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SOME BASIC CONCEPT OF CHEMISTRY

ATOMIC MASS

"The number which represents how many times one atom of an element is heavier than one atom of hydrogen or 1/12th part of one atom of C^{12} isotope is called atomic mass of the element."

Mathematically,

$$\text{Atomic Mass} = \frac{Mass\ of\ one\ atom\ of\ an\ element}{Mass\ of\ one\ atom\ of\ Hydrogen}$$

$$= \frac{Mass\ of\ one\ atom\ of\ an\ element}{\frac{1}{12}\times Mass\ of\ one\ atom\ of\ C{-}12\ isotope}$$

For example, atomic mass of oxygen is 16. It implies that, one atom of oxygen is 16 times heavier than one atom of hydrogen or 1/12th part of one atom of C^{12} isotope. Similarly, atomic mass of chlorine is 35.5. It implies that, one atom of chlorine is 35.5 times heavier than one atom of hydrogen or 1/12th part of one atom of C^{12} isotope.

Atomic masses of some important elements are listed here-

Element	Symbol	Atomic mass	Element	Symbol	Atomic mass
Hydrogen	H	1.008	Calcium	Ca	40
Carbon	C	12	Chromium	Cr	52
Nitrogen	N	14	Manganese	Mn	55
Oxygen	O	16	Iron	Fe	56
Fluorine	F	19	Cobalt	Co	59
Sodium	Na	23	Nickel	Ni	58.5
Magnesium	Mg	24	Copper	Cu	63.5
Aluminium	Al	27	Zinc	Zn	65
Phosphorus	P	31	Bromine	Br	80
Sulphur	S	32	Silver	Ag	108
Chlorine	Cl	35.5	Tin	Sn	118.5
Potassium	K	39	Iodine	I	127

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GRAM ATOMIC MASS (GAM)

"The amount of an element in gram equal to its atomic mass is called Gram Atomic Mass (GAM) of the element."

For example, atomic mass of oxygen is 16. Hence, its Gram Atomic Mass (GAM) will be 16 g. Similarly, atomic mass of chlorine is 35.5. Hence, its Gram Atomic Mass (GAM) will be 35.5 g.

1GAM of all the elements contains 6.022×10^{23} atoms of the respective element. Hence, it is also called 1 Mole of the element.

The number of GAM (moles) in given amount of an element is obtained using following formula-

$$\text{No. of GAM (moles), n} = \frac{Mass\ of\ element\ (g)}{GAM\ of\ Element}$$

MOLECULAR MASS

"The number which represents how many times one molecule of a substance is heavier than one atom of hydrogen or $1/12^{th}$ part of one atom of C^{12} isotope is called molecular mass of the substance."

Mathematically,

$$\text{Molecular mass} = \frac{Mass\ of\ one\ molecule\ of\ the\ substance}{Mass\ of\ one\ atom\ of\ Hydrogen}$$

or

$$\text{Molecular mass} = \frac{Mass\ of\ one\ molecule\ of\ the\ substance}{\frac{1}{12}\times Mass\ of\ one\ atom\ of\ C-12\ isotope}$$

For example, Molecular mass of oxygen is 32. It implies that, one molecule of oxygen is 32 times heavier than one atom of hydrogen or $1/12^{th}$ part of one atom of C^{12} isotope. Similarly, Molecular mass of chlorine is 71. It implies that, one molecule of chlorine is 71 times heavier than one atom of hydrogen or $1/12^{th}$ part of one atom of C^{12} isotope.

Molecular mass of the compounds is obtained by adding the atomic masses of the atoms present in the molecule of respective compound. For example,

Mol. mass of $CaCO_3$ = 1× At. Mass of Ca + 1 × At. Mass of C+ 3 × (At. Mass of O)
= 40 + 12 + 3×16 = 100 amu

Mol. mass of H_2SO_4 = 2×(At. Mass of H) + At. Mass of S+ 4× (At. Mass of O)
= 2×1+32+4×16 = 98 amu

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GRAM MOLECULAR MASS (GMM) –

"The amount of a substance in gram equal to its Molecular mass is called Gram Molecular Mass (GMM) of the substance."

For example, Molecular mass of oxygen is 32. Hence, its Gram Molecular mass (GMM) will be 32 g. Similarly, Molecular mass of H_2SO_4 is 98. Hence, its Gram Molecular mass (GMM) will be 98 gram.

1GMM of all the substances contains 6.022×10^{23} molecules of the respective substance. Hence, it is also called 1 Mole of the substance.

The number of GMM (moles) in given amount of a substance is obtained using following formula-

$$\text{No. of GMM (moles), n} = \frac{Mass\ of\ substance\ (g)}{GMM\ of\ Substance}$$

MOLE CONCEPT

'Mole' is a counting unit, which is used in counting atoms, ions, molecules and subatomic particles like electrons, protons, neutrons etc. By definition-

" The amount of a substance which contains as number of particles as number of carbon atoms present in 12g of C^{12} isotope is called 1 mole of the substance."

Experimentally, it has been found that 12g of C^{12} isotope contains 6.022×10^{23} carbon atoms. Hence, 'mole' can also be defined as under-

"The amount of a substance which contains 6.022×10^{23} particles irrespective of its nature is called 1 mole of the substance."

Thus,

1 Mole = 6.022×10^{23} particles

For example,

1 Mole H atoms = 6.022×10^{23} H atoms
1 Mole H_2 molecules = 6.022×10^{23} H_2 Molecules
1 Mole H^+ ions = 6.022×10^{23} H^+ Ions
1 Mole electrons = 6.022×10^{23} Electrons
1 Mole protons = 6.022×10^{23} Protons

1GAM of all the elements contains 6.022×10^{23} atoms of the respective element. Hence, it is also called 1 Mole of the element.

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The number of moles (GAM) in given amount of an element is obtained using following formula-

$$\text{No. of GAM (moles), n} = \frac{Mass\ of\ element\ (g)}{GAM\ of\ Element}$$

1GMM of all the substances contains 6.022×10^{23} molecules of the substance. Hence, it is also called 1 Mole of the substance.

The number of moles (GMM) in given amount of a substance is obtained using following formula -

$$\text{No. of GMM (moles), n} = \frac{Mass\ of\ substance\ (g)}{GMM\ of\ Substance}$$

AVOGADRO'S NUMBER

"The number particles present in 1 mole of a substance is called Avogadro's number."

Experimentally, it has been found that 1 mole of all the substance contains 6.022×10^{23} particles irrespective of their nature. Hence, Avogadro's number,

$$\boxed{N_0 = 6.022\times10^{23}}$$

ATOMIC MASS UNIT (amu)

" The mass of 1/12th part of one atom of C^{12} isotope is called atomic mass unit (amu)."

Since, **Gram Atomic Mass of C^{12} isotope = 12g**

$\therefore$ **Mass of 6.023×10^{23} atoms of C^{12} = 12g**

$\therefore$ **Mass of one atom of C^{12}** $= \frac{12}{6.022\times10^{-23}}$ **g**

$\therefore$ **Mass of 1/12th part of one atom of C^{12} isotope** $= \frac{1}{12}\times\frac{12}{6.022\times10^{-23}}$ **g**

$= \frac{1}{6.022\times10^{-23}}$ **g**

$= 1.66\times10^{-24}$ **g**

Thus, $\boxed{1\ amu = 1.66\times10^{-24}g}$

It is clear that, atomic mass unit is numerically equal to the reciprocal of Avogadro's number (N_0)

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Numericals –

Q.1 Calculate the no. of GAM (moles) in 2.3 g of sodium.

Sol - Since,

$$\text{No. of moles, n} = \frac{Mass\ of\ element\ (g)}{GAM\ of\ Element}$$

$$= \frac{2.3\ g}{23\ g}$$

$$= 0.1 \text{ moles}$$

Q.2 Find the total no of sodium atom in 2.3 g of sodium.

Sol- Since,

$$\text{No. of moles, n} = \frac{Mass\ of\ element\ (g)}{GAM\ of\ Element}$$

$$= \frac{2.3\ g}{23\ g}$$

$$= 0.1 \text{ moles}$$

$$\text{No. of Sodium atoms, N} = n \times No$$

$$= 0.1 \times 6.022 \times 10^{23}$$

$$= 6.022 \times 10^{22} \text{ atoms}$$

Q.3 Find the no. of atoms in 9 g of aluminium.

Sol. Since,

$$\text{No. of moles, n} = \frac{Mass\ of\ element\ (g)}{GAM\ of\ Element}$$

$$= \frac{9\ g}{27\ g}$$

$$= 0.33 \text{ moles.}$$

$$\text{No. of atoms, N} = n \times 6.022 \times 10^{23}$$

$$= 0.33 \times 6.022 \times 10^{23}$$

$$= 2.0073 \times 10^{23} \text{ atoms}$$

Q.4 Find the total no. of electrons present in 24g of Mg.

Sol - Since,

$$\text{No. of moles, n} = \frac{Mass\ of\ element\ (g)}{GAM\ of\ Element}$$

$$= \frac{24\ g}{24\ g} = 1 \text{ mole}$$

$$\text{No. of atoms, N} = n \times No.$$

$$= 1 \times 6.022 \times 10^{23}$$

$$= 6.022 \times 10^{22} \text{ atoms}$$

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No. of electrons = no. of atoms × atomic number

$$= 6.022 \times 10^{22} \times 12$$

$$= 7.2264 \times 10^{23}$$

Q.5 Find the total no. of protons in 3.55 g of chlorine.

Sol - Since,

$$\text{No. of moles, n} = \frac{Mass\ of\ element\ (g)}{GAM\ of\ Element}$$

$$= \frac{3.55\ g}{35.5\ g}$$

$$= 0.1 \text{ moles}$$

$$\text{No. of atoms. N} = n \times No$$

$$= 6.022 \times 10^{23} \times 0.1$$

$$= 6.022 \times 10^{22} \text{ atoms}$$

$$\text{No. of protons} = \text{no. of atoms} \times \text{atomic Number}$$

$$= (6.022 \times 10^{22} \times 17) \text{ protons}$$

$$= 1.02374 \times 10^{24} \text{ protons}$$

Q.6 Find the total no. of moles of HCl molecules in 3.65 g of HCl.

Sol:- Since,

$$\text{No. of GMM (moles), n} = \frac{Mass\ of\ substance\ (g)}{GMM\ of\ Substance}$$

$$= \frac{3.65\ g}{36.5\ g}$$

$$= 0.1 \text{ moles}$$

Q.7. Find the total no. of molecules of HCl in 3.65g of HCl.

Sol- Since, No. of GMM (moles),

$$\text{n} = \frac{Mass\ of\ substance\ (g)}{GMM\ of\ Substance}$$

$$= \frac{3.55\ g}{35.5\ g}$$

$$= 0.1 \text{ moles}$$

$$\text{No. of molecules, N} = n \times No$$

$$= 0.1 \times 6.022 \times 10^{23}$$

$$= 6.022 \times 10^{22} \text{ molecules}$$

Q.8. Find the total no. of H_2SO_4 molecules in 49 g of H_2SO_4.

Sol. Since, No. of GMM (moles),

$$\text{n} = \frac{Mass\ of\ substance\ (g)}{GMM\ of\ Substance}$$

$$= \frac{49\ g}{98\ g}$$

$$= 0.5 \text{ moles}$$

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No. of molecules, N = n × No

$= 0.5 \times 6.022 \times 10^{23}$

$= 3.011 \times 10^{23}$ **molecules**

Q.9. Find the total no. of atoms in 1.8 g of glucose.

Sol- **No of moles, n = 0.01 moles**

∴ **No of molecules = n × No**

$= 0.01 \times 6.022 \times 10^{23}$

$= 6.022 \times 10^{21}$ **molecules**

Since, no of atoms = total no. of molecules × atomicity.

$= 6.022 \times 10^{21} \times 24$

$= 144.55 \times 10^{21}$

$= 1.4455 \times 10^{23}$

Q.10. Find the total no. of oxygen atoms in 9.8 g of H_2SO_4.

Sol- **No of moles of H_2SO_4, n = 0.1 moles**

∴ **No. of molecules, N = n × No.**

$= 0.1 \times 6.22 \times 10^{23}$

$= 6.022 \times 10^{22}$

∴ **No. of oxygen atoms** $= 6.022 \times 10^{22} \times 4$

$= 24.088 \times 10^{22}$

$= 2.4088 \times 10^{23}$ **atoms**

Q.11. Find the total no. of calcium, carbon and oxygen atoms in 1 g of $CaCO_3$.

Sol- **No. of moles, n = 0.01 moles**

∴ **No. of molecules, N = n × No.**

$= 6.022 \times 10^{23} \times 0.01$

$= 6.022 \times 10^{21}$

∴ **No. of calcium atoms** $= 6.022 \times 10^{21} \times 1$

$= 6.022 \times 10^{21}$

No. of carbon atoms $= 6.022 \times 10^{21} \times 1$

$= 6.022 \times 10^{21}$

No. of Oxygen atoms $= 6.022 \times 10^{21} \times 3$

$= 18.066 \times 10^{21}$

$= 1.8066 \times 10^{22}$

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Concentration of Solution

"The amount of solute in given amount of solvent or solution is called conc. of solute in solution or conc. of solution.

Mode of Expression of Conc. of Solutions

(1) Mass Percentage - "The number of parts of solute by mass present in hundred parts of solution is called mass percentage of solute in solution."

Mathematically,

$$\text{Mass \%age} = \frac{\text{Mass of solute (g)}}{\text{Mass of solution(g)}} \times 100$$

(2)Volume Percentage - "The number of parts of solute by volume present in hundred parts of solution is called volume percentage of solute in solution."

Mathematically,

$$\text{Volume \%age} = \frac{\text{Volume of solute (ml)}}{\text{Volume of solution(ml)}} \times 100$$

(3) Gram / litre concentration (Strength of solution) - "The mass of solute in gram present in per litre of solution is called gram / litre conc. (strength) of solution."

Mathematically,

$$\text{Gram/litre conc. (strength)} = \frac{\text{Mass of solute (g)}}{\text{Volume of solution(l)}}$$

(4) Normality (N) - "The number of gram equivalent mass of solute present in per litre of solution is called normality solution."

Mathematically,

$$\text{Normality, N} = \frac{\text{Number of Gram Equivalent Mass of Solute}}{\text{Volume of Solution (l)}}$$

$$= \frac{Mass\ of\ solute\ (g)}{\text{GEM of Solute} \times \text{Volume of Solution (l)}}$$

$$= \frac{\text{Mass of solute (g)} \times 1000}{\text{GEM of solute} \times \text{volume of solution (ml)}}$$

If 1 gram equivalent mass of solute is present in per litre of solution, then the solution is called normal solution (N- solution). Similarly, If 2,3,4,------- gram equivalent mass of solute is present in per litre of solution, then the solutions are called 2N, 3N, 4N------ solutions respectively.

On the other hand, If 1/2 gram equivalent mass of solute is present in per litre of solution, then it is called semi - normal (N/2) solution and if 1/10 gram equivalent mass of solute is present in per litre of solution, then it is called desi- normal (N/10) solution.

Normality involves volume term and therefore it is dependent on temperature and is not considered to be good method for expressing the conc. of solutions.

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(5)Molarity (M) - "The number of gram molecular mass (moles) of solute present in per litre of solution is called Molarlity solution."

Mathematically,

$$\text{Molarity, } M = \frac{\text{Number of GMM (moles) of Solute}}{\text{Volume of solution(l)}}$$

$$= \frac{Mass\ of\ solute\ (g)}{\text{GMM of Solute} \times \text{Volume of solution (l)}}$$

$$= \frac{Mass\ of\ solute\ (g) \times 1000}{\text{GMM of Solute} \times \text{Volume of solution (ml)}}$$

If 1 GMM (moles) of solute is present in per litre of solution, then the solution is called molar solution (M- solution). Similarly, If 2, 3, 4,------- GMM (moles) of solute is present in per litre of solution, then the solutions are called 2M, 3M, 4M------ solutions respectively.

On the other hand, If 1/2 GMM(moles) of solute is present in per litre of solution, then it is called semi molar (M/2) solution and if 1/10 GMM (moles) of solute is present in per litre of solution, then it is called desi-molar (M/10) solution.

Molarity involves volume term and therefore it is dependent on temperature and is not considered to be good method for expressing the conc. of solutions.

(6) Molality (m) - "The number of gram molecular mass (moles) of solute present in per kg of solvent is called Molality solution."

Mathematically,

$$\text{Molality, } m = \frac{\text{Number of GMM (moles) of Solute}}{\text{Mass of Solvent (Kg)}}$$

$$= \frac{Mass\ of\ solute\ (g)}{\text{GMM of Solute} \times \text{Mass of Solvent (Kg)}}$$

$$= \frac{Mass\ of\ solute\ (g) \times 1000}{\text{GMM of Solute} \times \text{Mass of Solvent (g)}}$$

If 1 GMM (moles) of solute is present in per kg of solvent, then the solution is called molal solution (m- solution). Similarly, If 2, 3, 4,------- GMM (moles) of solute is present in per kg of solvent, then the solutions are called 2m, 3m, 4m------ solutions respectively.

On the other hand, If 1/2 GMM(moles) of solute is present in per kg of solvent, then it is called semi molal (m/2) solution and if 1/10 GMM (moles) of solute is present in per kg of solvent, then it is called desi-molal (m/10) solution.

Molality does not involves volume term and therefore it is independent of temperature and therefore does not change with change of temperature. Hence, it is considered to be good method for expressing the conc. of solutions.

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(7) Formality (F) - The term Formality is specially used to express the conc. of the solution of ionic solutes such as NaCl, KCl, $CuSO_4$ etc. By definition,

"The number of gram formula mass (moles) of solute present in per litre of solution is called formality of solution."

Mathematically,

$$\text{Formality, } F = \frac{\text{Number of Gram Formula Mass of Solute}}{\text{Volume of Solution (l)}}$$

$$= \frac{Mass\ of\ solute\ (g)}{\text{GFM of Solute} \times \text{Volume of Solution (l)}}$$

$$= \frac{\text{Mass of solute (g)} \times 1000}{\text{GFM of solute} \times \text{volume of solution (ml)}}$$

If 1 GFM (moles) of solute is present in per litre of solution, then the solution is called formal solution(F- solution). Similarly, If 2, 3, 4,------- GFM (moles) of solute is present in per litre of solution, then the solutions are called 2F, 3F, 4F------ solutions respectively.

On the other hand, If 1/2 GFM(moles) of solute is present in per litre of solution, then it is called semi formal (F/2) solution and if 1/10 GFM (moles) of solute is present in per litre of solution, then it is called desi- formal (F/10) solution.

Formality involves volume term and therefore it is dependent on temperature and is not considered to be good method for expressing the conc. of solutions.

(8) Mole Fraction - "The ratio of the number of moles of one component to the total number of moles in solution is called mole fraction of respective component in solution."

Let W_B gram of a solute B having molecular mass M_B is present in W_A gram of a solvent A having molecular mass M_A, then,

$$\text{Mole Fraction of solute, } X_B = \frac{\text{No.of moles of solute}}{\text{Total number of moles in solution}}$$

$$= \frac{n_B}{n_B + n_A}$$

$$= \frac{\frac{W_B}{M_B}}{\frac{W_B}{M_B} + \frac{W_A}{M_A}}$$

$$\text{Mole Fraction of solvent, } X_A = \frac{\text{No.of moles of solvent}}{\text{Total number of moles in solution}}$$

$$= \frac{n_A}{n_B + n_A}$$

$$= \frac{\frac{W_A}{M_A}}{\frac{W_B}{M_B} + \frac{W_A}{M_A}}$$

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Here,

$$X_A + X_B = \frac{n_A}{n_B + n_A} + \frac{n_B}{n_B + n_A}$$

or $$\boxed{X_B + X_A = 1}$$

It is clear that, the sum of the mole fractions of two components of a binary solution is always equal to one. Thus, if mole fraction of one component in solution is known, that of another can be calculated.

Mole Fraction does not involves volume term and therefore it is independent of temperature and is considered to be good method for expressing the conc. of solutions.

(9) Parts per million (ppm) conc. - This method is specially used to express the conc. of very dilute solutions. For example, conc. of chlorine in drinking water, conc. of polluting gases in air etc. are expressed in ppm. By definition ,

"The number of parts of solute either by mass or by volume present in 10^6 parts of solution is called ppm conc. of solute in solution."

Mathematically,

$$\text{ppm conc. of solute (by Mass)} = \frac{\text{Mass of solute (g)}}{\text{Mass of solution(g)}} \times 10^6$$

$$\text{ppm conc. of solute (by Volume)} = \frac{\text{Volume of solute (ml)}}{\text{Volume of solution(ml)}} \times 10^6$$

* The mode of expressing conc. if involves volume term then, it is dependent on temperature and changes with change of temperature. Hence, it is not considered to be good method for expressing the conc. of solutions. For example, normality, molarity, formality etc.

On the other hand, if it does not involve volume term then it is independent of temperature and is considered to be good method for expressing the conc. of solutions. For example, molality, mole fraction, mass %age etc.

* Relation between normality (N) and gram/litre conc. (strength) of solution -

$$\because \text{ Normality, } N = \frac{Mass\ of\ solute\ (g)}{\text{GEM of Solute} \times \text{Volume of Solution (l)}}$$

Or $$\boxed{N = S / E}$$

* Relation between molarity (M) and gram/litre conc. (strength) of solution -

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$$\text{Molarity, M} = \frac{Mass\ of\ solute\ (g)}{\text{GMM of Solute} \times \text{Volume of solution (l)}}$$

Or $\boxed{M = S / GMM}$

* Relation between normality (N) and molarity (M) of solution -

$$\text{Normality, N} = \frac{Mass\ of\ solute\ (g)}{\text{GEM of Solute} \times \text{Volume of Solution (l)}}$$

And $$\text{Molarity, M} = \frac{Mass\ of\ solute\ (g)}{\text{GMM of Solute} \times \text{Volume of solution (l)}}$$

Therefore, $$\frac{N}{M} = \frac{\text{GMM of Solute}}{\text{GEM of Solute}}$$

$\because$ $\frac{N}{M} = x$ (Where, x = valency of solute)

$\therefore$ $\boxed{N = x \times M}$

For example, For mono-basic acids (HCl, HCN, CH_3COOH, etc) or mono-acidic bases (NaOH, KOH, NH_4OH etc)-

$x = 1$ Hence, $\boxed{N = M}$

For di-basic acids (H_2SO_4, H_2CO_3, H_3PO_3, etc.) or di-acidic bases such as $Ca(OH)_2$, $Mg(OH)_2$ etc.-

$x = 2$ Hence, $\boxed{N = 2 \times M}$

For tri-basic acids such as H_3PO_4 or tri-acidic bases such as $Al(OH)_3$, $Fe(OH)_3$ etc.

$x = 3$ Hence, $\boxed{N = 3 \times M}$

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