MOLE CONCEPT

Vikasana – Bridge Course 2012

INTRODUCTION:

A mole is a unit which is used to express the amount of substance.

It is defined as the amount of substance which contains Avogadro number of particles . 6.022×10^{23},

is called Avogadro's number (represented by N_A), named in the honour of an 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).

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

MOLE IN TERMS OF NUMBER.

One mole of substance contain one Avogadro's number

1 gm mole of hydrogen atom contains 6.022×10^{23} hydrogen atoms.

1 gm mole of Hydrogen molecule contains 6.022×10^{23} hydrogen molecule.

Molecular mass of water (H_2O) is 18. One mole of water (H_2O) contain 6.022×10^{23} molecules of water.

MOLE IN TERMS OF VOLUME.

One mole of gas under standard temperature (273K) and Pressure 1 atm (STP). occupies 22.4 dm3 of volume.

A mole of gaseous substance can also be defined the amount of substance that can occupy the volume of 22.4 dm3 at STP or 0.0224 m3

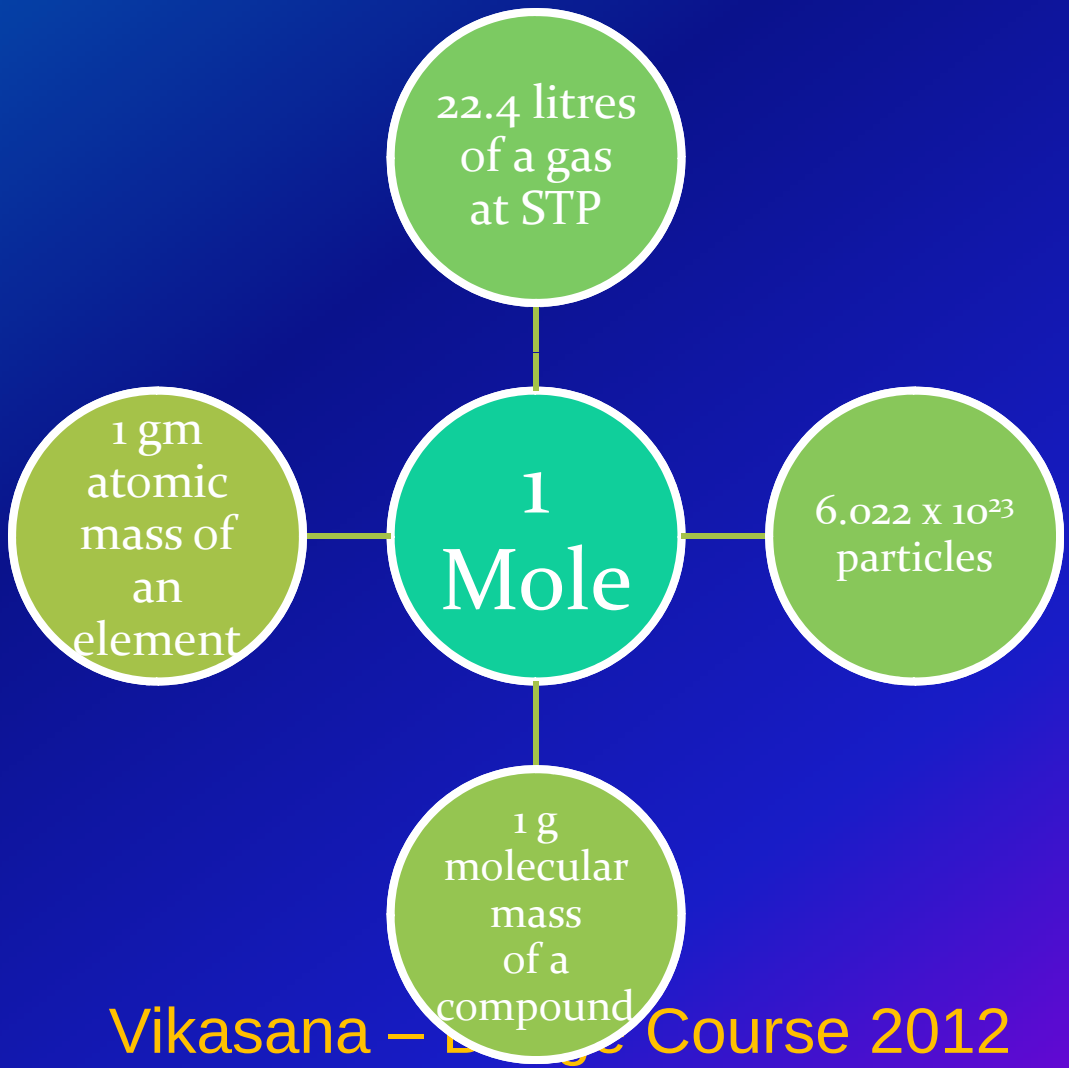
NUMERICAL PROBLEMS - HINTS

No. of moles = $\frac{\text{given mass in gm}}{\text{gram molecular mass}}$ OR

= $\frac{\text{given mass in gm}}{\text{gram atomic mass}}$

1 mole = 6.022×10^{23} particles = 1gm

Molecular mass = 22.4 dm^3 at STP


22.4 litres of a gas at STP
1 gm atomic mass of an element
1 Mole
6.022 x 10²³ particles
1 g molecular mass of a compound

NUMERICAL PROBLEMS

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 = $\frac{14 \times 5.6 \times 10^{19}}{6.022 \times 10^{23}}$

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

NUMERICAL PROBLEMS

Calculate the no. of moles in:

i) 60g of Ca (gram atomic mass of Ca = 40g)

ii) an iron sample containing 10^{22} atoms of iron.

i) 60g of Ca

$$\text{No. of moles of Ca} = \frac{\text{Mass of Ca in grams}}{\text{Gram Atomic Mass}} = \frac{60\ \text{g}}{40\ \text{g}} = 1.5\ \text{Mol}$$

ii) $$\text{No. of moles of Fe} = \frac{\text{No. of atoms of Fe}(N)}{\text{Avogadro's no. of atoms } (N_0)} = \frac{N}{N_0}$$

$$= \frac{(1.0 \times 10^{22}\ \text{atoms})}{(6.022 \times 10^{23}\ \text{atoms})} = 0.0166\ \text{mol}$$

PERCENTAGE COMPOSITION

Percentage composition of an element in a compound

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

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

   = 2 x atomic mass of H_2 + 1 x atomic mass of O_2

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

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

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

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

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

Ans. Molecular mass of $Na_2CO_3.10H_2O$

$= 2 \times 23 + 1 \times 12 + 3 \times 16 + 10 \times 18$

$= 46 + 12 + 48 + 180 = 286$

286 g of sodium carbonate decahydrate contains 180g of H_2O

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

3. Calculate the percentage by mass of elements 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

   % by mass of Na = $\frac{46}{106}$ x 100 = 43.39%

   % by mass of C = $\frac{12}{106}$ x 100 = 11.32%

   % by mass of O = $\frac{48}{106}$ x 100 = 45.28%

CHAPTER QUESTIONS

I. Answer the following:

1. Calculate the molecular mass of:
   i) H_2O ii) Na_2CO_3 ii) $CuSO_4.5H_2O$
2. Calculate the mass percent of different elements of:
   i) Na_2SO_4 ii) $CuSO_4.5H_2O$ iii) Find the % of water in $CuSO_4.5H_2O$
3. Calculate the number of oxygen molecules present in 64 g of oxygen.

1. i) Molecular mass of of H_2O = 2 x 1+ 1x 16 =18 u

ii) M.M. of Na_2CO_3 = 2x23 +1x12 + 3x16 = 106u

iii) M.M. of $CuSO_4.5H_2O$ = 63.5+36+64+5x18=249.5u

2. i)Mass % of $Na_2\ SO_4$

Molecular mass of Na_2SO_4 = 2x23 +1x36+4x16 = 142u

% of Sodium (Na) = $\frac{\text{Mass of Na}}{\text{Molecular mass}} \times 100$

$\frac{46 \times 100}{142}$ = 32.39 %

Similarly: % of Sulphur (S) $\frac{32}{142} \times 100$ = 22.54 %

% of Oxygen (O) 64/142 x 100 = 45.07 %

ii) Mass % of $CuSO_4.5H_2O$

Molecular Mass = 63.5 +32 + 64 + 5x18 = 249.5u

% Copper (Cu) = $\frac{\text{Mass of Cu}}{\text{Molecular Mass}} \times 100 = \frac{63.5 \times 100}{249.5} = 25.45\ \%$

% of total oxygen = $\frac{\text{Mass of oxygen}}{\text{Molecular mass}} = \frac{9x16\ x100}{249.5} = 57.7\ \%$

Similarly:% hydrogen and Sulphur are respectively = 4.0 % and 12.8 %

% Water in $CusO_4.5H_2O$ (M.M=249.5)

$= \frac{\text{Mass of water x 100}}{\text{Molecular mass}} = \frac{90 \times 100}{249.5} = 36.07\ \%$

iii) % Water in $CusO_4.5H_2O$ (M.M=249.5) =

$\frac{\text{Mass of water x 100}}{\text{Molecular mass}} = \frac{90 \times 100}{249.5} = 36.07\ \%$

A.3. No. of molecules in 64 g of oxygen.

G.M.M= 32 g

32 g contain 6.022×10^{23} molecules

64 g contain $6.022 \times 10^{23} \times 2$

$= 12.044 \times 10^{23}$

Q4. In 3 moles of ethane, calculate the:

i.Number moles of Carbon atoms.

ii.Number of moles of hydrogen atoms.

Iii.Number of molecules of Ethane.

Q5. Calculate the number of atoms present in:

i) 26 moles of helium ii) 26 g of helium

4 A. In 3 moles of ethane,(C_2H_6)

i) No. of moles of Carbon atom = 3 x 2 moles = 6 moles

ii) No. of moles of Hydrogen atom = 3 x 6 moles
= 18 moles

iii) No. of molecules of Ethane = 1 Mole of Ethane
= 6.022×10^{23} molecules

∴ In 3 moles of Ethane = $3 \times 6.022 \times 10^{23}$ molecules = 1.81×10^{24}

7 Q. What is the difference between the mass of molecule and molecular mass?

8. What is meant by Avogadro's number?

A 5. **i) One mole of He = 6.022×10^{22} atoms**

$\therefore$ 26 moles of He = $6.022 \times 10^{23} \times 26$

= 1.56×10^{25} atoms

ii) g M.M of He = 4g

4 g of He = 6.022×10^{23} atoms

$\therefore$ 26 gm of He= $\frac{6.022 \times 10^{23} \times 26}{4\ g}$ = 3.91×10^{24} atoms

6A Mass of a molecule is that of a single molecule which is also known as actual mass.

Molecular mass: It is the mass of Avogadro's number(6.022×10^{23}) of molecules.

Q 4. 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 mass

b) Law of definite proportion

c) Law of multiple proportions

d) Avogadro law.

CHAPTER QUESTIONS

II. Multiple choice questions:

1. One mole of oxygen atoms represents

a) 16 g of oxygen, b) 6.022×10^{-23} atoms of oxygen c) 6.022×10^{23} molecules of oxygen, d) 32 g of oxygen.

2. Which one of the following contains the most number of 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 HI,d) 5 g of HCl.

II Answers to Multiple choice questions

1. (a) 2. (a) 3.(C)