ALMUSTAQBAL UNIVERSITY

Department of Fuel and Energy Technologies Engineering

Analytical chemistry

First class / first term

Lecture Three

By

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miscellaneous methods that includes the measurement of such quantities as mass-to-charge ratio of molecules by mass spectrometry, rate of radioactive decay, heat of reaction, and rate of reaction, sample thermal conductivity, optical activity, and refractive index.

Fundamental Concepts

Atomic weight of element: The mass of a single atom in grams is much too small a number for convenience, and chemists therefore use a unit called an **atomic mass unit** (***amu***) also known as a *dalton* (Da). One **amu** is defined as exactly one-twelfth the mass of carbon isotope ^{12}C and equal to 1.66054×10^{-24} g.

Example: prove that carbon weighing 1.0×10^{-3} g contains 5.01×10^{19} carbon atom?

$$1.0 \times 10^{-3}\ g \times \frac{1\ amu}{1.6605 \times 10^{-24}\ g} \times \frac{1\ C\ atom}{12.011\ amu} = 5.01 \times 10^{19}\ C\ atoms$$

Molecular weight (Mwt): is the average mass of a substance's molecules. Numerically, is equal to the sum of the atomic weights of all atoms in the molecule.

$$molecular\ weight = \text{sum of atomic weight}$$

M.wt of water (H_2O) =2(1.008) +1(16.00) =18.02

M.wt of hydrogen (H_2) = 2(1.008) = 2.016

These weights are all relative to the mass of ^{12}C atom as 12.000 with (SI) system of units' .Molecular weight is expressed by g/mole

H.W: Calculate the M.wt. of $C_7H_{14}O_2$, $C_2H_5N_2SO_4$, Na_2CO_3, P_2O_5

Mole (mol): its Avogadro number (6.022137×10^{23}) of species, so one mole of something consists of 6.022137×10^{23} units of that substance.

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Concentrations expressions

$$No. of\ mole = \frac{mass\ of\ th\ substance\ in\ gm}{M.wt.} = \frac{wt}{M.wt.}$$

$$Molarity\ [M] = \frac{moles\ of\ solute}{volum\ of\ solution\ in\ liters}$$

$$M = \frac{wt}{M.wt.} * \frac{1000}{V\ in\ ml}$$

$$Nomality\ [N] = \frac{meq.of\ solute}{volum\ of\ solution\ in\ liters} \qquad N = \frac{wt}{Eq.wt.} * \frac{1000}{V\ in\ ml}$$

$$C = \frac{wt}{volume}\ \frac{g}{ml}$$

Density and Specific Gravity

Density (ρ): the mass per unit volume at the specified temperature. It is usual expressed in g/ml or g/Cm^3 at 20 °C

Density of water: is taken as 1.0 g/ml at 4 °C and 0.99823 g/ml at 20 °C

Specific gravity (sp.g.): is defined as the ratio between the densities of soluti at 20 °C to that of water at 4 °C, hence it is a dimensionless quantity.

Numerical values of density and specific gravity are equal since d_{water} at 4 °C =1.00 g/ml

$$The\ weight\ fraction = \%\frac{wt}{wt} = \frac{mass\ of\ solute}{mass\ of\ sample} * 100$$

$$\sum \% \left(\frac{wt}{wt}\right) = 100$$

$$The\ mole\ fraction = \frac{n}{n_t} = \frac{moles\ of\ solute}{total\ moles\ of\ sample} = \sum mole\% = 1.00$$

$$The\ volume\ fraction = \%\frac{V}{V_t} = \frac{volume\ of\ solute}{total\ volume\ of\ sample} * 100$$

$$The\ \frac{weight}{volume} fraction = \%\frac{wt}{V} = \frac{mass\ of\ solute}{total\ volume\ of\ sample} * 100$$

Parts per million (ppm): Used to express trace concentration of solute. It can be expressed either

$$ppm\left(\frac{wt}{wt}\right) = \frac{mass\ of\ solute(g)}{mass\ of\ sample(g)} * 10^6$$

$$ppm = \frac{mass\ of\ solute(mg)}{mass\ of\ sample(kg)}$$

$$ppm\left(\frac{wt}{V}\right) = \frac{mass\ of\ solute(g)}{Volume\ of\ sample(ml)} * 10^6$$

$$ppm = \frac{mass\ of\ solute(mg)}{volume\ of\ sample(l)}\ or\ \frac{\mu g}{ml}\ or\ \frac{g}{m^3}$$

There are a number of expression in which the concentration of solution can be expressed

Molarity: It is defined as the number of moles of solute in each liter of solution

$$\text{Molarity [M]} = \frac{\text{moles of solute}}{\text{vol.of solution in liters}} \quad , \qquad \text{Molarity [M]} = \frac{\text{wt}}{\text{M.wt.}} * \frac{1000}{\text{V in ml}}$$

Molality: the solution which contains 1 mole of solute per kilogram of solvent.

$$\text{Molality [m]} = \frac{\text{moles of solute}}{\text{1000 g of solvent}}$$

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The mass of 1 mole of an element is equal to its atomic mass in grams

$$no.of\ mole = \frac{\text{mass of substance in g}}{\text{M. wt.}}$$

$$1\ mol\ of\ HCl = \frac{36.5\ g}{36.5\ g/mol}$$

Examples: Calculate the number of moles in 200 mg of CaO?

- in 10 g of P_2O_5?
- in 5 mg of NaCl?
- in 25 mg of H_2SO_4?
- in 400 mg of K_2CrO_3?

Equivalent weight: is the molecular weight divided by the number of reacting units ($no.of\ equivalent$ = valency)

$$equivalent\ weight = \frac{molecular\ weight}{no.of\ equivalent}$$

For **acids**: the number of reacting units is the number of hydrogen ions that will furnish (acidic hydrogen).

For **bases**: the number of reacting units is the hydrogen ions that will react with it. (Bases hydroxide)

For **salt**: the number of positive parts in the salt Multiplied by its oxidation number.

For **redox reaction**: the number of reacting units is based on the number of electrons that the oxidizing or reducing agent will take on or supply. It can be computed also as the change in oxidation number (transfer electrons).

H.W: Calculate the Eq.wt. of H_2SO_4, H_3PO_4, HCl, CH_3COOH, Na_2CO_3, $NaHCO_3$, $Ca(OH)_2$, NaOH, KOH, $Ba(OH)_2$, K_2CrO_4, $FeCr_2O_4$, $CaCl_2$, Fe_2O_3, (Cr^{+3}- Cr^{+7}), ($KMnO_4$- MnO_2), (MnO_4^- -Mn^{+2}),($K_2Cr_2O_7$- $2Cr^{+3}$) $AgNO_3$, $HgCl_2$.

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Normality: A one normal solution (1 N) is that contains one equivalent weight of solute per liter of solution.

$$\text{Normality }[N] = \frac{\text{no.of equivalent of solute}}{\text{vol.of solution in liters}}, \qquad \text{Normality }[N] = \frac{wt}{Eq.wt.} * \frac{1000}{V\text{ in ml}}$$

The relation between Normality and Molarity: $N = M$ (valency)

H.W:

1) What volume of 3.25 M sulfuric acid is needed to prepare 0.500 L of 0.130 M H_2SO_4?
2) How do we prepare 75.0 ml of 0.96 M sulfuric acid from 18 M acid?
3) What volume of 6.39 M sodium chloride contains 51.2mmol sodium chloride?
4) Rubbing alcohol is an aqueous solution containing 70% isopropyl alcohol by volume. How would you prepare 250 ml rubbing alcohol from pure isopropyl alcohol?
5) How many grams of glucose and of water are in 500 g of a 5.3% by-mass glucose solution?
6) Calculate the molar concentration (Molarity) of a solution contains 1 ppm of lead (Pb), M.wt =207?
7) A sample with mass of 2.6g contains 3.6 µg of zinc; calculate the concentration of zinc in ppm?
8) 150mL of an aqueous sodium chloride solution contains 0.0045g NaCl. Calculate the concentration of NaCl in parts per million (ppm).
9) What mass in mg of potassium nitrate is present in 0.25kg of a 500ppm $KNO_{3(aq)}$?
10) A student is provided with 500ml of 600ppm solution of sucrose. What volume of this solution in millilitres contains 0.15g of sucrose?
11) Convert 78 ppm of Ca^{2+} ions to mol/L?