1

Basic Concepts of Chemistry

1.1. INTRODUCTION

Man has been harnessing chemical reactions ever since the members of some sub-human species learned to control fire. Before *any* histories were written, artisans unwillingly employed chemistry in the preparation of natural dyestuffs, the making of leather, the brewing of pharmaceutical conductions, the smelting of metallic ores, the making of alcoholic beverages. But all these early activities were highly empirical arts, shrouded in mystery. It was only a few generations ago that chemistry became something approaching an exact science.

The effect of the impact of the new science on old art has been phenomenal. When man began to understand molecules they found that they were opening the doors to a completely new world.

It is difficult to give clear cut answers to questions like what chemistry is. There will be various responses to this question depending on the knowledge, experience and interest of the person answering it. A very simple answer that a chemistry student will usually give is: chemistry is that branch of science which deals with matter, its properties and transformation. If such a definition means that energy is not at all studied in chemistry, then this definition is definitely incomplete. Chemists normally study the amount of heat evolved or absorbed in a reaction. No study of chemistry can be completed without the study of thermodynamics. Study of the properties of matter can be carried out only after the study of quantum mechanics. In other words, chemistry is what chemists do. Chemists try to purify, identify and characterize substances. They develop and use techniques of purification of a substance from a mixture of substances. Chemists also try to synthesis more and more substances. The branch of chemistry, where a new substance is prepared by the synthesis of two or more substances is termed as synthetic chemistry.

Study of properties of a substance is of interest in itself. Chemists engaged in the synthesis and study of a group of substances known as hydrocarbons and their derivatives are organic chemists. This branch of chemistry is termed as *organic chemistry*. Chemists engaged in the study of substances other than hydrocarbons and their derivatives are inorganic chemists and this branch is *inorganic chemistry*. Chemists engaged in the study of macroscopic, atomic, subatomic, and particulate phenomenon in chemical systems in terms of physical laws and concepts are physical chemists and this branch of chemistry is termed as *physical chemistry*. Chemist studying only living matter are biochemists.

1.1.1 Inorganic Chemistry

Inorganic chemistry is a major branch of chemistry that is generally considered to embrace all substances except hydrocarbons and their derivatives, or conversely, all substances that are not compounds of carbon, with the exception of carbon oxides and carbon disulphide etc. It covers a broad range of subject among which are atomic structure, crystallography, chemical bonding, co-ordination compounds, acid base reactions, ceramics and other various sub-divisions of electrochemistry (electrolysis, battery science, corrosion, semi-conduction, etc.). It is important to state that inorganic and organic chemistry often overlap; for example chemical bonding applies to both disciplines; electrochemistry and acid-base reactions have their organic counter-parts; organometallic and silicon chemistry are borderline areas.

Regarding the importance of inorganic chemistry, R.T. Sanderson has written: "All chemistry is the science of atom, involving an understanding of why they possess certain characteristic qualities and why these qualities dictate the behavior of atoms when they come together. All properties of material substances are the inevitable result of the kind of atoms and the manner in which they are attached and assembled. All chemical changes involve a rearrangement of atoms. Inorganic chemistry is the only discipline within chemistry that examines specifically the differences among all the different kinds of atoms.

1.1.2. Organic Chemistry

Organic chemistry is the major branch of chemistry which embraces all compounds of carbon except such binary compounds as the carbon oxides, the carbides, carbon disulphide, etc., such ternary compounds as the metallic cyanides, metallic carbonyls, phosgene ($COCl_2$), carbonyl sulphide (COS) etc. and the metallic carbonates, such as calcium carbonate and sodium carbonate. The total number of organic compounds is indeterminate. Large number of compounds have been identified and named. These fall into several structural groups (discussed in chapter on "Nomenclature of organic compounds").

There is no sharp dividing line between organic and inorganic chemistry for the two often tend to overlap.

1.1.3 Physical Chemistry

Inorganic and organic chemistry are concerned with the changes that take place in the chemical constitution of materials following a chemical reaction. Physical chemistry attempts to measure the influence of factors such as heat, light, pressure, concentration, electricity etc. on both the reactants and the reaction itself, and to deduce from these measurements the fundamental laws, governing chemical change. Thus, the physical chemistry is concerned with:

1. Collecting data regarding the physical properties of materials, and design the apparatus and techniques suitable for the accurate measurement of such data.
2. Measuring energy exchanges relating to chemical reactions, determining the speed of chemical reactions and the extent to which they take place, and studying the effect of changes in the various factors listed above on the reaction.
3. Correlating the information obtained, assessing its significance and systematizing it

in the form of laws.

4. Developing a theoretical explanation of these laws, and making deductions from them, leading to an advancement of the subject.

Thus, science of chemistry treats the following groups of phenomena:

(*i*) The structure of the molecules and the properties of substances in relation to their molecular structure.

(*ii*) The compositions of substances and the changes in the composition and the molecular structure of the substances, and the effect causing such changes.

The science of physics treats the following:

(*i*) The characteristics of bodies that are independent of their composition and the properties of substances in their general aspect, without reference primarily to their molecular structure or composition.

(*ii*) Changes not involving change in molecular structure or composition.

The above definitions, although interesting and reasonably complete are made with respect to a theoretical concept, the structure of molecule. A sharp line, however, cannot be drawn between these two on the basis of molecular structure and composition. Since the basis of both chemistry and physics (called together physical sciences) lie large bodies of general principle relating to matter and energy.

1.1.4. Environmental chemistry

It is that aspect of chemistry which is concerned with the study of the sources, reactions and effects of chemical species in the various segments of environment (like air, soil, water etc.) and the effect of human activity on these.

1.2. MEASUREMENTS AND SI UNITS

The introduction of International system of units, SI (System International) units in 1960 was intended to present an unambiguous set of standards accepted internationally in all branches of science and engineering. There are seven basic physical quantities on which the International System of units is based. List of these physical quantities along with units and symbols of these units are given in Table 1.1

Table 1.1 Seven basic physical quantities of international system of units.

Quantity	*SI unit*	*Symbol*
Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Temperature (absolute scale)	Kelvin	K
Amount of substance	Mole	mol
Luminous intensity	Candela	cd

Other physical quantities are derived from these basic ones by mathematical procedures such as multiplication, divison, differentiation etc. (for example, the derived quantity, speed is equal to length divided by time). Some commonly used physical quantities and their derived units are given in Table 1.2.

Table 1.2 Some commonly used physical quantities and their derived units.

Quantity	*SI Unit*	*Symbol*
Area	square metre	m^2
Volume	cubic metre	m^3
Density	kg per cubic metre	$kg\ m^{-3}$
Velocity	metre per second	ms^{-1}
Acceleration	metre per square second	ms^{-2}
Force	Newton	$N = Jm^{-1} = kg\ ms^{-2}$
Energy, work	Joule	$J = Nm = kg\ m^2s^{-2}$
Pressure	Pascal	$Pa = Nm^{-2} = kg\ m^{-1}s^{-2}$
Electrical charge	Coulomb	$C = As$
Potential difference	Volt	$V = JC^{-1} = JA^{-1}\ s^{-1}$
Electrical resistance	ohm	$\Omega = VA^{-1}$

Generally, we require units which may be multiples or fractions of the SI units.

A preferred set of fractions and multiples has been drawn up for use in conjunction with SI units as given in Table 1.3.

Table 1.3 Some commonly used prefixes with SI units.

Fraction	*Prefix*	*Symbol*	*Multiple*	*Prefix*	*Symbol*
10^{-1}	deci	d	10	deca	da
10^{-2}	centi	c	10^2	hecto	h
10^{-3}	milli	m	10^3	kilo	k
10^{-6}	micro	μ	10^6	mega	M
10^{-9}	nano	n	10^9	giga	G
10^{-12}	pico	p	10^{12}	tera	T

The SI system recommends the multiples such as 10^3, 10^6, 10^9 etc and fractions such as 10^{-3}, 10^{-6}, 10^{-9} etc., *i.e.,* the powers are the multiples of 3. For example, the SI unit of time is second (s). We can measure very fast changes by combining this unit (*i.e.* s) with prefixes such as milli-, micro-, nano- and pico-.