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Subject: - General Chemistry (1) (2024-2025) lecture (4)

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Molar& Normal Concentrations & mothed. Problem & Discussion

1-Definition of Mole: -

The mol is a unit of measurement that is the amount of a pure substance containing the same number of chemical units (atoms, molecules etc.)

The mass of 1 mole of molecules (or formula units) in grams is numerically equivalent to the mass of one molecule (or formula unit) in atomic mass units. For example, a single molecule of O_2 has a mass of 32.00 u, and 1 mol of O_2 hmolecules has a mass of 32.00 g. Mole Concept:
Mole which is Avogadro's number (6.022×1023) of atoms, molecules, ions or other species. Numerically: it is the atomic, molecular, or formula weight of a substance expressed in grams. 1 mole = 1000 mmole

$$\text{mole} = \frac{\text{weight (g)}}{\text{formula weight } \left(\frac{\text{g}}{\text{mole}}\right)}$$

Or

$$\text{mmole} = \frac{\text{weight (mg)}}{\text{formula weight } \left(\frac{\text{mg}}{\text{mmole}}\right)}$$

How calculate the mole :-

To calculate the number of moles of any substance in the sample, we simply divide the given weight of the substance by its molar mass.

1-Gram atomic weight: (gAw some time Awt): Is the weight of a specified number of atoms of that element (contains exactly the same number of atoms of that element as there are carbon atoms in exactly 12g of carbon 12 (this number is Avogadro's number = 6.022×10^{23} atoms).

2-Gram molecular weight:-(gMw sometimes M.wt): Defined as the sum of the atomic weight of the atoms that make up a molecular compound. Or the weight of Avogadro's number of molecules of any compound.

3-Gram formula weight:

(gFw. sometime F.wt) The sum of the atomic weight of the atoms that make up an ionic formula. (is the more accurate description for substances that do not exist as molecules but exist as ionic compounds e.q strong electrolytes-acids, bases, salts). Sometimes use the term molar mass (Molecular weight, M.wt) in place of gram formula weight, gFw).

Example (1) - Calculate the number of grams in one mole of CaSO .7H O (calculate gram molecular or formula weight).

Solution: One mole is the formula weight expressed in grams. (The atomic mass number for elements is (Ca=40.08, S=32.06, O=16.00, H=1.01))

Mwt of $CaSO_4.7H_2O$ = ((Ca ×1) +(S×1) + (O ×11) + (H ×14))

Ca × 1=40× 1 =40 , S × 1 = 32 ×1 = 32

O × 7 = 11 ×16= 176 H ×14 = 1 × 14 = 14

Mwt. of $CaSO_4.7H_2O$ = 262 gm/mol

Example (2):-Calculate the number of moles in 500 mg CaSO .7H O.
Solution :- the atomic mass number for elements is Ca=40 , S=32 , O=16 , H=1)
Mwt. of $CaSO_4.7H_2O$ = 262 gm/mol

$$\text{mmole} = \frac{\text{wt (mg)}}{\text{M. wt } (\frac{\text{mg}}{\text{mmole}})} = \frac{500\ (\text{mg})}{262\ (\frac{\text{mg}}{\text{mmole}})} = 1.908\ \text{mmole}$$

$$\text{mole} = \frac{\text{mmole}}{1000} = \frac{0.001902}{1000} = 0.001908\ \text{mmol}$$

Example (3): How many molecules are contained in 25.0 g H2.

Solution: (A.wt H= 1.008 g/mole)

$$\text{moles } H_2 = \frac{\text{wt (g)}}{\text{Fwt}} = \frac{25.0\ \text{g}}{2.016\ \frac{\text{g}}{\text{mole}}} = 12.40\ \text{mole}$$

No. Molecules =No. moles x Avogadro number

$=7.74 \times 10^{-24}$ molcules

Example (4): How many milligrams are in 0.250 mmole Fe_2O_3 (ferric oxide).

Solution: (Awt. O= 16 g/mole , Fe = 56.85 g/mole)

Mwt. of Fe O = (Fe ×2) + (O × 3) = (55.85×2) +(16 × 3) = 159.7

$$\text{wt (mg)} = \text{mmole} \times \text{M. wt } (\frac{\text{mg}}{\text{mmol}})$$

$$= 0.250\ \text{mmole} \times 159.7\ \frac{\text{mg}}{\text{mmol}} = 39.9\ \text{mg}$$

Example (5):- Calculate the number of mole of NaCl required to prepare 1Kg of AgCl according to the equation: (Na=23, Cl=35.5, N=14 , Ag =107.86, O = 16 g/mole)

Solution: $AgNO_3 + NaCl \rightarrow NaNO_3 + AgCl$

$$\text{No of mols(AgCl)} = \left(\frac{wt}{Mwt}\right) = \left(\frac{1\text{Kg}}{143.36(\frac{g}{mol})}\right) = \left(\frac{1000\text{g}}{143.36(\frac{g}{mol})}\right) = 6.98 mol$$

according to the balance equation the mole ratio between NaCl & AgCl equal 1:1 therefore we need 6.98 mol of NaCl .

Example (6): Calculate the number of mole of $Ca(HCO_3)_2$ required to prepare 1.5 mol of CO_2 according to the equation.

$$Ca(HCO_3)_2 + 2HCl \rightarrow CaCl_2 + 2CO_2 + 2H_2O$$

solution:

No. of mol of $Ca(HCO_3)_2$ = No. of mol of $CO_2 \times 0.5$

$= 1.5 \times 0.5 = 0.75$ mol of $Ca(HCO_3)_2$

2- Molarity: -

Molarity (M) in chemistry, the most commonly used unit for molarity is the number of moles per liter, having the unit symbol mol/L (mol/dm3 in SI units or mili-moles in milliliter) at particular temperature, is the most common unit of concentration.
A solution with a concentration of 1 mol /L is said to be 1 molar, commonly designated as 1 M .

$$\text{Molarity (M)} = \frac{\text{No.of moles of solute}}{\text{Volume of solution (L)}} \quad \text{------(1)}$$

$$\text{No. of moles of solute} = \frac{\text{Weight of solute(g)}}{\text{molecular weight (g/mol)}} \quad \text{------(2)}$$

Substitute equation 2 in equation 1 gives:

$$\text{Molarity} = \frac{\text{Wight of the substance in g}}{\text{gram-molecular weight (g/mol)}} \times \frac{1}{\text{Volume in (L)}} \quad \text{------(3)} \quad \text{or}$$

$$M\ (\text{mol/L}) = \frac{\text{Wt (g)}}{\text{M.Wt (g/mol)}} \times \frac{1}{\text{V (L)}} \quad \text{-----(3)}$$

Note: by rearrangement equation (3) it can used to prepare solid substance.

$$\text{Wt (g)} = \text{M.wt (g/mol)} \times M\ (\text{mol/L}) \times \text{V(L)}.$$

Example(1) : A monosaccharide $C_6H_{12}O_6$ (M.Wt=180) solution with a volume of 2.0 L contains 72 g, what is the molarity of the solution?

$$M\ \left(\frac{\text{mol}}{\text{L}}\right) = \frac{\text{Wt (g)}}{\text{M.Wt (g/mol)}} \times \frac{1}{\text{V (L)}}$$

$$M\ (\text{mol/L}) = \frac{72\ (\text{g})}{180\ (\text{g/mol})} \times \frac{1}{2\ (\text{L})}$$

$$\therefore \quad \text{Molarity} = 0.2\ \text{mol/L}.$$

Example(2): A 580 mg of adrenaline hormone (Epinephrine) need to make a 1 mM solution. What volume of water do you need to dissolve it in? The molar mass of adrenaline is 183.2 g/mol ?

Wt (g) =Molecular Wt (g/mol) × Molarity (mol/l) × Vol. of solution /1000

580 = 183.2 mg/mmol x 1 mmol/l x V/1000 = 3165 ml .

. Molality is the number of moles of a solute dissolved in one kilogram of a solvent.

3- Molality :-

Molality (m) or molal concentration is the number of moles of a solute dissolved in one kilogram (1kg)of a solvent.

$$\text{Molality (m)} = \frac{\text{No.of moles of solute}}{\text{Mass of solution (kg)}} \quad \text{------(1)}$$

$$\text{No. of moles of solute} = \frac{\text{Weight of solute(g)}}{\text{molecular weight (g/mol)}} \quad \text{------(2)}$$

Substitute equation 2 in equation 1 gives:

$$\text{Molality} = \frac{\text{Wight of the substance in g}}{\text{molecular weight (g/mol)}} \times \frac{1}{\text{Mass of solvent (kg)}} \text{------(3)}$$

$$\text{Molality (mol/kg)} = \frac{\text{Wt (g)}}{\text{M.Wt (g/mol)}} \times \frac{1}{\text{Mass (kg)}} \quad \text{------(3)}$$

Example – 1-: Calculate the molal concentration for solution preparing from mixing 4 g NaOH with 500 g water ? The atomic weight of Na, O, and H obtained from the periodic table. (Awt. Na=23 O=16 H=1)(Mwt. OF NaOH=40)

$$m\left(\frac{mol}{kg}\right) = \frac{4 \ (g)}{40 \ (g/mol)} \times \frac{1}{0.5 \ kg} \quad \therefore m = 0.2 \ mol/kg$$

Molarity	Molality
Moles of solute dissolved in one liter of solution (solvent + solute).	Moles of solute dissolved in one Kg of solvent.
Molarity of a solution depends upon temperature because volume of a solution is temperature dependent.	Molality of a solution is independent of temperature because the mass of a solvent is not affected by temperature.
Molality is never equal to molarity, but the difference becomes smaller as solutions become more dilute.	

4-Normality

Normality (N) is the number of equivalents of solute dissolved in one liter of solution. The equivalent weight (or the number of reacting units) depends on the chemical

reaction. It may vary most often in redox reactions, when different products are obtained.

$$\text{Normality} = \frac{\text{No. of equivalents of solute}}{\text{Volume of solution (L)}}$$

$$\text{No. of equivalents} = \frac{\text{Wt (g)}}{\text{Equivalent wt(g/eq)}}$$

Relationship between Molarity & Normality

$$M = \frac{\text{Wt g}}{\text{M.Wt g/mol}} \times \frac{1}{V} \qquad N = \frac{\text{Wt g}}{\text{Eq.Wt g/eq}} \times \frac{1}{V}$$

$$M = \frac{1}{\text{M.Wt g/mol}} \qquad N = \frac{1}{\text{Eq.Wt g/eq}}$$

$$\text{Where} \quad \text{Eq. Wt} = \frac{\text{M.Wt}}{\text{No. of equivalents}}$$

$$N = M \times \text{No. of equivalents}$$

Normality	Molarity
Also known as equivalent concentration.	Known as molar concentration.
It is defined as the number of gram equivalent per liter of solution.	It is defined as the number of moles per liter of solution.
It is used in measuring the gram equivalent in relation to the total volume of the solution.	It is used in measuring the ratio between the number of moles in the total volume of the solution.
The units of normality are N or eq L^{-1}	The unit of molarity is M or Moles L^{-1}

Name of substance	Formula	n	Equivalent weight= (M. wt)/n
Nitric acid	HNO_3	1	63/1=63
Sulphuric acid	H_2SO_4	2	98/2 = 49
Acetic acid	CH_3COOH	1	60/1 = 60
Phosphoric acid	H_3PO_4	3	98/3 = 32.66
Oxalic acid	$H_2C_2O_4$	2	90/2 = 45
Potassium hydroxide	KOH	1	56/1 = 56
Ammoniumhydroxide	NH_4OH	1	35/1= 35
Magnesiumhydroxide	$Mg(OH)_2$	2	58/2 = 29
Calcium hydroxide	$Ca(OH)_2$	2	74/2 = 37
Sodium chloride	NaCl	1	58.5/1 = 58.5
Sodium carbonate	Na_2CO_3	2	106/2 = 53
Magnesium chloride	$MgCl_2$	2	95/2 = 47.5
Calcium carbonate	$CaCO_3$	2	100/2 = 50
Copper sulphate	$CuSO_4$	2	159.5/2 = 79.75
Magnesium	Mg^{2+}	2	24/2 = 12
Ferrous	Fe^{+2}	2	56/2 = 28
Ferric	Fe^{+3}	3	56/3 = 18.6
Zinc	Zn^{2+}	2	65.4/2 = 32.7
Cupric	Cu^{2+}	2	63.5/2 = 31.75
Potassium	K^+	1	39/1 = 39