Methods of Expressing Concentration

Solutions may be described as **single phase** systems composed of two or more chemical substances representing **homogeneous molecular dispersion.** In general, the components of a solution retain their individual identities. Thus, a solution is properly termed a homogeneous mixture on the basis of the variability of composition.

The properties of a solution are uniform throughout the mixture because the dispersion of the solute molecules in the solvent is on a molecular scale, making the molecules indistinguishable by usual observation procedures.

Colloidal Solutions in Contrast **true solutions** contain very small particles, but these are not of molecular dimensions and may be observed by various techniques.

I. Concentration Expressions

The concentration of solute in a solution may be expressed in many ways, depending upon the convenience to those concerned with its use. Chemists more frequently prefer to work with the number of moles or equivalents of a particular solute. These quantities are also of importance to pharmacists as will be seen in the use of milliequivalents per litre (mEq/Ltr) for electrolyte solutions.

Pharmacists will also use percentage concentrations or some ther expression of the constituents by parts. The commonly employed concentration expression are reviewed in the following on a **physical basis** (weight or volume).

Expression of Strengths

Percent Concentration : The term "Per cent" or more usually the symbol "%" is used with one of four different meanings in the expression of concentrations according to circumstances. In order that the meaning to be attached to the expression in each instance is clear, the following notation is used...

a) Percent w/w (%w/w) - (Percentage weight in weight) expresses the number of grams of solute in 100 gm of product. The concentrations of strong acids, as available commercially, are expressed in this way.

e.g. H_2SO_4 98.0% w/w; CH_3COOH 33% w/w etc.

Also expressing the percentage purity of the solid dosage forms such as tablets, capsules etc. as percent weight/weight (%w/w).

b) Percent w/v (%w/v) - (Percentage weight in volume) It expresses the number of grams of solute in 100 ml of product. (i.e. 100 ml of solution). This is a common way of specifying solution composition of mixtures of miscible liquids, or solids in liquids.

e.g. H_2O_2 solution 5-7% w/v; $BaCl_2$ solution 10% w/v etc.

c) Percent v/v (%v/v) - (Percentage volume in volume) It expresses the number of millilitres of solute in 100 ml of product.

e.g. Alcohol 95% v/v.

d) Percent v/w (%v/w) - (Percentage volume in weight) It expresses the number of millilitres of solute in 100 gm of product.

Usually the strength of solutions of solids in liquids are expressed as percentage weight in volume, of liquids as percentage volume in volume and of gases in liquids as percentage weight in weight.

e) Parts per million (ppm) - When the concentration of a solution is expressed as **parts per million (ppm),** it means **weight in weight ,** unless otherwise specified. **ppm-** the number of grams of solute contained in 10^6 gm of solution.
e.g. In the limit test of chloride 25 ppm of cl.

II. The Chemical methods of expressing concentration

The Chemical methods of expressing concentration are based upon chemical formula or combining power, **The word "Concentration" is frequently used as a general term referring to a quantity of substance in a defined volume of solution .** But for quantitative titrimetric analysis use is made of standard solutions in which the base unit of quantity employed is the **"mole".** This follows the definition given by the International Union of Pure and Applied Chemistry (IUPAC) .

Solution containing very small amounts of solute may be expressed is millimolar (mM) concentration, defined as the number of millimole/ml of solution.

$$(1\ mM = 1x10^{-3}\ M)$$

1. Molarity (M) : The molarity of a solution expresses the number of moles (gram-molecular weights) of solute contained in1000 ml (1 Litre) of solution.

A solution containing 1 mole of solute in each litre of total solution is said to be a one molar (M) solution.

2. Molality (m) : The molality of a solution expresses as the number of moles of a solute contained in 1000 gm of a solvent.

This method of denoting concentration is used in many equations to express **thermodynamic properties** of solutions.

3. Normality (N) : The normality of a solution expresses the number of equivalents (gram-equivalent weight) of the solute in one litre of solution.

This is generally a much more useful expression since it is directly related to reactive concentrations of various species in solution.

4. Equivalent weight of Acid

Equivalent weight of the substance is that weight which contains 1 gm of replaceable hydrogen ion (1.008 gm).

5. Equivalent weight of Base

Equivalent weight of base is that weight which contains one gram of replaceable hydroxyl groups i.e., 17.008 gm of hydroxyl ion.

6. Saturated solution : A saturated solution is one which has dissolved all the solute it is capable of holding at a given temperature. The temperature is a very crucial aspect of saturated solutions, and unless otherwise specified, the temperature is assumed to be 25˚C.

An example of a saturated solution is Boric acid solution used as an Eye wash. The concentration of this solution is near enough to saturation (4.5 – 5 %) that a drop to below usual temperature will cause the boric acid to crystallize from the solution. This represents a caution to its use in the eye. If crystals are present, the solution should be warmed to dissolve them.

7. ***Formality (F) :*** Formality may be defined as the number of gram formula weight (GFW) of the solute dissolved per litre of solution.

$$\text{Formality (F)} = \text{GFW/Litres of solution}$$

III. Solubilty Expressions

The solubility of a compound may be expressed in many ways. The official compendia have adopted a system of stating the amount of a particular solvent necessary to dissolve 1 gm of the substance in question at 25˚ C.

When special quantitative solubility tests are given in the compendia these solubilities can be used as a criterion for assessing the purity of the compound. Whenever the exact solubility of a pharmaceuticall important compound is not known or designated, the following descriptive terms can be used.

S.No.	Descriptive Term	Approximate volume of solvent in millilitres per gram of solute.
1	Very Soluble	Less than 1
2	Freely Soluble	From 1 to 10
3	Soluble	From 10 to 30
4	Sparingly Soluble	From 30 to 100
5	Slightly Soluble	From 100 to 1000
6	Very Slightly Soluble	From 1000 to 10,000
7	Practically Insoluble, or Insoluble	More than 10,000