Prof. Md Shahidul Islam
Dept. of Biochemistry and Food Analysis
Patuakhali Science and Technology University
Dumki, Patuakhali-8602, Bangladesh

(1)

SL-07

CHE-111

04 tk

Introduction to Chemistry

Science: The word Science is derived from the latin word "Scire" which means to know. Science includes the interpretation and classification of question asked and the answered discovered. In short, Science is the systematic knowledge.

Chemistry: Chemistry is the science of properties of matter and changes in materials.

Branches of chemistry:

A. Pure chemistry: Pure chemistry deals with the basic principles of chemistry. It includes-

a) Inorganic chemistry- study of all element or compounds other than carbon.

b) Organic chemistry- study of the compound of Carbon.

c) Biochemistry– Study of chemistry of biologically important elements and compounds.

d) Physical chemistry- Study of the theoretical aspects of the structure and changes of matter such as how and why bonds are formed and energy changes take place.

e) Analytical chemistry: Study of what is present and how much of each constituents are present.

Classification of analytical chemistry

a) Nuclear chemistry- deals with the properties and changes in nucleus of an atom.

b) Thermo chemistry- deals with the effect of temperature in reactions.

c) Photochemistry- deals with the effect of light in chemical reaction or chemical process.

d) Electrochemistry- deals with the effect of electromotive force in analytical process.

B. Applied chemistry: Applied chemistry deals with the application of basic principles of chemistry to produce useful commodities (goods).

Branches of applied chemistry: It includes-

a) Industrial chemistry- deals with the production of industrial goods by applying basic principles of chemistry.

b) Agricultural chemistry- deals with the interaction of plant, soils and other agricultural commodities by applying the basic principles of chemistry.

1. Soil chemistry, 2. Fertilizer chemistry and 3.Pesticides chemistry

c) Food chemistry

d) Pharmaceuticals chemistry

e) High Polymer chemistry

MATTER

Atom: The basic unit of an element that can enter into the chemical combination. It is the smallest particle of an element, which retains the composition of the element. All atoms are composed of a nucleus containing protons, neutrons and a number of electrons outside the nucleus.

Proton- It is positively charged particles, its charge is +1 , mass is 1 and remain in the center of the nucleus

Neutron- It is charge less particles, its charge is Zero , mass is 1 and remain in the center of the nucleus.

Electron- It is negatively charged particles, its charge is -1 , mass is 1/1845 and remain outside of the nucleus.

Ions- Atoms and molecules possessing an electric charge.

Matter: Matter is anything that occupies space and has mass. Matter includes things we can see and touch (such as water); as well as things we cannot see and touch, but we feel only (such as air).

Matter are two types:

a) Pure substance: A substance is a form of matter that has a definite composition and distinct properties and that cannot be separated into other kinds of matter by any physical process. e.g. Water, Oxygen, and Ammonia etc.

Substances are two types

1. Element: An element is a substance that cannot be separated into simpler substances by chemical means. About 115 elements have been positively identified, 83 of them occur naturally on earth the others have been created by scientists via nuclear processes.

e.g. Hydrogen.

2. Compound: A compound is a substance composed of two or more elements chemically combined in fixed proportions. e.g. Water

b) Mixture: A mixture is a material that can be separated by physical means into two or more substances. Mixture are two types.

1. Homogeneous mixture: In which the composition of the mixture is the same throughout. when we dissolved NaCl in water we obtain a Homogeneous mixture. We can separate the mixture by the physical process of distillation.

2. Heterogeneous mixture: In which the composition of the mixture is not uniform or that consists of physically distinct parts each with different properties. e.g. Clay particle in water.

State of matter: There are three distinguishable states of matter. These are

1. Solid state 2. Liquid state 3. Gaseous state

Properties/Characteristics of matter:

Characteristics	Solid	Liquid	Gas
1. State of molecule	Molecules are very close together and held rigidily.	Molecules are very close together but are not held so rigidly	Molecules are separated by distance
2. Volume	Solid has a definite, unchanging and fixed volume.	Liquid has a definite volume	Gas has no definite volume
3.Shape	Solid has a definite, unchanging and fixed shape	Liquid has no definite shape, assumes shape of the container	Gas has no definite shape, but assumes shape of the container
4.Compressibility	Virtually incompressible	Slightly compressible	Very compressible
5. Density	High	High	Low
6. Motion of molecules	Vibrate about fixed position	Slide past one another freely	Very free motion
7. Inter-molecular attraction	High	Comparatively low	Very low

Analysis and Chemical analysis

Analysis: Analysis means discussion, experimentation, investigation, identification, determination or estimation of desired substance.

Chemical analysis:

A chemical analysis of a substance (pure and mixture) means putting apart (separately) its constituents which it is made of with the help of substances of known composition.

Needs of analysis

a) To identify the samples and its constituents.

b) To determine the amounts of constituents.

c) To establish the suitability and potentiality of a substance.

d) To diagnose the condition of the matter investigated.

Types of analysis

A) <u>On the basis of number of constituents analysed</u>

a. Complete analysis - When all the constituents are analysed.

b. Partial analysis – When only one or more constituents are analysed.

c. Proximate analysis - Analysis of radical or group.

B. <u>On the basis of sample size</u>

a. Macro analysis: When more than 0.1 g constituents analyzed.

b. Semi macro analysis: When 0.01-0.1 g constituents analyzed.

c. Micro analysis: When 0.001-0.01 g constituents analyzed.

d. Ultra-micro: When 0.001-0.01mg or 1-10 microgram (µg) constituents analyzed.

C. <u>On the basis of nature of analysis</u>

a. Qualitative analysis - To determine the presence of a constituent.

b. Quantitative analysis - To determine the amount of constituent.

CHE-111

Theory + Practical

03-02-19

SL-06

04 tk

SOLUTION

Solution: Solution is a homogeneous mixture composed of two or more substances so that every portion of its contains the same proportion of the constituents that are difficult to separate by simple means. A solution with water as the solvent is called an aqueous solution. Mixtures of gases, such as the atmosphere, are sometimes referred to as solutions as well. Solutions are distinct from colloids and suspensions in that the particles of the solute are of molecular size and are evenly dispersed among the molecules of the solvent. Solutions appear homogeneous under the microscope, and the solute cannot be separated by filtration. A simple **solution has two components**, a solute and a solvent.

Solute: A solute is a solid, liquid or gaseous substance which dissolves in the solvent, resulting in a solution. Solutes are usually presents in the smallest amount in a solution. Carbonated water is an example of a gas solute (carbon dioxide) dissolved in a liquid solvent (water). Sugar water is an example of a solid solute (sugar) dissolved in a liquid solvent (water). Many metals are soluble in one another, forming solid solutions known as alloys.

Solvent: A Solvent is a solid, liquid or gaseous substance that dissolves or disperses the solute. The most common solvent in everyday life is water. Most other commonly used solvents are organic (Carbon containing) chemicals. Solvents are usually presents in the greater amount in a solution.

Concentration of a solution: The concentration of a solution is the amount of solute dissolved in a given quantity of solvent or solution.

Dilute Solution: A solution that contains relatively small amount of solute.

Concentrated solution: A solution that contains a relatively large amount of solute.

Saturated Solution: A saturated solution is one which contains the maximum amount of solute that will dissolve in a given amount of solvent at a specific temperature.

Unsaturated Solution: The solution that contains less amount of solute than it has the capacity to dissolve.

Supersaturated solution: The solution that contains more amount of solute than is present in a saturated solution.

Basic ways of expressing concentration:

Mass percent solution: The concentration is expressed in term of grams of solute per 100 grams of solution. For W/W both solute and solvent would need to be weighed in the required ratio. A 10 % solution of KI is prepared by mixing 10gms of that salt in 90 gms of water

$$\text{Mass percent solution} = \frac{\text{gms of solute}}{\text{gms of solvents}} \times 100$$

Percent weight by volume: The concentration is expressed in term of grams of solute per 100 ml of solution. 2% NaCl means 2 gm NaCl is present in 100 ml of solution.

$$\text{Mass/volume percent solution} = \frac{\text{gms of solute}}{\text{ml of solvents}} \times 100$$

Volume percent: Solutions that are formulated from two liquids are often expressed as volume percent with respect to the solute. Volume would accordingly be measured using a measuring cylinder, Volumetric flask and Pipette etc. The concentration is expressed in terms of the volume of solute and solvent. For instance a 20% solution of ethanol is prepared by mixing 20ml of ethanol with 80 ml of water.

$$\text{Volume percent solution} = \frac{\text{ml of solute}}{\text{ml of solvents}} \times 100$$

Percent solution: Grams of solute present in 100 ml solution.

Milligram Percent solution: Milligrams of solute present in 100 ml solution

Parts per million: When 1 part of solute is present in 1 million parts of solvents or solution then it is called ppm. 10 ppm Na means 10 gms of Na in one million g or ml of water.

Equivalent weight: The Equivalent weight of a substance is defined as the weight of an element or compound which combines with or displaces from combination, 8.00 parts by weight of Oxygen or 1.008 parts by weight of Hydrogen or 35.5 parts by weight of chlorine. The Equivalent weight expressed in grams is termed gram Equivalent weight.

Equivalent weight of an acid: Equivalent weight of an acid is a number showing how many parts by weight of the acid contain one part by weight of replaceable hydrogen. The molecular

weight of HCl is 36.5 .Hence 36.5 parts by weight of HCl contain 1 part by wt. of replaceable hydrogen. The Equivalent weight of H_2SO_4 is 49 and that of H_3PO_4 is 98/3=32.6

$$\text{Gram equivalent of an acid} = \frac{\text{Molecular wt. of that acid}}{\text{No. of replaceable } H_2\text{/Its basicity}}$$

Equivalent weight of an Alkali and a base : In each case, this is a number which shows how many parts of the base or alkali just completely neutralize one gram Equivalent weight of an acid.

$$KOH + HNO_3 = KNO_3 + H_2O$$

56 gm of KOH neutralizes 63 gm of HNO_3 which is the gm equivalent of HNO_3. Hence the gram Equivalent weight of KOH is 56gm. Thus the gm equivalent of $Ca(OH)_2$ is 74/2=37 and that of $Fe(OH)_3$ is 107/3=35.66. or

$$\text{Gram equivalent of a base} = \frac{\text{Molecular wt. of that base}}{\text{No. of replaceable OH group or its acidity}}$$

Equivalent weight of an Oxidizing or reducing agent: It is that weight of reagent which contains or react with 1 gm of available hydrogen or 8 gm of available oxygen. The word available means capable of being utilized in oxidation or reduction.

$$\text{Equivalent weight of an Oxidizing or reducing agent} = \frac{\text{Molecular wt. of that Oxidizing or reducing agent}}{\text{Change in Oxidation number}}$$

Normality: It may be defined as the no. of gram – equivalent weight of solute per liter of solution. Normality is dependent in temperature

Normal solution: when One gram-equivalent wt. of solute dissolved in 1L of a solution is called normal solution. A 0.1 N solution of sulfuric acid contains 4.90397 grams of H_2SO_4 per liter of solution.

$$\text{Normality} = \frac{\text{gm equivalent of solute}}{\text{Liter of solution}}$$

Molarity: It may be defined as the no. of moles of solute per liter of solution and is expressed as moles of solute per liter of the solution. If 106 gm Na_2CO_3 is dissolved is dissolved in water to form 1 litre of solution , the Molarity of this solution is 1.
Molarity is defined in terms of volume of solution. Molarity is dependent in temperature

Molar solution: One gram-molecular wt. of solute dissolved in 1L of a solution is called molar solution. A 0.1 M solution of Sodium chloride contains 5.8443(58.443/ 0.1) grams of NaCl per litre of solution.

$$\text{Molarity} = \frac{\text{gm moles of solute}}{\text{Liter of solution}}$$

Molality: It may be defined as the no. of moles of solutes per Kg of solvent. A 0.1 m solution of Sodium chloride contains 5.8443(58.443/ 0.1) grams of NaCl per 1000 gms of solution

$$\text{Molality} = \frac{\text{gm moles of solute}}{\text{Kg of solvents}}$$

Molality is defined in terms of mass of solvent. Molality is independent in temperature

Formality: No. of formula wt. Of the solute per litre of solution. If 98 gm H_2SO_4 is present in one litre solution is called one formal solution.

Mole fraction: The mole- fraction of a solute may be defined as the ratio of the no. of moles of the solute to the total number of moles of solute and solvent taken together.

$$\text{Mole fraction of solute, } x = \frac{\text{Moles of solute}}{\text{Moles of solute + Moles of solvent}}$$

In the same way,

$$\text{The mole fraction of solvent, } y = \frac{\text{Moles of solvent}}{\text{Moles of solute + Moles of solvent}}$$