General Chemistry
Theoretical
First stage Student
Department of Physics

أستاذة المادة

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2024/2025

Analytical chemistry

Methods of expressing solution concentrations in chemical analysis and calculations related to volumetric analysis

Volumetric analysis involves measuring the volume of a standard solution of known concentration that is chemically equivalent to a component in the sample to be analyzed. From the weight of the sample and the concentration of the solution, the percentage of that component in the sample can be calculated. In analytical chemistry, there are several terms that should be explained well in order to understand the basics of quantitative volumetric analysis, its applications, and the calculations related to it.

The concentration of a solution is usually expressed in two basic ways:

First // In units of weight for the substance dissolved in a specific volume of solvent, which is what we call the standard solution, i.e. the solution whose concentration is precisely known, and the concentration is expressed in several ways, including**: normality , molarity, and formality.**.

1- Normality:(N) It is symbolized by the letter and it is defined as the number of gram equivalents of the solute in a liter of solution.

$$N = \frac{\textbf{No. of gram equivalent of solute}}{\textbf{Volume of solvent (Liters)}}$$

$$\textbf{No. of gram equivalent of solute} = \frac{\textbf{Wt. of solute}}{\textbf{Eq.Wt}}$$

$$N = \frac{\textbf{Wt.of solute}}{\textbf{Eq.Wt}} \times \frac{1000}{\textbf{Vml}}$$

Example: What is the normality of a **500 mL** solution containing **20 g** of sodium hydroxide base?

$$N = \frac{\text{Wt.of solute}}{\text{Eq.wt}} \times \frac{1000}{\text{V ml}}$$

M.wt NaOH =Sum. of At.wt
=1x23 +1x16 +1x1 =40 gm/mol

$$\text{Eq.wt of NaOH} = \frac{\text{M.Wt}}{\text{No. of } OH^-} = \frac{40}{1} = 40 \text{ gm/Eq.}$$

$$N = \frac{20}{40} \times \frac{1000}{500} = N = 1$$

Note

(عندما يتعادل**V1ml** من محلول ما عيارية **(N1** مع محلول اخر عياريته **(N2**وحجمه **V2ml)** فان عدد المكافئات الغرامية او الملي غرامية المذابة في كل من الحجمين متساوي وتكون :

N1 x V1 = N2 x V2

او

M1 x V1 = M2 x V2

Example: Calculate the volume of concentrated sulfuric acid with a Normality of **36.8 ml** required to prepare **200 ml** which its normality is **0.3** ?

N1 x V1 = N2 x V 2
200 x 0.3 = 36.8 x V ml
V= 1.63 ml

Example: What is the volume of concentrated ammonia solution **14.8 ml** required to prepare **500ml** from ammonia solution **0.1M** ?

2- Molarity: The molarity of a solution is defined as the number of gram molecular weights of the substance dissolved in one liter. The solution is called molar if one liter of it contains one gram molecular weight of the substance, whether the substance is in the form of molecules, ions, or any other type, as in the following equation:

$$M = \frac{\text{No. of Moles (solute)}}{\text{Volume of solvent (Liters)}}$$

$$\text{No. of Moles (solute)} = \frac{\text{Wt. of solute}}{\text{M.Wt}}$$

$$M = \frac{\text{Wt. of solute}}{\text{M.Wt}} \times \frac{1000}{\text{V ml}}$$

Example: How many grams are needed to prepare **500ml** from silver nitrate from its solution of concentration 0.125M?

If you know that the atomic weight of silver is 107.9

$$M = \frac{\text{Wt.}}{\text{M.wt}} \times \frac{1000}{\text{V ml}}$$

M.Wt. ($AgNO_3$) **= Sum . of At.Wt**

= 107.9 x1 + 14x1 + 3x16 = 169.9 gm/mol.

$$Wt = \frac{M \times M.Wt \times V}{1000}$$

$$Wt = \frac{0.125 \times 169.9 \times 500}{1000} = 10.62 \text{ gm}$$

Note

في كثير من الحالات تقتضي الضرورة لتحضير محاليل قياسية تقريبية ان تخفف محاليل مركزة الى حجوم اخري بتراكيز اقل وذلك بالاستعانة بكثافة المذاب وتركيزه في المحلول ومن المعلومات الاخرى التي تحملها قناني المواد مثل نسب التراكيز المئوية التقريبية واوزانها النوعية وذلك وفقا للعلاقات الاتية:

$$\mathbf{N} = \frac{\text{Density (Sp.gr) x Percentage (\%)} \quad \text{x1000}}{\text{Eq.wt}}$$

$$\mathbf{M} = \frac{\text{Density (Sp.gr) x Percentage (\%)} \quad \text{x1000}}{\text{M.wt}}$$

ملاحظة

(Sp.gr) هي **Specific gravity :** وتعني الكثافة النوعية

$$\textbf{Specific gravity (Sp.gr)} = \frac{\textbf{Density of matter}}{\textbf{Density of water}}$$

Example: Calculate the volume of concentrated sulfuric acid to prepare **500 ml** from a solution of sulfuric acid, the molarity of which is **0.1 M** **If you know its specific weight 1.84. The percentage of hydrogen sulfate in it 96% ?**

M. Wt. (H_2SO_4)= Sum .of At. Wt

2 x1 +1x32 +4x16 =98 gm/mol

$$\mathbf{M} = \frac{\textbf{Density (Sp.gr) x Percentage (\%)} \quad \textbf{x1000}}{\textbf{M.Wt}}$$

$$M = \frac{1.84 \quad x \quad 96\% \quad x1000}{98}$$

= 18.02 M

M1 V1 = M2 V2

18.02 x V1 = 0.1 x 500

V1 = 2.77 ml

Example: Calculate the volume of concentrated sulfuric acid to prepare **500 ml f**rom a solution of sulfuric acid, the molarity of which is **0.1 N**. **If you know its specific gravity 1.84** .**The percentage of hydrogen sulfate in it 96% ?**

Second // It is expressed in units of weight for the dissolved substance in a specific volume or weight of the solvent or solution and includes the **weight percentage concentration**, **molality concentration**, **concentration in molar fraction** and **percentages**:

1- Molality (m): is the number of moles of solute in 1000 grams of solvent.

$$\mathbf{m = \frac{No\ of\ Moles\ (solute)}{1000\ gm\ of\ solvent}}$$

$$\mathbf{m = \frac{Wt.}{M.Wt} \times \frac{1000}{gm}}$$

Example: What is the molality concentration of the sodium hydroxide solution resulting from dissolving **4 g** of it in **500 g** of water?

$$\text{No. of Moles (solute)} = \frac{\text{Wt. of solute}}{\text{M. Wt.}}$$

M. wt (NaOH) = Sum. of At.wt

1x23 + 1x16 + 1x1 = 40 gm/mol.

$$\mathbf{m} = \frac{\text{No of Moles (solute)}}{\text{1000 gm of solvent}}$$

$$m = \frac{Wt.}{M.wt} \times \frac{1000}{gm}$$

$$m = \frac{4}{40} \times \frac{1000}{500} = 0.2\ m$$

2- Weight Volume Ratio w/v:

Concentrations can be expressed as a ratio of the weight of the solute to a given volume of solution, such as: **(gm /l , mg/l , μg/l)**

Another commonly used ratio it is the ratio of parts per million or billion:

Parts per million (ppm) , Parts per billion (ppb)

In a liter of solution or solvent one part per billion equals one microgram of solute per liter of aqueous solvent.

$$\text{No. of grams} = \left(\% \frac{gm}{100\ ml}\right) \times Vml$$

$$\text{No. of milligrams} = ppm \left(\frac{mg}{1000ml}\right) \times Vml$$

$$\text{No. of micrograms} = ppb \left(\frac{\mu g}{1000ml}\right) \times Vml$$

<u>Example :</u> If the gallon **3800 ml** of a solution containing ethyl alcohol at a rate of ten parts per million. **10ppm** Calculate the number of milligrams of alcohol in the solution?

$$\mathbf{mg = ppm \left(\frac{mg}{1000\ ml}\right) V\ ml}$$

$$\mathbf{= \frac{10\ mg}{1000} \times 3800\ ml}$$

mg = 38

Example : If a solution contains one and a half liters of fruit juice at a rate of **20** parts per millions **20ppm** . How many milligrams of juice does the solution contain?