**CHEMISTRY**

**DEFINITION:**

Chemistry is the branch of natural science which deals with the study of composition matter, properties of matter and changes that occurs in matter. It also deals with the laws and principles governing these changes.

**BRANCHES OF CHEMISTRY:**

Due to wide range of study of matter, chemistry has been divided into various branches. The main branches of chemistry are:

1. Physical Chemistry.
2. Organic Chemistry.
3. Inorganic Chemistry.
4. Analytical Chemistry.
5. Bio Chemistry.
6. Industrial Chemistry.
7. Nuclear Chemistry.
8. Environmental Chemistry.
9. Polymer Chemistry.
10. **PHYSICAL CHEMISTRY:**

It is the branch of chemistry which deals with the physical properties of substance and their dependence on chemical bonding. It also explains the laws and principles governing the combination of atoms and molecules in chemical reactions.

1. **ORGANIC CHEMISTRY**:

It is the branch of chemistry which deals with the study of carbon containing compounds with the exceptions of carbonates , bicarbonates , cyanides , cyanates , thiocyanates , carbides and oxides of carbon . actually it is the study of hydrocarbons and their derivatives.

1. **INORGANIC CHEMISTRY:**

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

1. **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.

1. **BIO CHEMISTRY:**

It is the branch of chemistry which deals with the study of compounds and their reactions (metabolism) occurring in the bodies of living organisms i.e. plants and animals.

1. **INDUSTRIAL CHEMISTRY:**

It is the branch of chemistry which 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.

1. **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.

1. **ENVIRONMENTAL CHEMISTRY:**

It is the branch of chemistry that deals with the study of the interaction of chemical materials and their effects on the environment of plants and animal’s personal hygiene, pollution and health hazards are important areas of environmental chemistry.

1. **POLYMER CHEMISTRY:**

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

**IMPORTANCE OF BRANCHES OF CHEMISTRY**

Every branch of chemistry has its own importance in human life.

1. **BIO CHEMISTRY** is the backbone of medical science.
2. **ENVIRONMENTAL CHEMISTRY** tells us about the environmental composition and that how we can protect our environment from environmental hazards.
3. **INDUSTRIAL CHEMISTRY** helps us in the manufacturing of the industrial products and their use.
4. **ANALYTICAL CHEMISTRY** is important to understand the composition of compounds, quality of products, analysis of biological samples, such as water, milk, blood, urine, soil and the use of research techniques, such as the chromatography and spectroscopy.
5. **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.
6. **POLYMERIC CHEMISTRY** provides us knowledge about the preparation of different kinds of plastics, synthetic fibres and papers.

**ROLE OF CHEMISTRY IN SOCIETY**

Chemistry plays an important role in our daily life. It has not only changed the standard of living but also has improved our health conditions. There are many lifesaving drugs.

* There are many chemicals which have become essential ingredients of our lives. For instance chlorine has become an important chemical substance. Now a days thousands of useful chemical substances are made from chlorine which have great importance in chemical industry like polyvinyl chloride (PVC) which is a plastic and is used in making pipes.
* Other chemicals compounds are used as bleaches, disinfectants, solvents, pesticides, refrigerants, flame retardants and drugs.
* Chlorine has eliminated many dangerous diseases like cholera, typhoid, dysentery which spread from contaminated water. The reservoirs of water are treated with chlorine which kills all the germs in the water.
* Chemistry plays an important role for the modern world, e.g. food synthetic fibres, plastics, medicines, soaps and detergents, cosmetics fertilizers, glass, explosives all are gifts of chemistry.
* Fluoride compounds such as sodium fluoro phosphate and sodium fluoride in our tooth pastes help to protect and control tooth decay.

**LANDMARKS IN THE STUDY OF CHEMISTRY**

Chemistry is as old as human civilization over the century’s chemistry has undergone remarkable progress. The development of chemistry can be divided into following periods.

1. The Greek Period.
2. Muslim or Al-Chemical Period.
3. The Modern Period.
4. **THE GREEK PERIOD:**
5. The Greek philosophers, plato, Aristotle and Democritus and few others took part in the early development of chemistry.
6. The presented the concept of elements, atoms and chemical reactions.
7. They believed that the universe was made of four elements i.e. air, water, earth and fire and that one material could be converted into another.
8. The Greek were the first to use the word atom.
9. Unfortunately, the Greek presented science as a theory subject. They were not serious about the experiments and chemistry is basically a practical (experimental) science. Therefore chemistry could not make great progress during this period.
10. **THE MUSLIM PERIOD:**

**IMPORTANT SCIENTISTS OF MUSLIM PERIOD**

1. Jabir-Bin-Haiyan (721-803 A.D)
2. Abu Baker Al-Zakaria Al-Razi (862-930 A.D)
3. Al-Beruni (973-1048 A.D)
4. Abu-Ali Ibn-e-Sina (980-1037 A.D)

**ACHIEVEMENTS OF MUSLIM PERIOD:**

1. During the Muslim period (600-1600 A.D) foundation of modern science took place. The Muslim scientists made rich contributions to various branches of science.
2. They made use of scientific methods and treated chemistry as an experimental science.
3. Muslim scientists developed laboratory equipment’s such as funnels, beakers, balances, weighing scales, crucibles (for melting metals) etc.
4. They discovered fundamental methods of chemistry like, filtration, distillation sublimation, crystallization and fermentations.

**CONTRIBUTION OF MUSLIM CHEMISTS**

* **JABIR BIN HAIYAN: (721-803 A.D)**
* He is known as “the father of chemistry”. He built first chemical laboratory.
* He developed various chemical methods such as filtration, distillation, sublimation and crystallization.
* He discovered the methods for the extraction of metals from their ores.
* He was familiar with the making of steel and dyeing of clothes.
* He invented experimental methods for the preparation of minerals acids like nitric acid and hydrochloric acid.
* He also discovered a method for the preparation of white lead.
* **AL-RAZI (862-930 A.D)**
* Al-Razi was a physician, chemist and philosopher.
* He was an expert surgeon.
* He was the first who used opium as an anesthesia.
* He divided the substances on the basis of living and non-living organisms.
* He prepared sulphuric acid.
* He prepared alcohol by the fermentation process.
* **ABU REHAN AL-BERUNI: (973-1048 A.D)**
* He contributed in chemistry, physics, Geography history and mathematics.
* He measured the circumference of the earth.
* He determined the densities of various substances.
* **IBN-E-SINA: (980-1037 A.D)**
* Ibn-e-Sina was an expert physician. He described the composition and function of more than 760 medicines.
* He was probably the first scientist who rejected the idea that a base metal can be converted into gold.
* He wrote more than hundred books on different subjects related to science.

**THE MODERN PERIOD**

Following are the contributions of the Modern Scientists to the field of chemistry.

* **ROBERT BOYLE: (1627-1691 A.D)**

He is considered as father of modern chemistry. He studied the behavior of gases.

* **JOSEPH BLACK: (1742-1786 A.D)**

He described the study of carbon dioxide gas.

* **SCHEELE: (1742-1786 A.D)**

He discovered chlorine gas.

* **LAVOISIER: (1743-1794 A.D)**
* He discovered that oxygen gas constitutes about one-fifth of the air.
* He invented the physical balance.
* **JOHN DALTON: (1786-1844 A.D)**

He proposed the famous atomic theory.

* **CAVENDISH: (1731-1810 A.D)**

He discovered and explained the properties of Hydrogen gas.

* **GAY LUSSAC: (1778-1850 A.D)**

He studied the diffusion of gases. He also proposed a law which is called as law of combining volumes.

* **AVOGADRO: (1776-18856 A.D)**

He studied the relative atomic masses of different substances.

* **BERZELLIUS: (1779-1848 A.D)**

He introduced the idea of symbols and chemical formulas of different substances.

* **MANDELEEV: (1824-1907 A.D)**

Dimitri Mandeleev published the periodic Table of elements.

* **ARRHENIUS: (1859-1927 A.D)**
* He explained the behavior of electrolytes.
* He gave the concept of acids and bases.
* **MICHAEL FARADAY: (1791-1867 A.D)**

He put forward the laws of electrolysis.

* **J.J.THOMPSON: (1856-1940 A.D)**

He studies the properties of cathode rays and discovered electrons.

* **HENRY BECQEREL: (1852-1908 A.D)**

He studied the properties of radioactive substance.

* **MADAM CURIE: (1867-1934 A.D)**

She discovered the nature and properties of radioactive substances.

* **RUTHERFORD: (1891-1937 A.D)**

He discovered nucleus and proposed a model of atom.

* **NEIL BOHR: (1885-1962 A.D)**

He put forward a model of atom by improving the Rutherford’s model.

* **JOSEPH PRIESTLY: (1733-1804 A.D)**

He discovered Oxygen gas, Sulphur dioxide gas and hydrogen chloride gas.

* **DR. ABDUSSALAM:**

He got Noble Prize for his famous Theory of Unification.

**SCIENTIFIC METHOD**

**DEFINITION:**

A method which is used in the systematic study of science (as well as chemistry) to determine the facts, making theory and scientific law is known as scientific method.

Following are the steps involving scientific method.

1. **OBSERVATION:**

The first step of scientific method in chemistry is the process of noticing and watching of a specific phenomenon in the nature, observation is the 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 is made by using five senses and the equipment’s for observation.

1. **HYPOTHESIS:**

An explanation or idea which is established on the basis of collected facts from observation is known as hypothesis. It is tentative solution of a phenomenon. The validity of hypothesis is then tested through the results obtained from experiments and by the discussion among the scientists. As results a hypothesis may be accepted or discarded.

* **Prediction:** The process which gives the explanation of more phenomena in nature on the basis of the facts collected by observation and hypothesis is called prediction.
* **Experiment:** The process which helps in testing the facts collected by observation, hypothesis and prediction is called Experiment. It is done with the help of measuring and observatory instruments.

1. **THEORY:**

The hypothesis which is supported by a large amount of different types of observations and experiments and to be proved is called theory. It is scientifically an acceptable idea or principle top explain a phenomenon. A good theory predicts new facts and unravels new relationship between naturally occurring phenomenon.

1. **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 known as Scientific Law.

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 in variably due to the material under investigation or the lack of suitable working equipment’s.

**CHAPTER # 2**

**CHEMICAL COMBINATIONS**

**LAWS OF CHEMICAL COMBINATIONS**

**INTRODUCTION:**

Chemistry deals with matter and the changes occurring in it. Chemist had found that these changes are governed by some empirical laws known as laws of chemical combinations. These laws are:

1. Law of conservation of mass.
2. Law of constant composition or Law of definite proportions.
3. Law of multiple proportions.
4. Law of reciprocal proportions.

**LAW OF CONSERVATION OF MASS**

**INTRODUCTION:**

Matter undergoes changes. However, it has been found that in all chemical changes, there is no change in the mass of a substances being changed. The French chemist, Antoine Lavoisier in 1785 studied a number of chemical reactions especially the decomposition of red oxide of Mercury to form metallic mercury and a gas which he named oxygen, and found that in a closed system, the total mass of the system was not changed. He summarized his findings by formulating a law called law of conservation of mass.

**STATEMENT:**

“During a chemical reaction, mass can neither created nor be destroyed.”

In other words,

“In any chemical reaction the initial mass of reacting substances is equal to the final mass of the products.”

**DEMONSTRATION:**

The law of conservation of mass may be demonstrated by the union of hydrogen and Oxygen to form water. If the and are weighed before they unite, it will be found that their combined weight is equal to the weight of water formed.

**PRACTICAL VERIFICATION (LANDOLT EXPERIMENT)**

German chemist H. Landolt, studied about fifteen different chemical reactions with a great skill, to test the validity of the law of conservation on of mass. For this he took H-shaped tube and filled the two limbs ‘A’ and ‘B’, with silver nitrate in limb ‘A’ and hydro chloric acid in limb ‘B’. the tube was sealed so that the material could not escape outside. The tube was weighed initially in the vertical position so that the solution should not intermix with each other. The reactants were mixed by inverting and shaking the tube. The tube was weighed after mixing (on the formation of white ppt of ). He observed that weight remains same.

**MODERN VIEW IN THE LIGHT OF EINSTEIN MASS ENERGY EQUATION:**

In ordinary chemical changes, relatively small amount of energy change occurs. But in nuclear changes where uranium atoms undergo fission (break up) into smaller atoms plus newton’s, the total mass of products is noticeably less than that of starting material. This clearly indicates that some mass of uranium has been converted into energy, which is evident to us as heat and radiation.

The relationship between mass lost and the heat energy liberated is given by the equation.

Here,

E = energy released

m = mass

and c = velocity of light =

**LAW OF CONSTANT COMPOSITION OR LAW OF DEFINITE PROPORTION**

**INTRODUCTION:**

By the end of Eighteenth century, chemists showed that a given compound has a definite (constant) composition. A French Chemist Proust (in 1799) summarized this result in the form of the law of definite proportion.

**STATEMENT:**

“Different samples of the same compound always contain the same elements combined together in the same proportions by mass.”

**FOR EXAMPLE:**

Every sample of pure water though prepared in the laboratory or obtained from rain, river or water pump contains one part hydrogen (H) and eight parts of Oxygen (O) by mass. E.g.

(Parts by mass)

**BERZELIUS DEMONSTRATION**

One of the earliest illustrations of the law of definite proportion is found in the work of Swedish Chemist J.J. Berzelius (1799 - 1848).

Berzelius heated of lead with the various amounts of Sulphur . He got exactly of lead Sulphide and the excess of sulphur was left over, when he used of lead with of Sulphus , he got exactly of lead sulphide and the of lead remained unused.

**LAW OF MULTIPLE PROPORTION**

**INTRODUCTION:**

The fact that the same element, can combine in more than one ratio to from different compounds was published by John Dalton, (1803) in the form of law of multiple proportion.

**STATEMENT:**

“If two elements combine to form more than one compound, the masses of one element that combines with a fixed mass of the other element are in the ratio of small whole number or simple multiple ratio.”

**EXAMPLES:**

1. Carbon forms to stable compounds with Oxygen namely carbon monoxide and carbon dioxide .

The different masses of oxygen which combine with the fixed mass of are in ratio of , i.e. , which is simple whole number ratio, and obeys the law of multiple proportion.

|  |  |  |  |
| --- | --- | --- | --- |
| **Compound** | **Fixed Mass of Carbon** | **Varying Mass of Oxygen** | **Ratio of Oxygen** |
| **Carbon monoxide,** | **12** | **16** | **1** |
| **Carbon dioxide,** | **12** | **32** | **2** |

1. Another example of this law is the formation of water and from hydrogen and oxygen.

The different masses of oxygen , which combine with the fixed mass of hydrogen are in the ratio of i.e. which is again in a simple whole number ratio.

|  |  |  |  |
| --- | --- | --- | --- |
| **Compound** | **Fixed Mass of Carbon** | **Varying Mass of Oxygen** | **Ratio of Oxygen** |
| Water of Hydrogen oxide, | 2 | 16 | 1 |
| Hydrogen peroxide, | 2 | 32 | 2 |

1. The excellent illustration of law of multiple proportion is famished when the element. Nitrogen (N) and Oxygen (O) combine together to form a series of five oxides of nitrogen in which these two elements are present in various proportions.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Compound** | **Mass of N** | **Mass of O** | **Fixed Mass of N** | **Varying Mass of O** | **Ratio of O** |
| Nitrous oxide, | 28 | 16 | 14 | 8 | 1 |
| Nitric oxide, | 14 | 16 | 14 | 16 | 2 |
| Nitrogen trioxide, | 28 | 48 | 14 | 24 | 3 |
| Nitrogen tetraoxide, | 28 | 64 | 14 | 32 | 4 |
| Nitrogen pentaoxide, | 28 | 80 | 14 | 40 | 5 |

**LAW OF RECIPROCAL PROPORTION**

**INTRODUCTION:**

This law was put forward by Pitcher in 1792. This law gives the relation between the combining weights of three (or more) elements, which combine with each other.

**STATEMENT:**

“When two different elements separately combine with the fixed mass of third element, the proportions in which they combine with one another shall be either in the same ratio or some simple multiple of it.”

**EXAMPLES:**

1. **METHANE , WATER AND CARBON DIOXIDE :**

When two elements separately combines with to form methane and water respectively, it is very clear, that in methane of combines with of and in water of combine with the same (fixed) mass i.e. of , now when combine with each other to form they do in the same proportion i.e. parts by mass.

1. Another illustration of law of reciprocal proportion is proved when, of combine with of to form carbon dioxide and of Sulphur combines with the same (fixed) mass of Oxygen i.e. to for Sulphur dioxide.

The above example, shows that the mass of that combines with the same mass of are in the proportion of i.e. .

According to the law of reciprocal proportion, that the proportion in which combines with one another shall be either in the same ratio or some multiple of it i.e. .

**MOLE CONCEPT**

**Atomic Mass Unit:**

“One twelfth of the mass of one atom of is termed as Atomic Mass Unit, abbreviated as . i.e.”

**ATOMIC MASS**

“The relative mass of the isotope of an element as compared to the mass of one atom of is known as Relative atomic mass.”

* It is the no. of times one atom of an element is heavier than of one atom of .
* The sum of number of protons and neutrons gives the approximate atomic mass, which is called Atomic Mass Number.
* For example the sum of protons and the neutrons of one atom of is , so its approximate atomic is .

**MOLECULAR MASS**

“Molecular mass is the number of times one molecule of a substance is heavier than of one atom of .”

* Molecular mass of a substance is the sum of atomic masses of all atoms present in a molecule of a substance shown by its molecular formula.

**FOR EXAMPLE:**

The sum of atomic masses of in is , so its molecular mass is .

**FORMULA MASS**

“Formula mass of a substance (ionic compound) is the sum of atomic masses of all atoms in formula unit shown by its simplest or empirical formula.”

* Crystalline (ionic) compounds (e.g. etc) do not consist of molecules. Their atoms are bounded with each other in a network structure as aggregate of positive and negative ions. These compounds are represented by their empirical formula which simply shows the relative no. of atoms of each element and the smallest unit of ionic compound is called formula unit.

**EXAMPLES:**

**GRAM ATOMIC MASS (GRAM ATOM)**

“The relative atomic mass of an element expressed in grams is called Gram Atomic Mass or Gram atom. atom of all the elements contains atoms.”

**FOR EXAMPLE:**

**GRAM MOLECULAR MASS (GRAM MOLECULE)**

“The relative molecular mass of a substance (element or compound) expressed in grams is called Gram Molecular Mass or Gram Molecule.” One gram molecule of all substances contains molecules.

**FOR EXAMPLE:**

**MOLE**

The S.I unit of chemical amount of a substance is ‘mole’, which is defined as:

“The gram atomic mass, gram molecular mass of gram formula mass of any substance (i.e. element or compound) which contains Avogadro’s number of particles (atoms, molecules or formula unit) is called mole.”

**S.I DEFINITION OF MOLE:**

“A Mole is that amount of substance that contains as many number of elementary particles as there are atoms contained in exactly of the pure carbon isotope.”

**EXAMPLES OF MOLE:**

**FORMULA:**

**AVOGADRO’S NUMBER**

“The number of elementary particles (atoms, molecules, ions or formula units) contained in one mole ( atomic or molecular or formula mass) of a substance (element or compound) is found to be . This no. is a constant and is called Avogadro’s number. It is denoted by .”

**EXAMPLES:**



**CHEMICAL FORMULA**

**DEFINITION:**

“Chemical Formula is an abbreviation used for the full name of a compound by the help of chemical symbols of elements.”

**EXAMPLES:**

1. Chemical formula for water is .
2. Chemical formula for glucose is .

**TYPES OF CHEMICAL FORMULA:**

Chemical formula has its three types.

1. Molecular formula.
2. Empirical formula.
3. Structural formula.

**MOLECULAR FORMULA**

**DEFINITION:**

“It is the type of formula which expresses the actual number of atoms of each element present in the molecule of a compound.”

**EXPLANATION:**

1. It gives the actual atomic ratio of various elements present in the molecule.
2. It is the simple integral multiple of empirical formula.
3. Organic or covalent compounds are usually expressed by their molecular formula.
4. The molecular formula of two or more compounds may or may not be the same. The compounds having same molecular formula but having different structural formula are called Isomers.

**FOR EXAMPLE:**

Ethyl alcohol and dimethyl ether have same molecular formula of

1. **EXAMPLES:**

* Molecular formula of glucose is .
* Molecular formula of acetic acid is .
* Molecular formula of benzene is .
* Molecular formula of Acetylene is .

**EMPIRICAL FORMULA**

**DEFINITION:**

“It is the type of formula which expresses the relative number of each kind of atoms in a molecule of a compound.”

**EXPLANATION:**

1. It gives the simplest whole number ratio of combining elements present in a compound.
2. It is derived chemical Analysis.
3. Ionic or inorganic compounds are generally represented by their empirical formula.
4. The empirical formula of two or more compounds may be the same e.g. benzene and acetylene, both have same empirical formulae.
5. **EXAMPLES:**

* Empirical formula of glucose is .
* Empirical formula of acetic acid is .
* Empirical formula of benzene is .
* Empirical formula of Acetylene is .