Exercise 2

PREPARATION OF MOLAR, NORMAL AND PERCENT SOLUTIONS

Structure

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2.1 INTRODUCTION

In the first Unit of course BBCCT-101 you have learnt about various units used for the expression of weights and volumes of substances and solutions used in biochemistry experiments. In connection to that here in this exercise you'll be exposed to some units that are useful and play a crucial role in the expression of solute (analyte) concentration per Unit volume. Among such expression the widely used ones are Molarity (M), Normality (N) and Percent (%) solutions. This exercise is mainly focused on the definition and sample examples how to prepare a solution with specific concentration. Though this is smaller exercise by content but it plays key role in your present and future research work.

Expected Learning Outcomes

After going through this exercise, you should be able to:

- define molarity and normality;
- distinguish between molar, normal and percent solutions; and
- perform the preparation of molar, normal and percent solutions.

2.2 MOLAR SOLUTIONS

For better understanding let us start with a simple a known example, we all know how to prepare a sugar solution; preparation starts by taking a table spoon of sugar and ends by dissolving it in a glass of normal water.

simple experiment water is known as *solvent* and sugar as *solute.* But it is tough to say the concentration of the sugar solution? And whether it is a molar or normal or percent solution! To overcome such issues scientific community has come up with a concept of expressing solute (analyte) concentration per unit volume using the terms Molar, Normal and Percent solutions. Now let's discuss one by one.

A molar solution consists of "***gram molecular weight***" (formula weight) of a solute or substance in grams. Gram Molecular weight (GMW) is obtained by combining the atomic weights of all atoms present in that particular solute molecule.

Molarity is defined as "the number of moles of solute per litre (L) of solution",and is expressed as

$$\text{Moles} = \frac{\text{Weight of solute in grams}}{\text{Gram Molecular Weight}}$$

It's essential to remember that, the term mole represents the amount of substance (in grams), irrespective of the volume where the substance is dissolved.

Example:

No. of moles of sodium hydroxide (NaOH) present in 40 gm is $= \frac{40}{40} = 1$

Molecular weight of NaOH is Na: 22.99; O: 16; H:1 i.e., 39.99 = 40

Let us understand this with a simple excercise of *How to prepare 1 L of 1M solution of NaOH*?

Since molecular weight of NaOH is 40, dissolve 40 grams of NaOH in 1 liter of water to make a 1M NaOH solution per 1 L.

Similarly one mole of sodium chloride (NaCl) is 58.45 (MW 58.45)

The formula to calculate how much weight of solute or substance is needed to prepare a specific solution is:

Weight in grams = desired molarity x volume needed in litres x GMW

Ex: How much weight of NaCl is required to prepare 500mL of 1 M NaCl solution

Weight in grams= 1M x 500 mL x 58.45 GMW

Weight in grams= 29.225 grams of NaCl to be dissolved in 500 mL of water to make it 1M NaCl solution

2.3 NORMAL SOLUTIONS

Normality (N) is also another way of expressing the concentration of solute in the solution. This is partially similar to Molarity but uses gram equivalent weight (Eq.Wt) rather than gram molecular weight (GMW) of solute per

litre. In detail it is explained as"*1N solution contains 1 gram-equivalent weight of solute per liter of solution*" it is also defined as "number of gram equivalents of solute per litre of the solution". To obtain gram equivalent weight one should know the *no of hydrogen atoms that can be added or removed* from the given substance. When you divide the GMW of the substance with no of replaceable hydrogens you'll get EW.

$$\frac{\text{GMW}}{\text{number of replaceble hydrogen atoms}} = \text{Eq. Wt (EW)}$$

For example: Molecular weight of NaOH is Na: 22.99; O: 16; H:1 i.e., 39.99 = 40; NaOH possess 1 hydrogen atom that can be replaced , hence Eq.Wt of NaOH is:

$$\frac{40}{1} = 40$$

Let us understand this with another example of *How to prepare 500 mL of 0.5N solution of NaOH*.

(Atomic weight of NaOH is Na: 22.99; O: 16; H:1 i.e., 39.99 = 40)

$$\text{Weight in grams} = \frac{\text{desired normality x volume required in litres x GMW}}{\text{Valence}}$$

$$\text{Weight in grams} = \frac{0.5\ \text{N} \times 500\ \text{mL} \times 40\ \text{GMW}}{1\ \text{EW}} = 10\ \text{g of NaOH}$$

10 grams of NaOH is needed to prepare 500mL of 0.5N solution of NaOH.

It should be noted that a given solute in solution may have more than one normality value, depending upon the number of electrons lost or gained (oxidation-reduction status) in the reaction. Thus, normality is not a good expression of concentration, as compared to molarity, wherein only one molecular mass exists for a given substance.

Normality= Molarity x N

Where N is equal to no of replaceable hydrogen ions

Reference 1: Experimental Biochemistry: A student Companion

2.4 PERCENT SOLUTIONS

This is another way to express the solute concentrations in a given solution. The following are the two major well-known expressions used for this purpose.

i. weight/volume (wt/vol): Used to express weight (grams) of specific substance in 100 mL solvent.

Example: 1% glucose solution consists of 1 gram glucose in 100 mL of water.

This can be further expressed as g% solution and mg% solution depending on the weight of the solute in 100 mL of solvent.

ii. volume/volume (vol/vol): Used to express volume (mL) in 100 ml of solution

Example: Prepare 100 mL of 60% (v/v) ethanol from 95% ethanol.

% of stock solution you have x unknown volume to be taken (*X*)= 60 % of working ethanol solution you want to prepare x Volume wanted (mL final volume)

$$\frac{60 \times 100}{95} = (x)\ 63.15\ \textit{mL of ethanol}$$

Hence, to prepare 100 mL of 60% ethanol, from 95% ethanol stock-take 63.15 mL of and make up to 100 mL with distilled water, i.e., add 36.85 mL of distilled water to 63.15 mL of ethanol.

Apart from the above two expressions sometimes we use a third type for expressing the concentration of a substance in a mixture.

iii. weight/weight (wt/wt): This is used to express the percentage of a particular substance in a mixture of substances.

Example: 1.If you notice a commercial advertisement of chocolate saying 50 % DARK, indicates that half of its weight (50%) made up of cocoa.

2. Protein content in soya bean is 40 % (i.e., in 100 grams of soya bean by weight contains 40 grams of protein).

Self-Assessment Questions

1. Calculate the weight of NaOH required for preparing 1 L of 0.5 M NaOH solution?
2. How to prepare 20% glucose solution?
3. Calculate the amount of NaCl is required to prepare 1000 mL of 1 N NaCl solution?
4. How to prepare 70% ethanol?

2.5 SUMMARY

All the above discussed expressions are widely used in biochemistry lab for preparing various reagents and diluting the stock solutions.

- Molarity is used to express the mole concentration of a solute in a solvent
- Normality is used to express the gram equivalent weight of solute in a solvent
- Percentage solutions are of two types like wt/vol and vol/vol.
- The other expression used for substance in mixture is wt/wt.

2.6 FURTHER READINGS

1. Experimental Biochemistry: A student Companion. Beedu Sashidhar Rao and Vijay Deshpande. ISBN 81-88237-41-8, I.K. International Pvt. Ltd.

2. Practical Biochemistry: for medical, dental and allied courses. 2nd edition, Dr. G. Rajagopal and Dr.B.D. Toora.ISBN 81-901769-5-1, Ahuja publishing house.

3. Preparative Organic Chemistry CHE-08 (L), Chemistry Lab-III. ISBN 81-7263-333-5, Published by Indira Gandhi National Open University, 1993 (Reprint December-2006).

4. Laboratory manual of Microbiology and Biotechnology (second edition), K.R. Aneja. ISBN 978-93-87025-49-3. MEDTECH a division of Scientific international (Pvt. Ltd).