6×10^{19} atoms nitrogen = $\frac{14}{6.023 \times 10^{23}} \times 5.6 \times 10^{19}$

   $= 13.017 \times 10^{19} \times 10^{-23} = 13.017 \times 10^{-4}$ g

2. Calculate the no. of moles of the following:
   i) 52 g of He ii) 12.044×10^{23} atoms of He

   i) 52 g of He

   No. of moles of He = mass of helium / Molecular mass

   = 52 = 13 moles

) 12.044×10^{23} atoms of He

1 mole of He = 6.023×10^{23} atoms

∴ = 12.044×10^{23} atoms

= $\frac{12.044 \times 10^{23}}{6.023 \times 10^{23}}$ = 2 moles

PERCENTAGE COMPOSITION.

Percentage composition of an element in a compound

$$= \frac{\text{Mass of element in one molecule}}{\text{Molecular mass of compound}} \times 100$$

Problems.

1. Calculate the percentage composition of H_2O. (Given relative atomic of H =1 O = 16)

Water contains two elements, i.e., Hydrogen and Oxygen

Molecular mass of water = mass of Hydrogen + mass of oxygen

= (2 x 1) + (1 x 16) = 2 + 16 = 18

Since 18 g of water contains 2 g of hydrogen 16 g of oxygen.

$$\% \text{ of } H_2 = \frac{2}{18} \times 100 = 11.11\% \text{ Hydrogen}$$

$$\% \text{ of } O_2 = \frac{16}{18} \times 100 = 88.89\% \text{ Oxygen}$$

2. Calculate the percentage water in $Na_2CO_3.10H_2O$(At.mass of Na = 23, C =12, O = 16.)

Ans.Molecular mass of $Na_2CO_3.10H_2O$

= 2 x23 + 1x12 + 3 x 16 +10(18)

= 46 + 12 + 48 +180 = 286

286 g of sodium decahydrate contains 180g of H_2O

Therefore $\%H_2O = \frac{180}{286} \times 100 = 62.93\%$

3. Calculate the percentage of element in Na_2CO_3 (At.mass of Na = 23, C =12, O = 16.)

Ans. Molecular mass = 2 x 23 + 1 x 12 + 3 x 16

= 106

$$\% \text{ of Na} = \frac{46}{106} \times 100 = 43.39\%$$

$$\% \text{ of C} = \frac{12}{106} \times 100 = 11.32\%$$

$$\% \text{ of O} = \frac{48}{106} \times 100 = 45.28\%$$

I. Chapter questions

1. Calculate the molecular
   i) H_2O, ii) Na_2CO_3 ii) $CuSO_4.5H_2O$
2. Calculate the mass per cent of different elements

   i) Na_2SO_4, ii) $CuSO_4.5H_2O$ iii) Find the %water in question.(ii)
3. Calculate the number of oxygen molecules present in 64 g of oxygen.
4. In 3 moles of ethane, calculate the following
   i) Number moles of Carbon atoms.
   ii) Number of moles of hydrogen atoms.
   iii) Number of molecules of Ethane.
5. Which one of the following will heave largest number of atoms?
   i) 1 g of gold ii) 1 g of sodium iii) 1 g of lithiumiv)1 g of chlorine.
6. Calculate the number of atoms present in
   i) 26 moles of helium. ii) 26 g of helium.
7. What is the difference between the mass of molecule and molecular mass?
8. Why is it necessary to balance the chemical equation?
9. What is meant by Avogadro's number?
10. Why the atomic mass of chlorine is 35.5 but not awhole number?. Explain.

II Multiple choicequestions.

1. One mole of oxygen atoms represents
   a)16 g of oxygen b) 6.023 x 10^{-23} atoms of oxygen
   c) 6.023 x 10^{23} molecules of oxygen. d) 32 g of oxygen.
2. Which one of contains the most molecules?
   a) 1 mole of water b) 1g of hydrogen c) 1g of water d) 1g of methane
3. Which of the following has the least volume of gas at STP
   a) 5 g of HF b) 5g of HBr c) 5g of HId) 5 g of HCl.
4. 16 g of oxygen have same number of molecules as in:
   a) 16g of CO b) 28g of Nitrogen c) 1 g of Hydrogen d)14 g of nitrogen
5. "Compounds are formed when atoms of different elements combine in a fixed ratio" Which of the following laws are related to the above statement.
   a) Law of conservation of massb) Law of definite proportion
   c) Law of multiple proportions d) Avogadro law.