CHAPTER-1

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ

INTRODUCTION TO CHEMISTRY

You will learn in this chapter about :

* What is chemistry, its definition and importance.
* Land mark in the history of chemistry.
* Chemistry and society
* Branches of chemistry.
* The scientific approach in chemistry.

1.1 WHAT IS CHEMISTRY (Definition and its Importance)

People in the industrialized nations have a higher standard of living than the human race has ever known. More nutritious food, better health, better life and much more of this is due to chemistry. Chemistry enables us to design all sorts of materials, drugs to fight disease, pesticides to protect our health and fertilizers to grow our crops for abundant food, fuels for transportation, fibres to provide comfort and variety in clothes and a lot of other things.

Chemistry also helps us to understand the nature of our environment and about ourselves. The theories of chemistry illuminate our understanding of the material world from tiny atom to giant galaxies.

Definition:

Chemistry is the branch of science that deals with the properties, composition and structure of matter. Chemistry also deals with the changes involved in the matter. It also deals with the principles governing the changes which matter may undergo.

1.2 LANDMARKS IN THE HISTORY OF CHEMISTRY

Over the centuries, chemistry has undergone remarkable progress. Chemistry from the very beginning was, however, used in a number of

arts and crafts, such as pottery making, glass making, dyeing and in metallurgy. All these developments were empirical (experimental) that is they were achieved by trial and error and not on the basis of any systematic study.

1.2 (a) THE GREEK PERIOD

Greek philosophers like Plato (347 - 428 B.C), Aristotle (322-384 B.C), Democritus (357-460B.C) and many others contributed a lot in number of small ways to the early development of chemistry. They introduced the concept of elements, atoms and the chemical reactions. They thought that all matter was derived from four elements, earth, air, fire and water. These elements have properties of their own such as hot, dry, cold and wet. According to them, fire was hot and dry, earth was dry and cold, water was cold, hot and wet and air was cold, wet and hot.

The Romans developed the chemical arts still further. They improved metallurgical processes and introduced the enamelling of pottery. However, they developed little theoretical knowledge in this regard. Their works were all empirical.

(b) THE MUSLIM PERIOD

The Muslim period was from 600 to 1600 A.D in the history of chemistry and is known as the period of alchemists. In the middle ages, chemistry was given a spurt of work. During the first few centuries of Hijra, the Muslim scientists made rich contributions to the various branches of science, specially in the field of chemistry and introduced scientific methods and experimentations. The modern scientific knowledge is based on the contributions of these Muslim scholars.

The alchemists developed and used many laboratory equipments such as funnels, beakers, crucibles for melting and fusion, retorts for distillation, balances for weighing, etc. They discovered various acids, alcohols and medicines.

Jabir Ibne-Haiyan (721 - 803 A.D), generally known as the father of alchemy, invented experimental methods for the preparations of nitric acid, hydrochloric acid and white lead. He also developed methods for the extraction of metals from their ores and dyeing cloths.

Al-Razi (862 - 930 A.D) was a physician, alchemist and a philosopher. He was an expert surgeon and was the first to use opium as an anaesthesia. He divided the substances into living and non-living origins, which was later adopted by Berzellius, in 1806 to classify chemical compounds on the basis of their origins as organic and inorganic compounds. Al - Razi prepared

ethyl alcohol by the fermentation process.

Al - Beruni (973 - 1048 A.D) contributed a lot in physics, metaphysics, mathematics, geography and history. In the field of chemistry, he determined the densities of different substances.

Ibne-Sina (980 - 1037 A.D) was famous for his contribution in the field of medicines, medicinal chemistry, philosophy, mathematics and astronomy.

These Muslim alchemists were interested more in finding a way to prolong life and to convert baser metals like lead, copper into gold. Although their efforts were futile but their researches led to the discoveries of many substances and laid the foundation of chemistry. By the late sixteenth century, a lot of chemical laboratories sprang up and the important reagents like sulphuric acid, nitric acid, hydrochloric acid, silver nitrate, etc were discovered. Chemists of that period, however, devoted their energies mainly to the production of drugs for the use of medicines.

(c) THE MODERN PERIOD

Robert Boyle (1627 - 1691 A.D) described affectionately as the father of modern chemistry, was the first to put forward the idea that chemistry should be regarded as a systematic investigation of nature with the sole aim of promoting knowledge. As a result, lot of discoveries were made during later years.

J. Black (1728 - 1799) made a study of carbon dioxide.

J. Priestly (1733 - 1804) discovered oxygen, sulphur dioxide and hydrogen chloride.

Scheele (1742 - 1786) discovered chlorine. Cavendish (1731-1810) discovered hydrogen, Lavoisior (1743 - 1794) discovered that oxygen constituted about one-fifth of air. John Dalton (1766 - 1844) made a great stride in chemistry with his atomic theory of matter. The idea of atoms and molecules became the established fact and the concept of atomic weight was also given by John Dalton.

Gay - Lussac (1778 - 1850), Avogadro (1776 - 1856), Dulang (1785 - 1838) and Petit (1741 - 1820) and others led to the determination of relative atomic and molecular masses of many substances. Meanwhile J. J. Berzelius (1779 - 1848) introduced the idea of symbols, formulae and chemical equation to make the study more systematic. This was further enhanced by Mendeleeff (1824 - 1907) who discovered the periodic arrangement of the elements. The ionic theory and the laws of electrolysis were put forward by Arrhenius (1859 - 1927) and M. Faraday (1791 - 1867), respectively. The works of J.J. Thomson (1856 - 1940), H. Becquerel (1852 - 1908), M. Curie (1867 - 1934), Neil Bohr (1885 - 1962) and E. Rutherford (1891 - 1937) led

to the discoveries of structure of atom, radioactivity, there by opening the door of the present nuclear age.

1.3 CHEMISTRY AND SOCIETY

There are three significant reasons to study chemistry. First, chemistry has important practical applications in the society. The development of life saving drugs is one and a complete list would touch upon most areas of modern technology.

Second, chemistry is an intellectual enterprise, a way of explaining our material world.

Finally, chemistry figures prominently in other fields, such as in biology, in the advancement of medicines. Chemistry in every field is a useful intellectual tool for making important decisions.

The role of chemistry in the prevailing society is of enormous benefits. We are familiar with many chemicals which have become part and parcel of our daily life.

Chlorine has become an important commercial chemical. Today chlorine has turned into the main element for producing more than one thousand chlorine compounds, which are of great importance in chemical industry, producing Poly Vinyl Chloride (PVC) as plastics for pipes. Other Chlorine compounds are used as bleaching agent, disinfectants, solvents, pesticides, refrigerants, flame retardant and drugs.

Cholera, typhoid fever and dysentery are dangerous diseases, transmitted through impure drinking water. All such water - borne diseases are all but eliminated from most of the parts of the world, when water supplies are treated with chlorine which kill pathogenic (disease-causing) organisms. Chemistry plays an important role in the modern world. For example food, synthetic fibers, plastics, medicines, soap, detergents, cosmetics, cement, fertilizers, glass and explosives are the major gifts of chemistry.

The applications of chemistry are much like the science itself, undergoing constant changes. Chemistry is an extremely practical science and has deep influence on our daily living. It matters with the protection of environment, providing our everyday needs of food, clothing and shelters. Using chemistry we have discovered pharmaceutical chemicals that enhance our health and prolong our lives. Unfortunately some chemicals have the potentials of harming our health or the environment. It is in our best interest as educated citizens and consumers to understand the profound effect, both positive and negative that chemicals have on our lives.

We use fluoride compounds such as SnF_2, Na_2PO_4. F (Sodium fluoro phosphate) and NaF in our tooth pastes to protect and control tooth decay. It is a great beneficence of chemistry on the society.

1.4 BRANCHES OF CHEMISTRY

There are various branches of chemistry. The main branches of chemistry are:

(1) Physical chemistry
(2) Organic chemistry
(3) Inorganic chemistry
(4) Analytical chemistry
(5) Bio chemistry
(6) Industrial and Applied chemistry
(7) Nuclear chemistry
(8) Environmental chemistry
(9) Polymeric chemistry

(1) Physical Chemistry:

It is the branch of chemistry that deals with the laws and the principles governing the combination of atoms and molecules in chemical reactions.

(2) Organic Chemistry:

It is the branch of chemistry that deals with carbon compounds with the exception of CO_2, CO, metal carbonates, bicarbonates and carbides. Actually it is the chemistry of hydrocarbons and their derivatives. Most of the consumers products are organic in nature.

(3) Inorganic Chemistry:

It is the branch of chemistry that deals with the chemistry of elements and their compounds, generally obtained from non-living organisms i.e. from minerals.

(4) Analytical Chemistry:

It is the branch of chemistry that deals with the study of the methods and techniques involved to determine the kind, quality and quantity of various components in a given substance.

(5) Biochemistry:

It is the branch of chemistry that deals with the compounds of living organisms i.e. plants and animals and their metabolism in the living body.

(6) Industrial Chemistry:

It is the branch of chemistry that deals with the study of different

chemical processes involved in the chemical industries for the manufacture of synthetic products like glass, cement, paper, soda ash, fertilizers, medicines etc.

(7) Nuclear Chemistry:

It is the branch of chemistry that deals with the study of changes occurring in the nuclei of atoms, accompanied by the emission of invisible radiations.

(8) Environmental Chemistry:

It is the branch of chemistry that deals with the study of the interaction of chemical materials and their effect on the environment of animals and plants. Personal hygiene, pollution and health hazards are important areas of environmental chemistry.

(9) Polymeric Chemistry:

It is the branch of chemistry that deals specially with the study of polymerization and the products obtained through the process of polymerization such as plastics, synthetic fibers, papers etc.

Every branch of chemistry has its own importance in human life. Biochemistry is the backbone of medical sciences. Environmental chemistry tells us about the environment composition and that how one can protect its environment from environmental hazards. Industrial chemistry helps us in the manufacturing of the industrial products and their uses. Analytical chemistry is important to understand the composition of compounds, quality of the products, analysis of biological samples, such as water, milk, urine, blood, soil and the use of research techniques, such as chromotography and spectroscopy. Nuclear chemistry provides us radio isotopes for the treatment of many diseases, such as cancer and also to give atomic energy for the benefits of mankind.

1.5 THE SCIENTIFIC APPROACH IN CHEMISTRY (Observation, Hypothesis, Theory and Law)

Over the years science has developed through a series of discoveries which started off as observed natural phenomenon which had to be explained. This was done by using scientific method in a systematic manner.

(1) Observation:

Different people observe a phenomenon in different ways. Some of us observe something very critically to extract from it a new point.

Observation is a basic tool to go forth for elaborating a phenomenon but it may vary from person to person according to his own skill of elaboration. Observation of a thing is one of the scientific approaches in chemistry.

(2) Hypothesis:

When a phenomenon is observed; a scientist ponders over it and carries out relevant experiments. He sieves through the data and arrives at a possible explanation for the nature of the phenomenon. This explanation; which is still only a trial idea is called hypothesis. It may or may not undergo a change as a result further investigations and accumulation of more knowledge or facts.

(3) Theory:

The scientist conveys his hypothesis to other workers of the same field for the discussion and for further experimentation. When the hypothesis is supported by a large amount of different types of observations and experiments, then it becomes a theory i.e. scientifically acceptable idea or principle to explain a phenomenon. A good theory predicts new facts and unravels new relationship between naturally occurring phenomenon.

(4) Scientific Law:

A theory which is tested again and again and found to fit the facts and from which valid predictions may be made is then known as scientific law or principle.

However, not all hypothesis and theories pass successfully to become scientific laws. Some may sound very convincing and be supported by mathematical calculations but are very difficult to prove experimentally. This is invariably due to the material under investigation or the lack of suitable working equipments. A typical example is Avogadro's hypothesis which has not been proved conclusively and yet it is accepted as Avogadro's law.

Science cherishes all forms of ideas and proposals. Even obsolete ideas are kept as reference. It is said that there is no end to knowledge, so development in science too may have no limits.

SUMMARY

1. Chemistry is the branch of science that deals with the properties, composition and structure of matter. It also deals with the principles and laws governing the changes involved in the matter.
2. Chemistry is as old as human civilization. Over the centuries chemistry has undergone remarkable progress and was used in pottery making, glass making, dyeing and in metallurgies.
3. Greek philosphers (347 to 460 B.C) Plato, Aristotle, Democritus and many others contributed in the early developments of chemistry in a number of ways. The concepts about elments, atoms and chemical reactions were introduced by them. However they developed little theoritical knowledge in chemistry. Their works were mostly empirical.
4. The Muslim period started from 600 A.D and ended about 1600 A.D in the history of chemistry and was known as the period of alchemia. During the first four centuries of Hijra, the Muslim scientists contributed richly towards many branches of science, specially in the field of chemistry and introduced scientific methods and experimentations. The alchemists developed and used many laboratory equipments, such as funnels, beakers, crucibles, retorts for distillation, balances etc. The modern scientific knowledge is based on the contributions of these Muslim scientists or scholors like Jabir-Ibne-Haiyan, Al-Razi, Al Beruni, Ibne-Sina, etc.
5. Modern chemistry began in the 17th and 18th century as a result of experimentations, free discussion and communication of work of chemists through out the world. Robert Boyle is described as the father of modern chemistry. J.J. Berzelius introduced the idea of symbols, formulae and chemical equations to make the study of chemistry more systematic. J.J Thomson, Henry Becqueral, Rutherford, Neil Bohr, M.Curie led to the discoveries of structure of atom, radioactivity which opened the door of present nuclear age.
6. Chemistry has great impact on the society. It has important practical applications in the society, in medicines in modern technology, industries, environmental composition and its protection from environmental hazards.
7. There are various branches of chemistry which are physical chemsitry, organic chemistry, inorganic chemistry, analytical chemistry, biochemsitry, industrial chemistry, environmental chemistry, nuclear chemistry, etc.

8. The observed natural phenomenon had to be explained by different scientific methods in systematic manner. The scientific approach in chemistry can be described through observations, hypothesis, theory and law.

Observation is the basic tool for elaborating a phenomenon but it may vary from person to person according to his own skill. It is one of the scientific approaches in chemistry.

After observation of a phenomenon, scientist ponders over it and carries out relevant experiments and arrives at a possible explanation for the nature of the phenomenon. This explanation which is a trial idea is known as hypothesis. A hypothesis is liable to undergo changes as a result of further investigations.

When the hypothesis is supported by a large number of different types of observations and experiments by other workers on the same phenomenon, then a theory is developed. A good theory predicts new facts and figures, unreavelling new relationships between naturally occurring phenomenon.

When a theory is tested again and again and is found fit according to the facts, giving valued predictions, is called as scientific law.

EXERCISE

1. Fill in the blanks :

(i) The early Greeks believed that every thing in the universe was made up of four elements _____ ; _____ , _____ and _____.

(ii) Al-Razi divided chemical substances on the basis of their _____.

(iii) _____ is the branch of chemistry which deals with the carbon compounds.

(iv) Biochemistry is the backbone of _____.

(v) PVC which is a plastic is the short name for _____.

(vi) Oxygen was discovered by _____.

(vii) The best disinfectant is _____.

(viii) The periodic arrangement was the result of _____ work.

2. Write answer of the following questions :

(i). Write a note on the historical development of chemistry with special mentioning of the contribution of Muslim scientists in the field of chemistry.

(ii). Define chemistry and describe its importance.

(iii). What important role chemistry plays in the society ?

(iv) Name the different branches of chemistry and define them.

(v). What do you mean by the scientific approach in chemistry? How will you differentiate between hypothesis and theory ?

(vi). What is scientific law?