Calculations using the mole concept

Objectives:

To introduce the concept of the mole as the unit of measurement for amounts of compounds; atoms, molecules and ions.

Introduction:

A mole of any substance: is the amount of the substance which contains a number of particles (atoms ; molecules ; etc.).

It is the relative atomic mass (RAM) expressed in grams for atoms.

e.g. One mole of Carbon atom c_{12} is 12 grams (RAM of C atom = 12).

One mole of Sodium atom Na_{23} is 23 grams (RAM of Na atom = 23).

This explains **The Molar Mass of a substance**: is the mass of one mole of the substance ***(M_r)***, It is the relative mass in grams .

No. of moles = total mass in grams /molar mass (M_r)

e.g. M_r of Na atom =23 grams (RAM of Na atom = 23)

M_r of NaOH molecule =23+16+1=40 g .(RAM of Na, O and H atoms=23, 16and 1)

So M_r of atom equal its RAM but M_r of molecule equal sum of RAM of its atoms

N.B: One mole of any substance contains the **same number of particles** which is equal to ***Avogadro's constant*** (6.02×10^{23}). But the **Mass of the mole (M_r)** of any substance **differs** according to relative atomic mass of its atoms.

e.g. 1 mole of Carbon contains 6.02×10^{23} particles and also 1 mole of Sodium contains 6.02×10^{23} particles while the mass of one mole of carbon atom is 12 gm but that of sodium atom is 23 gm

Examples :

1-How many moles of CO_2 molecules are present in 11g of CO_2 molecule ?

Solution: By formula : M_r of CO_2 = 12+16+16 = 44 gm

Number of moles = total mass in grams/mass of 1 mole (molar mass) =11/44 =0.25 mole.

2-What is the mass of 2 moles of Ethanol molecule (C_2H_5OH) ? if RAM of C, H and O = 12, 1 and 16)

Solution: By formula: M_r of C_2H_5OH = (12+12)+(1+1+1+1+1+1)+(16)= 46 gm (this is the mass of one mole of the molecule)

So the mass of 2 moles = 46× 2=92 gm.

3-How many atoms are there in 5 moles of Carbon?

Solution: One mole of the carbon contain 6.02×10^{23} atom (***Avogadro's constant***)

So 5 moles contain = 5 X 6.02×10^{23} =30.1 X 10^{23} atoms.

Moles for Gases :

Definition : One mole of molecules of any gas occupies :

24L at room temp. and pressure (**R.T.P**)

Or 22.4L at standard temp. and pressure (**S.T.P**) which equal(0^{O}C or 273 K for temp. and 1 atmosphere for pressure).

No. of moles of Gas (at R.T.P) = $\frac{\text{volume}}{24\text{L}}$

No. of moles of Gas (at S.T.P) = $\frac{\text{volume}}{22.4\text{L}}$

e.g **How many moles of a gas if this gas occupy 12L at R.T.P ?**

Solution: No. of moles of Gas (at R.T.P) = $\frac{\text{volume}}{24\text{L}} = \frac{12}{24}$ = 0.5 mole.

Molar Solution (M):

Is a solution of a substance where **one liter** (1000 cm^3) (1000 mL) contains **one mole** of the substance dissolved in it.

Molarity of solution = No. of moles x $\frac{\text{1000 Cm3}}{\text{Volum used (Cm3)}}$

$= \frac{\text{Total Mass}}{\text{Molar mass (Mr)}}$ **x** $\frac{\text{1000 Cm3}}{\text{Volum used (Cm3)}}$

N.B: molarity may be used to express the concentration of the solution.

Exercises:

Complete :

1-A mole of Oxygen **atom**(O) contains …….**atoms**. (6.02×10^{23})

2-A mole of Oxygen **molecule** (O_2) contains …….. **molecules**. (6.02×10^{23})

3-A mole of Oxygen **molecule** (O_2) contains …….. **atoms**. ($2X6.02\times10^{23}$)

4-A mole of Oxygen **atom**(O) weights ……. g. **Mass = No. of moles X Molar mass or RAM of O atom =(1X16)= 16**

5-A mole of Oxygen **molecule** (O_2) weights … g. **Mass = No. of moles X Molar mass (Mr) of O_2 molecule=(1X(16 + 16))= 32**

Convert :

1- 5.31 moles of C to grams of C (R.A.M. of C atom = 12).

Mass = No. of moles X Molar mass or RAM of C atom =(5.31X12) = 63.72 gm

2- 5 moles of Cl_2 to grams of Cl_2 (R.A.M. of Cl atom = 35.453).

Mass = No. of moles X Molar mass of Cl_2 molecule =(5X(2 X 35.453)) = 354.53 gm

3- 100g. of Fe to moles of Fe (R.A.M. of Fe atom = 55.84).

No. of moles = total mass in grams /molar mass or RAM of Fe atom (M_r)= 100/55.84 = 1.7908 mole

4- 30ml Hg (density(d.)of Hg=13.6g/ml) to moles of Hg (R.A.M. of Hg atom= 200.59).

d= mass/volum so mass= V X d = 30 X 13.6 = 408 gm

No. of moles = total mass in grams /molar mass or RAM of Hg atom (M_r)= 408/200.59 = 2.034 mole

H.W. 5- 40g. of N_2 to moles of N_2 (R.A.M. of N atom =14).

6-22.5moles of Ag to grams of Ag (RAM of Ag atom= 107.86)