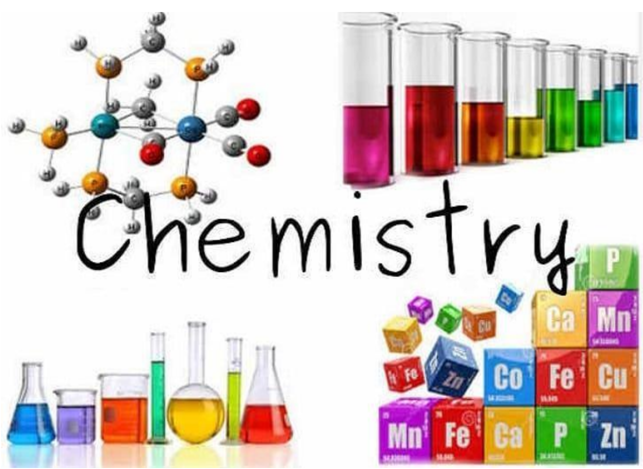
Al Mamoun University College
Laser and Optoelectronics Engineering Department
Chemistry



Analytical Chemistry

Lecture ***Two***

ChapterTwo

ToolsofAnalyticalChemistry

- ***Componentsofmatter***
- ***NumbersinAnalyticalChemistry***
- ***FundamentalUnitsof Measure***
- ***UnitsforExpressing Concentration***
- ***Molarity***
- ***Formality***
- ***Normality***
- ***Molality***
- ***Weight,Volume,andWeight-to-Volume***
- ***Ratios***

Components of matter

***Matter*: anythingthathasmassandtakes up space.**

EveryMatterisconsistingofbasicunitscalled molecules.

EachMoleculeiscomposed ofsmallestparticlescalled“Atom”.

Atom: smallest unit consist of a central nucleus that is surrounded by one or more negatively charged electrons.

Nucleus: consists of ***subatomic particles*** called ***Protons***, which are ***positively charged*** and ***neutrons***, which has ***no charge (neutral).***

The positive charges equal the negative charges, so the atom has no overall charge; it is electrically neutral

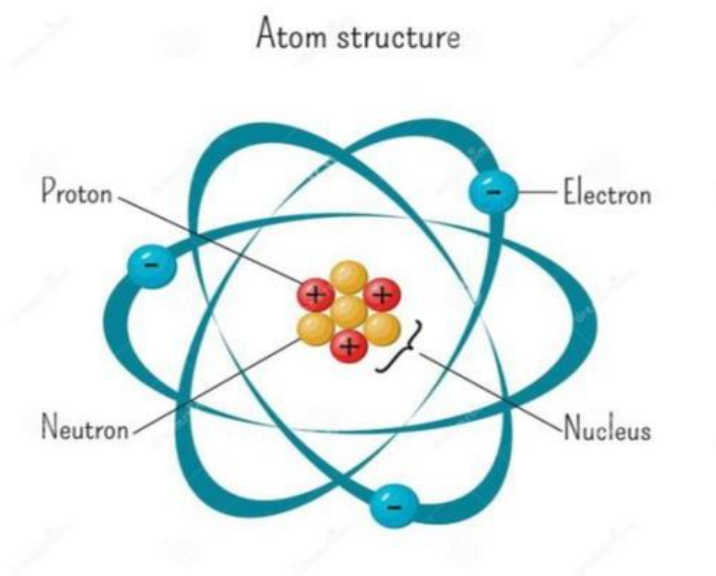
Electron(e−):Itisnegativelychargedsubatomicparticlewhichits number is equal to the number of proton in a neutral atom.

Proton(P+):Itispositivelychargedsubatomicparticlewhichis more massive than electrons.

Neutron (N): It is neutral subatomic particles that have approximately the same mass of protons.

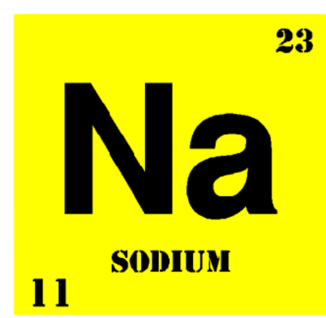
Atomicnumber=numberofprotons=numberofelectrons

Massnumber=No.ofprotons(Atomicnumber)+No.ofneutrons



Example:

Theatomicnumberofasodiumatomis11anditsmass numberis23. Calculate the number of protons, neutrons and electrons it contains



Theatomicnumberofsodiumis11.Everysodiumatomhas11protons and 11 electrons.

Ithas11positivechargesand11negativecharges.

Themassnumberofanatomisitstotalnumberofprotonsandneutrons. The atomic number of a sodium atom is 11 and its mass number is 23.

Calculatethenumberofprotons,neutronsandelectronsitcontains. Number of protons = 11

Numberofelectrons= 11

Numberofneutrons(massnumber-atomicnumber)

= 23-11= 12

➢ NumbersinAnalyticalChemistry

Analytical chemistry is inherently a quantitative science. Whether determining the concentration of a species in a solution, evaluating an equilibriumconstant, measuring a reaction rate, or drawing a correlation between a compound's structure and its reactivity, analytical chemists make measurements and perform calculations.In this section we briefly review several important topics involving the use of numbers in analytical chemistry.

➢ FundamentalUnitsof Measure

Imagine that you find the following instructions in a laboratory procedure: "Transfer 1.5 of your sample to a 100 volumetric flask, and dilute to volume." How do you do this? Clearly these instructions are incomplete since the units of measurement are not stated. Compare this withacompleteinstruction:"Transfer1.5gofyour sampletoa100-mL volumetric flask, and dilute to volume." This is an instruction that you can easily follow.Table (2.1)(Fundamental SI Units).For example, we measure the quantity of heat produced during a chemical reaction in Joules,(J),where

$$1\ \mathrm{J} = 1\,\frac{\mathrm{m^2 kg}}{\mathrm{s^2}}$$

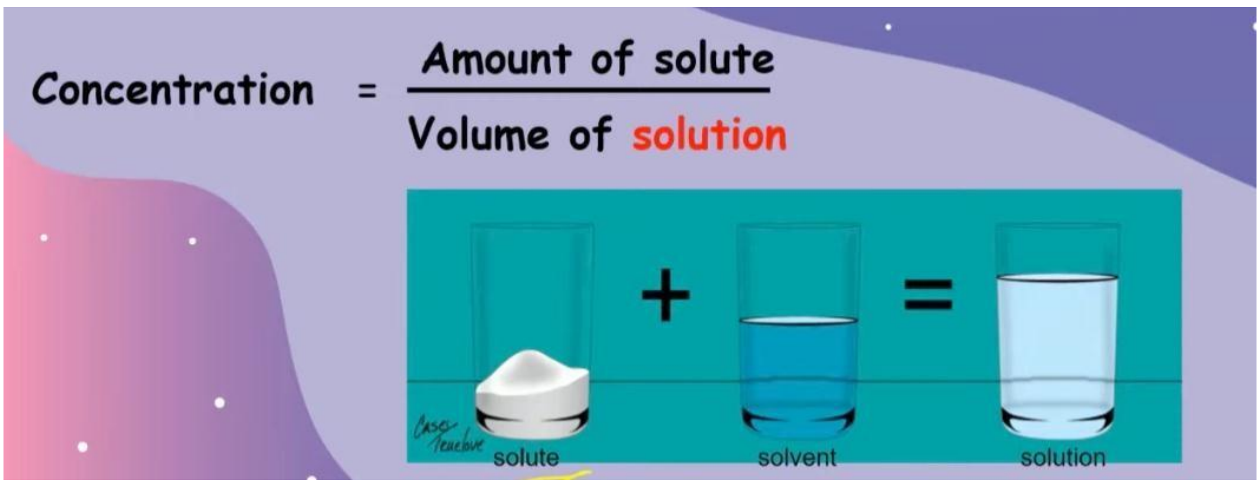
Table 2.1 Fundamental SI Units

Measurement	Unit	Symbol
mass	kilogram	kg
volume	liter	L
distance	meter	m
temperature	kelvin	K
time	second	s
current	ampere	A
amount of substance	mole	mol

Table(2.1)(FundamentalSI Units)

➢ *UnitsforExpressing Concentration*

Concentration:isageneralmeasurementunitstatingtheamountof solute present in a known amount of solution.



Although the terms "solute" and "solution" are often associated with liquid samples, they can be extended to gas-phase and solid-phase samples as well. The actual units for reporting concentration depend on how the amounts of solute and solution are measured.

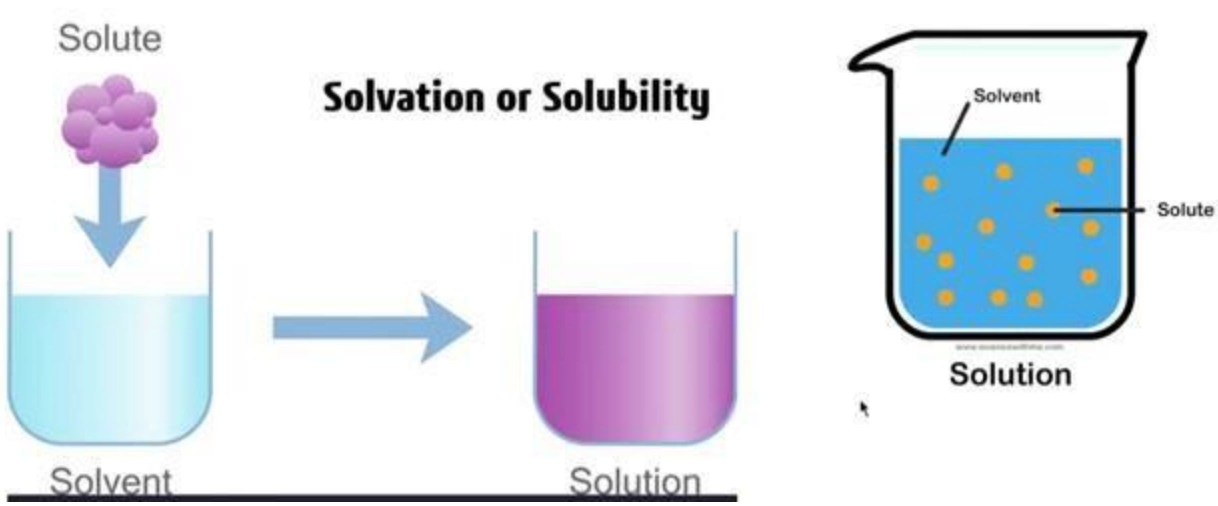
Solution:isahomogenousmixtureof2ormoresubstances.

Solute:isthesubstancepresentinthesmalleramount(s).

Solvent:isthesubstancepresentinthelargeramount.

Since there are different ways for expressing the **"amount"** of a givensubstance, there's more than one way to write a **concentration.**

Q: What is the difference between solvent and solution???



FormulaWeight:

It is assumed that you can calculate the formula or molecular weights of compounds from respective atomic weights of the elements forming these compounds. The formula weight (F.Wt) of a substance ***is the sum of the atomic weights of the elements from which this substance is formed from.***

TheFormulaWeightorMolecularWeightof$CuSO_4.5H_2O$

Element	**No.ofatoms**	**AtomicWeight**
Cu	1	1χ 63.54
S	1	1χ32.06
O	9	9χ16.00
H	10	10χ1.00
F.Wt		249.6g/mol

Example:

Find the molecularweightof$CaSO_4.7H2O$

Mole: The Mole (symbol: mol) is the unit of measurement for amountof substance in the International System of Units (SI).

Alternativedefinitionofthemole:Theatomic,molecular,orformula weight of the substance, expressed in grams.

Mole= $\frac{m(g)}{F.Wt(\frac{g}{mol})}$ =mol

Where:m=mass(gram)

F.Wt=formulaweightormolecularweight(gram/mol). OR

mmol= $\frac{m(mg)}{F.Wt(\frac{mg}{mmol})}$ mmol

Example:

Find the number of g contained in 0.25 mol of Fe_2O_3 (F.Wt=159.7 g/mol)

$$\text{Mole}= \frac{m(\text{g})}{F.\text{W}t(\frac{g}{mol})}$$

$$0.25= \frac{m}{159.7}$$ ⟹ m=159.7(g/mol)χ0.25mol

m(g)= 39.9g

Mole:Itis thenumber of Avogadronumber of atom, molecule, electron and proton (6.022 x 10^{23}).

Mole=$\frac{Nu}{NA}$

WhereNu=thenumberofmoleculesoratomsorelectrons.

NA=Avogadronumber(6.022x10^{23}).

Example:

Find the number of magnesium mole which contains 1.25*10^{23}atoms?

Mole=$\frac{Nu}{NA}=\frac{1.25*10^{23}}{6.022*10^{23}}$ =0.2mol

Example:

FindthenumberofH$_2$Omoleculeswhichispresentin0.360 mol?

Mole= $\frac{Nu}{NA}$

$0.360=\frac{Nu}{6.022*10^{23}}$ ⇒ Nu=0.360*6.022*10^{23}=2.1molecule

WaystoexpressConcentration

1- Molarity(M):numberofsolutemolesdissolvedinsolutionvolumes in liter.

$$M\left(\frac{mol}{L}\right)=\frac{No.of\,moles\,of\,solute}{Volume\,of\,solution\,L}=\frac{n(mol)}{V(L)}=\frac{n(mmol)}{V(mL)}=\frac{\frac{m(g)}{F.Wt(\frac{g}{mol})}}{V(L)}=\frac{m}{F.Wt*V(L)}$$

Example:

Findthemolarityofasolutionresultingfromdissolving1.26gof $AgNO_3$(F.Wt=169.9g/mol)inatotalvolumeof250mlsolution.

Mol= $\frac{m(g)}{F.Wt(\frac{g}{mol})}=\frac{1.26}{169.9}=7.42*10^{-3}mol$

$$M\left(\frac{mol}{L}\right)=\frac{n(mol)}{V(L)}=\frac{7.42*10^{-3}}{0.25}=0.0297\ \frac{mol}{L}$$

OR

$$M\left(\frac{mol}{L}\right)=\frac{m}{F.Wt*V(L)}=\frac{1.26}{169.9*0.25}=0.0297\ \frac{mol}{L}$$

$\frac{250ml}{1000}=0.25L$

OR

$$M\left(\frac{mol}{L}\right)=\frac{m}{F.Wt}\ \chi\ \frac{1000}{V(ml)}$$

2- Normality(N)

Can be defined as the number of equivalents of solute dissolved in 1 L of solution. The number of equivalents, n, is based on a reaction unit, which is that part of a chemical species involved in a reaction. Gram equivalent weight is the measure of the (***reactive capacity***) of amolecule.

$$N(\frac{eq}{L}) = \frac{No. of moles of gm equivalents of solute}{Volume of solution L} = \frac{Eq(eq)}{V(L)} = \frac{\frac{m(g)}{EM\frac{g}{(eq)}}}{V(L)}$$

$N(\frac{eq}{L})=Normality$

$Eq(eq)=Number of equivalents=\frac{m(g)}{EM\frac{g}{(eq)}}$

$EM(\frac{g}{eq})=Equivalent\ Weight=\frac{F.Wt}{\eta}$

$\eta=Number of reacting unit$

$$N(\frac{eq}{L}) = \frac{m*\eta}{F.Wt*V}$$

ReactiveCapacity

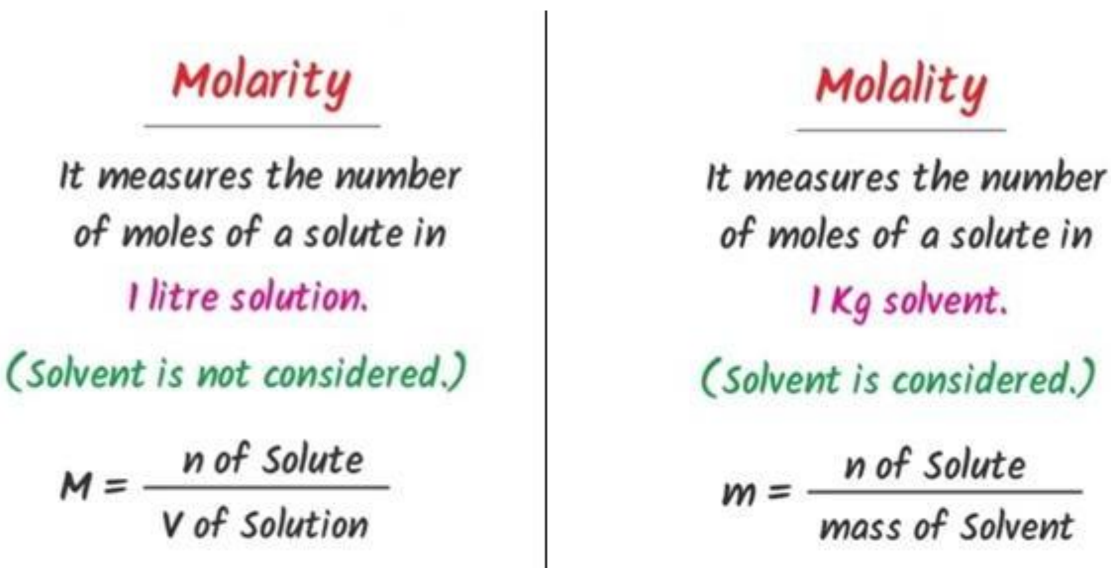
Acid
No.ofreplaceableH^+

Alkali No.of OHgroups

Salt
No.ofmetalionsvalency

3- Molality:

Itusedinthermodynamiccalculationswhereatemperature independent unit of concentration is needed.



4- Formality:

Thenumberofmolesofsolute,regardlessofchemicalform,perliter of solution (F).

5- Weight,Volume,andWeight-to-Volume Ratios:

Weight percent (% w/w), volume percent (% v/v) and weight-to-volume percent (% w/v) express concentration as units of solute per 100 units of sample. A solution in which a solute has a concentration of 23% w/v contains 23 g of solute per 100 mL of solution.

Weightpercent**:**Gramsofsoluteper100gofsolution. (% w/w).

VolumePercent:Millilitersofsoluteper100mLof solution (% v/v).

weight-to-volumepercent:Gramsofsoluteper100mLof solution (% w/v).

The End