EXPRESSIONS OF CONCENTRATION AND DILUTION

Introduction

The simple interrelationships of moles, weights, volumes, and so forth are usually covered in general chemistry. These basic concepts tend to give many students problems in the biochemical laboratory. It is important to become familiar with these units and concepts. In the future it will be assumed that you know how to make these solutions.

Keep in mind, that in the metric system one can inter-convert mass (grams), fluid volume (liters) and spatial volumes (cubic centimeters (cc)). Specifically, under most laboratory conditions, 1 ml of water or dilute aqueous solution weighs approximately 1 g and occupies approximately 1cc of volume.

Moles: Mass (weight) values of grams, milligrams, and so forth may be converted into units of moles with knowledge of the molecular weight and use of the various expressions of equation 1.

1. mass in grams/molecular weight = number of moles

Expressions based on molecular weight or gram-equivalent weight

The three most useful expressions of concentration, molarity, molality and normality assume that the molecular weight or the equivalent weight of the solute is known.

Molarity (M) is defined as the number of moles of solute per liter of solution and is denoted by M. This is the most common expression of concentration for solids of known molecular weight. Molarity usually describes solutions of accurate concentrations; solutes are weighed on an analytical balance and solutions are measured in volumetric flasks. Milli-molarity (mM) or micro-molarity (μM) are the range for most solutions in biochemistry and molecular biology.

Therefore, volume and mole values relate to molarity or molar (M) values by use of the various expressions of equation 2.

2. volume in liters x molarity = number of moles

To prepare a liter of 50mM sodium citrate, one would need to weigh 50mmol x453.6mg/mmol of sodium citrate and dissolve it in enough water to make 1.00L of solution (as measured in a volumetric flask).

Molality (m) is defined as the number of moles of solute per 1000 grams of solvent. Molality can be more precise than molarity, since both solute and solvent are weighed. Molality is more not widely used in biochemistry; however, it is used in physical chemistry.

Normality (N) is defined as the number of gram-equivalent weights of solute per liter of solution. This designation is useful for solutions of acids and bases. One gram-equivalent weight of an acid is the quantity of the acid that can donate one mole of hydrogen ions to a base; in contrast one gram-equivalent of a base is that amount of base that can accept one mole of hydrogen ions. For a monoprotic acid (one that can donate one proton per molecule), which yields one mole of hydrogen ions upon complete disassociation, the gram-equivalent weight is equal to the molecular weight.

$$CH_3\text{-}COOH \longleftrightarrow CH_3\text{-}COO^- + H^+$$

1 g-mol=60g

1 g-equiv=60g

Fumaric acid, a diprotic acid, yields two moles of protons when reacted completely with a base. The gram-equivalent weight of fumaric acid, therefore, is half the molecular weight.

To make a 0.5N solution of fumaric acid, one would weigh 0.5 gram-equivalent of fumaric acid and dissolve in enough water to make 1.00L of solution. The molecular weight of fumaric acid is 126g; the equivalent weight is 63g. For a 0.5N solution, 0.5 gram-equivalent weight x 63g/g-equiv = 31.5 g needed to make 1.00L of 0.5N solution.

Volume and equivalent values relate to normality or normal (N) values by use of various expressions of equation 3.

3. volume (in liters) x normality = number of equivalents

Percent-of-Solute

Expression of concentration as **percent-of-solute** is frequently used for liquids and for solids of undetermined molecular weight. Three types of percent-of-solute designations are used: volume per volume (**v**/**v**), weight per volume (**w**/**v**), and weight per weight (**w**/**w**). The most commonly used expression is weight per volume, in which 5.5g of solid solute diluted to 100 ml with solvent is a 5.5%(w/v) solution. A solution with 5.5ml of liquid solute in 100ml of solution would be expressed as 5.5%(v/v) solution and a 5.5g of solid solute in 100g of solution would be expressed as a 5.5%(w/w) solution. In the biochemistry laboratory v/v percent-of-solute solution is not as common as the w/v solution and the w/w solution is rarely used but is commonly seen in physical chemistry.

PROBLEM SET #1

Describe <u>how</u> you would prepare the following *(do the calculations and then briefly describe how you would prepare the solutions)**:***

1. 500mL of a 2N solution of H_2SO_4 from an 8M stock

2. 2L of 10%(w/v) solution of sodium hydroxide (f.w. 40)

3. A 400 mM solution (250mL) of sodium acetate (f.w. 82)

4. A 100 mM solution (1L) of HCl from a 11.6N concentrated stock.

5. A 70% (v/v) ethanol solution (1L) from pure reagents.

6. A 0.5L of a 3N solution of NaOH (f.w.40)

Problems similar to these will be found on Tests 1 and 2!