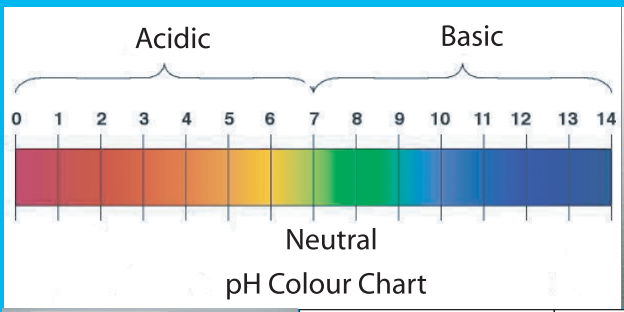
Chemistry

Classes 9-10




Sangu Gas Field

pH range	Description	Colour
0-3	Strong Acid	
3-7	Weak Acid	
7	Neutral	
7-11	Weak Base	
11-14	Strong Base	

Universal Indicator Colour Chart

NATIONAL CURRICULUM & TEXTBOOK BOARD, DHAKA

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CHEMISTRY

Class-IX-X

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PREFACE

Education is the pre-requisite for holistic development. In order to face the challenges of the fast changing world and to accelerate the development and prosperity of Bangladesh, there is a need for well-developed human resources. One of the most important objectives of Secondary Education is to develop students' intrinsic talents and potentials to build the country in line with the spirit of the Language Movement and the Liberation War. Besides, purpose of education at this stage is also to prepare students for higher levels of study by integrating and enhancing the basic knowledge and skills acquired at the primary level. The secondary level of education also takes into consideration the process of learning that helps students become skilled and worthy citizens in the backdrop of country's economic, social, cultural and environmental realities.

The new curriculum of secondary education has been developed keeping in mind the aims and objectives of the National Education Policy 2010. In the curriculum, national ideals, aims, objectives and demands of the time have been properly reflected. It will ensure also the learning of the students according to their age, talent and receptivity. In addition, a broad range starting from moral and human values of the students, awareness of history and culture, the Liberation War, arts-literature-heritage, nationalism, environment, religion-caste-creed and gender is given due importance. Everything is done in the curriculum to enable students to grow up as a scientific-minded nation able to apply science in every sphere of life and to realize the Vision Bangladesh 2021.

All textbooks are written in light of this new curriculum. In the development of the textbooks, students' ability, inclination aptitude and prior experience are given due consideration. Special attention is paid to the flourishing of creative talents of the students and for selecting and presenting the topics of the textbooks. In the beginning of every chapter, learning outcomes are added to indicate what they might learn. Various activities, creative questions and other tasks are included to make teaching-learning and assessment more creative and effective.

The contents of **chemistry** have been chosen in terms of global needs, technological advancements, environment and employment opportunities. The book is developed considering the scopes of **chemistry** in day to day life, practical tasks, chemical processes and environment polution.

This textbook is written keeping in mind the promise and vision of the 21st century and in accordance with the new curriculum. So, any positive and logical suggestions for its improvement will be paid mentionable attention. Very little time was available for writing the textbook. As a result, there could be some unintentional mistakes in it. In the next edition of the book, we will be more careful to make it attractive, illustrative and error free.

We are truly thankful to all who have contributed immensely by their hard work in composing, editing, sketching, preparing sample questions and publishing of the textbook. It is our sincere hope that the textbook will help students acquire expected skills from its reading.

Professor Md. Mostafa Kamaluddin

Chairman

National Curriculum and Textbook Borard, Dhaka.

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Chapter One
Concept of Chemistry

Chemistry is one of the diverse branches of physical science. It is known as the science for life. The practice of chemistry has been in constant increase since the ancient time. The present day chemical industries have been evolved from the early practices of the Alchemists. Chemistry as a discipline encompasses a wide range of areas. It has always been devoted to the welfare of human and its environment. Therefore, in this age of information technology, it is necessary for all to know where and with which processes chemistry is involved in so that we can be benefited from applying the knowledge in our daily life. This chapter contains a simple introduction to chemistry, its scopes and intervention in various fields, common concepts of investigation and research methodologies in chemistry and the issues of preserving chemical substances, as well as, the hazards in using them.

[From left: An ancient, a modern chemistry laboratory and a chemical industry]

By the end of this chapter we will be able to-

(1) explain the concept of chemistry.
(2) identify the scopes of chemistry.
(3) explain the relation of chemistry to the other branches of science.
(4) explain the importance of learning chemistry.
(5) describe the methods of investigation and research in chemistry
(6) plan various types of investigative tasks, choose hypothesis and conduct experiments.
(7) take necessary safety measures while doing practical experiments in chemistry.
(8) explain the phenomena of the natural and physical world in terms of chemistry.

1.1 Introduction to chemistry

Chemistry is one of the ancient and main disciplines of sciences. Various kinds of changes such as formation, destructions, growth, transformation, production etc. are discussed in chemistry. The practice of chemistry has been continuing for a number of millennia. The process of beautifying clothes by applying dyes was on track in the Indian sub continent about 5000 years ago. Men started making metallic weapons, columns and statues quite a long ago. In ancient times, precious metals like gold, silver, lead etc. were extracted from mines using chemical technologies. Gold was extracted by the Egyptians during 2600 B.C that is adored as a classy and precious metal till today. The practice of chemistry during the ancient and Middle Ages is known as Al-chemy. The word Al-chemy takes its origin from the Arabic word Al-chimia which would signify the Egyptian civilization. The Ancient Egyptian civilization became capable of meeting the needs of its people to a great extent through the practices of chemistry. Now a days, in mills and industries, the manufacturing of many consumer products starting from oil, sugar, paper, pen, medicine, cloth, shampoo, soap, rod-cement etc. is done through the use of chemistry.

What is interesting is, present time chemistry is not confined only within the activities of industries and testing or research laboratories. If we observe the incidents happening around us, we will see the presence of chemistry everywhere. Some events are cited in table-1.1 for example.

Table 1.1: Presence of chemistry

Subject	Analysis
Mango becomes yellow as it ripens	Color is a chemical substance. The change in the color of mango to yellow means the creation of yellow coloured new compound in the mango through biochemical process.
Rust in iron	Iron is hard, rust is fragile. Pure iron in presence of moisture reacts with oxygen of air and form a substance named iron oxide, which is generally known as rust.
Burning of wood, kerosene, natural gas or candle	These substances are mainly made of carbon compound. For example, wood is mostly cellulose, natural gas is methane and wax is a compound of carbon and hydrogen. Burning these substances means the burning of carbon compound, which is a kind of chemical reaction that results in the production of carbon dioxide gas, water vapor and heat.

Now, make groups of three students with the help of your teacher. Each team thinks about some incidents where chemistry may be present. Then every team describes any three topics from their own thinking explaining the presence of chemistry in the Table-1.2.

Table-1.2 Describe three topics with explanation of presence of chemistry

Subject	Analysis

So it can easily be assumed that, chemistry is somehow related to the different changes happening in our environment. The acts of making differences in the tastes of food through cooking may be called a kind of chemistry. In fact, from the ancient civilization to modern age, the immense journey of chemistry is observed in the society, that is, in almost all fields of science.

1.2 Scope of chemistry

The scope of chemistry is enormous, which is devoted to serve to human race. The practice of chemistry is increasing with the pace of time. Let us consider the use of chemistry in our life. You have got up from bed with a heavy breathing and after brushing teeth, washed your hands and faces with water. Then, you have sat in front of your table to study after massaging an oily substance in your hands and mouth and combing your hair with a comb. Opening the red covered book you have seen the writings on white paper with black ink – chemistry is present in all these. After studying for some time, you wrote the answers to some questions in your exercise book with a pen or pencil. After that you had your food, and started for school wearing a white shirt and a blue pant. On your way to school, you saw a farmer using fertilizer in his garden or field. You also noticed a motor cycle running past you with emitting smokes. Chemistry is also present in all these incidents.

Now consider the presence of chemistry in the useable things shown in Table-1.3.

Table-1.3 Example of thinking about the scope of chemistry.

Substance	Element	Source
Air taken by inhalation	Mostly oxygen	Environment, air.
Brush, comb, artificial color, paper, exercise book, ink, pencil, pen	Made by the combination of different chemical compounds	Made in industries through the chemical changes of different materials
Drinking water	Pure water is made of hydrogen and oxygen atoms. There are other minerals too in drinking water.	Water exists in nature, eg. river, drain, canal, khal, bill, ocean, rain, water fall etc.
Food	Starch, protein, fat all are organic compounds and different mineral substances.	Plants (by photosynthesis) and animals produce and deposit foods by different process. When we take food, metabolic process occurs in our bodies and we get energy.

Substance	Element	Source
Shirt and pant	They are made from the combination of organic compounds and fibers.	Clothes are made in textiles and fabrics industries by combining dyes with natural or synthetic fibers made of different compounds through chemical reactions.
Fertilizer	These are made of oxygen, nitrogen, carbon, phosphorus etc. and combination of different chemical compounds.	Fertilizers are manufactured in industries by chemical reactions. Chemical fertilizers supply nutrients the soils with nutrients for the plants.
Motor cycle and its energy to move	It is made by the combination of different parts made of various metals and plastics. A motorcycle gains the energy to run by combustion of petroleum.	Metals are extracted from the minerals using chemical methods. Plastics are also made in industries by chemical reactions. Combustion of petroleum is a chemical process.

Look at the pictures Fig- 1.1 and observe the incidents carefully. Complete the following table (Table 1.4) showing the relation of chemistry with the substances used in the incidents given and complete the incomplete sentence on the scopes of chemistry.

Fig- 1.1 Irrigation in paddy field, fire in the forest and a sister is giving medicine to her brother.

Table 1.4: Fill in the table by yourself

Substance	Element	Source
Chemistry is always involved in providing human demands such as -……..., ……., ……..., ……., …….		

1.4 Relation of chemistry with the other brunches of Science

We have learned that chemistry is one of the main branches of science. There is a particular relation of chemistry with the other branches of science like mathematics, physics, zoology, environmental science, geological science etc. In fact, as the other branches of science are dependent on chemistry, similarly, the explanations and theoretical concepts of many events of chemistry are given with the help of other sciences.

You have read in life cycle that, directly or indirectly, plants serve as the source of foods for all animals. Plants deposit foods in different ways by a bio-chemical process called photosynthesis. Again animal body is made of different complex molecules such as- protein, fat, compounds of calcium, DNA etc. the birth and growth of animal function through a bio-chemical process, which is a subject of biology.

In modern time, features well-known as the contribution of science like electricity, magnet, computer and theory of different electronic production and uses are discussed in physics. If we observe, we can see that all these materials are produced by the combination of different chemical properties of matters. The production and distribution of electricity may be considered here for example. Electricity is produced from the combustion of oil, gas, and coal, that is, from the heat generated through chemical reactions and distributed by the flow of electrons of metallic wire (e.g. copper). Various small parts of computer and other electronic goods like- CD, memory disk, monitor are produced by the combination of chemical properties of different matters. On the other hand, it is said that, the amount of copper that is already used in production of computer and other electronic goods is greater than the amount is still stored unused in nature. If copper is being used in this rate, one day it will be finished. Besides, the amount of such unusable goods will increase day by day and will cause harm to our environment. So it is necessary to recycle copper from those goods and to reuse. It can also be done by practicing chemistry.

On the other hand, plant and animal bodies get rotten after death and mix with soil through various microbial processes. Due to the absorbed heat and pressure of earth the materials which mix with soil undergo more chemical changes. As a result, they are converted to different minerals such as, petroleum; coal, natural gas etc. In atmospheric science identification of the ozone layer and ozone layer depleting gases are performed by different process of chemistry.

Now the dependency of chemistry on the other sciences can be considered. It is impossible to present the theories of chemistry or to acquire the theoretical knowledge of chemistry without mathematics. Calculations in chemistry, derivation of a rule and mathematical relations all are mathematics. Quantum mechanics is, in fact, mathematical calculations to explain the atomic structure. On the other hand, different experiments in chemistry are instrument dependent. The principles of these instruments or experimental principles are established on the basis of physics. From the above discussion it is

understood that, there is a strong relation between chemistry and the different branches of science.

1.5 Importance of learning chemistry

We have understood from our reading of the scope of chemistry that, chemistry is always involved in providing basic human needs like- food, clothing, housing, medication and material of education. It is worth mentioning here that, the belief held by people of different sectors of the society that chemical substance means something hazardous, it is not correct.

Whatever we are eating, such as, rice, pulses, oil, sugar, salt and what we are using like- soap, shampoo, detergent powder, medicine etc. are all chemical substances. Aren't they?

The fertilizers and insecticides used in agriculture are all chemical substance. Insects are prevented from destroying the crops by using insecticides. We are using coil or aerosol to prevent mosquitoes. Soaps, shampoo, detergents are used in cleaning. We take medicines, antibiotics and vitamins to maintain our health. Various types of natural substances like turmeric, henna and artificial cosmetics and colors are used in beautification. In addition to that we are taking various types of herbal medicines and other materials to protect our health and for beautification. Sometimes inexperienced and dishonest people or farms produce and distribute these materials. Banned chemicals are being used unconsciously or dishonestly to prevent fish and meat from being rotten and to get fruit ripen quickly without considering the damage they cause to human health. Similarly illegal and non-food graded dyes are being using to make foods attractive.

To preserve processed foods for a long time preservatives are used specially in juice, sauce, cake, biscuit etc. Processed food without preservative may be harmful for life, but unfortunately, in most cases, in processing these foods excess amounts of forbidden and non food graded preservatives are uses.

On the other hand the heat used in burner for cooking is created by burning of wood or natural gas, where heat, carbon dioxide and other substance are produced from the reaction of oxygen in the air, wood or natural gas. It is worth mentioning that if wood and natural gas is burnt in presence of insufficient air, a gas called carbon-mono-oxide, which is very harmful for human health may be produced. Besides, on burning of wood or coal harmful carbon particles are produced, we call it soot (*kali*), when they settle on the wall of the container. In the same way carbon dioxide gas is being produced from industries and automobile engines, which is very harmful to the environment.

Excess fertilizer, pesticide, soap, detergent, shampoo, etc. are polluting the soil and water of rivers and canals. We take the smoke of mosquito coil and aerosols with our inhalation. We use the artificial cosmetics, colours and herbals which reach to the different parts of our body with blood circulation. On the other hand, the produced carbon dioxide on production of heat or energy go to air and contribute to the increase of the temperature in our atmosphere.

We know, excess use of chemical fertilizer causes harm to the plants even may cause them to die. Similarly carbon-mono-oxide gas which is very harmful for human is produced on burning of wood or coal with limited supply of air. Excess doses of medicines may even cause people to die. Therefore, it is clear that for good results, the recommended uses of chemical substances are necessary and that can be ensured only by thorough understanding of chemistry. On the other hand, one can be aware of the risk factors and hazards of various chemical substances from studying chemistry which can build up us as conscious citizens. Along with this we, the users and manufacturers of various products can play important roles in protecting our society and environment by ensuring the proper uses of such products through quality assessment. Therefore, it is clear that, it is very important for everyone to have some knowledge of chemistry.

1.6 Investigation and research methods

Inquiry about something leads to the path of investigation and research originates from investigation. For example, if the first question relating water is, "what is this?" the next question will be, "Where is water available?" Certainly, the question that will arise next is, "What substances is water made of?" The first query about water has given birth to the second query, "Where is water available?" It is possible to know the answer to this question through investigation that the source of water is river, ocean, rain and waterfalls etc. And research is required to know what the constituents of water are? Similarly, more questions will arise such as, "What elements are there in the water of river and ocean?" We know that ocean water is salty, and then the next question may be, "How can we get drinking water from sea water?" It is clear that investigation and research on any subject is related to one another in this way and they expand like branches in a tree. Different steps of investigation and research work are discussed below.

The first step of investigation and research is to specify the subject or identify the problem. To specify the subject is an important step of research. The subjects of investigation and research are selected considering certain views and objectives which are or will be necessary for the wellbeing of the society. For example, there is acute crisis of drinking water in the world, although it is not much realized in our country.

So, investigation of drinking water and research on exploring drinking water from alternative sources is indeed an important subject. On the other hand, stock of fossil fuels like- natural gas, coal, petroleum etc. is running out and it is said that it will be used up within next one hundred years. Considering the future needs, investigation in to and research on alternative fuels is a very important issue. When selecting a subject for investigation and research, environment, social customs and religious feelings are taken into consideration.

Once the subject of investigation is selected, a plan is designed, probable decisions are made and testing is carried out to make the investigation a success. The process of investigation also involves collection of data, collection of the chemicals and other materials for conducting tests, collection, analysis and interpretation of the data derived from experiment.

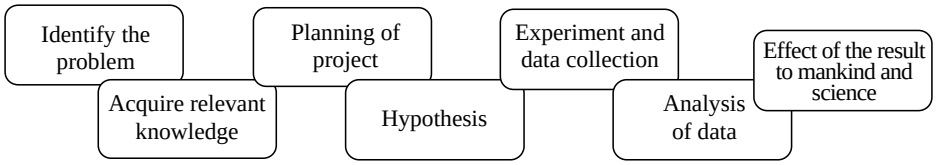


Table- 1.5: Different steps in investigation and research.

The second step is to acquire relevant knowledge about the subject. One need to know how the stuff produced from the investigation and research might be used for purposes other than human welfare and what damage of human and animal health might be caused by the chemicals used in the experiments. Sufficient knowledge and skills are required to give the scientific explanation of different phases of investigation and research and to address any unanticipated situation while conducting the experiment. Collection of previously published scientific data on the subject and the experiments on it is the first condition of carrying out investigations. Let us think that we want to investigate the fruits contain citric acid. Now, the idea of which type of fruit may contain citric acid needs to be gathered from books or the information published in scientific journals. At the same time, information on which tests can be used to detect the substance called citric acid needs to be collected. The next step is to make a hypothesis on which type of fruit may contain citric acid and which experiments can be conducted to detect it. At the time of planning a project, one must keep in mind of the essential tests without which the detection of citric acid will not be complete and only those methods should be chosen from a selection of testing methods which needs materials that are easily available and environment friendly.

Planning the project is the third step of investigation and research. The required knowledge of the subject and making a hypothesis make the planning the project easier. For the convenience conducting the investigation and research, it is better to plan the project in a certain order, not in a disorderly manner. That is, the task without the concept of which a next task can not be initiated and interpreted, should be chosen first, to be followed by the next task.

Anticipation or hypothesis of the expected result of research is an important step of investigation and research. If the results of an experiment can be predicted earlier, there will be no unnecessary curiosity about it and, as a result, proceeding on to the next step will be faster and easier. Moreover, predicting the results facilitates the planning of the project, that is, ideas for planning the next work are generated on the basis of the findings of a certain work.

Investigation and research in chemistry are mostly dependent on experiments. However, in some cases information and data are collected through questionnaires instead of

experiment. The experiments and collection of data are done following the methods accepted to all so that the result and data are explicable to all. The next step is to organize (verification) and analysis of the collected data. Following scientific explanations of the obtained results, a picture is illustrated showing which part of the result is acceptable and which part is to be denied.

The discussion of the possible effect of the results obtained from investigation and research on science and mankind is another part of investigation and research process. It should mention which fundamental aspects of science will be explained or which areas of science will be clarified by the results obtained through investigation and research. It also gives a specific guideline on the welfare issues of human being that will be brought about by the selection of a particular subject. Through such discussions the significance of the subject of investigation and research is revealed.

From the above discussion it is clear that, investigation and research process is carried out through a definite plan and one step is supplementary the other.

Let us do an investigative work in group now. Each group finds out at least ten fruits or vegetable which may contain organic acid and write down their names in table 1.6. There is a clue to help you- acid tastes sour. Confirm the presence of acid by using litmus paper with help from your teacher.

Table- 1.6: Fill it in group.

1.	2.	3.
4.	5.	6.
7.	8.	9.
10.		

1.6 Precautionary measures in preservation and uses of chemical substances during conducting chemical investigation

As it is difficult to conduct investigation and research in chemistry without experiment, similarly any experiment is not possible without the uses of chemical substances. Many chemical substances directly of indirectly are very harmful for health and environment. There are many substances which can explode easily, can be toxic, flammable, sensitive to human health and carcinogenic. It is essential to have the primary knowledge about the functions of chemical substances before collection and doing experiment.

As the uses and trades of chemical substances in the fields such as laboratory, industry, agriculture, medication etc is increasing all over the world; the precautionary measures in preservation and uses of chemical substances have become very important. In order to

devise a globally harmonized system reading this, a summit titled Environment and Development was held in 1992 with the initiative of the UN. The objectives of the summit were (a) to classify the chemical substances in terms of their risks and extent of risks. (b) to prepare a database of the precaution of risks and (c) to decide on some universal signs to indicate the hazard and the extent of hazard. Some of the signs are discussed in table- 1.7 for example.

In order to supply and preserve any chemical substance it is highly desired to attach a necessary sign according to class on the level of the container. If this is done, a user can get the primary idea of the functions of a chemical substance from the level on container, and will be able to use it with an awareness of its risk factors. For example, seeing the level of a chemical container with dangerous sign, it will be understood that the chemical substance is a dangerous toxic substance (Table-1.7). At the same time the user will also be aware of the fact that special precautions should be taken while using this substance so that it does not enter his or her body. Moreover, this may help the user decide whether chemical mixture needs to be exposed in the open air after the experiment, it should be treated properly. In addition to that, ideas can be found on where and how a chemical substance should be stored to preserve its quality and to avoid the unanticipated accidents.

Table- 1.7: The universal signs of expressing risks and the extent of risk of chemical substances; risk, extent of risk and precaution.

Sign	Risk, extent of risk and precaution
 Exploded bomb	Explosive substance, unstable, reacts automatically, such as- organic peroxide. Store in remote and stable places, handle carefully, avoid the situation of friction, mix with others very slowly and were a safety glass in eyes when using them.
 Flame of fire	Flammable substance- gas, liquid, solid. May catch fire easily. Produce heat on reaction such as, aerosol, petroleum. Keep them away from flame and heat, avoid the situation of friction.
 Flame on circle	Oxidizing agent gas or liquid substances, like- chlorine gas. May cause problems with breathing if inhaled, and may cause of corrosion if come in contact with skins. If gaseous substances, store in an airtight container, do not keep in a container that may support oxidizing reaction, Wear hand gloves, safety glasses masks to protect your nose and mouth when using them.

Sign	Risk, extent of risk and precaution
 Dangerous	Highly poisonous substances- gas, liquid, solid. May cause of death inhaled, come in contact with skins or consumed. Store in a locked place. Wear hand gloves, safety glasses masks to protect your nose and mouth when using them. Avid situation where they may enter the body. The reaction mixture needs to be treated after experiments.
 Health hazard	Sensitive to respiratory system, mutagenic, carcinogenetic. Keep away from human and store in safe places. Wear gloves in hand, safety glass in eyes and use masks on nose and mouth when in use. Avid touching. The reaction mixture needs to be treated after experiments.
 Environment	Hazardous to environment, harmful for aquatic lives. Do not allow to run into rivers other water reservoirs. Reaction mixtures need to be treated properly
 Radioactive ray (trefoil)	International ray sign was first used in America in 1946. The sign is called trefoil. It means the highly hazardous ray. These rays may cripple the human body and cause cancer. Store in a thick container that does not to allow the ray to pass away. Maintain safety distance, wear necessary dresses, wear special glasses when using.

Suppose a bottle has the following sign on its label. (Table 1.8). Now in your classroom, try to describe the possible hazards and extent of hazards using the table above (Table-1.7).

Table – 1.8 Fill the table form your learning outcome.

 Flame on circle	
	Preservation and precaution

Exercises

Multiple choice questions.

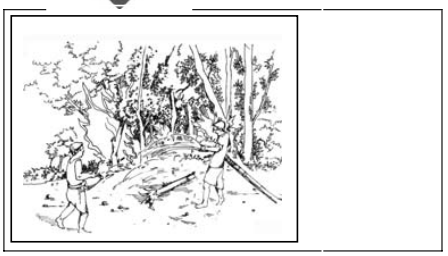
1. Which of the following substances is used to preserve processed foods for a long time?
   a) Preservatives b) Vinegar
   c) Ethylene d) Acetylene

2. Which one is an organic compound?
   a) Water b) starch
   c) protein d) fat
3. There is chlorine gas in one drum. Which sign will you attach to the label of the drum?

a.  b. 

c.  d. 

4. It is understood from the picture-



i) It is a chemical process
ii) Carbon dioxide is produced here
iii) It is a oxidation reaction

Which one is correct?

a) i and ii b) ii and iii
c) i and iii d) i , ii and iii

Creative questions

1.  

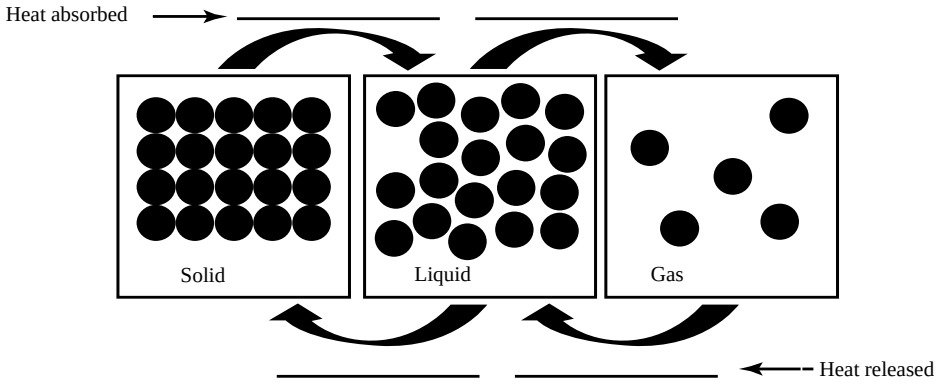
Fig-1: Taking medicine Fig-2: spraying pesticide in a vegetable field

a) What is rust?
b) Why ripe papaya is yellow?
c) How is chemistry related in figure-1 of the stem? Explain.
d) Excess of which as shown in the picture is harmful for the environment? Write with reasons.

Chapter Two

States of Matter

Matter is such a physical entity that has mass and occupies space. Usually, all matters can exist in three different states- solid, liquid and gaseous states. However, at normal room temperature some matters can exist as solids, some as liquids and some as gaseous. The state of a matter is changed with the change of temperature. They have their own characters and properties in all three states but no changes take place in their molecular structure. The molecules in solid state keep vibrating constantly staying very close to one another. These molecules get motion as they are heated and start moving away from one another. The solid, liquid and gaseous matters have the tendency of spreading in different media which may occur spontaneously or due to pressure.



By the end of this chapter we will be able to-

(1) explain the physical properties of matter in terms of the postulates of kinetic theory of particle.
(2) explain the diffusion and effusion with the help of kinetic theory.
(3) describe melting and sublimation of solid and distillation of liquid.
(4) explain the relationship between physical state of a matter and heat.
(5) demonstrate practically the increase in the rate of diffusion with increasing heat.
(6) demonstrate practically melting and sublimation of solid and distillation of liquid.
(7) show interest in explaining the real happenings in nature on the basis of chemistry.
(8) use the chemical substance and thermometer properly.

2.1 Matter and states of matter

Anything that has mass, occupies space and has inertia is matter. We knew earlier that matter can usually exist in three different states- solid, liquid and gaseous states.
Picture of some solid, liquid and gaseous matters are given below:

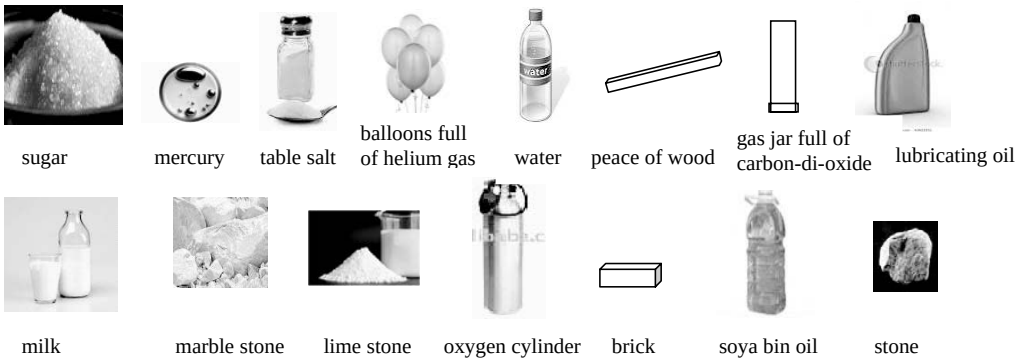


Figure 2.1: some solid, liquid and gaseous matters

Arrange them in the following table according to their physical state:

Solid	Liquid	Gaseous

Table 2.1: Matters of different states

By observing and examining matters we can get ideas about their various properties such as- shape, volume, compressibility, density, fluidity, expansion ability etc.

Do it by yourself

Apply pressure on a pencil, a stone or any other solid matter brought from home.
Observe the shape and volume.
Now take water in a glass, transfer it to a pot of different shape. What do you observe?
Fill up two syringes with water and air, remove the needles and press the pistons with the needle holes closed. Observe the change that occurs.
Fill an empty balloon with air from mouth, than open its mouth.
Note the results of these observations in your exercise book.

Group work

Explain which of the above characteristic you could identify through observations and experiments and which ones you could not. You may conduct experiments to identify the two properties, density and expansion ability, in laboratory with the help of your teacher.

2.2 Kinetic theory of particles:

Every matter is made of small particles and can exist in any particular state- solid, liquid and gaseous states. The particles of a matter remain kinetic in each state.

The arrangements of particles of a matter in three states are shown below. Draw the diagrams in your notebook and arrange them according to which is in solid state, which is in liquid state and which is in gaseous state.

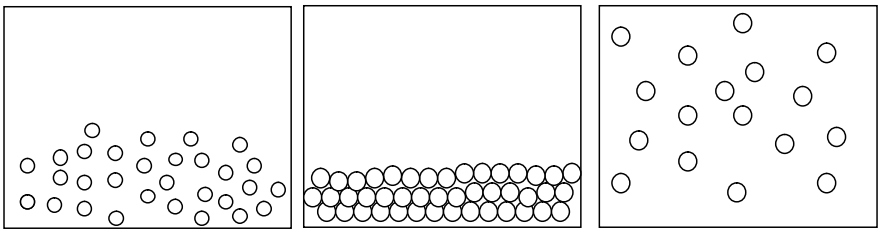


Figure 2.2: Arrangements of particles of matter on the basis of the three states.

Think

- How the same matter can be converted from solid into liquid and from liquid into gaseous states.
- How do the particles exist in the three states?
- In which state do the molecules stay closest to one another, when at medium distance and when at far away?
- When the attractive force of one molecule with another is the highest, when it is slightly less and when does it hardly exist?
- Explain the kinetic state of three states of particles.

We all know about the three states of water; ice (solid), water (liquid) and water vapor (gaseous). Changes in the three states of water have been shown in the following figure;

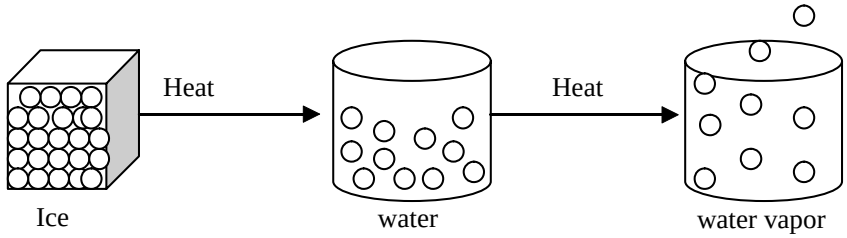


Figure 2.3: Changes in states of matter on heating.

Think: How can water vapor be converted into water and water into ice? How does water turn into ice when stored in deep freezer?

What will you observe when a cup of freshly boiled hot water is placed on a table. Particles of water vapour are spreading in air above the cup. If the cup were heated further, it would become empty at a certain time. But if the cup were left aside normally, it would cool down slowly; you could not have seen the water vapour being spread out.

How the molecules remain in motion at solid, liquid and gaseous states is known from the kinetic theory of particles.

Fig 2.4: Boiled water in a cup

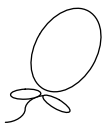
Solid has a fixed volume and definite shape. Molecules in solid remain vary close to one another and keep vibrating due to the strong attraction force.

Liquid takes the shape of the container in which they are kept without changing their volume. Volume is slightly compressible with pressure. The motion of particles of liquid is higher than that of solid. The intermolecular compulsion force is less than that in solid so the molecules in liquid remain at a moderate distance.

Gaseous substance can occupy the whole area of the container in which it is kept. Distances between gas molecules are large, as they have little attractive force. The particles of gaseous substance move freely. The molecules spread around with motion. Volume is highly compressible with pressure.

The kinetic energy of the molecules increases with increase of heat and they start moving fast. Molecules in liquid remain at large distance. On boiling gaseous molecules go out from the upper layer of liquid and gain sufficient energy as they can move around freely.

It is possible to transform a matter from one state to using heat energy on the basis of theory of kinetics. When solid is heated to its melting point it converts into liquid. When liquid is heated to its boiling point it converts to gaseous state.



The gaseous particles in the balloon continuously bang at the inner wall of the balloon and push it outwards. It is called the gaseous pressure.

Explain why pressure will increase with increased heat.

In solid state inter molecular attraction force is the highest. Inter molecular distance is the lowest.

In liquid state inter molecular attraction force is relatively lower. Inter molecular distance increases.

In gaseous state inter molecular attraction force is very little. Inter molecular distance is increased to an extent that the molecules travel around freely and spread outside beyond the intermolecular attractions.

2.3 Diffusion

Place a gas jar filled with air in the inverted position on another gas jar filled with freshly prepared ammonia gas by removing the lids, you will see that in the upper gas jar ammonia gas is mixed with air. To prove, enter a wet red litmus paper, it will turn blue.

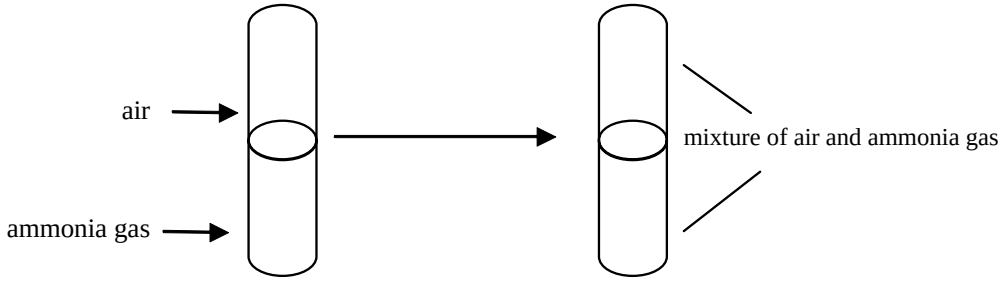


Fig 2.5 : Diffusion of gas particle in gas

Do the following experiments in class in group

Experiment-1

1. Take some liquid blue/ ink/ copper sulphate solution in a test tube.
2. Add water slowly using a dropper.
3. Observe the time required by whole water to become of the same colour and take notes.
4. Now put another test tube in a beaker of hot water and take notes of the required time to occur the process no 3 after completing the process no 1 and 2.

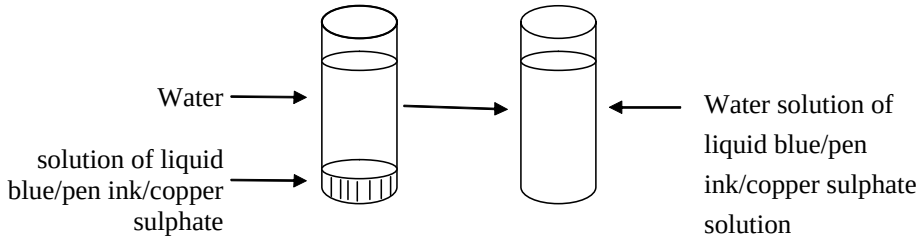


Figure 2.6: Diffusion of solution particle in liquid

Experiment-2

1. Place a crystal of potassium per manganate in a test tube. Add water to it.
2. Note the required time of turning the whole water into light violet colour.
3. Now put another test tube in a beaker of hot water and note the time required to complete the process no 1 and 2. Use a watch to record time.

You can do this experiment also with sugar, table salt. Though they are colorless, you have to taste them to observe weather the particles of sugar or salt have got mixed with water.

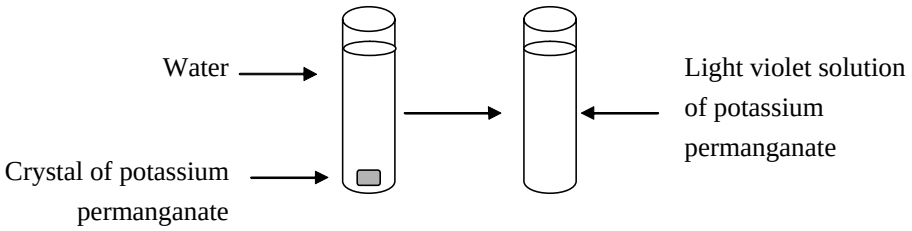


Figure 2.7 : Diffusion of solid particle in liquid

What have you observed in test 1 and 2? More time is required before heating and less time is required after heating. The pace of spreading of the particles was higher in test 1 then comparing to test 2. Again the pace of spreading of the particle was higher in hot water then that of normal water. If we could do the test on gaseous substance (ammonia gas) by ourselves, we would see that, the rate of spreading of the particles much higher then that of the test 1. From the above experiments determine the relation of rate of diffusion with temperature.

In the above experiments no pressure is applied in any case.

The tendency of solid, liquid or gas to spread spontaneously and uniformly in any medium is called the diffusion.

Write some practical examples of diffusion depending on the above experiments and your own experience.

Think :

1. Out of He, H_2, and CO_2 gases, the time of diffusion is the highest. In case of CO_2. Why will the required time be a minimum for H_2? What will happen in case of He?
2. What is relation is there between the effects of heat and kinetics in case of liquid and solid?

2.4 Effusion

Take a balloon filled with helium gas or air. Make a small hole. Observe what happens. Within a very short time the balloon will be squeezed. Do you think why it happens so? The particles of gas or air went out through the small hole. Did any pressure work in this case? If any pressure worked, it would not be possible for the gas to spread spontaneously and uniformly. Small hole hindered the spontaneous movement of the molecules. The spontaneity increased with the increase of the size of the hole. When completely free from pressure it was converted to diffusion.

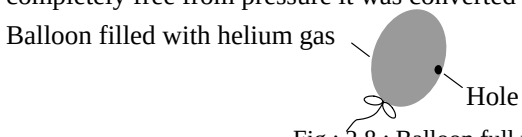


Fig : 2.8 : Balloon full with helium gas.

The pressure of helium gas inside and outside the balloon is not the same. The pressure inside the balloon is higher. The passage of gases from a region of high pressure to a region of low pressure through fine pores, is called effusion.

For example, natural gas or methane gas (CH_4) is converted to C.N.G (Compressed natural gas) by applying high pressure and used as fuel for vehicles. Methane gas and Butane and propane gas gathered from refinery are compressed in cylinders at high pressure to be used as household fuels. Oxygen gas is stored in cylinder at high pressure for clinical use. In case of any leakage in these cylinders, gas will burst out with high speed. That may cause a dangerous situation.

If a ripe jackfruit is kept in a room of a house, the smell of jackfruit comes out through the pores of jackfruit skin and spread to other rooms. Coming out of smell through the pores of skin is effusion and spreading the smell to other rooms is diffusion.

Think: From which container gas will flow out faster? Mass and density of methane gas is the lowest, mass and density of oxygen gas is more than that of methane, they are the highest in butane. Mass and density of propane gas is less than that of butane.

Diffusion and effusion depends upon mass and density of the substance. As the mass and density of the substance increase, the rate of diffusion and effusion decrease.

Class work: Write the hazards of diffusion and effusion in your own exercise book.

2.5 Burning of Wax Candle and three states of matter

When candle burns, the three states of matter are observed together. When wax starts to melt, the thread of candle absorbs it. Wax turns to gaseous state at the top of the thread. We call it wax-vapour then it burns in presence of air. The candle keeps burning, as long as the thread exists. As the wax is a hydrocarbon i.e an organic compound, carbon-di-oxide and water vapour is produced from the burning of wax in presence of sufficient air.

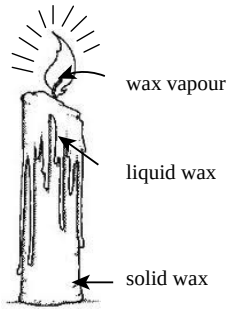


Fig 2.9 : Burning of candle

$$Wax + O_{2(g)} \longrightarrow CO_{2(g)} + H_2O_{(g)} + Heat + Light$$

2.6 Melting and Boiling

Melting and boiling of a matter happened at specific pressure and temperature.

Experiment 1: Melting of matter

1. Take some grated wax in a heat proof glass tube and thrust the wax with a stick.
2. Arrange the apparatus and materials according to the figure. Tie the melting tube to the thermometer with a rubber band.
3. Apply heat slowly in low flame and stir the water of the beaker with a stirrer. Note the temperature at which the wax starts to melt. Remove the heat when it starts to melt. Note the temperature after every one minute.

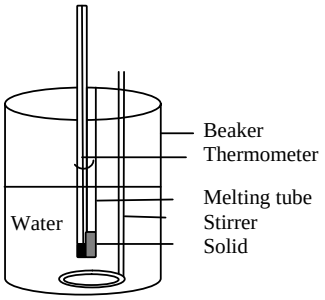


Fig 2.10 : Melting of solid

4. In the experiment note the temperature from beginning to the end after every one minute using a watch.
5. Draw a curve, putting time in the X-axis and temperature in Y-axis of a graph paper and determine the melting point from it.

Experiment 2: Boiling of matter

1. Arrange the apparatus and materials as shown in the figure. Make sure that the thermometer remains much above the water surface.
2. Heat until the water starts to boil. That is, stop heating when the water boils completely with bubble and water vapour comes out.
3. Maximum temperature has to be noted.

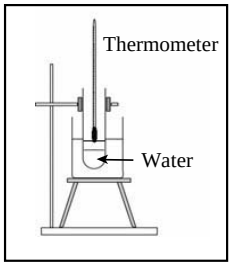
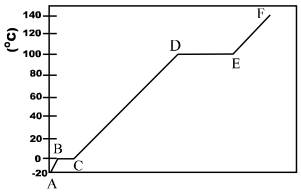


Fig 2.11 : Boiling of liquid

4. Note the temperature at every minute rom beginning to end with a watch.
5. Determine the boiling point using a graph paper as done in experiment 1.

At normal pressure (1 atm), the temperature at which a solid matter turns into liquid state is called the melting point of solid.

At normal pressure (1 atm), the temperature at which a liquid matter attains gaseous state is called the boiling point of liquid

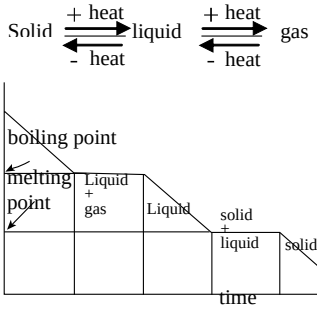


E-F – Water vapor
D-E – Water boiling (both liquid and vapor)
C-D – Water (liquid)
B-C – ice melting (both solid and liquid)
A-B – ice (solid)

Fig 2.12 Heating curve

Think: Temperature has changed at the region A-B but not at the region B-C. Again temperature has changed at the region C-D but not at the region D-E. Again temperature rose at E-F. Heat energy was applied but why temperature did not increase? Have you heard about the latent heat?

The change of states of matter can be written as-

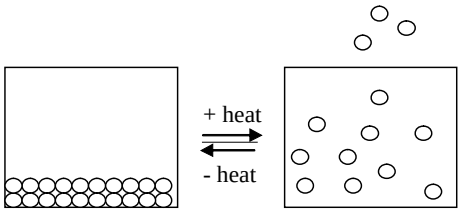


General cooling curve

Project: Similarly analyze the states of water at different points showing the water cooling curve. Describe, temperature does not change on heating at which temperatures.

2.7 Sublimation:

Look at the following picture



Think:
Waht will be the heating and cooling curve for the figure of the left side?

Fig 2.13 : Siblimation of solid matter.

Write the names of some matters which convert to gaseous state directly from solid and on cooling convert to solid from gas. Napthalin, iodine, corpur, solid CO_2 etc.

Experiment: Arrange the apparatus and materials as shown in the figure. Apply heat slowly under the beaker.

Write down about the changes that you observe. In the same method, you may convert napthalin, corpur etc. from solid to gas by heating and gas to solid.

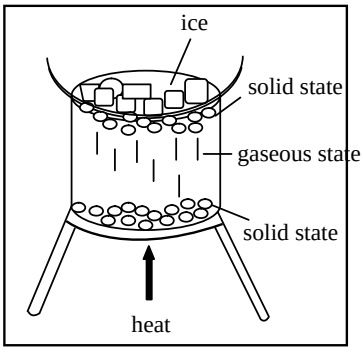


Fig. 2.14 Sublimation of volatile matter

So it can be said that, if a solid directly converts to gas on heating and the gas directly converts to solid on cooling, this phenomenon is called sublimation.

Project : 1. Take corpur and ice in two pots placing them side by side and stir. What changes do you observe and why? What has happened after two days and why?

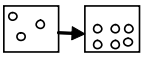
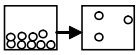
Exercise

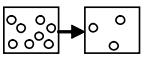
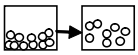
Multiple choice questions

1. When hot tea is kept in a cup, what type of change take place?
   a) vaporization b) sublimation
   c) diffusion d) effusion

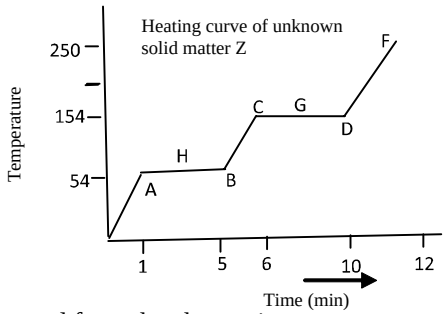
2. What will happen to the particles, when water vapour is condensed?
   a) size will reduce b) will remain in movement
   c) will vibrate at the same position. d) energy will evolve to surroundings.

3. Which of the following picture is applicable to sublimation?

a)  b) 

c)  d) 

4. Heating curve of unknown solid matter Z.



It is understood from the above picture-

i) The melting point of Z is 54^0c

ii) Z is volatile.

iii) A-B and C-D curves indicate the melting and boiling points of Z

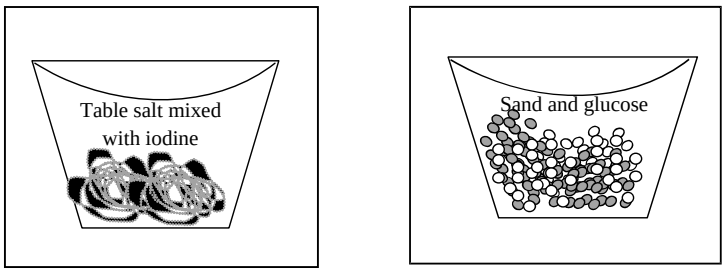
Which of the following is correct?

a) i and ii b) ii and iii

c) i and iii d) i, ii and iii.

Creative question:

1.



A- pot B- pot

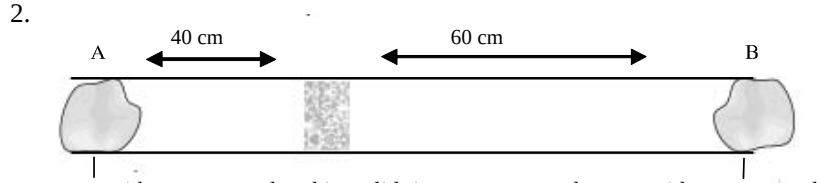
a) What is diffusion?

b) Which of diffusion and effusion occur first in case of body spray.

c) Which of the above matter of the stem will evaporate first if the temperature is increased?

d) Is it possible to separate the elements in Pot A and B is by the same method? Explain with reasons. soak

2.



a) What is effusion?

b) Why are the melting point and boiling point of the same matter different?

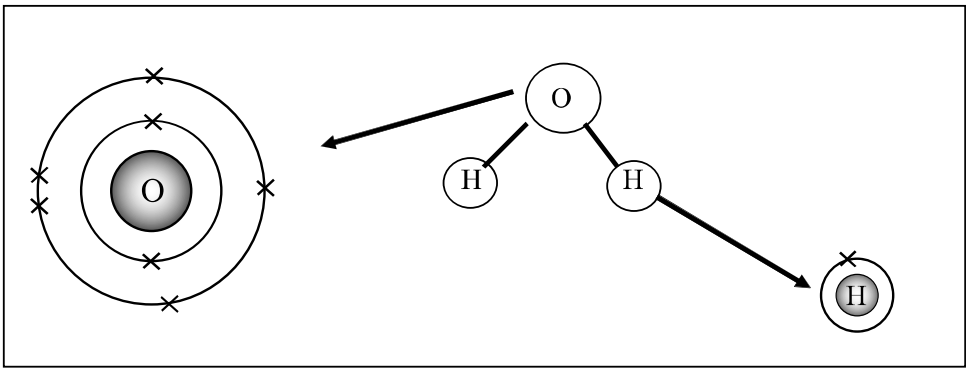
c) What type of change is shown in the process given in the stem? Explain.

d) Why is white smoke produced at the end A of the tube? Explain with logic.

Chapter Three

Structure of Matter

Every matter of the universe is made of small particles. They are so small that they are not even visible with the high efficiency microscope. The name of smallest particle of the fundamental element is called atom and the smallest particle of compounds are called molecule. Every atom has its own characteristics. A principal characteristic is its atomic number. Atom and molecule have actual and relative mass. Proton, electron and neutron are the principal particles of atom. Nucleus, at the centre of the atom, is composed of proton and neutron which bears the total mass of the atom. Electrons of the same number of proton moves around the nucleus on various axis. The same elements again have atoms with different atomic mass which are called isotopes. They have multifarious uses in various fields of human life.



By the end of this chapter we will be able to-

1. describe the development of the concept of atom.
2. describe the characteristics of fundamental and stable particles.
3. describe the atomic number, mass number, relative atomic mass number.
4. calculate the relative molecular mass from the relative atomic mass.
5. calculate the number of electron, neutron and proton of an atom.
6. describe the uses of isotope.
7. describe the Rutherford and Bhor atomic models
8. explain which of the atomic model is more acceptable among Rutherford and Bohr model
9. arrange electrons of atoms in orbits and in different sublevels of orbits.

3.1 Elements

Nitrogen	Phosphorous	Carbon
Oxygen	Helium	Calcium
Argon	Magnesium	Sulfur

Table- 3.1 Names of different elements

Names of some elements are given above. Write their symbols and atomic numbers

Name of the element	Symbol	Atomic number

Do it by yourself: Write the electron arrangement of elements

Table- 3.2 Name of elements, symbols and atomic numbers

3.2 Particles of atom

In atoms, there are different particles including proton, electron and neutron. These three are the permanent particles of atom. Generally, the number of electron and proton in an atom are equal. The number of neutron may be equal or may sometimes be greater. The atoms of each element have the same characteristics. The relative mass of a proton is equal to the relative mass of a neutron; the relative mass of an electron is equal to 1/1840 divisions of a proton or neutron. That is, the mass is so small that it can be considered that it has hardly any mass. But every particle has actual mass.

Particle	Symbol	Relative mass	Relative charge	Real mass	Real charge
Proton	p	1	+1	1.67×10^{-24}g	1.60×10^{-19} coulomb
Neutron	n	1	0	1.675×10^{-24}g	0
Electron	e	$\frac{1}{1840}$	-1	9.11×10^{-28}g	-1.60×10^{-19} coulomb

Table 3.3: Mass and charge of different particles

Nucleus remains at the centre of atom. In nucleus there exist neutron and proton. The total number of protons and neutrons is called nucleon, which is also called the mass number. The number of proton is called the atomic number, which bears the unique entity of an atom or its identity.

The number of electron/proton of lithium atom is 3, the number of neutron is 4. In the nucleus there exist positive charge protons and charge neutral neutrons. Electrons take positions in different energy levels around the nucleus according to their own energy and keep rotating.

A diagram of the structure of the lithium (Li) atom is given below:

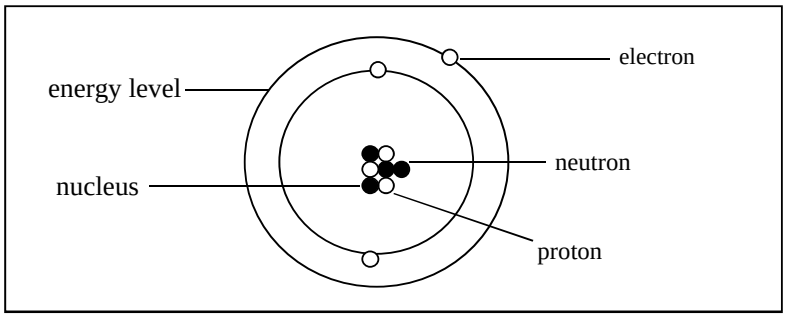


Fig 3.1: Diagram of lithium (Li) atom

Element	Number of proton/electron	Number of neutron
B	5	6
N	7	7
Mg	12	12

Table 3.4: Proton and neutron number of different elements

From the data given in table 3.4, draw the atomic diagram of the atoms showing the arrangements of electrons in different energy levels and showing neutron and proton in nucleus. (Group work)

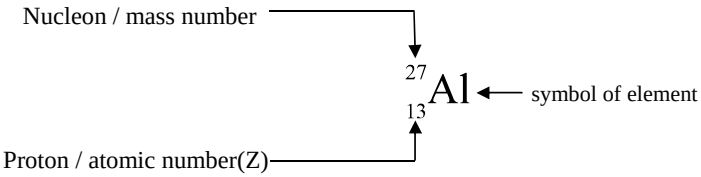
3.3 Identity of an Atom

Proton number (atomic number) and nucleon number (mass number)

Every element has its own proton number and nucleon number. Atomic number is denoted by Z and the mass number is denoted by A.

For example, let the proton number of aluminium (Al) is 13 and nucleon number is 27. Number of neutron will be 27(A) – 13(Z) = 14.

It is represented in short as-



The atomic number and mass number of the first 10 elements listed in the Periodic Table are given below. From this calculate the electron proton and neutron numbers and write their short forms.

Symbol of element	Atomic number (Z)	Mass number (A)	Number of proton	Number of electron	Number of neutron	Short form
H	1	1	1	1	1–1=0	$^{1}_{1}H$
He	2	4	2	2	4-2=2	$^{4}_{2}He$
Li	3	7				
Be	4	9				
B	5	11				
C	6	12				
N	7	14				
O	8	16				
F	9	19				
Ne	10	20				

Test how much you have understood.

1. Explain, what do you mean by proton number.

2. Are the nucleon number and mass number the same? Explain.

3. From the symbol below calculate atomic number and number of proton electron & neutron.
$^{28}_{14}Si$, $^{31}_{15}p$, $^{17}_{8}O$, $^{39}_{19}K$,
$^{14}_{6}C$, $^{64}_{29}Cu$, $^{56}_{26}Fe$

Table- 3.5 Short form of different atom

3.4 Isotope

The atomic structure of three types of hydrogen atoms, their symbols, neutron numbers and percentage of abundance is given in the following table:

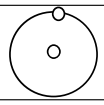
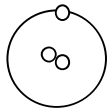
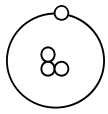
Name	Atomic structure	symbol	Number of neutron	Percentage of abundance
Hydrogen or protium		$^{1}_{1}H$	0	99.98
Deuterium		$^{2}_{1}H$ or $^{2}_{1}D$	1	0.015
Tritrium		$^{3}_{1}H$ or $^{3}_{1}T$	2	produced by radioactivity and found in very small amount in nature

Table – 3.6 Three stable isotopes of hydrogen

Though there are 7 isotopes of hydrogen (^{1}H, ^{2}H, ^{3}H, ^{4}H, ^{5}H, ^{6}H, ^{7}H). Among them three are available in nature. The rest four are synthesised in laboratory.

Think:

- What have you understood by analysing the table?
- What is the proton and electron number of each atom? What is the mass number and nucleon number of each atom?
- What is the reason for changing of the mass number?
- What decisions may you take analysing everything?

Atoms of the same elements with different mass numbers are called isotope of each other. This is happens due to the differences in number of neutron. The numbers of electron or proton of the atom of the same element never change.

3.5 Relative atomic mass

The mass of hydrogen is found from the mean of percent abundance of the three types of isotopes of hydrogen and, it is 1.008. We can call it relative atomic mass.

You will see on observation, the atomic mass of many elements remain in decimal fractions, not in full number. For example, the relative atomic mass of chlorine is 35.5. Chlorine has two isotopes, and, in respect of percent abundance, the amount of ^{35}Cl and ^{37}Cl is the 75% and 25%.

Method of determining the relative atomic mass of chlorine is shown below.

	^{35}Cl	^{37}Cl
Mass number	35	37
% abundance	75	25
Relative atomic mass	35 x 75 ÷ 100 + 37 x 25 ÷ 100 = 35.5	

Table 3.7 Relative atomic mass of chlorine

Now a days all scientists have taken the fraction of carbon-12 isotope as standard for atomic mass.

According to modern definition-

$$\text{The relative atomic mass of element} = \frac{\text{mass of one atom of element}}{\frac{1}{12} \text{ of mass of a carbon 12}}$$

From the definition explain, why relative atomic mass of element has no unit? Why is it called relative atomic mass?

It is to mention that, all the atomic mass of the atom given in the Periodic Table is relative atomic mass of element. The mass number and relative atomic mass is same for the atoms that have no isotope.

Using above rule you can calculate the relative atomic mass of an element by dividing the total real mass of proton and neutron of an element by the fraction of mass of carbon-12 isotope. Note that, the mass of the $\frac{1}{12}$ fraction of carbon -12 isotope is 1.66×10^{-24}g.

Task: The proton number of Al is 13. If the mass of its one atom of Al is 4.428×10^{-23}g, what will be its relative atomic mass?

3.6 Relative molecular mass from relative atomic mass.

We know, relative atomic mass of oxygen is 16.

Then what will be the relative molecular mass of oxygen?

One oxygen molecule (O_2) is composed of two oxygen atoms.

The relative molecular mass of oxygen (O_2) will be

16 x 2 = 32 [16 is the relative atomic mass of oxygen and 2 is the number of atom]

Similarly, determine the relative molecular mass of CO_2, N_2, HCl, H_2SO_4.
Write down the calculations in your exercise book as part of class work.

Think: How will you determine the mass of an atom and a molecule using the two formulas given above?

3.7 Radioactive isotope and their uses

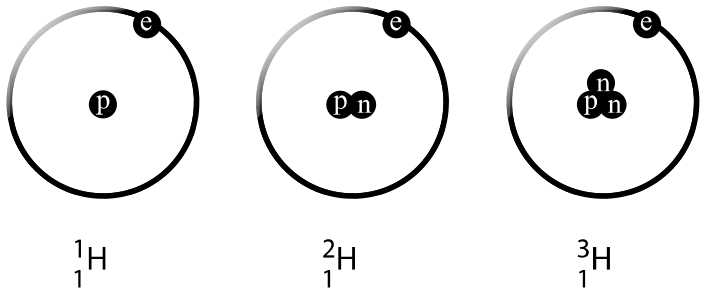


Fig 3.2: Three stable isotope of hydrogen

We have learnt about the above three isotopes earlier. There are a large number of isotopes found in nature, such as-

^{13}C, ^{14}C, ^{87}Rb, ^{90}Sr, ^{115}In, ^{130}Te, ^{131}I, ^{137}Cs, ^{138}La, ^{147}Sm, ^{148}Sm, ^{176}Lu, ^{187}Re, ^{186}Os, ^{222}Rn, ^{226}Ra, ^{235}Yh, ^{232}Th and ^{234}U to ^{238}U etc.

Besides these many isotopes are synthesised for various purposes.

The number of isotopes either natural or synthesised has exceeded 1300. Among these some are stable and maximum are unstable. The unstable isotopes convert to the isotopes of another elements by emitting different types of rays such as (α-ray, β-ray , γ-ray). This property of the atom of elements is called radioactivity. Isotopes of such types are called radioactive isotopes. In fact, changes occur in the nucleus of these atoms. The rays

emitted from the atoms have high speed. The γ-ray causes damage to the living cells. These radioactive isotopes can be produced by nuclear reaction.

Uses of radioactive isotopes

1. In medical science: There are mainly two types of uses in this field.

(a) Diagnosis of any disease and locate the affected area.

(b) Cure of disease.

(i) In order to diagnosis the expansion of bone and the reason of pain and to locate the spot of pain, Tc-99m or ^{99m}Tc (Isotope of Technetium) are injected and after some time the location and type of the bone pain will be visible on screen. γ–ray emits from the ^{99m}Tc. The symbol 'm' after the mass number expresses the Meta stable condition of isotope. ^{99m}Tc converts to isotope of mass ^{99}Tc emitting γ–ray.
(^{99m}Tc → ^{99}Tc + γ ray)
^{153}Sm or ^{89}Sr is used to the treatment of bone pain.

(ii) To determine the presence of tumor and the locate its position radioactive isotopes are used. In treatment cancer tissues are damaged by emitting γ– ray from ^{60}Co.

(iii) ^{131}I prevents the growth of thyroid glands.

(iv) Phosphate ^{32}P is used in treatment of blood leukemia.

(v) Plutonium-238 is used to set pacemaker in heart.

In different types of cancer treatment ^{131}Cs, ^{192}Ir, ^{125}Pd, ^{106}Ru are used.

2. In agriculture: New high yielding varieties are being developed in agriculture using radioactive rays and by uses of these both qualities and quantity of product are increased. Solution of radioactive ^{32}P phosphate is injected to the root of plants. The scientists can detect the movement of phosphate thoroughly within the plants using Geiger counter, and from this they can determine the mechanism of using phosphorous for enhancing growth of plants.

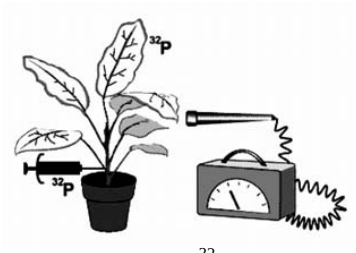


Fig. 3.3: Use of ^{32}P in plants

3. In food preservation: Various harmful bacteria grow due to lack of proper preservation of all kinds of vegetables and fruit or if the cooking process is not appropriate and these bacteria are harmful for our health. In some cases it may cause death. Generally the γ–ray that emits from the ^{60}Co kills these harmful bacteria. This ray is also used in poultry farms when any bacterial disease is spread. Foods are preserved using radioactive rays of a certain dose. Use of excess radioactive rays is very harmful for health. Radioactive rays must be applied to food at a limited dose and in a restricted place. This radioactive ray (γ - ray) of limited dose is safe as sunlight.

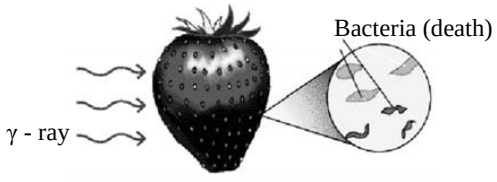


Fig. 3.4: Preservation of food stuff using radioactive rays

4. Production of electricity: At the time of decay or nuclear reaction a large amount of heat is evolved. This heat energy can be converted to electric energy using various devices. In many countries of the world huge amount of electricity is produced from nuclear reaction in nuclear reactors.

Besides this, radioactive rays can be used in pest control, in industrial plants, in measuring the thickness of metal sheets, measuring the height of liquid in a closed vassal, locating the hole in pipe lines. The ages of various objects of the world along with fossil, mummy, and even the age of the universe can be calculated by C-14.

The hazardous effects of using radioactive isotopes

Various types of rays emit from the radioactive isotopes. The life times of some of these elements are short and some are long. Radio activity is a major cause of cancer. When not used in recommended doses, it causes harm instead of doing better.

Radio active substance is used in chemo therapy. The side effects of chemo therapy cause hair fall out and nausea. Sometimes it kills the useful bacteria in our body.

As the nuclear energy obtained from the nuclear reaction used in electricity production, it might also be used for destructive purposes.

The source of energy of all nuclear bombs along with the bomb thrown in Hiroshima and Nagasaki is nuclear reaction.

3.8 Atomic model

3.8 (a) Rutherford's atom model: solar model

Based on the alpha particle emition experiment Rutherford proposed a model on the structure of atom in1911. This is as follows-

1. In the center of the atom there is a positively charged massive substance. This massive substance is called the centre of nucleus of the atom. Compared to the whole volume of the atom the volume of nucleus is negligible. It possesses almost the whole mass and all positive charges.
2. Atoms are electrically neutral. So nucleus is surrounded by a number of negative charge electrons, equal to the number of positive charge proton of the nucleus.
3. Electrons always move round the nucleus as the planets revolve round the sun in the solar system. The centripetal force due to the electrostatic force between the positive nucleus and the negative electrons is equal to the centrifugal force of the moving electrons.

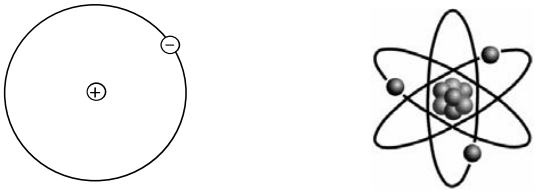


Fig 3.5 Rutherford's atom model

Group work: Analyze critically each postulate of Rutherford's atom model and write what limitations you find in this model.

Compare the limitations given below with the limitations you have found in group work-

The limitations are:

1. Planets in the solar system are electrically neutral, but the electrons are negatively charged.
2. According to Maxwell's electromagnetic theory of radiation any charged particle, if moves in a circular way, always emits radiation and it radius of movement will become smaller gradually and ultimately reach the centre. Therefore, electrons gradually emit energy and ultimately reach the nucleus. Thus, according to Rutherford's atom model, atoms will get an unstable state. But atoms do not emit energy, or electrons never enter into the nucleus.
3. This model can not give satisfactory explanation of the formation of the spectrum of atom.
4. Rutherford's atom model did not give any idea about the shape and size of the orbit where the electron moves.
5. There is no explanation regarding how the electron will move round the nucleus in case of atoms having more than one electrons.

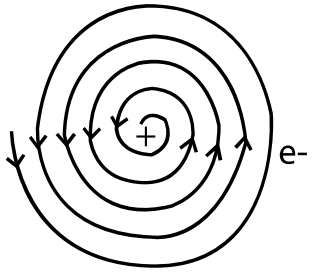


Fig 3.6: Possible emission of energy by moving electrons and fall of electrons to the nucleus

3.8 (b) Bohr's atom model

To explain the structure of atom as well as the atomic spectrum of atom, Neils Bohr give his momentous theory in 1913. The main postulates of this model are as follows:

1. Electrons move round the nucleus of atom in some circular paths.
2. Around the nucleus there are some circular stable axes on which electron moves around. These are called energy level or orbit. The energy levels are designated as capital letters K, L, M, N in terms of the value of the hypothetical number 'n'. The first energy level is denoted as n = 1 (K energy level), the second energy level as n = 2 (L energy level) and, in this way, the value of n keeps increasing in full numbers such as 3, 4, 5 while the energy levels are marked by capital letters M, N, O respectively. While remaining in a certain orbit electrons neither emit nor absorb energy.
3. When any electron gets transferred from a lower orbit or energy level such as n = 1 to a higher orbit or energy level such as n = 2, it absorbs a certain amount of energy. Again when any electron is transferred from a higher orbit or energy level such as n = 2 to a lower orbit or energy level such as n = 1, it emits a fixed amount of energy.

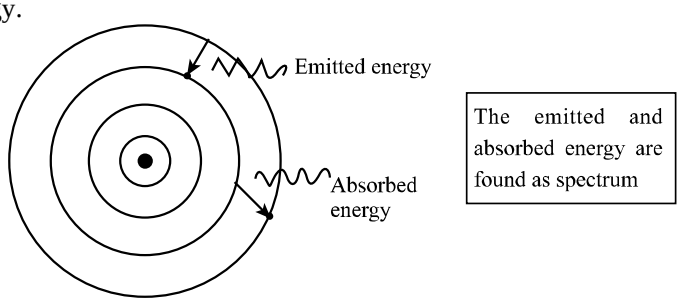


Fig 3.7: Bohr's atom model and the source of line spectrum.

Limitations of Bohr's atom model:

As the Bohr's atom model has many advantages it also has some limitations. Such as-

1. Although Bohr's atom model can explain the spectrum of hydrogen and atoms or ions like hydrogen containing one electron, but it can not explain the spectrum on ions or atoms containing more then one electrons.
2. When electrons are transferred from one energy level to another energy level according to Bohr's atom model there would be a single line in spectrum. But observing the spectrum of hydrogen or other ions with a sensitive apparatus it is seen that every line splits into several fine lines.

3.9 Arrangement of electron in Energy level

We have known from the Bohr's atom model that the electrons remain in several energy levels according to their own energy. The nearest energy shell of a nucleus is marked as

the 1st energy level i.e. n=1 or K shell, the 2nd energy level is n=2 or L shell and the 3rd energy level is n=3 or M shell. Similarly there are principle energy levels up to Q.

The maximum electron bearing capacity of each principle energy level is $2n^2$, where n = 1, 2,3, 4….. etc. According to $2n^2$ theory-

Electron bearing capacity of shell K is = $2x\ 1^2 = 2$.

Electron bearing capacity of shell L is = $2x\ 2^2 = 8$.

Electron bearing capacity of shell M is = $2x\ 3^2 = 18$.

Electron bearing capacity of shell N is = $2x\ 4^2 = 32$

Elements having atomic number 1 to 18, that is, from Hydrogen to Argon follow this theory. Electrons of these elements can be arranged at their different energy levels according to the above capacity. Electrons enter into the next upper energy level being filled with the lower energy level with electrons first.

Distribution of electrons to different energy levels of elements with different atomic number:

Atomic number	**Element**	**K**	**L**	**M**
1	H	1		
2	He	2		
6	C	2	4	
9	F	2	7	
15	P	2	8	5
18	Ar	2	8	8

Table 3.8 Arrangements of electrons to different energy levels of elements with different atomic number.

Try yourself: Arrange the electrons of elements with diagram having atomic number 1 to 18. (excluding the elements in Table)

In the case of arrangement of electrons of elements with atomic number 19 or more, electrons enter at the 4th energy level without fulfilling the 3rd energy level. This can not be explained by the concept of distribution of maximum number of electrons in energy levels. Each energy level has some sublevels. That can be explained by distribution of electrons in sublevels.

Potassium (K) atomic number 19, Calcium (Ca) atomic number 20 electronic configurations are as follows:

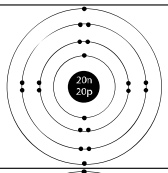
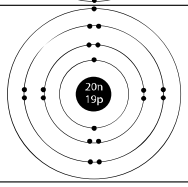
Atomic number	Elements	Orbit or principle energy level				Diagram of distribution
		K	L	M	N	
19	K	2	8	8	1	
20	Ca	2	8	8	2	

Table 3.9: Distribution of electrons of elements energy levels

According to the $2n^2$ theory there would have 9 electrons in M shell of potassium and 10 electrons in M shell of calcium. Why did not that happen?

In answer to that we can say that, every principle energy level (orbit) is composed of one or more sub energy levels (orbital). The energy of one of the sublevels at 4^{th} energy level is lower then the one sub level of 3^{rd} energy level. These sub levels are marked by s, p, d, f etc. The maximum electron bearing capacity of an s sub level is 2, p sub level is 6, d sub level is 10 and f sub level is 14. It is the general property of electrons that they fill the sub level (orbital) of lower energy first and gradually enter into the sub levels of higher energy.

The number of sublevels of K or the 1^{st} shell is 1 and marked as 1s.

Here 1 is used to denote the 1^{st} principle energy level.

The number of sublevels of L or the 2^{nd} shell is 2 and marked as: 2s, 2p.

The number of sublevels of M or the 3^{rd} shell is 3 and marked as: 3s, 3p, 3d.

The number of sublevels of N or the 4^{th} shell is 4 and marked as: 4s, 4p, 4d, 4f.

During the electronic arrangements of atom, electron enter into different orbital (sub energy level) according to the order of their energy- lower to higher. To gain the stability electrons enter into the orbital of lower energy first, fill them and then gradually fill the orbital of higher energy.

The order of energy of orbital is as follows:

1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, 7p, 8s

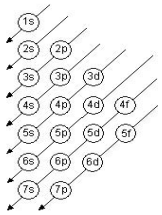
According to this rule we can show the electronic configurations of K (19) and Sc (21).

K (19) $\rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^0\ 4s^1$

Sc (21)$\rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1\ 4s^2$

As the energy of 4s orbital is lower then the energy of 3d orbital, so the last electron of potassium (K) entered into 4s orbital not entering 3d orbital. On the other hand in case of

scandium (Sc) the last 21st electron entered into the next higher energy 3d orbital fulfilling the 4s orbital. You can take help of the table given blow to memories the order of energy of sub levels.



Do it by yourself:
Configure the electrons of the elements given below with the help of above table.
$_{20}$Ca, $_{23}$V, $_{26}$F, $_{30}$Zn, $_{33}$Ar, $_{36}$Kr, $_{38}$Sr, $_{35}$Br.

Fig 3.8: Table of memorizing the order of energy of orbital.

It may be remembered specially at the time of writing electronic configuration that all the orbital of principle energy level have to write aside.

For example;

		K	L	M	N	
Sc (21)	→	$1s^2$	$2s^2$ $2p^6$	$3s^2$ $3p^6$ $3d^1$	$4s^2$	write in this way

Sc (21) → $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^1$ not in this way.

If you don't follow this, there is possibility of making errors while drawing the electronic configuration.

Some exceptions of general rule of electronic configuration: Generally it is seen that, when the orbital of equal energy remains fully filled or half filled, the electronic configuration attains more stability. That means, np^3, np^6, nd^5, nd^{10} and nf^{14} have the most stability. For this reason the elements of electronic configuration $d^{10}s^1$ and d^5s^1 become more stable.

Following this rule electronic configuration of Chromium (Cr) is:

Cr (24) → $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^5$ $4s^1$

Try yourself: Electronic configuration of Copper (29) or $_{29}$Cu.

Exercises

Multiple Choice Questions

1. Which isotope is used both in medical science and agriculture?
   a) ^{131}I b) ^{125}I
   c) ^{32}P d) ^{153}Sm

2. Z is an element of proton number 111 and neutron number 141. Which of the following can be used to express the atom?
   a) $^{111}_{141}Z$ b) $^{141}_{111}Z$
   c) $^{252}_{111}Z$ d) $^{141}_{30}Z$

3. What is the relative atomic mass of the element X?

Isotope	% abundant
^{146}X	25
^{154}X	75

[Here X is used as symbol, not as the symbol of any regular element]

a) 148 b) 150

c) 152 d) 153

4. $^{56}_{26}Y$

The element in the stem has

i) more than one valency

ii) different numbers of proton and neutron

iii) regular electronic configuration.

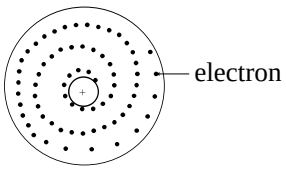
Which one is true?

a) i and ii b) ii and iii

c) i and iii d) i , ii and iii

Creative questions

1. When asked to draw an atomic model of an element, Farid a student of class nine has drawn the picture below.



a) What is atomic number?

b) The nucleon number of the atom $^{64}_{29}X$ and $^{64}_{30}Y$ are the same but the neutron number is different- Explain.

c) Explain the atomic model that is indicated by the model drawn by Farid.

d) According to the model drawn, give logical explanations of the stability of atom.

2.

$_4W$	$_{12}X$	$_{20}Y$	$_{29}Z$

[Here W, X, Y and Z is used as symbols, not as the symbols of any regular element]

a) What is mass number?

b) The valances of $_3Li$ and $_{11}Na$ are the same, explain why?

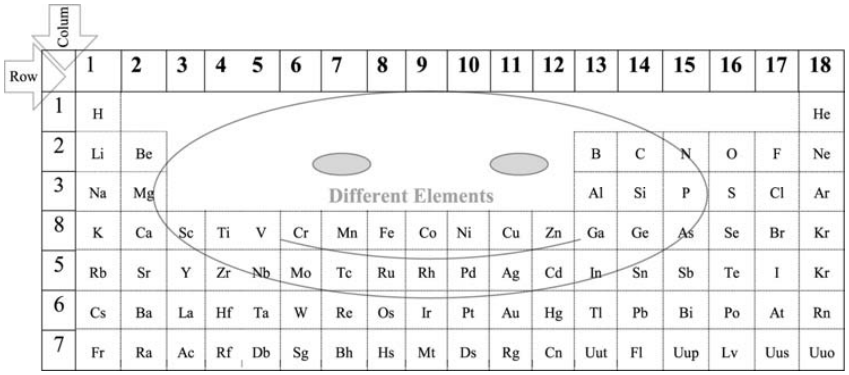
c) Which elements have the equal number of electron at their outermost energy level?

d. The electrons of one of the above elements can not configured in general rule- explain with logic.

Chapter Four

Periodic Table

Periodic Table is a conceptual diagram of the properties of the elements expressed in table. A total 118 elements are detected up to the year 2012. It is not possible to remember all the properties of each element separately. In Periodic Table elements are classified on the basis of their properties. From the periodic table we can assume the chemical behavior of an element. Starting with the invention of periodic table, its applications and significance are discussed in this chapter.



Row \ Colum	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	H																	He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
8	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Kr
6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo

By the end of this chapter we will be able to-

1. describe the background of development of periodic table.
2. describe the relation of the electronic configuration of outermost energy level of the elements to the principle groups (first 30 elements).
3. determine the period of an element.
4. assume the physical and chemical properties of an element in terms of its position in periodic table.
5. describe the reasons for special naming of the element .
6. describe the significance of periodic table.
7. demonstrate the similar properties of the compounds of the elements of the same group with practical experiment.
8. Make proper uses of the glass apparatus at the time of experiment.
9. take precautions at the time of experiment.
10. Show interest in assuming the properties of the elements following the periodic table.

4.1 History of Periodic Table

Periodic Table is the outstanding reflection of collections of different chemical concepts gathered over hundreds of years. From the beginning scientists made attempts to give a combined shape of the concepts about elements and their properties gathered in a scattered way. This, later on helps classify the elements on the basis of their properties, that is, lead to the introduction of modern periodic table. In the year 1789 Antoine Lavoisier first divided the elements in three groups on the basis of he physical states of the elements. Later in the year 1864, English scientist John A. R. Newlands, while arranging the elements according to their mass, discovered similarities in physical and chemical properties for each 8^{th} element. In the year 1869 Russian scientist Dmitri I. Mendeleev and German scientist J. Lothar Meyer individually published a table in an attempt to contain the elements with similar properties in the same group. This is known as the Periodic Table in chemistry.

A total of 118 elements have been detected till the year 2012. Among them International Union for Pure and Applied Chemistry has recognized 114. It is to know here that the organization is called IUPAC in short. The organization supervises and controls different matters of chemistry and applied chemistry like- various rules and regulations, overseeing which of the escalating changes or inventions are to accept or discard etc. However 112 elements have been named out of the 114 elements recognized at the latest . Among these, 98 elements exist in nature. The rest of the elements can be synthesised in high standard laboratories. Among the 98 elements 84 are called primary elements and the rest 14 elements are produced by radioactivity. The interesting mater is that, Antoine Lavoisier made a table of only 33 elements. Later on Russian scientist Dmitri I. Mendeleev introduced modern periodic table with 67 elements, among which 63 elements were invented and the rest 4 were not invented until that time but invented later.

After that, by the year 1900 another 30 elements were added to the periodic table. So we have realized that most of the elements of periodic table were invented during the eighteenth century.

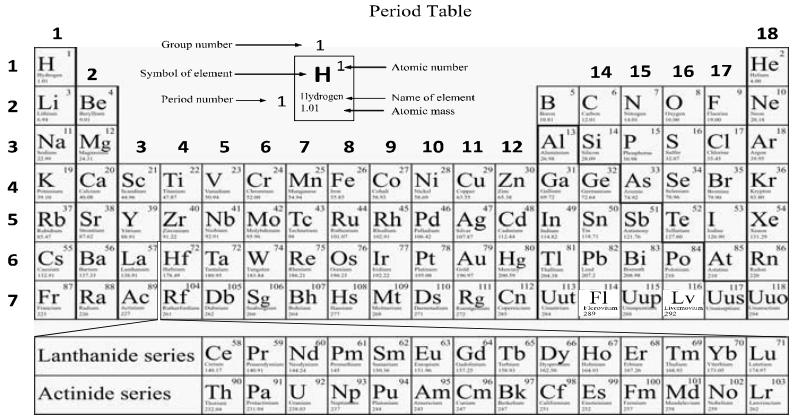


Fig 4.1 Different element of periodic table

4.2 Characteristics of periodic table

In terms of physical features, periodic table is the arrangement of chemical elements in a table. In fact, the periodic table is the conceptual diagram of properties of elements. Periodic table has been revised and changed from time to times after its invention. The latest periodic table recognized by IUPAC is given in Fig-4.1. This is called the modern periodic table. Some important characteristics of the modern periodic table are as follows:

- There are 7 periods (horizontal row) and 18 groups (vertical column) in the periodic table.
- All periods start with group 1 at the extreme left and extend up to group 18 at the extreme right.
- A small table composed of 2 horizontal rows and 14 perpendicular columns is displayed beneath the main periodic treble. It is also the part of period-6 and period-7 of main periodic table.
- In the first period (period-1) there are only two elements, which exist in group-1 and in group-18. Similarly both the period-2 and period-3 contain 8 elements, which exist in group-1 to group-3 and in group-13 to group-18
- Each group of every period from period-4 to period-7 is filled with elements.
- In the case of the two periods, period-4 and period-5, both have 18 elements in 18 groups. That is one element has occupied a place in every group.

- Exception is found in of period-6 and period-7. In these case of each of them a period has 32 elements in 18 groups. Out of them only group-3 contains 15 elements and the rest 17 groups contain one element each. In this way a total of 32 elements are arranged in these periods.

Let us complete the following work. Write the number of elements exist in different periods. To indicate the presence of elements in the different groups, fill the essential number of rectangular boxes of the table with pencil. If the rectangular boxes are not sufficient to show all the elements present in every period, draw and fill the necessary boxes in the big rectangular area. When completed compare the table with the given periodic table (fig 4.1).

Period	Total elements	Group																
		1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 0
1																			
2																			
3																			
4																			
5																			
6																			
7																			

Table 4.1: Different elements of periodic table

The above characteristics are visible as one takes a look at the periodic table. Now consider the periodic table in terms of properties of the elements.

- Properties of the elements change from left to right in the same period.
- Generally, the properties of the elements depend on their group. The physical and chemical properties of the elements of the same group are almost similar.
- Generally, the number of electrons in the last shell of the elements is equal to their group number.
- The number of total energy shell (orbit) of the elements is equal to their period number.

4.3 Various periodic laws

Scientists divided the elements invented earlier into two groups- metals and nonmetals. The metals again are divided into two groups as relatively less reactive metals (gold,

silver which are called elite metals) and more reactive metals (iron, zinc which are called inferior metals). At the beginning of 19th century, after the invention of Dalton's atomic theory, a great changes were taking place in practice of chemistry. In 1829 German scientist J. W. Doberiner gave the law of triads on the basis of the atomic mass of the elements.

Law of Triads: The mean of the mass of the two elements is nearly the same of the other element and the properties of the three elements are almost the same. If these three elements are arranged according to their mass the mean of the 1st and 3rd will be the same as that of the 2nd. The three elements are called "Doberiner Traids"

For example, the mean of the total mass of Li (7) and Potassium (39) is the same as Sodium (23).

In 1864 English scientist John A. R. Newlands found similarities in properties of every eighth elements by arranging the elements in the increasing order of their atomic mass. Based on that finding he proposed the Law of Octaves.

Law of Octaves: Similarities in properties of every eighth elements are found by arranging the elements in the increasing order of their atomic mass. This is known as the "Law of Octaves" in periodic table.

Russian scientist Dmitri I. Mendeleev examined the chemical properties of elements and arranged the elements invented in 1869 in the increasing order of their atomic mass and found that the elements of same properties are placed in the same column. Based on this he proposed the periodic law. Though there is contribution of many scientists in the invention of periodic table, Mendeleev's is called the father of the periodic table taking in to account the importance of his contribution.

Mendeleev's periodic law: If elements are arranged according to their increasing atomic mass, their physical and chemical properties repeat periodically.

In the year 1913 Mendeleev revised his periodic law after the invention of atomic number by scientist Henry G. J. Moseley.

Mendeleev's revised periodic law: The physical and chemical properties of the elements repeat periodically with their atomic number.

4.4 The prime basis of the periodic table

Mendeleev first tried to arrange the elements on the basis of their atomic mass in the modern periodic table. But on arrangement of elements in periodic table according to their atomic mass there remained some discrepancies. Consider the position of

Potassium (K) and Argon (Ar) as example. Atomic mass of Potassium (K) is 39 and atomic mass of Argon (Ar) is 40. If we arrange them in order of increasing atomic mass K has to be placed before Ar. In that case Potassium would come in group-18 and Argon would go in group-1. Actually in terms of physical and chemical properties resemblance of K is found with the alkali metals of group-1 and Ar with the inert gases of group-18. But arrangement of the elements according to their atomic number resolved these types of difficulties.

We have known about electron and proton in third chapter. The number of proton is called the atomic number and the number of proton in an atom is equal to the number of electron. That is why the number of electron in an atom may also be called the atomic number of the element. Although the atom does not change with the change of electron number but the atom does change with the change of proton number. In periodic table the physical and chemical properties of the elements repeat periodically with their atomic number depending upon the electronic arrangement of the elements. In fact, the electronic configuration of an element indicates its chemical properties.

In the year 1869 Mendeleev introduced modern periodic table, when the concept atomic number did not exist. In the year 1913, scientist Henry G. J. Moseley gave the concept of atomic number. Later on Mendeleev proposed his revised modern periodic table incorporating the concept of atomic number. Scientist Mendeleev is honored for the invention of modern periodic table. Because it is assumed that, if the concept of atomic number were known, scientist Mendeleev might have used the atomic number instead of atomic mass in his proposed periodic table.

4.5 Determination of the position of elements in periodic table from the electronic configuration

We have known from above that, electronic configuration is the basis of the periodic table. That is why, position of any elements in periodic table may be assumed from the electronic configuration of that element. Electronic configurations of some elements are given in the table below (Table-4.2). Electron arrangement of elements in different levels is shown. In an element the number of energy levels where electrons are configured, is the period number of the element. For example consider the case of H and He. In these elements electrons are arranged in only one energy level and the position of them is in period-1of periodic table. Similarly the electrons of the elements from Na to Ar are configured in three energy levels. So it can easily be said that the number of their period is 3.

Other than some exceptions, usually, the number of electrons at their outermost energy level may be called the group number of that element in a certain period. Then, if we think, we will understand that, the above rule will be applicable in the case of group-1 of all the seven periods. That is, the number of electrons at the outermost energy level of the elements of group-1 is 1. That is why, according to rule, the number of that group is 1. Similarly in the case of group-2 we will get the idea of group number from the number of electrons at their outermost energy level. On the other hand, the elements whose outermost energy level is filled with electrons are placed in group-18.

Period	Group																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	**H** 1																	**He** 2
2	**Li** 2,1	**Be** 2,2											**B** 2,3	**C** 2,4	**N** 2,5	**O** 2,6	**F** 2,7	**Ne** 2,8
3	**Na** 2,8,1	**Mg** 2,8,2											**Al** 2,8,3	**Si** 2,8,4	**P** 2,8,5	**S** 2,8,6	**Cl** 2,8,7	**Ar** 2,8,8
4	**K** 2,8,8,1	**Ca** 2,8,8,2																

Table 4.2: Electonic configuration of different elements.

In the case of period-2 and period-3, that is, the elements that have electrons configured in two or three energy levels, elements who have 3 electron in outermost energy level is placed in group-13. Because in the case of period-2 and period-3 there is no element presents in group-3 to group-12. Then in the case of elements who have electron arrangement in two to three energy levels, if the outer most energy level contains more then two electrons, then the group number can be determined by adding ten (10) with the number of electron present in the outermost energy level.

From period-4 to period-7 the elements that have electrons at ‘d’ sublevel, the sum of the number of electrons at ‘d’ sublevel and the number of electrons at the outermost energy level indicate their group number. For period-6 and period-7 the elements that have electrons at ‘f’ sub level, are placed separately at the bottom of the main periodic table.

In groups of five students work out the problem given in the following table (Table-4.3). Nitrogen is shown as an example.

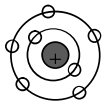
Element	Electron arrangement	Position in periodic table	Explanation
N		Period-2 Group-15	Electrons configured in two energy levels. So the number of period will be 2. The number of electron at outermost level is 5, but the number of period is 2. So number of group will be (5+10=15), not will be 5.
Li			
Al			
Ne			
Cl			

Table 4.3: Determination of the position of elements in periodic table from the electronic configuration.

4.6 Periodic properties of elements

On observation of any one period in the periodic table it is seen that the elements at the left are metal and gradually it turns to sub metal and to nonmetal. There is Na at the extreme left end of the period-3 which is a reactive metal. Again, Cl (2^{nd} from right) is a reactive nonmetal. A continuity of transformation from metal to nonmetal is observed in the elements exist between these two. Na, Mg and Al are of metallic properties. Si is a sub metal (bears the properties of both metal and non metal). P, S and Cl all are non metals and their melting point and boiling point is low. In any group the physical and chemical properties of elements gradually rotates periodically. For example, the alkali metals of group-1 are soft and have low melting point. The melting point of the metals of this group decreases with the increase of atomic number. From left to right of the periodic table that is from group-1 to group-17, the melting point and boiling point increases first (up to metal) then decreases (from nonmetal). In this way the melting point and boiling point of halogens of group-17 is much lower then the alkali metals of group-1. In case of halogen, similar gradual changes in different physical properties are observed. For example the melting point, boiling point and density increase with increase in atomic number.

Besides these some important properties of elements like- atomic radius, ionization energy, electronegativity, electron affinity etc. rotate periodically in periodic table. In a period of periodic table atomic radius decreases from left to right and in a group atomic radius increases from top to down. In a period of periodic table other properties except

atomic radius increases from left to right (with some exceptions) with the increasing atomic number. That is, the ionization energy of alkali metals of group-1 is low and the ionization energy of halogens of group-17 is high. Similarly in a group of periodic table these properties decrease from top to down with the increasing atomic number. You will learn more about these in higher classes.

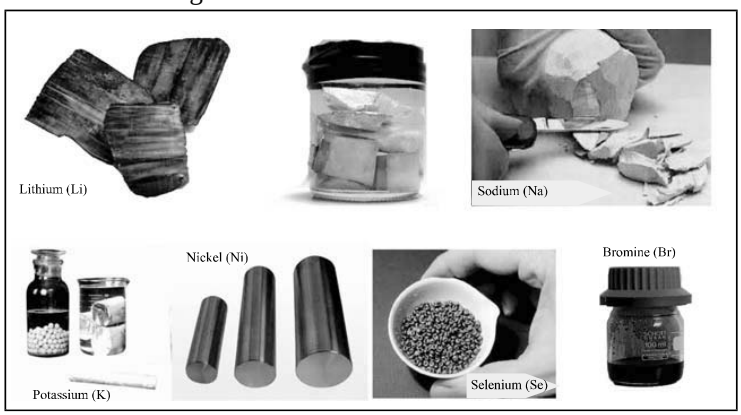


Fig 4.2: Different elements.

4.7 Special names of elements present in different groups (Alkali metal, alkaline earth metal, coinage metal, halogen, inert gas, transition element)

Alkali metal: The elements of group-1 in the periodic table e.g. Li, Na, K, Rb, Cs and Fr are called alkali metal. All these elements produce hydrogen gas and alkaline solution when reacts with water. They form ionic compounds (salt) by donating the only electron at the outermost energy level.

Alkaline earth metal: The elements of group-2 in periodic table from Be to Ra are called alkaline earth metal. Its properties are almost same as that of alkali metals. Oxides of these metal produce alkaline solutions when reacts with water. They also form ionic compounds (salt) by donating the two electrons of the outermost energy level. These elements exist in soil as different compounds.

Transition elements: The elements of group-3 to group-11 in periodic table are known as transition elements. Transition elements have their own colors. They are used as metallic substances. They form ionic compounds by donating the electrons of outermost energy level. In a period of periodic table properties of compound of the transition metals change from ionic character to covalent character from metals placed at the left to right.

Coinage metal: The elements of group-11 in periodic table Cu, Ag, Au have metallic character like brightness. Historically coins were made of these metals and were used as

a medium of exchange in trades and other needs. They are called coinage metals. In fact, they are transition metal.

Halogen group: The elements of group-17 in periodic table F, Cl, Br and I, and At, these five elements together are called halogen. The meaning of the word halogen is salt maker. They form halide ion by receiving one electron at their outermost energy level. The main source of halogens is the sea salt. They themselves form di-atomic molecules by sharing electrons.

Inert gas: The elements of group-18 in periodic table are called inert gas. As their outermost energy level is filled with sufficient electrons, they do not show any tendency to form compound by accepting, donating or by sharing electrons. That means, they remain inactive to form bonds or to take part in chemical reactions.

4.8 Advantages of Periodic Table

Periodic table is an essential tool for chemistry student and applied chemist. Practice of chemistry is not possible without modern periodic table. We have known earlier that 118 elements have identified till now. Let us consider the four physical properties of each element e.g. melting point, boiling point, density and physical state (solid, liquid, gaseous) and four chemical properties like- reaction with oxygen, water, acid and base. Thus, for 118 elements 4 physical and 4 chemical properties total in 472 properties. Is it not impossible to memorize such a large number of properties? We also know that, the properties of elements is not limited in 4 physical properties and 4 chemical properties. There are a large number of similar types of physical and chemical properties There are a large number of similar types of physical and chemical properties that we will learn later. However it is understood that all elements of periodic table have thousands of properties and to memorize them individually is really impossible.

1	H
2	Li
3	Na
4	K
5	Rb
6	Cs
7	Fr

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3	Na	Mg											Al	Si	P	S	Cl	Ar

We can get the idea of physical and chemical properties easily from the position of the elements in periodic table. For example, elements of group-1 except hydrogen are called alkali metal and it is possible to cut them by a knife. All these elements can donate the only electron at its outermost energy level. All the elements except hydrogen react with

water to form hydrogen gas. Similarly, the idea of properties of any element present in any group can be remembered by comparing the properties with other elements of that group. On the other hand, differences in properties of elements that exist in various groups of the same period can be assumed by observing the surroundings i.e. by comparing with the properties with their neighbouring elements. Considering the physical properties of elements present in various groups of period-3 we see that, Na is alkali metal which is a solid substance and can be cut by a knife. The physical properties of the elements on the right side of periodic table change gradually. Even Cl and Ar remain in gaseous state though the number of liquid elements in periodic table is small.

So we have understood that, though in relative view it is meant that the periodic table is the arrangement of elements in a simple table but actually it has great significance. We can say in one word that, practice in chemistry in present time is not possible without Periodic Table.

4.9 Reaction of water and diluted acid with the compounds of the elements of the same group of periodic table.

Detection of gas produced from the reaction of water and diluted acid with metal by experiment:

Experiment: (group work)

Materials: Na_2CO_3, K_2CO_3,/$CaCO_3$, $MgCO_3$, diluted hydrochloric acid (HCl)/vinegar (ethanoic acid), lime water, $Ca(OH)_2$, bent glass tube, cork, glass rod, beaker, stick, safety match.

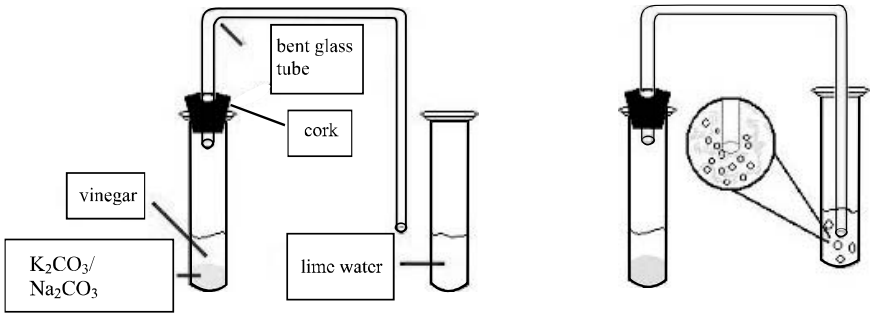


Fig 4.3: (a) materials and settings (b) Passes the produced gas into lime water.

Take approximately 2/3 g Na_2CO_3 in a glass tube then dissolve it in pure water and add diluted HCl to the solution. Observe if any gas produces. Test the produced gas by burning stick. For chemical test pass the produced gas through a bent glass tube into the

clean lime water in a beaker and observes the change. Try to explain the cause of this change. If more gas is passed into the lime water, observes the change and try to explain the cause of this change.

Repeat the experiment taking approximately 2/3g K_2CO_3. After the experiment complete the following table.

Added materials	**Na_2CO_3 in test tube**		**K_2CO_3 in test tube**		**Comments**
	Change and cause of change	**Chemical reaction occurred**	**Change and cause of change**	**Chemical reaction occurred**	
Pure water					
lemon juice/ vinegar/ dil.HCl					
Hold the burning stick to the gas					
Pass the produced gas of lime water					
Pass the excess amount of produced gas of lime water					

Exercises

Multiple choice questions

1. What is the real basis of periodic table?
   a) Atomic number b) Atomic mass
   c) Relative atomic mass d) electronic arrangement.
2. A = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$; what group of periodic table does the element belong to?
   a) Group-2 b) Group-5
   c) Group-11 d) Group-13

Answer questions no. 3 and 4 from the table below:

Part of a group of periodic table

$_{19}K$
X
Y
Z

[Here X, Y and Z is used as symbols, not the symbols of any regular element]

3. What period of the periodic table does element X belong to?

a) 3^{rd} b) 4^{th}

c) 5^{th} d) 6^{th}

4. In the above elements-

i) there is 1 electron at the outermost energy level.

ii) atomic radius decreases gradually.

iii) reactivity increases gradually.

Which one is correct?

a) i and ii b) ii and iii

c) ii and iii d) i, ii and iii

Creative questions:

1.

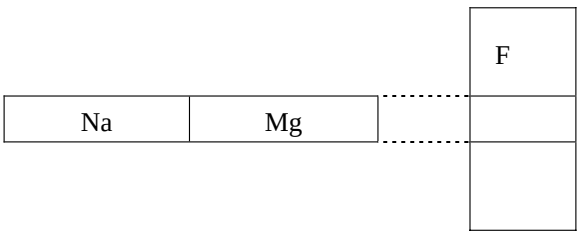


Diagram of the stem is a part of periodic table

a) Write down the Triads law.

b) Why is barium called the alkaline earth metal?

c) Which of the elements in the stem is bigger in size? Explain.

d) The first two elements in the period and group of the stem are highly reactive though the causes of their reactivity are different- give reasons.

2.

Group	Number of electrons in valency shell
A	3
B	7
D	8

[Here A, B and D is used as symbols, not the symbol of any regular element]

a) What is coinage metal?

b) Why is it not placed in group-2?

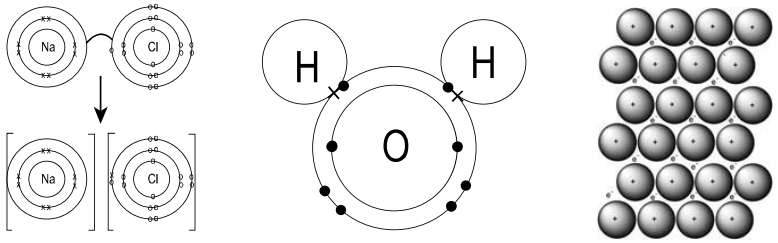
c) Explain the source of the elements of group B.

d) Compare the ionization energy of the elements in groups A and D.

Chapter Five

Chemical Bonds

Inert gases are stable in nature as mono-atomic gases, except these gases the atoms of other elements can not exist independently in nature. Molecules of fundamental gases are di-atomic like O_2, N_2, F_2, Cl_2, Br_2 etc. Again molecules of some elements consist of more than two atoms. For example O_3, P_4, S_8. Again, compounds are formed by the combination of atoms of different elements like NaCl, H_2O, HCl, CH_4 etc. In all molecules atoms remain attached together by a special kind of attraction force; this force is called the binding force. Generally, at the bond formation every atom wants to achieve the electronic configuration of its nearest inert gas at its last energy level. Generally metal and nonmetal form ionic bonds while nonmetal and nonmetal form covalent bond. In metallic pieces metal atoms attached with one another by metallic bond. The elements or compounds formed by three types of bonds have unique characteristics of.



By the end of this chapter we will be able to-

1. explain the concept of valiancy electrons.
2. explain the stability of inert gases.
3. explain the concept of octet and duet rules.
4. explain the chemical bonds and the cause of their formation.
5. explain how and why ions are formed.
6. explain the method of formation of ionic bonds.
7. explain the method of formation of covalent bonds.
8. explain properties like melting point, boiling point, solubility, electrical conductivity and crystal formation with ionic and covalent bonds.
9. explain the concept of metallic bonds.
10. explain the electric conductivity of metals with metallic bonds.
11. identify the ionic and covalent compounds among the easily available local objects.

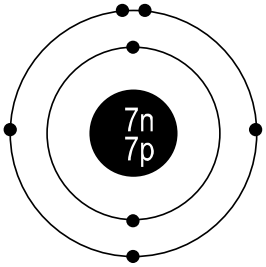
5.1 Valency electron

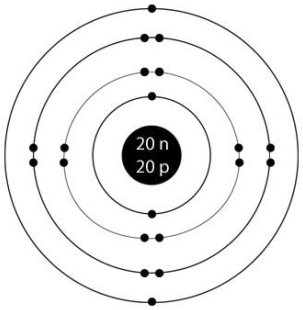
Symbols of some elements are given. Writing down their atomic number, configure the electrons and draw the diagram of electronic configurations.

Li, Na, O, F.

Write, how many electrons are there at the outermost energy level of each element.

The number of total electrons at the principle outermost energy level of an element is called the valency electron of that element.





Do it yourself: How many valency electrons are there in nitrogen and calcium?

[Though the two electrons of first orbit is shown unpaired, in fact, they are paired in a sublevel]

Fig 5.1: Electronic configurations of Nitrogen and Calcium.

5.2 Inert gas and its stability

You must have known that the elements of group-18 in the periodic table are called the inert gases.

Configure the electrons of He, Ne, Ar and Kr of this group.

Think: What types of similarities and dissimilarities do you observe in the electronic configurations?

The electronic configurations of the inert gases are given below.

He (2) : $1s^2$

Ne (10) : $1s^2\ 2s^2\ 2p^6$

Ar (18) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Kr (36) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}$

Xe (54) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6$

Rn (86) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ 6p^6$

It is seen from the above electronic configurations that all inert elements except helium have eight electrons at their valency shell. Atomic number of He is 2. Due to the exixtance of one sublevel(s) at the 1^{st} principal energy level, its valency shell is filled

with two electrons, which is the stable configuration for he. The two 2 electrons of He and 8 electrons of the other inert gases at the valency shell provide the stable conditions. Due to their lack of interest in changing these electronic configurations the elements remain chemically inactive. On the other hand, other elements do not have such electronic configurations at their outermost energy levels and they are interested in obtaining more stable configurations of this kind in different ways.

5.3 Octet and Duet rules

Earlier you have configured the electrons of Li and Na.

Explain how Li will obtain the electronic configuration of He and how Na will obtain the electronic configuration of Ne.

On the other hand, you have made the electronic configurations of oxygen and chlorine. Configure the electrons of Calcium. Explain, to gain the stability, the electronic configuration of which inert element will these three elements want to obtain and how they will obtain it.

There is only one electron in the valency shell of hydrogen. At the formation of molecules of compounds hydrogen atom will want to obtain the electronic configuration of its nearest inert gas helium. This is why at compound formation hydrogen atom receives one electron (in fewer cases) or share the electron of hydrogen with another electron.

So we may come to the conclusion from the above explanation and analysis that-

Atoms of different elements obtain electron configuration of 2 or in most cases 8 electrons at their outermost shell by exchanging and of electrons among themselves. Obtaining the arrangement of He in this way is called the rule of duplet or duet and obtaining 8 electron arrangements at valency shell is called the Octet rule.

5.4 Chemical Bonds and Causes of Chemical Bond formation

You have seen in the case of Li, Na and Ca that they get electronic configurations according to Duet or Octet rule at their valency shell by donating electrons. O and F atom get octet electronic configuration at their valency shell by accepting electrons.

At the formation of H_2 molecule, two hydrogen atoms share one electron each.

In this way different elements form bonds by receiving–donating or sharing of electrons.

So we have to remember some necessary information regarding the formation of chemical bonds-

1. The electrons of outermost energy level i.e. the valency electrons of an element take part in bond formation.
2. Every atom has the intention to gain the electronic configuration of its nearest inert element.
3. The elements of atomic number 1 to 17 follow the duplet or octet rule very easily on bond formation. Though the maximum electron bearing capacity of the 3rd energy shell is 18, some elements (e.g. K, Ca) fill the 1st sub shell (4s) of the 4th energy level having the 3rd shell filled with 8 electrons. They also follow the octet rule during bond formation.

Atoms form bonds following the facts described above and that is attraction or affinity is created between one another. So it may be said that-

The attraction force by which one atom is bonded with other atom is called chemical bond.

5.5 Cation and Anion

Draw the diagrams of electronic configurations of Sodium and Neon side by side.

How will sodium gain the electronic configuration of neon? Atomic number of Na is 11.

It will do so by donating the single electron of last energy level, won't it ?

Na	$Na^+ + e^-$	Charge formation of Na^+
2,8,1	2,8	Charge of 11 proton = +11
		Charge of 10 electron = -10
		Total charge = +1

The elements which have fewer number (1, 2, 3) of electrons at their last energy level or valency shell, the electrons of such elements remain loosely attached with the nucleus relative to the other elements of that period due to their long distance from the nucleus and these elements want to gain the mature state of duet or octet by releasing electrons. For this reason they donate electrons easily. At normal condition the number of electrons and protons in an atom remains the same. Due to the donation of one electron, the positive charge of nucleus is increased by one unit with respect to the number of electrons at different shells. Then it converts into unit positively charged atom.

Do it yourself:
Draw the figures of electronic configurations of chlorine and argon side by side.

Positively charged atom is called Cation.

It is seen that the number of valency shell electrons of chlorine is 7, the number of total electrons is 17; on the other hand, the number of electrons of inert gas Argon is 18, and the number of valency shell electrons is 8. To gain the electronic arrangement of Argon Chlorine needs one more electron.

$Cl + e^-$	Na^-	Charge formation of Cl^-
2,8,7	2,8,8	Charge of 17 proton = +17
		Charge of 18 electron = -18
		Total charge = -1

Chlorine becomes a negatively charged chloride ion by receiving one electron.

Negatively charged atom is called Anion.

Do it yourself: Draw the diagrams of electronic configurations of magnesium and oxygen and show how the two atoms will turn to cation and anion by gaining the electronic configurations of their nearest inert gas Neon.

5.6 Ionic Bond

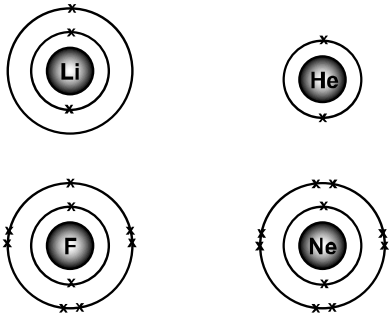


Fig 5.2 Electron arrangements of different atoms

How lithium will gain the electron configuration of helium, and florine will gain that of neon? Lithium atom releasing one electron from its valency shell will gain the stable duplet configuration of helium and frorine receiving one electron at its valency shell gain the stable octet configuration as in the valency shell of neon.

When the two atoms come closer, lithium atom will donate the electron of its valency shell to florine atom and florine will receive that donated electron and the atoms will turn to Li^+ and F^- ions respectively. The two ions will combine together to form the compound LiF.

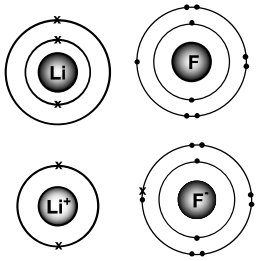


Fig 5.3 Compound formation process of LiF.

Do it yourself:

Show the NaF compound formation process from the combination of sodium and florine atoms in the same way.

Group work:

Show in diagram the formation methods of Magnesium oxide, calcium chloride and potassium chloride compounds and answer the following questions.

1. How many electrons do magnesium and oxygen gain or loose during the formation of magnesium oxide bond?
2. Why does Mg convert to Mg^{2+} ion and O convert to O^{2-} ions?
3. What is the formula of calcium chloride?

Reviewing all the examples above it is seen that the metals donate electrons and the non metals receiving that donated electron(s) of metal to become cation and anion respectively. Cation and anion come close to each other and form ionic bonds.

The attraction force by which cation (positively charged ion) or anion (negatively charged ion) formed by exchanges of electrons are held together within the atoms of a compound is called ionic bond.

Ionic bonds are formed by two different kinds of atoms.

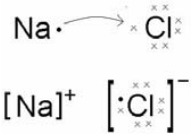


Fig 5.4 Ionic bond formation in NaCl.

It is important to know that, ionic bonds generally occur between the metals of group 1 & 2 and the nonmetals of group 16 & 17. The elements of the middle position of periodic table having the large number of electrons in their outermost energy level need more energy to accept or donate electrons that is why they are not interested in accepting or donating three or four electrons. Among these, Al^{3+} ion is exceptional. However, it is seen that, Al does not always form ionic bond by donating three electrons.

It needs mentioning that, the elements of periodic table having atomic numbers of 1 to 20 actually follow the duplet or octet rules in bond formation.

5.7 Covalent Bond

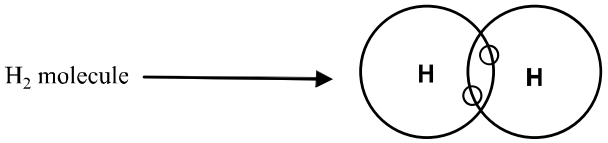
Draw the diagram of electronic configurations of Hydrogen, Carbon, Oxygen, Nitrogen and Florine.

All of these elements are nonmetals.

What happens in the case of bond formation of nonmetal-nonmetal?

What happens when one hydrogen atom combines with another hydrogen atom?

In this case it is not possible for hydrogen to receive or donate electron to gain the stable duplet electronic arrangement of helium. In that case the atoms will gain the stable configuration of helium by sharing electrons.



How many electrons are there in the valence shell of carbon, nitrogen and florin?

Carbon has 4, nitrogen has 5 and florine has 7 electrons.

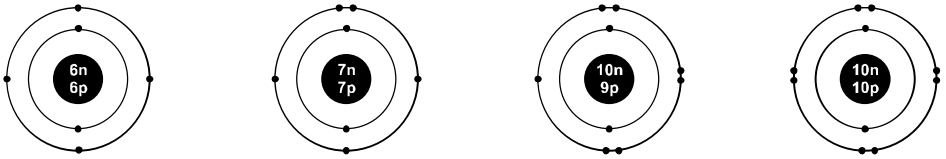


Fig 5.5: Electron arrangements of different elements.

In case of bond formation of carbon with nonmetals carbon requires to accept or release 4 electrons to attain the electronic configuration at valency shell as the stable octet of neon or stable electronic configuration of Helium. Nitrogen requires to accept 3 electrons or to release 5 electrons. Florin requires to accept 1 electron or to release 7 electrons. Nonmetals accept electrons only when they form bonds with metals. What will happen in case of bond formation of nonmetal-nonmetal?

It is not possible for any element to accept or release such a large number of electrons. Because, it requires a huge amount of energy which is beyond the ability of any element.

What will happen in the formation of chlorine molecule?

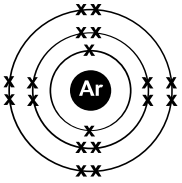


Fig 5.6 electronic arrangements of Argon

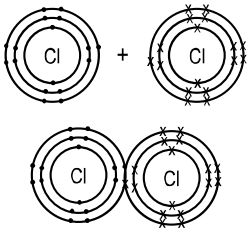


Fig 5.7 Bond formation of Cl_2 molecule

It is seen that in the formation of chlorine molecule, each atom achieves the electronic configuration of its nearest inert gas Argon by sharing of one electron of its valency shell.

Do it yourself: Draw the diagram of bond formation of oxygen and florin molecules. Explain on which case single bond and on which case double bond is found.

The molecules discussed above are fundamental. There are even more fundamental molecules. Look what will happen in the formation of compounds from the combination of different nonmetal atoms.

H_2O, is a molecule of water which is composed of two hydrogen atoms and one oxygen atom.

Atomic number of oxygen is 8, the electronic configuration is 2,6. Atomic number of hydrogen is 1, the electronic configuration is 1. To get the electronic arrangement of Neon, Oxygen requires two electrons at its outermost shell

That is why, two hydrogen atoms share one electron each from the two valency shell electrons of the oxygen and, thus, hydrogen achieves duet & oxygen achieves octet configurations.

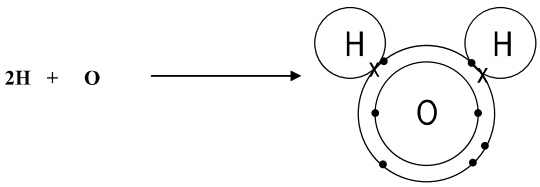


Fig 5.8 Structure of H_2O molecule.

The formation of covalent molecules by sharing of valency electron can be illustrated by diagram.

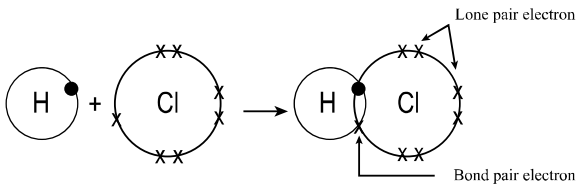


Fig 5.9: The formation of HCl molecule by sharing of valency electron.

Covalent molecules and covalent compounds are formed by covalent bond. Formulas of some molecules are given in the following table. (Table 5.1). Draw the diagram of their bond formation (by sharing the electrons of valency shell).

Molecule	**Number of atoms**	**Bond formation diagram**
Methane CH_4	C +4H	
Ammonia NH_3	N + 3H	
Carbon-di-oxide CO_2	C + 2O	

Table 5.1 Diagram of covalent bond formation

Think: How many bond-pair electrons are there in each atom after the bonding of molecules H_2O, NH_3, CO_2 and CH_4 and how many bonds have taken part in the formation of lone-pair electrons?

Reviewing all the examples above it is seen that, the atoms forming covalent molecules are all non-metals. Except hydrogen all non-metal atoms have more than three electrons at their outermost energy level. As they do not have the required energy to donate or accept electrons at the formation of compound according to duet or octet rule, they share electrons among themselves.

The bond formed by sharing of electrons to obtain stable electronic configuration at the outermost energy level of atoms is called covalent bond.

Notice that-

- Covalent bonds are usually formed between two non-metals.
- The atoms taking part in bond formation create one or more electron pairs by donating the equal number of electrons that is equally shared by both the atoms.

The fundamental molecules formed by covalent bond (e.g. O_2) is called covalent molecules and the compound (e.g. CO_2) is called covalent compounds.

Some covalent molecules exist in gaseous state at low temperature (NH_3, CO_2 and CH_4 etc.) Some exist in liquid state (H_2O, C_2H_5OH ethanol etc.) and some exist in solid state {sulfur (S_8), Iodine (I_2) etc.}. These molecules are attached together by weak vander Waals force which breaks at low temperature. NH_3, CO_2 and CH_4 etc. have no Van Der Waals force at all. As a result they move in gaseous state as single molecule.

Fig : 5.10 The formation of CO_2 molecule by sharing of electrons of outermost energy level.

5.8 Properties of Ionic and Covalent bonds

Melting point and Boiling Point (Group work): Each group take table salt (NaCl) and sugar in separate heat proof glass tube and keep heating them. Record the results of observation. As the melting point of NaCl is very high, it may not be possible to determine its melting point easily in the laboratory. As the melting point of sugar is very low, it will be easy to determine it; however determination of boiling point will be very difficult because after melting it turns black from brown. That is called caramel. You can perform this experiment by sodium nitrate, if available, instead of table salt. You can determine the boiling point of water instead of sugar. The materials need to be arranged the same way as you did in chapter two. The molecular formula of sugar is: $C_{12}H_{22}O_{11}$.

Task for students: It is seen from the experiment that the melting and boiling point of ionic compounds are high and the melting and boiling point of covalent compounds are low- Explain the reason.

Information: As there are positive and negative ends in the molecules of ionic compounds, they have high inter atomic attraction. On the other hand as the atoms of covalent compounds are neutral, there exists weak Van Dar Waals attraction force.

Solubility (Group work): Add washing soda, sodium chloride and copper sulphate in a certain amount of water separately and go on stirring. Write down which of them mixes with water and which do not. It may be mentioned that all of these compounds are ionic. Again, add the covalent compounds naphthalene (powder), flower, oil and sugar in separate pots in a certain amount of water. Write down the results of observations.

In this case a question may arise in your mind e.g. why most of the ionic compounds dissolve in water, some do not dissolve, again, why most of the covalent compounds do not dissolve in water, and some do? Why?

Upon testing of solubility you have seen that almost all ionic compounds dissolve in water, although water is a covalent compound. On the other hand most of the covalent compounds do not dissolve in water but sugar, alcohol, despite being covalent compound dissolve in water. What is the reason for it? After bond formation in water molecule, both nucleuses attract the shared electron pair between atoms. The ability of this attraction is higher in oxygen then in hydrogen (The ability of attraction of shared electron in covalent bond is called the electro negativity). Due to the attraction the shared electron pair are transferred toward oxygen atom. That is why there arises partial negative charge on oxygen atom and partial positive charge on hydrogen atom. This phenomenon is called the polarity of covalent compounds. The covalent compound where polarity arises is called the polar covalent compound.

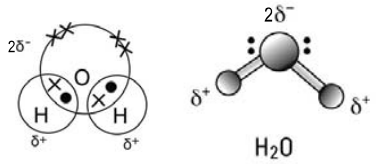


Fig: 5.11 Polarity in water molecule.

Ionic compounds have positive and negative ends. The positive end of ionic compounds are attracted by the negative oxygen end of water and the negative end are attracted by the positive hydrogen end of water. The covalent compounds which have polarity are also attracted similarly and dissolve in water.

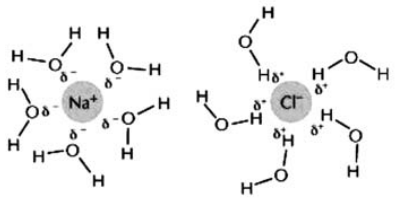


Fig : 5.12 Water molecule with added Na^+ and Cl^- ion

Electric conductivity (Group work): Take solutions of table salt in a beaker and solution of sugar in another beaker. Now, take two graphite rods as electrode. Attach copper wire, battery and torch bulb with the rods.

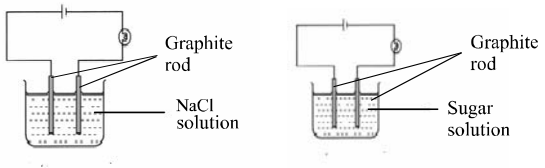


Fig 5.13 Determination of electrical conductivity of solutions.

Observe and determine the difference of electrical conductivity of ionic and covalent compounds. Metallic rods may be used instead of graphite rods. Explain the reason of the solutions becoming electrical conductor or insulator of.

Information: The presence of free ion or electron and their mobility is required for electric conductivity.

Lattice formation:

Home work: Everybody prepare saturated solutions of table salt and sugar in separate containers and apply heat to the solutions slowly. When the volumes of the solutions get reduced to half of the initial volume, leave them to cool down. After some time

observe the shape of solid particles settled at the bottom of the container from the solution of salt and sugar. (Explain from your observation of the shape of the particles, how a large number of them stay side by side and, why more heat energy is needed to melt the lattice of salt than that of sugar.)

Class work: Make the lattice of copper sulphate from solutions of copper sulphate in the same way.

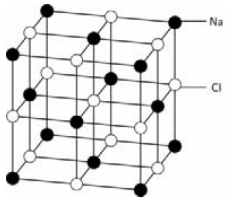


Fig 5.14 Crystal lattice of NaCl

Some more ionic compounds have crystal lattice e.g, Magnsia (MgO), Alumina (Al_2O_3) which have high melting point; their physical condition remain unchanged at 1500^0 C temperature. Generally ionic compounds exist in solid state at low temperature. As electrons cannot move at this state, they can not conduct electricity. Figure of crystal lattice of some covalent molecules are given below:

Fig 5.15 Lattice of sand (SiO_2), diamond and graphite.

In lattice state covalent compounds also have high melting and boiling points.

Think: There are two varieties of carbon; diamond is a nonconductor but graphite is electric conductor why?

Information: In diamond each carbon atom form covalent bond with four carbon atoms and in graphite each carbon atom form covalent bond with three carbon atoms.

5.9 Metallic bonds

You often see copper wire, aluminium foil, door and window made of aluminium, iron, zinc coated corrugated sheet and different types of pots. Atoms of these do not form bonds with other elements; again, do not stay at di atomic or tri atomic states within themselves. The atoms of each particular molecule stay together side by side. You have

known earlier that, every metal atom has lesser number of electrons at their outermost energy level. Due to their distant positions from the nucleus the electrons of these elements have less electron attraction compared to the other elements of the same period of the periodic table. So in metal lattice these electrons come out of the orbit and moves freely in the whole metal pieces. The disrupted electrons may not belong to any certain atom. Rather they belong to the whole metal pieces. The metal atoms become ion loosing electrons and remain in a three dimensional lattice. It is assumed that the metal ions are submerged in a sea of electrons. Characteristics such as high heat and electric conductivity, flexibility, heat resistance prevail in metal pieces for these delocalized electrons.

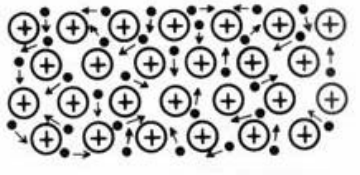


Fig 5.16 Ions and electrons in metal lattice.

The attractive force by which the metal atoms are bonded together is called the metallic bonds.

The cause of electric conductivity of Metals;

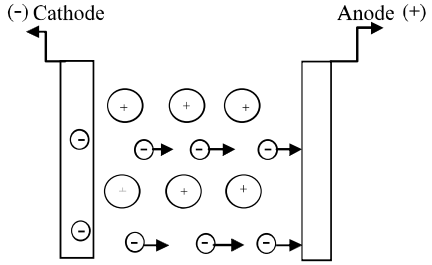


Fig 5.17 Electrical conductivity in metal lattice.

All metals are electrical conductor. As the inner electrons of metal lattice moves freely. Therefore, due to applied electric field or if the metal pieces are connected to battery and complete the circuit, the free electrons easily moves from negative end to the positive end and, in this way, they conduct electricity. You will be able to understand the phenomenon observing the above figure.

Expriment : Test the electrical conductivity of some materials like iron, aluminium, zinc, small lid of metallic pot, a pencil sharpened at both ends, rubber, pieces of wood, rubber band etc. Use the above materials in position B of the circuit. Differentiate them as conductors and non conductors.

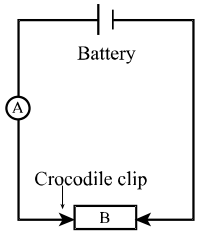


Fig 5.18 Experiment of electric conductivity.

Exercises

Multiple choice questions

1. What is the attraction force by which atoms are bonded in molecules?

a. Electron affinity b. Electronegativity

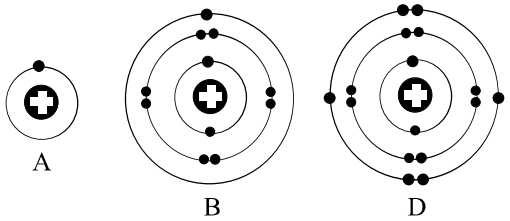
c. Chemical bond d. van dar Waals force.

2. On formation of which molecule every atom attains the electronic configuration of neon?

a. KF b. CaS

c. MgO d. NaCl.

On the basis of the electronic configurations of the following elements, answer questions 3 and 4.



[Here A, B and D are used as symbol, they are not the symbol of any regular elements.]

3. Which valency is impossible for the element marked by D?

a. 2 b. 3

c. 4 d. 6

4. The element B-

i. forms two types of bonds.

ii. donates electron to A

iii. dissolves in water combining with D.

Which of the following is correct?

a. iii. b. ii and iii.

c. i and iii d. i, ii and iii.

Creative questions

1.

Element	Period	Group
A	2	15
B	3	15

[Here A and B are used as symbol, they are not the symbol of any regular elements.]

a. Which is called the valency electron?

b. Explain, Why $CaCl_2$ conduct electricity.

c. How many bond pair electrons are there in chloride of A? Explain.

d. In explanation of stability of BCl_5 the rules of duet is more effective than octet rule, explain with logic.

2.

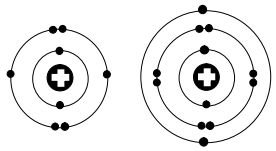


Fig-X Fig-Y

[Here X and Y are used as symbol, they are not the symbol of any regular elements.]

a. Which is called covalent bond?

b. Why there are differences in the shape of Na and Na^+ ?

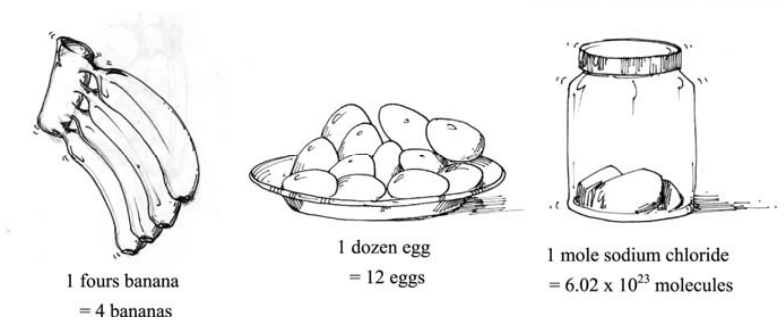
c. What type of bond is present in the compound X and Y of the stem? Explain.

d. Y never forms covalent bond though X forms both ionic and covalent bond- explain with logic.

Chapter Six

Concept of Mole and Chemical calculations

In performing a chemical reaction, it is indeed necessary for a chemist to determine what amount of substance is to use as reactant and what amount of product and byproduct and unwanted substances are produced. Particularly, in chemical industries this calculation is a must for economic considerations. This is why the number of molecules and the number of atoms and ions in a molecule of reactant and product of a chemical reaction are to be calculated. Molecules, ions and atoms are so small particles that, they cannot be calculated as pairs, fours, dozens, hundreds, thousands even not in corers. Chemists use a large number to count molecules, ions and atoms. The value of this number is 6.02 x 10^{23}. According to the name of Italian scientist Amedeo Avogadro this number is called the Avogadro number or Avogadro constant. The amount of a substance containing 6.02 x 10^{23} number of molecules, ions and atoms are called mole. In chemistry, calculation of molecule, atom, ion, reactant and product is known as Stoichiometry.



1 fours banana
= 4 bananas

1 dozen egg
= 12 eggs

1 mole sodium chloride
= 6.02 x 10^{23} molecules

By the end of this chapter we will be able to-

1. do the simple mathematical calculations using the concept of mole.
2. prepare solutions of certain density.
3. write the symbol of elements, formula of radicals and can write the formula of compounds using their valency.
4. determine the percent composition of elements present in the compounds using the given data.
5. determine the empirical and atomic formula using the percent composition.
6. write chemical equations and balance the equation using symbol, formula and valency of elements and radicals.
7. solve mass related mathematical problems of reactant and product from the quantitative significance of chemical reaction.
8. calculate the percent composition of lattice water of copper sulphate.
9. do the measurement of the chemical substances using balance.

6.1 Mole

The word mole is used with different meanings in biology and chemistry. In biology the mole means small livings with hair and in chemistry the word mole means certain amount of a chemical substance. Mole is the unit of measurement of chemical substance. As fours and dozens unit are used to count eggs or bananas, similarly mole unit is used to count the particles of chemical substance. For example, one mole of water means 6.02×10^{23} number of water molecules. Though one dozen eggs or bananas can be measured by counting but one mole of substance cannot be calculated by counting. This amount of chemical substance is measured in mass. That is, there is a relation of unit of mass gram/milligram with mole. The atomic mass or molecular mass of a chemical substance when expressed in gram unit is called the mole.

The amount of a chemical substance which contains the Avogadro number (6.02×10^{23}) of molecules, ions or atoms is called the mole of the substance. The number is so large that if all people of the world start to count them at a time, the sum of their counts for the whole life will not be the same as this number.

Avogadro number can be represented as 602 000 000 000 000 000 000 000.

Relative atomic mass of carbon is 12. That is, there are 6.02×10^{23} numbers of atoms in one mole carbon, mass of which is 12 g.

Relative molecular mass of water is 18. That is, there are 6.02×10^{23} number of molecules in one mole water, mass of which is 18 g.

Similarly,

1 mole hydrogen atom	=1.008g	= 6.02×10^{23} number of atoms.
1 mole oxygen atom	=16g	= 6.02×10^{23} number of atoms.
1 mole oxygen molecule	= 32g	= 6.02×10^{23} number of molecules.
1 mole carbon dioxide molecule	= 44g	= 6.02×10^{23} number of molecules.

6.2 Molar volume

The volume of one mole of substance is called the molar volume. Molar volume of Solid, liquid and gaseous substances are different. But in standard condition, the volumes of one mole of different gases are equal. The volume of a substance is pressure and temperature dependent. The volume of substance increases/decreases with the increase/decrease of temperature. On the other hand, the volume of gas decreases with the increase of temperature. The volume of a substance changes in large amount with the

change of pressure and temperature. So in calculating the volume of gaseous substance, it is required to mention the pressure and temperature. You will learn here only the molar volume of a substance only at standard temperature and pressure. 25°C temperature and 1 atmospheric pressure are called the standard temperature and pressure. In standard condition molar volume of any gaseous substance is 22.4 liter.

In standard condition volume of 1 mole or 44g Carbon dioxide is 22.4 liter. Similarly, In standard condition volume of 1 mole or 32g Oxygen is 22.4 liter. In standard condition volume of 1 mole or 2g hydrogen is 22.4 liter.

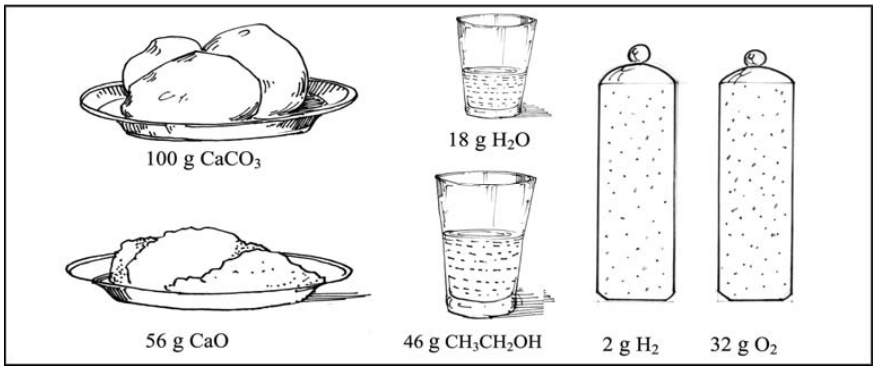


Fig 6.1: Volume of one mole of different substance.

Task: Calculate the number of molecule of one gm of the following substances

$CaCO_3$, NaCl, H_2SO_4

Task: Calculate the number of molecule and volume at standard condition of one gm of the following gaseous substances

H_2, O_2, CO_2, H_2O

Task: Calculate the mass of each atom of the following substances

$H_2O_{(l)}$, NaOH, $HCl_{(g)}$

Task: Calculate the number of atoms of one gm of the following substances

$C_{(s)}$, KOH, CH_4, O_2

6.3 Mole and molecular formula

The number of atoms of an element that can combine with a certain number of atoms of an element can be known from the molecular formula of an element. For example, CO_2 molecule is composed of carbon and oxygen elements. CO_2 molecule is formed by combining one atom of carbon with two atoms of oxygen. In terms of mole, CO_2

molecule is formed by combining one mole of carbon atom with two moles of oxygen atom. Atomic formula of a substance can be determined by calculating the number of mole from the mass of the elements.

It is seen from experiment that, 3gm carbon combines with 8gm oxygen and forms carbon dioxide. Molecular formula of the formed molecule can be determined as follows. (when molecular formula and empirical formula is similar).

Name of events	Carbon	Oxygen	Molecular formula
Atomic mass of element	3g	8g	CO_2
Number of mole = $\frac{\text{atomic mass}}{\text{gm atomic mass}}$	3/12 = 0.25	8/16 = .05	
Relative number of mole (in full digit)	1	2	

Table 6.1: Determination of molecular formula from amount of elements.

Certain amount of atom of an element combines with how much amount of atoms of another element can be determined from the molecular formula of an element using the concept of mole. In hydrochloric acid ($HCl_{(g)}$) molecule one mole of hydrogen atom combines with one mole of chlorine atom. That is, 1.008 or 1g hydrogen joins with 35.5g chlorine. If 1gm hydrogen and 85g chlorine is kept together in any container, on appropriate condition, 1g hydrogen will combine with maximum of 35.5g chlorine. The excess chlorine will remain in the container.

Task: If 5gm hydrogen and 10gm chlorine is kept together in any container, on apprpriate condition if HCl is produced, what and how much of rest amount will remain in container?

Task: The amount of hydrogen and oxygen in water molecule is 3g and 24g respectively. Determine the molecular formula of water.

6.4 Symbol of Elements

In chemistry the atom of each element is expressed with a symbol. The symbol of an element is denoted by one or two letters of English alphabet. The symbol of atom is expressed by writing the first letter (capital letter) of the English name of the element or the first letter (capital letter) of English name of element with the second or third or any other letter (Small letter).

When the symbol is written with two letters, the symbol is made by writing side by side the first letter of the English name of the element and the letter which pronounced next. When more then one element have the same English name and same pronunciation, three letters are written in a row to make the symbol. Symbols of some elements are written from their Latin names, not from the English name.

Task: Make a table of symbols of elements from the periodic table using different system show it to your teacher.

Symbol with first letter		Symbols with first and second letters		Symbols with first and third letters		Symbols with three letters	
English name	Symbol	English name	Symbol	English name	Symbol	English name	Symbol
Hydrogen	H	Aluminium	Al	Chlorine	Cl	Ununseptium	Uns
Boron	B	Cobalt	Co	Zinc	Zn	Ununpentium	Uup
Carbon	C	Bromine	Br	Chromium	Cr	Ununoctium	Uno
Oxygen	O	Nickel	Ni	Manganese	Mn		

Table 6.2: Different symbols of elements taken from English name

English name of element	Latin name of element	Symbol
Sodium	Natrium	Na
Copper	Cuprum	Cu
Potassium	Kalium	K
Lead	Plumbum	Pb

Table 6.3: Different symbols of elements taken from Latin name

6.5 Valency

The number of electrons in the outermost energy level or the number of unpaired electrons at the electronic configuration of an element is called the valency of that element. In the case of metal atoms the number of electron in the outermost energy level and in the case of non metals atom the number of unpaired electrons in the outermost energy level indicates the valency. The number of unpaired electron changes due to the electronic rearrangement in the sub energy levels of the outermost energy level of the element. These elements show the variable valency or more then one valency. The metallic element with large atomic number shows variable valency. In fact, the valency

of an element denotes its capacity for combining with other elements. The inert group elements of periodic table generally do not combine with other elements, so valency of these elements is considered zero.

Symbol of element	Electronic configuration of element	Number of electron in the outermost energy level	Number of un pair electron in the outermost energy level	Valency
$_1H$	$1s^1$	1	1	1
$_3Li$	$1s^2\ 2s^1$	1	1	1
$_4Be$	$1s^2\ 2s^2$	2	0	2
$_4Be^*$	$1s^2\ 2s^1\ 2p_x^1$	2	2	2
B	$1s^2\ 2s^2\ 2p_x^1$	3	1	3
B*	$1s^2\ 2s^1\ 2p_x^1\ 2p_y^1$	3	3	3
$_6C$	$1s^2\ 2s^2\ 2p_x^1\ 2p_y^1$	4	2	2
$_6C^*$	$1s^2\ 2s^1\ 2p_x^1\ 2p_y^1\ 2p_z^1$	4	4	4
$_7N$	$1s^2\ 2s^2\ 2p_x^1\ 2p_y^1\ 2p_z^1$	5	3	3
$_{11}Na$	$1s^2\ 2s^2\ 2p^6\ 3s^1$	1	1	1
$_{15}P$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p_x^1\ 3p_y^1\ 3p_z^1$	5	3	3
$_{15}P^*$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p_x^1\ 3p_y^1\ 3p_z^1\ 3d^1$	5	5	5

Table 6.4: Electronic configuration and valency

* refers to the excited state of element

Task: Comment on the valency after electron arrangement.
$_2He$, $_{12}Mg$, $_{17}Cl$, $_9F$, $_{13}Al$, $_{19}K$, $_{10}Ne$, $_{16}S$

6.6 Radical

Radical is a bundle of more then one atoms of more then one elements which acts as a single ion. Radicals are written with their charge. These may be of positive or negative charge. The charge of a radical is its valency.

Name of radical	Formula of radical	Charge	Valency
Ammonium	NH_4^+	+1	1
Phosphonium	PH_4^+	+1	1
Hydroxide	OH^-	-1	1
Carbonate	CO_3^-	-2	2
Sulphate	SO_4^-	-2	2
Sulphite	SO_3^-	-2	2
Nitrate	NO_3^-	-1	1
Nitrite	NO_2^-	-1	1
Phosphate	PO_4^-	-3	3

Table 6.5: Name, formula, charge and valency of some radicals

6.7 Formula of compounds

As every element has a symbol, similarly, every compound has individual formula. Formula represents the ratio of atom or ion in the molecule of a compound. Compound molecule is formed by neutral atoms and charged ions (negative or positive). If the molecule of a compound is formed by negatively or positively charged ions, they combine such a way that the total charge of the compound will be zero. Though the charge of the negatively or positively charged ions are their valency or the ability to combine with the opposite ions, the compound is formed by joining a mono positive charged ion with a mono negative charged ion. Two mono-positive charged ions combine with one di-negative charged ion. One di-positive charged ion combine with two mono negative charged ion. At the time of writing formula of a compound formed by the negatively and positively charged ions, the positive part is written first and next the negative part.

Positive ion and their charge	Negative ion and their charge	Number of required ion in writing formula			Formula of compounds
		Positive	Negative	Total charge of compound	
Cu^{2+}, +2	SO_4^{2-}, -2	1	1	0	$CuSO_4$
Na^+, +1	PO_4^{3-}, -3	3	1	0	Na_3PO_4
Al^{3+}, +3	NO_3^-, -1	1	3	0	$Al(NO_3)_3$

Table 6.6: Formula of some compounds formed by positive and negative ions

Task: Write ten formulas with positive and negative charge and show to your teacher.

At the time of writing the formula of a compound formed by the neutral atoms, the elements in the left side of the periodic table are written first. Relatively more positive elements are written first. The valency of an element expresses its capacity of combining with other elements. Formula is written considering the velancy of an element as the number of the other element and from the ratio of the number of atoms.

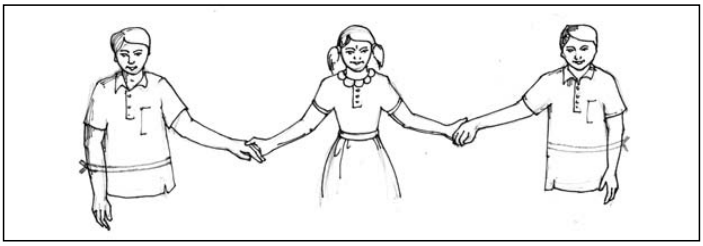


Fig 6.2: Concept of molecular formula with the help of valency.

First element and its valency	Second element and its valency	Number of required atom and their ratio in writing formula			Formula of the compound
		Number of atom of first element	Number of atom of second element	Ratio	
H, 1	Cl, 1	1	1	1 : 1	HCl
C, 4	H, 1	1	4	1 : 4	CH_4
C, 4	O, 2	2	4	1 : 2	CO_2
N, 5	O, 2	2	5	2 : 5	N_2O_5

Table 6.7: Formula of some compound formed by neutral atoms.

6.8 Molar solution

Solutions are made by mixing solute and solvent. Different liquid substances (water, alcohol, acid) are used to make solutions. In this chapter we will learn to make solutions using only water as solvent. This solution is called aqueous solution. The substance which get dissolved in solvent to make a solution is called the solute. If different amount of solute is dissolved in every unit volume of a solution, the density of the solutions will be different. There are different regulations to express the density of a solution. Molarity is a regulation of expressing density.

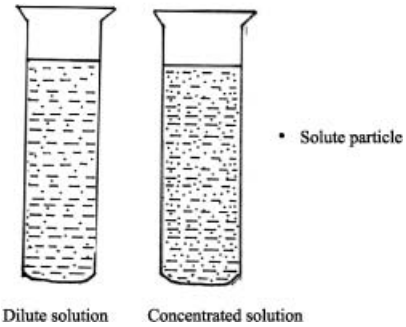


Fig 6.3: Solutions of different density

In one molar solution, one mole amount of solute get dissolved in one liter or one dm^3 solution. In semi molar (0.5 molar) solution, half mole (0.5) amount of solute get dissolved in one liter solution. When 2 mole amount of solute dissolve in one liter solution, it is called two molar solution. The volume of asolution is temperature dependent. Molarity of a solution is defined as:

The number of mole dissolved in every liter of solution at a certain temperature is called the molarity of the solution. It is marked by "M".

For the preparation of a solution of certain density the steps described are to be followed. First, a glass container or any other container of a certain volume (0.5 liter, 1 liter, 2.5 liter etc.) has to be taken. The container of that volume should be taken, as the volume of solution is to be made. Considering one mole in one liter, the amount of solute will have to calculate in gm unit for the a certain volume of definite density. Take the calculated amount of solute in the container weighing by a balance and with a funnel. Transfer the solute settling on the wall of the funnel to the container by distilled or pure water and make the solution by jerking with little amount of water. Then add water to fill the volume up to the definite mark and the solution of desired density will be prepared. For example, for the preparation of 0.5 liter of 0.1 molar Na_2CO_3 solution, take 0.1x0.5 mole or 0.1x0.5x106g Na_2CO_3 weighing by balance in a 0.5 liter container and make solution. Thus 0.5 liter 0.1 molar Na_2CO_3 solution will be prepared.

Calculation:

For 1 liter 1 molar solution 1 mole solute is required.

For 0.5 liter 0.1 molar solution solute required 0.1x0.5 mole.

1 mole = 106 g Na_2CO_3

0.1x0.5 mole = 0.1 x 0.5 x 106 g Na_2CO_3

Task: Prepare solution of 2 liter 0.1 molar or 0.1(M) cupper sulphate ($CuSO_4.5H_2O$).

6.9 Percent composition of elements in compound.

A compound is formed by more then one elements. The percent of mass of a certain element in the total mass of the compound is called the composition of that element.

The sum of the percent composition of the elements of a compound will be 100. The percent composition of a certain part of the compound is determined instead of any element composition. For example, composition of lattice water of copper sulphate $CuSO_4.5H_2O$ is determined. In a certain compound the percent composition of the elements will be specific. If water is taken anywhere from the world, the percent composition of hydrogen and oxygen will be the same. For the calculation of the percent composition of an element or any certain part of the compound, the relative atomic mass will have to determine from the molecular formula of the compound. Then by calculating the mass of each element individually and, if necessary, by determining the mass of the certain part, the percent composition of an element in a compound is determined.

Determination of the percent composition of hydrogen and oxygen in Hydrogen chloride (HCl) gas:

Molecular formula of Hydrogen chloride: HCl

Its relative molecular mass = (1+35.5) = 36.5.

In the compound relative atomic mass of hydrogen= 1 and

relative atomic mass of chlorine = 35.5.

Composition of hydrogen = 1x100/36.5% = 2.74%

Composition of chlorine = 35.5x100/36.5% = 97.26%

Determine the percent composition of copper, sulfur, oxygen, hydrogen and lattice water of Cupper sulphate $CuSO_4.5H_2O$;

Molecular formula of Cupper sulphate is

$= CuSO_4.5H_2O$

Lattice water: Lattice water is essential for lattice formation but not essential for formula of compound.

Its relative molecular mass = (63.5+32+16x9+1x10) = 249.5.

In the compound relative mass of copper, sulfur, oxygen, hydrogen and lattice water is 63.5, 32, 144, 10, 90 respectively.

Composition of copper = 63.5x100/249.5% = 25.45%

Composition of sulfur = 32x100/249.5% = 12.83%
Composition of oxygen = 144x100/249.5% = 57.72%
Composition of hydrogen = 10x100/249.5% = 4.00%
Composition of lattice water = 90x100/249.5% = 36.07%

Think: From the above calculation, the total composition of HCl is 100, but in $CuSO_4.5H_2O$, the total composition is more then 100. Why?

Task: Determine the composition of the elements of the compounds.	**Task:** Determine the composition of the radicals of the compounds.
H_2O, H_2SO_4, Na_2CO_3, NaOH	H_2SO_4, Na_2CO_3, NaOH, $NaNO_3$

6.10 Determination of empirical formula from the percent composition

If relative atomic mass of an element is "A" and the relative molecular mass is "M", composition of element = n x A x 100/M%. Here n = number of element in the molecular formula of the compound. For a certain molecule there is a certain value of M and 100/M. So, by dividing the percent composition of different element by the relative atomic mass of that element, we will get 100/M times of the number of atoms in the molecule. That is, dividing the percent composition of different elements by the relative atomic mass of that element, and from the ratio of the obtained result empirical formula can be determined. Though the percent composition of element of molecule found from the molecular formula (H_2O) and the simple multiple of molecular formula [$(H_2O)_n$] are the same, the formula determined from the ratio found from above system expresses the ratio of the elements of the molecule. The formula of which shows the ratio of the number of atoms of different elements present in a molecule is called the empirical formula.

In a compound, composition of oxygen is 88.89% and composition of hydrogen is 11.11%. Determine the empirical formula of the compound.

Subject	**Hydrogen, H**	**Oxygen, O**	**Emperical formula of the compound**
Composition of element	11.11	88.89	H_2O
$\frac{\text{Composition of element}}{\text{relative atomic mass}}$	$\frac{11.11}{1}$ =11.11	$\frac{88.89}{16}$ = 5.55	
Ratio of H and O atom in the compound	11.11 : 5.55 = 2 : 1 (or the full number of ratio divide by the small number 5.55)		

Table 6.8: Determination of the empirical formula of the compound from the composition of the elements

In a compound, composition of carbon is 92.31% and composition of hydrogen is 7.69%. Determine the empirical formula of the compound.

Subject	**Hydrogen, H**	**Carbon, O**	**Emperical formula of the compound**
composition of element	7.69	92.31	CH
$\frac{\text{Composition of element}}{\text{relative atomic mass}}$	$\frac{7.69}{1}$ =7.69	$\frac{92.31}{12}$ = 7.69	
Ratio of H and C atom in the compound	7.69 : 7.69 = 1 : 1 (or the full number of ratio divide by the small number 5.55)		

Table 6.8: Determination of the empirical formula of the compound from the composition of the elements

6.11 Determination of molecular formula of a compound from the percent composition

Molecular formula of a compound is the simple multiple of its empirical formula. For some compounds the molecular formula and the empirical formula will be the same. The empirical formula of the above compound is CH and the molecular formula is $(CH)_n$. If the molecular mass of the compound is known by determining the value of 'n' molecular formula is determined. If the molecular mass of the above compound is 78 determine its molecular formula.

Emperical formula of the compound = CH

Molecular formula of the compound = $(CH)_n$

Molecular mass of the compound = (mass of carbon x 1 + mass of hydrogen x 1) x n

= (12 + 1) x n

= 13n

There fore, 13n = 78

n = 6

So, Molecular formula of the compound = $(CH)_6$

= C_6H_6

6.12 Chemical reaction and chemical equation

Chemical equation is used to represent the chemical reaction in short. That is, equation is the chemical shorthand and expression of a chemical system in chemical language.

Rules of writing chemical equations:

1. Chemical reaction starts with substances that are called reactants and the substances that are formed from chemical reaction, known as, products. In a chemical equation the reactants are written on the left side and the products are written on the right side; an equal sign (=) or an arrow (→) is placed in the middle.
2. If there are more then one reactants or products, they are written with plus sign (+).
3. The number of atoms of different elements on the left side and the number of atoms of same elements on the right side is to make equal. Though reactants and products are different compound, they are composed of the same elements. As a result, conservation of mass rule is followed.
4. The physical states of reactants and products are written on the right side of the compound in first brackets ( ) as subscripts. If the physical state of compound is solid (s) is written, if liquid (l) and if gaseous (g) is written. If any compound of reactants and products remain as aqueous solution, (aq) is written.

If coal or carbon is burnt in presence of air, carbon (IV) oxide or carbon dioxide is produced. Here, carbon and oxygen are reactants and carbon (IV) oxide is the product. The reactant carbon is solid, oxygen is gaseous and product carbon (IV) oxide is gaseous substance. The equation of the reaction is as follows:

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$$

Solid calcium carbonate reacts with aqueous solution of hydrochloric acid to produce aqueous solution of calcium chloride, carbon (IV) oxide gas and water. The equation of the reaction is as follows:

$$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(g)} + CO_{2(g)} + H_2O_{(l)}$$

6.13 Balancing the chemical equation

Chemical reactions are expressed in short by chemical equations. In a chemical reaction reactants and products follow the rule of conservation of mass. So in the chemical reaction the number of atoms of different elements of reactants and the number of atoms of different elements of products will be the same. To make the number of atoms of different elements equal, the formula of reactants and produced are to be multiplied by suitable numbers (2, 3, 4 etc.). Though there is not any certain rule for balancing the equation, some techniques techniques are to be followed.

1. Write the equation of reaction using the right formula of reactants and products.
2. If the reactants and products are compound substances that is if the atoms of more then one element is present in formula, balance the equation by multiplying the reactants or products or both with required numbers.
3. Then balance the number of atoms of fundamental reactants and products.
4. In balancing the equation generally full number is used as multiplier with the reactants and products.

Magnesium metal reacts with hydrochloric acid to produce magnesium chloride and hydrogen.

$$Mg_{(s)} + HCl_{(aq)} \rightarrow MgCl_{2(s)} + H_{2(g)}$$

In order to balance the reaction, firstly, the reactant HCl is multiplied with 2 in order to make the number of atom of chlorine equal. Thus, the atoms of other elements become equal. The balanced equation is-

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(s)} + H_{2(g)}$$

Aluminium oxide reacts with hydrochloric acid; produce aluminium chloride and water.

$$Al_2O_{3(s)} + HCl_{(aq)} \rightarrow AlCl_{3(s)} + H_2O_{(l)}$$

In the equation, 2 is multiplied with the product $AlCl_3$ to make the number of aluminium atom equal, 6 is multiplied with the reactant HCl to make the number of chlorine atom equal and 3 is multiplied with the product H_2O to equal the number of hydrogen atom and oxygen make. The balanced equation is-

$$Al_2O_{3(s)} + 6HCl_{(aq)} \rightarrow 2AlCl_{3(s)} + 3H_2O_{(l)}$$

When magnesium nitrate is heated, magnesium oxide, nitrogen oxide and oxygen gas is produced.

$$Mg(NO_3)_{2(s)} \rightarrow MgO_{(s)} + NO_{2(g)} + O_{2(g)}$$

In the equation, 2 is multiplied with the product NO_2 to make the number of nitrogen atom equal and ½ is multiplied with the product O_2 to make the number of oxygen atom equal. The balanced equation is-

$$Mg(NO_3)_{2(s)} \rightarrow MgO_{(s)} + 2NO_{2(g)} + ½\ O_{2(g)}$$

Task: Balance the following equations:

$$AgNO_{3(s)} \rightarrow Ag_{(s)} + NO_{2(g)} + O_{2(g)}$$

$$Na_2CO_{3(s)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(g)} + CO_{2(g)}$$

6.14 Mole and chemical equation

Certain amount of a reactant reacts with the certain amount of another reactant. Similarly, certain amount of product is formed from certain amount of reactant. In chemistry, the process in which calculation of amount of reactant and product of a reaction is done is called Stoichiometry. Number of atom, number of mole and mass of reactant and product can be calculated from a balanced equation.

$2Mg_{(s)}$	+	$O_{2(g)}$	$\rightarrow$	$2MgO_{(s)}$
2 mole		1 mole		2 mole
$2x6.023x10^{23}$		$1x6.023x10^{23}$		$2x6.023x10^{23}$
2 mole = 2x24 g		1 mole = 1x32 g		2 mole = 2x40 g

In the reaction, 2 molecule magnesium reacts with 1 molecule oxygen and produces 2 molecule magnesium oxides. In terms of mole, 2 mole magnesium reacts with 1 mole oxygen to produce 2 mole magnesium oxides.

Determination of mass of one reactant from the mass of other reactant;

(5g magnesium metal reacts with how much gm of oxygen?)

According to above equation,

48g magnesium reacts with 32 g oxygen

5g magnesium reacts with $\frac{32 \times 5}{48}$ g oxygen

= 3.33 g oxygen

Determination of the mass of a product from the mass of a reactant;

(What gm of magnesium oxide is produced from 2g magnesium?)

According to above equation,

48g magnesium produced 80 g magnesium oxide

2g magnesium produced $\frac{80 \times 2}{48}$ g magnesium oxide

= 3.33 g magnesium oxide

The condition is that sufficient oxygen is to be supplied to react with 2g magnesium metal.

Determination of mass of one reactant from the mass of product;

(How much gm of oxygen is required to produce from 10g magnesium oxide?)

According to above equation,

80g magnesium oxide produced from 32 g oxygen

10g magnesium oxide produced from $\frac{32 \times 10}{80}$ g oxygen

= 4 g oxygen

The condition is that sufficient magnesium is to be supplied to react with 4g oxygen.

6.16 Limiting Reactant

If there is more then one reactant in a chemical reaction, it is not possible always to supply the all reactants in required amount when supplied by weighing. In the above reaction 1 molecule of oxygen gas is required to react with 2 atom of magnesium metal. Similarly, 2 molecules of oxygen gas is required to react with 4 atoms of magnesium metal. But in reaction if 4 molecules of oxygen gas is supplied to react with 4 atoms of magnesium metal, 2 molecules of oxygen gas will remain in reaction medium. In this condition magnesium metal is called the limiting reactant. That is, at the time of reaction among more than one reactants the reactant that does not remain in reaction medium is called the limiting reactant. At the time of calculation the amount of product form reactant, it is done from the amount of limiting reactant.

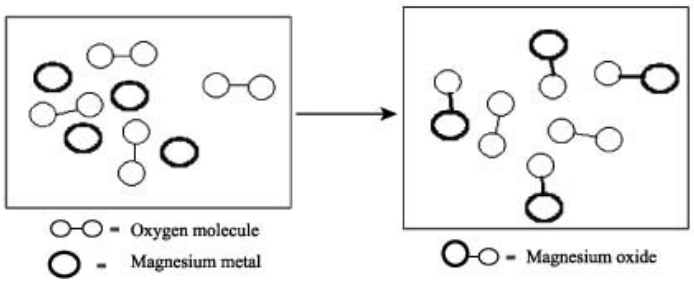


Fig 6.4: Concept of limiting reactant

6.17 Percentage of yield

The reactants used in chemical reactions are not found as 100% pure. The purest chemical substance is called the Analar. Analar chemicals are all 95.5% pure. These are used at synthesis in research. The purity of chemical substance depends on their preparation and the method of purification. If the reactants are not 100% pure The amount of product found will be lesser than that of calculated from the amount of limiting reactant. The product found lesser in amount is expressed by the percentage of yield of product.

$$\% \text{ of yield} = \frac{\text{Amount of Product obtained from reaction x 100}}{\text{calculated amount of product from reaction}}$$

Task: 39 g CaO is obtained by heating 80g $CaCO_3$. Calculate the percent amount of the product.

6.18 Determination of percent composition of lattice water of copper sulphate

Materials: Copper sulphate, balance, porcelain bowl, net, tripod stand, crucible, tongs, burner/ sprit lamp.

Principle: Blue Vitriol $CuSO_4.5H_2O$ is composed of copper sulphate and five moles water. Hydrated copper sulphate crystal lattice is blue in color. The color of the dehydrated copper sulphate ($CuSO_4$) is white. When blue copper sulphate is heated, the water vaporizes and it converts to white colored copper sulphate. Weighing the mass of the copper sulphate before and after heating, the mass of lost water can be calculated and, thus, the mass of the lattice water of copper sulphate can be calculated

$$CuSO_4.5H_2O \xrightarrow[-5H_2O]{\Delta} CuSO_4$$

blue color — white color

1 Mole = 249.5g — 1 Mole =159.5g

Theoretically 1 mole (249.5g) hydrated blue copper sulphate produce 159.5 g dehydrated white copper sulphate on heating by releasing 90gm water.

Procedure : Take approximately 5 to 7g of $CuSO_4.5H_2O$ in a porcelain bowl weighing by balance. Put it on the tripod stand and heat it until white color of copper sulphate appears. And when the copper sulphate become white in color stop the heat and measure the mass quickly. If the mass is not taken quickly, on cooling, copper sulphate may absorb water and may convert to blue again.

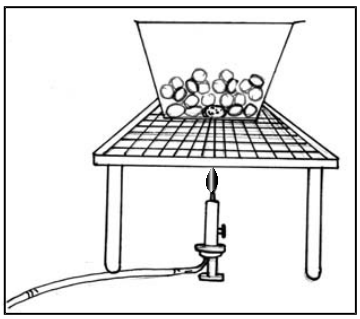


Fig 6.5: Dehydration of copper sulphate.

Calculation: Mass of porcelain crucible = a g

Mass of porcelain crucible with $CuSO_4.5H_2O$ = b g

Mass of $CuSO_4.5H_2O$ = (b - a) g

After heating mass of porcelain crucible with $CuSO_4$ = c g

Mass of $CuSO_4$ = (c - a) g

Mass of removed water by heat = (b-a) – (c-a) g

= (b-c) g

Mass of lattice water of (b-a) g $CuSO_4.5H_2O$ = (b-c)

Mass of lattice water of 100 g $CuSO_4.5H_2O$ = $\frac{(b-c) \times 100}{(b-a)}$ g

Exercises

Multiple choice questions

1. What is the volume of 2gm hydrogen in standard condition?

a) 2.24 L b) 11.2 L

c) 22.4 L d) 44.8 L

2. Which is the formula of calcium phosphate?

a) $CaPO_4$ b) $Ca(PO_4)_2$

c) $Ca_2(PO_4)_3$ d) $Ca_3(PO_4)_2$

Answer questions 3 and 4 on the basis of the stem below:

5gm hydrogen gas is passed on to 75 gm chlorine gas.

3. How many of chlorine atoms are used in the reaction in the stem?

a) 1.27×10^{24} b) 2.54×10^{24}

c) 6.02×10^{23} d) 6.36×10^{23}

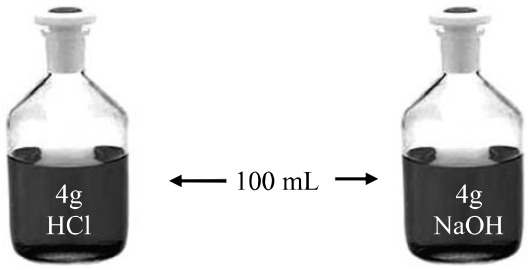
4. Which of the following collect as remains in the reaction in the stem?

a) 1.44 mole H_2 b) 1.44 mole Cl_2

c) 2.89 mole H_2 d) 2.89 mole Cl_2

Creative questions

1.



a) What is mole?

b) Why the are valency and the valency electron of nitrogen not equal? Explain.

c) Determine the composition of the salt that can be formed by combining the solutions shown in the stem.

d) Will the density of the illustrator solutions be the same? Give mathematical explanation.

2. 4.4g carbon dioxide and 5g calcium oxide is mixed to produce 10g $CaCO_3$. The expected amount of product is not found through the reaction.

a) What is chemical equation?

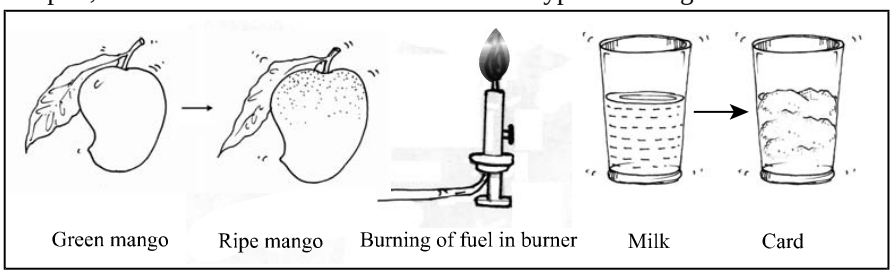
b) Explain the molar volume of carbon dioxide.

c) Determine how many moles of carbon dioxide was used in the reaction?

d) Give logical explanation of the less amount of expected product found in the reaction in the stem.

Chapter Seven
Chemical Reaction

The elements present in nature are changing gradually. There are different kinds of changes. Some of the changes are physical and some are chemical. Every change has some effects. Particularly chemical changes have both good and bad effects. So it is mandatory to have proper knowledge about the effects of chemical changes. By studying this chapter, we will be able to know about different types of changes and their effects.



Different types of chemical changes

By the end of this chapter we will be able to-

1. differentiate between physical changes and chemical reactions.
2. identify chemical reactions by analyzing the changes in a substance.
3. classify the chemical reactions- redox/nonredox, reversible/irriversible, exothermic/endothermic and detect the types of reaction.
4. explain the amount of products gained through cemical reaction in terms of Le Chatelier's principle.
5. detect the type of redox-nonredox reactions by analyzing the change.
6. explain many reactions occuring in various fields of real life.
7. find out the ways to control or prevent the harmful reactions in real-life situation (finding appropriate ways to prevent rusts on iron made materials).
8. explain and compare the concerned reaction rate.
9. examine and compare the reaction speed or rate by using various materials.
10. show consciousness in using metal substances in our day to day life.
11. demonstrate the acid-base neutralisation reaction and precipitation reactions.
12. show the differences in the reaction rate through experiments.

7.1 Changes in Matters

The substances existing in nature undergo changes due to the external heat, pressure and contact with other substances. A chemical substance is composed of one or more then one elements. Pure substances have a certain percent of composition of its elements. Sometimes, changes occur only in physical conditions of substances leaving their percentage composition unchanged. For example, if we place a piece of ice in open air it will convert to liquid by absorbing heat form the surrounding and if we heat the liquid water at 100^0C, water vapor will produce. The chemical formula of ice, liquid water and water vapor is H_2O. The percent composition of hydrogen and oxygen in all the three states are the same. This change of a substance is called physical change.

$$H_2O(s) \rightleftharpoons H_2O(l) \rightleftharpoons H_2O(g)$$

Similarly wax and sealing wax melts to liquid state on heating and quickly convert to solid state on withdrawal of heat. Sometimes, when a substance changes due to the external heat, pressure and contact with other substances, new substances are produced through changes in the percent composition of the existing elements. The new substance can formed from the elements of the previous substance or by the dissociation or addition of any element. The physical state of the new substance may be different or the same to the previous one. As the elements are different in the new compound, there are changes in the percent composition. For example, the main constituent of wax is various mixes of hydrocarbon. When wax is burnt, only some portion of it melts into liquid state from solid, through physical change and again turns solid on cooling. At the same time, some parts of the wax reacts with the atmospheric oxygen and form carbon-di-oxide and water vapor. This means that both physical and chemical changes occur due to burning of wax. On burning of wax carbon and hydrogen combine with the atmospheric oxygen and form carbon-di-oxide and water vapor. As new substances are produced during the burning of wax, this change is a chemical change or chemical reaction. In chemical changes new bonds are formed by breaking the existing bond between the atoms. The formation and breaking of bonds are associated with change of heat energy. The chemical reaction is as follows:

$$C_xH_y + \left(\frac{x+y}{2}\right)O_2 \xrightarrow{\triangle} xCO_2 + yH_2O + \text{Energy}$$

On burning of natural gas or methane it reacts with atmospheric oxygen and form carbon-di-oxide and water vapor. Only chemical reaction takes place here.

$$CH_{4(s)} + 2O_{2(g)} \xrightarrow{\triangle} CO_{2(g)} + 2H_2O_{(l)}$$

Limestone ($CaCO_3$) reacts with acid and produce carbon-di-oxide and water.

$$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + CO_{2(g)} + 2H_2O_{(l)}$$

Task: Give your opinion in terms of percent composition of different substances in the processes above.

In physical changes the changed substances can easily be retained to its previous state but in chemical changes the changed substances may not be returned completely to its previous state.

7.2 Classification of chemical changes or chemical reactions

In a chemical reaction, the substances with which the reaction starts is called the reactant and the substance produced is called the product. The physical and chemical properties of reactants and products are different. Even their physical states may also be different. A chemical reaction is occured by transferring of electrons from the reactants or addition of electrons to the reactants. Reactants convert to products during the reaction process, at the same time, the products may also convert to reactants. A chemical reaction is accomplished by the formation of new bonds through the breaking the existing bonds between the atoms. In fact, chemical bonds are a kind of energy. The formation and breaking of bonds are associated with change of energy that we feel as heat. So, there is a change of heat in chemical reactions. Some reactions evolve heat and some absorb heat. Chemical reactions can be classified on the basis of the following factors:

1. Direction of reaction
2. Heat change of reaction
3. Electron transition

1. Direction of reaction: Depending on the direction, reactions can be divided into two types.

a. Irreversible Reaction: In irreversible reaction only reactants convert to products. Products cannot be converted to reactants by reaction if any one of the products produced from reaction is removed from the reaction medium. The equation of irreversible reaction is presented by using oneway arrow sign (→) between the reactants and products.

When limestone (calcium carbonate; $CaCO_3$) is heated at high temperature, limestone dissociates to lime (calcium oxide; CaO) and carbon-di-oxide (CO_2). This reaction occurred in open container is irreversible.

$$CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}\uparrow \quad \text{(in open container)}$$

The product generated through this reaction are solid calcium oxide and gaseous carbon-di-oxide. Gaseous carbon-di-oxide is removed from the container if the reaction takes place in open container. As a result, calcium carbonate ($CaCO_3$) can not be produced by the reaction of calcium oxide (CaO) and carbon-di-oxide (CO_2); that means the reaction in opposite direction can not take place.

b. Reversible Reaction: In a reversible reaction, the reactants react and convert to products, at the same time, the products react again and convert to reactants. In reversible reaction two reactions continue simultaneously. In one reaction reactants react and produce the products, this is called forward reaction. In the other one, the products react again and convert to reactants; this is called backward reaction. In the case of reverse or backward reactions, the products of main reaction (i.e. the forward reaction) acts as reactants. The equation of reversible reaction is presented by using double headed arrow sign ($\rightleftharpoons$) between the reactants and products.

In presence of inorganic acid (H^+) ethanol and organic acid reacts and produce ester. This is a reversible reaction. In this reaction the product ester decomposes and produces ethanol and organic acid.

$$CH_3CH_2OH + CH_3COOH \overset{H^+}{\rightleftharpoons} CH_3CH\text{-}O\text{-}\overset{\overset{O}{\|}}{C}\text{-}CH_3$$

Again the decomposition reaction of limestone, if occurred in closed container, is reversible.

$$CaCO_3(s) \overset{\Delta}{\rightleftharpoons} CaO(s) + CO_2(g) \quad \text{(in closed container)}$$

The products of the reaction are solid calcium oxide gaseous and carbon-di-oxide. If the reaction occur in closed chamber, calcium carbonate ($CaCO_3$) can be produced by the reaction of calcium oxide (CaO) and carbon-di-oxide (CO_2) as reaction in opposite direction take place.

In fact, almost all reactions are reversible under appropriate condition. But in some reactions the amount of backward reaction is so little compared to the forward reaction that the reaction appears to be irreversible.

2. Heat change of reaction: Depending on the heat change reactions can be divided into two types.

a. Exothermic reaction: When heat is evolved at the time of producing the products form reactants, the reaction is called exothermic reaction. The reaction container and solution become hot when exothermic reaction occurr. The evolved heat is expressed by

adding it with the products or as ΔH. The value of ΔH will be negative in exothermic reaction. For example, 92 kJ heat is produced during the production of 2 moles of ammonia from the reaction of nitrogen and hydrogen in presence of heat, pressure and catalyst.

$$N_{2(g)} + 3H_{2(g)} \underset{200\text{-}250\ atm,\ 450\text{-}550^0C}{\overset{Fe}{\rightleftharpoons}} 2NH_{3(g)} + 92\ kJ$$

Or

$$N_{2(g)} + 3H_{2(g)} \underset{200\text{-}250\ atm,\ 450\text{-}550^0C}{\overset{Fe}{\rightleftharpoons}} 2NH_{3(g)} \quad ; \triangle H = -92kJ$$

B. Endothermic reaction: When heat is absorbed at the time of producing the products form reactants, the reaction is called endothermic reaction. The reaction container and solution become cool when endothermic reaction take place. The evolved heat is expressed by deducing it from the products or by adding with the reactants or as ΔH. The value of ΔH will be positive in endothermic reactions. For example, 180 kJ heat is absorbed on producing 2 moles of nitric oxide from the reaction of nitrogen and oxygen in presence of heat, pressure and catalyst.

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)} - 180\ kJ$$

Or

$$N_{2(g)} + O_{2(g)} + 180\ kJ \rightleftharpoons 2NO_{(g)}$$

Or

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)} \quad ; \triangle H = 180\ kJ$$

[You will know detail about exothermic and endothermic reactions in the next chapter. (Chapter eight, Chemistry and Energy)]

3. Electron Transfer: Depending on the electron transfer, reactions can be divided into two types.

a. Redox reaction
b. Non redox reaction

a. Redox reaction: The word redox comes from 'red' of reduction and 'ox' of oxidation. That means, *redox* means oxidation-reduction. Oxidation-reduction reaction occurrs by electron transfer. When oxidation-reduction reaction occurs from one reactants, electron transition occurs in more than one elements of the reactants. When

oxidation-reduction reaction occurs from two reactants, electron transition occurs between the reactants. As a result, oxidation number of the reactant is changed.

Oxidation Number: At the formation of compounds, the number of electron released to form positive ions and the number of electron received to form negative ion is called the oxidation number of an element. The oxidation number of a neutral or free element is considered zero (0). When negative ion is formed by accepting electrons, the oxidation number of the element is called negative oxidation number. When positive ion is formed by donating electrons, the oxidation number of the element is called positive oxidation number. Generally the oxidation number of metal is positive, the oxidation number of nonmetal is negative and the oxidation number of radicals follow their charge. For example, in HCl, oxidation number of H is +1, in H_2 oxidation number of H is 0 (zero), in $FeSO_4$ oxidation number of Fe is 0 (zero). Similarly in HCl, oxidation number of Cl is -1 and in Cl_2 oxidation number of Cl is 0 (zero).

Group work: Compare oxidation number and valency.

Determination of oxidation number: In fact the oxidation number of an element is related with electronic configuration. In a compound, the oxidation number of an element depends on the oxidation number of other elements of the compound. To determine the oxidation number of an element in a compound, standard oxidation number of other elements is used. The Standard oxidation number of some elements, ions and radicals are given below-

Rule of oxidation number	Formula of compound	Element/radical and oxidation number
Oxidation number of metals is positive and oxidation number of nonmetals is negative	NaCl	Na = +1 Cl = -1
Oxidation number of a neutral or free element is zero	Fe, H_2	Fe = 0 H = 0
Total oxidation number of atoms of a neutral compound is zero	Fe, H_2	H_2O H = +1, O = -2 Total=0
Total oxidation number of atoms of charged ion is equal to their charge	SO_4^{2-} NH_4^+	SO_4^{2-} = -2 NH_4^+ = +1
Oxidation number of alkali metal is +1	KCl, K_2CO_3	K = +1

Rule of oxidation number	Formula of compound	Element/radical and oxidation number
Oxidation number of alkaline earth metal is +2	CaO, $MgSO_4$	Ca = +2, Mg = +2
Oxidation number of halogen in metal halide is -1	$MgCl_2$, LiCl	Cl = -1
In most compounds oxidation number of hydrogen is +1 but oxidation number of hydrogen in metal hydride is -1	NH_3, $LiAlH_4$	H = +1 H = -1
In most compounds (oxides) oxidation number of oxygen is -2 but oxidation number of oxygen in peroxide is -1 and oxidation number of oxygen in superoxide is -1/2 (i.e. -0.5)	K_2O, CaO, K_2O_2, H_2O_2, NaO_2, KO_2	O = -2 O = -1 O = - 1/2

Table 7.1: Oxidation number of different atoms in different compounds

Determination of Oxidation number of Mn in $KMnO_4$

Let, oxidation number of Mn = x

Oxidation number of K = +1

Oxidation number of O = -2

As the $KMnO_4$ neutral compound total oxidation number of atoms is = 0.

So, $(+1) + x + (-2) \times 4 = 0$

$+1 + x - 8 = 0$

$x - 7 = 0$

$x = 7$

Oxidation number of Mn in $KMnO_4$ is = +7

Task: Determine the Oxidation number of the underlined elements of compounds or ions: $\underline{Mn}O_2$, $K_2\underline{Cr}_2O_7$, $\underline{N}O_3^-$, $H_2\underline{S}O_4$, $\underline{Mn}O_4^-$, $\underline{Cu}SO_4$, Na$\underline{O}$H

In an oxidation-reduction reaction, usually, one reactant accept electron and another reactant donate electron. The reactant which accepts electron is called the oxidant and the reactant which donates electron is called the reductant. Metallic zinc reacts with copper sulphate and produce zinc sulphate and metallic cupper.

This is a redox reaction. There are two parts of a redox reaction- oxidation part and reduction part.

$$Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$$

Ionic form of the reaction is:

$$Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$$

Oxidation: In a redox reaction the mechanism of donating or releasing electrons by reactants is called the oxidation. In the above reaction, oxidation number of reactant Zn is zero (0) and in the product $ZnSO_4$, oxidation number of Zn is +2. That means, in the reaction, reactant Zn is oxidized by donating two electrons and turns to $ZnSO_4$. Oxidation part of the reaction can be written as

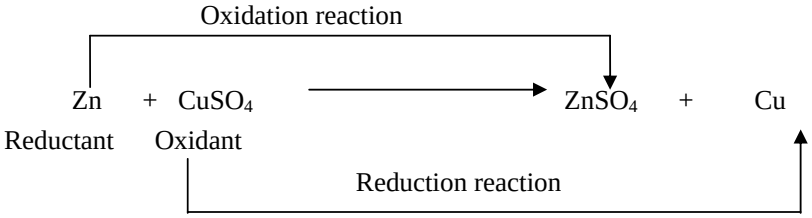
$$Zn - 2e^- \longrightarrow Zn^{2+}$$

Reduction: In a redox reaction the mechanism of accepting or receiving electrons by reactants is called the reduction. In the above reaction, in reactant $CuSO_4$ oxidation number of Cu is +2 and, in the product, oxidation number of Cu is zero (0).

That means, in the reaction, reactant $CuSO_4$ is reduced by accepting two electrons turning to Cu. The reduction part of the reaction can be written as

$$Cu^{2+} + 2e^- \longrightarrow Cu$$

In the reaction, reactant $CuSO_4$ is reduced by accepting two electrons and oxidized the Zn, that means, $CuSO_4$ is the oxidant in this reaction. In the other way Zn is oxidized by donating two electrons and reduce the $CuSO_4$; that means, Zn is the reductant in this reaction. In redox reaction, when oxidant accept electrons from reductant and reduced as well as reductant donate electron to oxidant and become oxidized. That means oxidation and reduction occurred simultaneously.



In the above reaction although it is said to be oxidation and reduction reaction, oxidation or reduction is only half of the full reaction. So it is better to say the oxidation reaction as oxidation half reaction and the reduction reaction as reduction half reaction.

All the reactions that occur by transition of electron are included in oxidation- reduction. Reactions that occur through transition of electrons are;

1. Addition Reaction.
2. Decomposition Reaction.
3. Substitution Reaction.
4. Combustion Reaction.

1. Addition Reaction: A reaction in which the new compound is formed by combination of two or more elements or molecules is called addition reaction. Iron(II)chloride reacts with chlorine and forms iron(III)chloride. (In old method addition of chlorine or negative part with any compound is called oxidation.)

$$2FeCl_{2(aq)} + Cl_{2(g)} \longrightarrow 2FeCl_{3(aq)}$$

Hydrogen gas reacts with chlorine gas and forms hydrogen chloride gas;

$$H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$$

In addition reaction, when two or more elements combine together to form new compound is called synthesis.

2. Decomposition reaction: The process in which a compound breaks into one or more elements or molecules is called decomposition reaction. Phosphorous(V)chloride, when heated, produces Phosphorous(III)chloride and chlorine. It is an irreversible reaction. (In old method releasing of chlorine or negative part from any compound is called reduction).

$$PCl_{5(l)} \xrightarrow{\Delta} PCl_{3(l)} + Cl_{2(g)}$$

Water decomposes to produce hydrogen and oxygen on electrolysis.

$$2H_2O_{(l)} \xrightarrow{\text{electrolysis}} 2H_{2(g)} + O_{2(g)}$$

3. Substitution or displacement reaction: The process in which an element or radical displaces another element or radical from a compound and takes its place is called substitution reaction. Usually, relatively less reactive elements or radicals are substituted by more reactive elements or radicals. Zinc reacts with sulfuric acid and produce zinc sulphate and hydrogen gas. In this reaction more reactive zinc metal substitutes less reactive hydrogen. [To compare the reactivity see Mineral resource (metal-nonmetal) chapter]

$$Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + H_{2(g)}$$

Metallic sodium reacts with cupper sulphate and produce sodium sulphate and metallic copper.

$$2Na_{(s)} + CuSO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + Cu_{(s)}$$

4. Combustion reaction: The process in which any compound or element is burnt in presence of atmospheric oxygen and converts to oxides of its elements is called combustion reaction. Usually heat is evolved in combustion reactions. The heat obtained from burning of methane gas or natural gas is used other other purposes along with cooking foods. (In old system addition of oxygen or negative part with any compound is called oxidation.)

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$$

In the same way carbon, sulfur, hydrogen and magnesium produce their oxides when burnt.

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$$
$$S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$$
$$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$$
$$2Mg_{(s)} + O_{2(g)} \longrightarrow 2MgO_{(s)}$$

Fig 7.1: Burning of fuels.

Task: Explain the oxidation-reduction of above reactions in terms of electron transfer.

b. Non-Redox reaction: When no electron transition occurs between the existing elements during the formation of new compound from one or more reactants, the reaction is called the non-redox reaction. In this reaction there is no involvement of increase or decrease of oxidation number of any reactant. Reactions where accepting-donating or transition of electrons are not involved are as follows:

1. Neutralisation Reaction.
2. Precipitation Reaction.

1. Neutralisation reaction: This reaction is called acid-base reaction. There are some particular characteristics of aqueous solutions of acid, such as, if blue litmus paper is dipped in the solution, it will turns red in color. pH of the solution is less then 7. Correspondingly, there are some particular characteristics of aqueous solutions of base, such as, if red litmus paper is dipped in the solution, it turns blue. pH of the solution is

greater then 7. When the aqueous solution of acid and base is mixed together, salt is produced.

$$\text{Acid} + \text{Base} \longrightarrow \text{Salt} + \text{Water}$$

In the formation of salt from the reaction of acid and base in aqueous solution, the pH of the solution comes close to 7. On completion of neutralisation reaction the value of pH reaches at 7. During the reaction acid loses its acidity and base loses its alkalinity to become neutralized. The reaction in which acid and base react in aqueous solution and form salt is called the neutralisation reaction. All neutralisation reactions are exothermic. Hydrochloric acid (HCl) and sodium hydroxide (NaOH) react in aqueous solution and form sodium chloride (NaCl) and water (H_2O). Sodium chloride remains dissolved in reaction container.

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$

In fact, in the reaction, hydrogen ion (H^+) of acid and hydroxide ion (OH^-) of base combine together and form water. Sodium chloride remains as sodium ion (Na^+) and chloride ion (Cl^-) in aqueous solution. In aqueous solution sodium ion (Na^+) and chloride ion (Cl^-) do not undergo reaction. These are called spectator ion. No electron transition occurs in this reaction.

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$$

Or

$$H^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$$

Or

$$H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$$

2. Precipitation reaction: When two soluble compounds are mixed in a certain solvent and if any new compound is produced that is insoluble or sparingly soluble in that solvent, the compound settles at the bottom of the container as solid. If the new compound settled at the bottom of the container is not dissolved in the solvent, it is called precipitation. The reaction in which the produced compound steeled at the bottom of the container as precipitation is called the precipitation reaction. In precipitation reaction the reactants taking part in reaction are generally ionic compounds. In a reaction whether the products will settle as precipitation or not will not depend upon the solvent used. The product of a reaction may be precipitated in water solvent, may also not be precipitated in another solvent. Maximum chemical reactions are performed in water solvent. So, if one of the products is insoluble in water, the reaction is called the

precipitation reaction. The reactions that are performed only in water solvent will be disused in this chapter. In writing a chemical equation the product which settles as precipitation, 's' is written in first braked at the right side of the product as subscript. In many times, in chemical equation a down arrow sign (↓) is used in front of the product to express precipitation. Sodium chloride and silver nitrate react in aqueous solution and form aqueous solution of sodium nitrate and precipitate of silver chloride.

$$NaCl_{(aq)} + AgNO_{3(aq)} \longrightarrow NaNO_{3(aq)} + AgCl_{(s)}$$

Or

$$NaCl_{(aq)} + AgNO_{3(aq)} \longrightarrow NaNO_{3(aq)} + AgCl \downarrow$$

In fact, in the reaction, silver ion (Ag^+) of silver nitrate and chloride ion (Cl^-) of sodium chloride combine together and form precipitate of silver chloride. Sodium nitrate remains as sodium ion (Na^+) and nitrate ion (NO_3^-) in aqueous solution. In aqueous solution sodium ion (Na^+) and nitrate ion (NO_3^-) do not undergo reaction. These are called Spectator ion. No electron transition occurs in this reaction.

$$NaCl_{(aq)} + AgNO_{3(aq)} \longrightarrow Na^+_{(aq)} + NO^{3-}_{(aq)} + AgCl_{(s)}$$

Or

$$Na^+_{(aq)} + Cl^-_{(aq)} + Ag^+_{(aq)} + NO_3^-{}_{(aq)} \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)} + AgCl_{(s)}$$

Or

$$Ag^+_{(aq)} + Cl^-_{(aq)} \longrightarrow AgCl_{(s)}$$

In most cases the precipitation reaction is a double displacement reaction. In this reaction silver ion of silver nitrate is replaced by the sodium ion of sodium chloride as well as sodium ion of sodium chloride is replaced by the silver ion of silver nitrate.

If both the products of a double displacement reaction is soluble in water, no precipitation is found and it seems that no reaction occurs. Sodium chloride and potassium nitrate react in aqueous solution as double displacement reaction and produce sodium nitrate and potassium chloride. Both remain dissolved in aqueous solution. That is why, all the ions remain as spectator ion. That is, no chemical reaction happened.

$$NaCl_{(aq)} + KNO_{3(aq)} \longrightarrow NaNO_{3(aq)} + KCl_{(aq)}$$

Or

$$Na^+_{(aq)} + Cl^-_{(aq)} + K^+_{(aq)} + NO_3^-{}_{(aq)} \longrightarrow Na^+_{(aq)} + NO_3^- + K^+_{(aq)} + Cl^-_{(aq)}$$

Molecular formula of some compound insoluble in water.

$BaSO_4$, $PbSO_4$, AgI, $CaSO_4$, $BaCl_2$, CuS, PbS, PbI_2

Most precipitation reactions are non-redox. Sometimes, one of the products of redox reaction occurred by transition of electrons, can be found as precipitation. This type of reaction is commonly known as oxidation-reaction reaction instead of precipitation reaction. For example, silver nitrate solution in basic medium is called as *"Tollen's reagent"*. Tollens reagents when reacts with organic compounds like aldehyde form metallic silver which settle at the bottom of the container as precipitate. In this reaction silver ion of silver nitrate is reduced by accepting one electron and precipitated as metallic silver.

In aqueous solution silver nitrate reacts with sodium hydroxide or ammonium hydroxide and form silver hydroxide. Product silver hydroxide decomposes and precipitates as silver oxide.

$$AgNO_{3(aq)} + NaOH_{(aq)} \longrightarrow AgOH_{(aq)} + HNO_{3(aq)}$$

$$2AgOH_{(aq)} \longrightarrow Ag_2O_{(s)} + HNO_{3(l)}$$

If aqueous ammonia solution is added to silver oxide in drops, all precipitate become dissolved solution of silver ammonia ion or *Tollen's reagent* $[Ag(NH_3)_2]^+$ is produced.

$$Ag_2O_{(s)} + 4NH_3 + H_2O_{(aq)} \longrightarrow 2[Ag(NH_3)_2]^+_{(aq)} + OH^-_{(aq)}$$

Silver ion of Tollen's reagent reacts with aldehydes and reduce and precipitate as metallic silver. At the same time, aldehyde oxidized and converts to organic acid.

$$CH_3CHO + 2Ag^+_{(aq)} + 2OH^-_{(aq)} \longrightarrow CH_3COOH + 2Ag_{(s)} + H_2O_{(l)}$$

Some special reactions: There are some reactions which do not fall in to the above classes.

1. Hydrolysis reaction: There are positive hydrogen ions (H^+) and negative hydroxyl ions (OH^-) in water molecule. The two ends of any compound join with the two oppositely charged parts of water and form new compound. This reaction is called hydrolysis reaction. Hydrolysis reaction is similar to double displacement reaction (discussed in precipitation reaction). As water takes part in this reaction, it is called hydrolysis reaction. No electron transition occurs in this reaction. Aluminum chloride reacts with water and form aluminum hydroxide & hydrochloric acid. Here aluminum ion (Al^{3+}) of aluminum chloride joins with hydroxyl ion (OH^-) of water and the chloride ion (Cl^-) of aluminum chloride joins with hydrogen ion (H^+) of water. The product aluminum hydroxide is insoluble in water and settles at the bottom of the container as precipitate.

$AlCl_{3(s)} + 3H_2O_{(l)} \longrightarrow Al(OH)_{3(s)} + HCl_{(aq)}$

Similarly, silicone tetrachloride is hydrolysed in presence of water and forms silicone hydroxide and hydrochloric acid.

$SiCl_4 + 4H_2O \longrightarrow Si(OH)_4 + H_2O$

2. Hydration reaction: When one or more molecules of water join with ionic compounds during formation of crystal lattice. This reaction is called hydration reaction. Water molecule that joins with ionic compounds is called lattice water or hydrated water. For the joining of water molecules this reaction is named so. This reaction is similar to addition reaction, but no electron transition occurs in this reaction like addition reaction.

$CaCl_2 + 6H_2O \longrightarrow CaCl_2.6H_2O$

$MgCl_2 + 7H_2O \longrightarrow MgCl_2.7H_2O$

$CuSO_4 + 5H_2O \longrightarrow CuSO_4.5H_2O$

3. Isomerisation reaction: Two compounds with similar molecular formula and with different properties are called isomar to each other. For example, two compounds with similar molecular formula C_2H_6O are-

$CH_3\text{-}CH_2\text{-}OH$		$CH_3\text{-}O\text{-}CH_3$	
Name:	Ethanol	Name:	Di methyl ether
Physical state:	Liquid	Physical state:	Gaseous
Boiling point:	78^oC	Boiling point:	-24^oC
Solubility:	Soluble in water	Solubility:	Sparingly soluble in water

Molecular formulas of ethanol and di methyl ether are similar but their properties are different. Ethanol and di methyl ether are isomar to each other. A chemical reaction in which atoms in a molecule rearranged to give one isomer from other isomer is called the isomerisation reaction. In this reaction atoms are rearranged in the same molecule. Thus electron transition is not possible.

$CH_3\text{-}CH_2\text{-}OH \longrightarrow CH_3\text{-}O\text{-}CH_3$

Ammonium cyanate (NH_4CNO) and urea ($NH_2\text{-}CO\text{-}NH_2$) are isomar to each other. When ammonium cyanate is heated, its isomar urea is formed. This reaction is an example of isomerisation reaction.

$$NH_4CNO \xrightarrow{\Delta} NH_2\text{-}CO\text{-}NH_2$$

4. Polymerisation reaction: A large number of molecules of the same compound combine together to give a large molecule of heavy atomic mass under the influence of high temperature and pressure. Each of the small molecules which combine together are called monomer and the new large molecule that forms is called polymer. The reaction in which polymer is formed from innumerable monomer is called polymerization reaction. On high temperature and pressure innumerable molecules of venyal chloride (CH_2=CHCl) combine together and form poly venyl chloride (PVC) of heavy atomic mass.

$$n\,H_2C{=}{=}CHCl_{(g)} \xrightarrow[\text{and pressure}]{\text{High temperature}} \left[\, CH_2\text{-}CHCl \,\right]_{n(s)}$$

No electron transition occurs in polymerisation reaction.

7.3 Some chemical reactions that happen in real life situation

Different elements of environment react with the substances that we use in our daily work,

Think:
1. Why sand is used in sleepy roof of buildings in rainy season.
2. Why grandmothers were kept nidles in coconut oil.
3. Why do we eat tamarid when throad irritate after eating esculent root.

1. If a substance made of iron is exposed in open air, the iron undergoes reaction with oxygen and water vapor. Iron reacts with water vapor and produces iron oxide (rust) As a result, metallic iron becomes corrode. It is necessary to prevent corrosion of this limited resource found in mines. Iron oxides separated from the body of metallic iron and the metal surface again comes in contact with air and reacts to produce iron oxide (rust). Chemical formula of rust is $Fe_2CO_3.nH_2O$. The number of water molecules attached with rust molecule is unknown. So the number of attached water molecule is expressed by 'n'. The formula of rust is also written as FeO(OH).

$$4Fe_{(s)} + 6H_2O + 3O_2 \longrightarrow 4Fe(OH)_{3(s)}$$

$$2Fe(OH)_{3(s)} \xrightarrow{-H_2O} Fe_2O_3.nH_2O_{(s)}$$

2. Like iron, aluminium metal also reacts with oxygen of air and produces aluminium oxide which can not be removed from the body of the metal pieces. Aluminium oxide prevents the lower layer of aluminium from coming to contact with air.

3. The poison that enters from the body of insect to a spot stung by bee contains acidic elements. People use lime or honey at the affected place to cure the pain and irritation. Lime and honey are alkaline substances, it undergos neutralisation reaction with acidic elements.

4. Energy is produced in our body from foods by chemical reactions. Carbohydrate foods like starch (rice, bread) sugar, glucose etc. reacts with the oxygen received from air and produce carbon-di-oxide, water and energy. This process happened in human body is called the respiration. Starch and sugar decomposes into glucose and fructose before taking part in reaction with oxygen.

Carbohydrate + Oxygen $\longrightarrow$ Carbon-di-oxide + Water + Energy

$C_6H_{12}O_{6(s)} + 6O_{2(g)} \longrightarrow 6CO_{2(g)} + 6H_2O$ + Energy

glucose

5. People who have excess hydrogen chloride gas produced in their stomach due to metabolic process of body take medicines like antacid on consultation with a physician. Antacids contain metallic hydroxide which is alkaline and hydrogen chloride (HCl) gas is acidic. Alkaline antacid neutralizes acidic hydrogen chloride gas through neutralisation reaction.

$3HCl + Al(OH)_3 \longrightarrow AlCl_3 + 3H_2O$

$2HCl + Mg(OH)_2 \longrightarrow MgCl_2 + 2H_2O$

6. When fuel is burnt Carbon-di-oxide, water and energy is produced. But if the supply of oxygen is not sufficient, then due to partial combustion carbon-mono-oxide or carbon is produced instead of carbon-di-oxide and little heat is procued.

$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$ + Energy

Fuel

$CH_{4(g)} + 1\frac{1}{2} O_{2(g)} \longrightarrow CO_{(g)} + 2H_2O_{(g)}$ + Energy

Fuel

$CH_{4(g)} + O_{2(g)} \longrightarrow C_{(s)} + 2H_2O_{(g)}$ + Energy

Fuel

7. Sometimes, in rainy season, banana trees near the pond or lake died when come in contact with water. Due to acid rains in the rainy season water becomes acidic. Banana tree has alkaline elements. The acid in water neutralizes the alkali of banana tree. As a result, banana trees die.

7.4 Method of prevention of harmful reactions

Chemical reactions are carried out to produce the required products and energy. Some products of reaction can cause harm to human health, environment and cause financial loss. Safety measures should be taken to prevent these harms. Safety measures are different for different reactions.

When iron come in contract with air water, it produces iron oxide (rust). As a result, iron corrodes and cause financial loss. Iron is a limited resource. The main way to prevent this loss is to keep the metal atom away from contact of air and water. To do this iron is coated with paints or with other metals. Coating of zinc on other metals is called galvanizing, coating with tin is called tin-plating and coating with other metals by electrolysis is called electroplating. Corrosion of iron is prevented by coating the iron made substance with plastic. Corrosion is also prevented by making alloy of metals.

1. Slippery substance is basic and sand (SiO_2) is acidic- neutralisation reaction happens between them.
2. Sewing needle becomes rusted in presence of air and water vapor.
3. Esculent root has basic elements and tamarind has organic acid which neutralizes basic substances.

7.5 Rate of reaction:

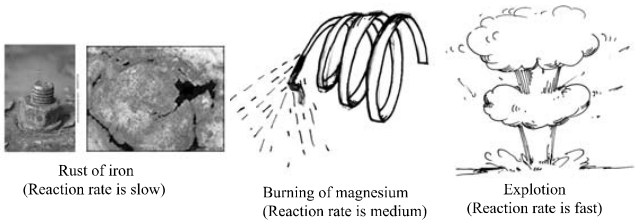


Fig 7.2 Reactions of different rate

Experiment of rate of reaction:

Take four test tubes or glasses and marke them as 1, 2, 3 and 4. Take in every test tube an approximate amount of 0.5/1mg sodium carbonate (Na_2CO_3) or washing soda. Then add normal water to the test tube 1 & 2 and hot water in 3 & 4. Now add 1ml lemon juice (Citric acid) or vinegar (5-6% Acetic acid). Observe the following changes.

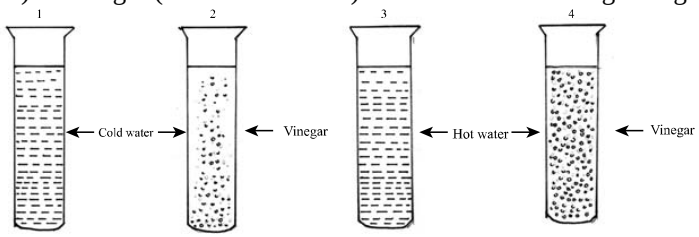


Fig 7.3: Reaction of sodium carbonate with vinegar or acetic acid

1. Gas comes out with bubble from which test tube?
2. Gas comes out with huge bubble from which test tube?

3. Gas comes out with a few bubbles from which test tube?
4. Gas comes out in huge amount from which test tube of 2 & 4?

Think: Why does gas come out with huge amount from one of the test tubes 2 & 4?

It is clear from above experiment that at a certain time (1min/ 5min/ 10min) equal amount of gases do not emit from all test tubes. That means at a certain time equal amount of products do not form in all test tubes or equal amount of reactants do not undergo reaction.

$$Na_2CO_{3(s)} + 2CH_3COOH \longrightarrow 2CH_3COONa + CO_{2(g)} + 2H_2O$$

Vinegar

In a reaction medium, the amount of product density is increased or the amount of reactant density is decreased per unit time (sec/ min/ hour) is called the rate of reaction or reaction rate. The concentration of reactant or product is expressed as mole-liter^{-1} unit (chapter six). So the unit of reaction rate will be *mole-liter* $^{-1}$ *time* $^{-1}$. Reaction rate depends on reaction temperature, concentration of reactants, surface area of reactants and the catalyst used in reaction. Reaction rate increases with the increase of reaction temperature, concentration of reactants and the surface area of reactants. Reaction rate may be increased or decreased with the use of catalysts. Reaction rate is increased or decreased depending on the types of catalysts used. Even products may be different depending on the type of catalysts used.

Le Chatelier's principle: In reversible reaction, if the forward reaction is exothermic, the backward reaction will be endothermic. In reversible reaction, initially reactants convert to products. After some time when the amount/concentration of product increases than products begin to convert to reactants. At the beginning the concentrations of reactants remain high so the rate of forward reaction will be high. The concentration of reactants decreases with time, so rate of forward reaction will decrease and the rate of backward reaction will increase when the concentration of products increases. While changing, at one point the rate of both the reactions will be the same. At this state concentration of reactants and product will not be changed. This state of reaction is called the equilibrium of reversible reaction. In equilibrium both the reactions continue at equal rate. In equilibrium of reaction the amount or concentration of product will depend on the factors of reaction (temperature, pressure and concentration of reactant). At the equilibrium of reversible reaction the amount of product is controlled by Le Chatelier's principle.

At the equilibrium of reversible reaction if any of the factors (Temperature, Pressure and Concentration of reactant) is changed, the equilibrium position will shift in such a way that the effect of change of factor is relieved.

Explanation of Le Chatelier's principle:

Effect of temperature: The reversible reaction in which changes of temperature occur, there is effect of temperature on equilibrium. Example

$$A + B \rightleftharpoons C + D, \quad \Delta H = -X\ kJ$$

The forward part of the reversible reaction is exothermic and the backward part is endothermic. If temperature increases, the equilibrium state of the reaction will be shifted to left side and will increase the concentration of reactant. It means the effect of temperature rise will be minimized by increasing the endothermic reaction. Similarly, if temperature decreases, the equilibrium state of the reaction will be shifted to right side and will increase the concentration of the product. It means, the effect of temperature decrease will be minimized by increasing the exothermic reaction.

The reversible reaction in which changes of temperature does not occur, there is no effect of temperature on equilibrium.

Effect of pressure: In equilibrium of gaseous reaction, equilibrium of the reaction will change with the change of pressure.

The reversible reaction in which changes of gaseous molecule occurs in those reaction there is effect of pressure on equilibrium. Example,

$$A(g) + B(g) \rightleftharpoons C(g)$$

If the reaction is forward, the number of molecule of reactants decreases. As a result pressure decreases in the same volume. If pressure increases, equilibrium is shifted to right side. That means pressure will decrease by increasing forward reaction and the effect of pressure increase will be minimized. If pressure decreases, equilibrium is shifted to left side. That means pressure will increase by increasing backward reaction that will increase the concentration of reactant and the effect of pressure decrease will be minimized. The reversible reaction in which changes of gaseous molecule does not occur there is no effect of pressure on equilibrium.

Effect of concentration: There is effect of concentration at equilibrium of every reaction. In equilibrium, if concentration of any one of the reactants is increased, equilibrium is shifted to right side and will increase the forward reaction and the effect of change will be minimized by increasing the concentration of product. Similarly, if concentration of any one of the reactants is decreased, equilibrium is shifted to left side and will increase the backward reaction and the effect of change will be minimized by increasing the concentration of reactants.

7.6 Demonstration of neutralisation reaction

Required materials: 0.1 Molar HCl solution, 0.1 Molar Na_2CO_3 solution, 0.2 Molar Na_2CO_3 solution, litmus paper, beakers, measuring cylinder and dropper or burette.

Take 5mL of 0.1 Molar HCl solution in two small beakers. Dip one piece of red litmus paper to both the solutions. In acid solution red litmus paper remains red. Measure pH of the solution using pH paper and record in your note book.

Take 5ml of 0.1 Molar Na_2CO_3 solution in a measuring cylinder and 5mL 0.2 Molar Na_2CO_3 solution in another measuring cylinder. Add 0.1 Molar Na_2CO_3 solution in one of the above beakers and 0.2 Molar Na_2CO_3 solution in another beaker using separate droppers or burettes. Shake the beakers during the addition of solution and observe the change in colour of litmus paper. The red litmus paper becomes blue in basic solution. Measure pH of the solution using pH paper after some intervals. Measure pH of the solution just when the color of the litmus paper turns blue.

$$2HCl + Na_2CO_3 \longrightarrow 2NaCl + CO_2 + 2H_2O$$

Initially there is HCl solution in the beaker. The pH of this solution is less then 7 and the color of the litmus paper remains red. When adding Na_2CO_3 in drops to the solution, reaction with HCl produces NaCl, CO_2 and H_2O. The amount of HCl decreases in the solution of beaker and the value of pH increases to near 7. When the HCl is completely neutralized by the reaction then the value of pH becomes 7 and the color of the red litmus paper of the solution turns blue.

Observation: How does the value of pH change with addition of Na_2CO_3 solution in drops?

How much volume of Na_2CO_3 solution is needed to neutralize the HCl of each beaker?

Home work: How many gm of HCl was dissolved in each beaker before adding Na_2CO_3 solution.

How many gm of Na_2CO_3 was added in each beaker to neutralize the HCl?

Think: How does the value of pH change on addition of HCl in drops after taking a certain amount of Na_2CO_3 in the beaker first?

7.7 Demonstration of Precipitation reaction

Required materials: Sodium hydroxide solution, ferrous sulphate, pure water, test tubes.

Take a clean test tube. Taking 1ml ferrous sulphate Solution add sodium hydroxide solution in drops and observe the changes.

$FeSO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Fe(OH)_{2(s)} + Na_2SO_{4(aq)}$

Sodium hydroxide solution reacts with ferrous sulphate solution to produce water insoluble ferrous hydroxide and water soluble sodium sulphate. The insoluble ferrous hydroxide which is light green in color will deposit at the bottom of the test tube as precipitate.

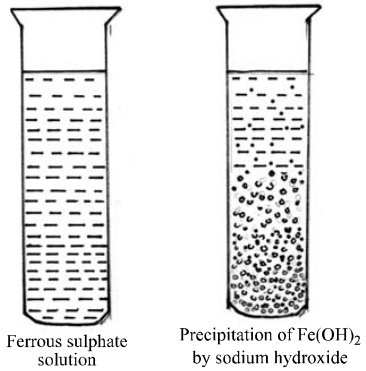


Fig 7.4: Precipitation reaction

Exercises

Multiple choice questions

1. Which of the following acid is present in vinegar?

a) Cytric acid b) Acitic acid

c) Turtaric acid d) Ascorbic acid

2. Which can be used at the injured spot of bee stinging?

a) Lime b) Venegar

c) Table salt d) Water

3. What type of reaction does occur when taking medicines like antacid?

a) Neutralisation b) Combustion

c) Addition d) Replacement

4. $H_2SO_4 + MgO \longrightarrow$

In this reaction

i. heat is produced
ii. electron transition occurs
iii. precipitation occur

Which one is correct?

a) i b) ii and iii

c) i and iii d) i, ii and iii

Creative questions:

1. Both Opu and Setu use natural gas for cooking. Although there are black shades at the bottom of the pans in Opu's house but there is no such shades at the bottom of the pans in Satu's house.

a) What is called irreversible reaction?

b) What is meant by chemical equilibrium?

c) What type of reactions occur due to the cooking at their houses?

d) In you opinion, in which of the houses of the stem gas is wasted during cooking? Give reasons in favor of your answer.

2. $Pb(NO_3)_2 + 2KI \longrightarrow$

The table below has been filled in as per the reaction given above.

Elements	1^{st} container	2^{nd} container	3^{rd} container	4^{th} container	Total volume used (mL)	Precipi-tation
Volume of 0.2 M $Pb(NO_3)_2$ (mL)	1	2	3	4	10	
Volume of water (mL)	4	3	2	1	10	
Volume of 0.5 M KI (mL)	1	1	1	1	4	
Total volume of solution of each container (mL)	6	6	6	6	-	

a. What is combustion raction?

b. Why are not periodic number and oxidation number the same?

c. What is the total amount of KI used in the period? Determine to demonstrate.

d. According to you, solution of which container will be more yellow? Explain with reasons.

Chapter Eight

Chemistry and Energy

In fact chemical bond is a store of energy. Energy is associated with formation and breaking of chemical bonds. As the number of changing in chemical bond happened in the world, in all cases transformation of energy happened. We perform our every day works using the energy of the changes which occur spontaneously. The amount of this energy is finite in the world and is decreasing day by day. So it is necessary to think about alternative source of energy. In the mean time, attempt is gong on to increase the number of lighting, making solar panels using the power of sun. On the other hand effort has been started to make use of nuclear power in our country like developed countries.

By the end of this chapter we will be able to-

1. explain the relation of producing energy with chemical changes.
2. realize the importance of purity of fuel in energy production; limit the consumption of these fuel for saving the environment and show consciousness in selection of appropriate fuels.
3. keeping in mind the safety measure to find out the chemical reaction related problems and preparing the investigation plan, implementation and to test its effectiveness.
4. take the responsible decision spontaneously with confidence in performing chemical reactions and in producing energy.
5. explain the idea of direct current using the electronic concept of oxidation-reduction reactions.
6. describe the process of producing electricity by chemical reactions.
7. carry out the reactions using electricity.
8. present opinion on the product of electrolysis of different substances and their commercial uses.
9. differentiate between the electrical cell and galvanic cell.
10. give opinion on nuclear electricity production after relative analysis.
11. carry out experiments on endothermic and exothermic reactions.
12. showing consciousness on the worse effect of chemical reactions.
13. showing interest on using pure fuels.
14. show experimentally the heat change on dissolving salts and on chemical changing.
15. construct the electrode of galvanic cell.

8.1 Chemical energy

A. Bond energy and change of energy in chemical reactions.

We have known that, elements in a molecule joined together by mutual energy between them. The energy by which the elements are joined together is chemical bonds. Besides this molecules or ions of a compound comes closer by an energy named inter molecular force composed of various energy and create a particular state as solid, liquid and gaseous. The inter molecular force of ions or molecules of any solute, if high forms solid, if low forms liquid and if more lower forms gaseous states. That is inter molecular force differs at different states of the same compound. For example, ice, water and water vapor is solid, liquid and gaseous states of water, when water is heated water vapour is produced that means water converts from liquid to gaseous state by absorbing heat. Again on cooling of water that means taking out heat from water, water converts to solid (ice). On the other hand energy is also associated with bond formation. In different compound molecules joined together with different bond energy. Now let us think, what will happen, if the total energy of the products is less or greater than the total energy of the reactants. If the energy of the product is lower, energy will be evolved and if greater, energy will be absorbed. On the whole, in all chemical reactions more or less amount of heat is either evolved or absorbed, although we are not able to feel that. So it is clear that, as energy is associated with the physical changes with solute, so as with the process of forming new compounds by chemical reactions.

B. Exothermic and Endothermic Reactions

Now classify the chemical reactions on the basis of heat change from the above discussion. On the basis of heat change chemical reactions are of two kinds like, (1) Exothermic Reactions and (2) Endothermic Reactions.

Exothermic Reactions: The chemical reactions in which heat is evolved are called the exothermic reactions. For example, if wood, coal or gas is burnt heat is evolved. Wood or coal is mainly carbon and other compounds of carbon, which on burning reacts with atmospheric oxygen produce carbon-di-oxide (CO_2) and heat. When water is added to

lime heat is produced. Lime is calcium oxide (CaO), which reacts with water and form calcium hydroxide; $Ca(OH)_2$ and heat.

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)} + \text{Heat}$$

$$CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)} + \text{Heat}$$

Now explain the phenomenon of evolving heat energy. In the first case the total stored energy of reactants carbon and oxygen is greater than the total stored energy of produced carbon-di-oxide. Similarly, in the second case the total stored energy of the produced calcium hydroxide is less than the total stored energy of reactants calcium oxide and water. It can be easily described that, the excess amount of stored chemical energy of the reactant after consumption in the formation of new compound is evolved as heat; that is Heat evolved = Total energy of produced compound, (E_2) – Total energy of reactants compound (E_1).

Heat of reaction: The amount of changed heat in a chemical reaction is called heat of reaction.
Heat of combustion: When 1mole of substance is burnt, the amount of heat evolved in the process is called the heat of combustion.

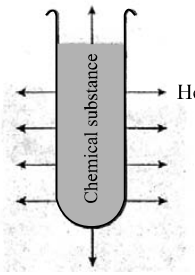


Fig 8.1: Exothermic reaction

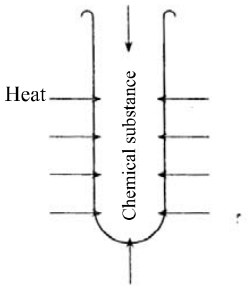


Fig 8.2: Endothermic reaction

Endothermic reactions: Chemical reactions in which heat is absorbed are called endothermic reactions. In case of exothermic reactions we generally feel the evolution of heat directly. But in the case of endothermic reactions, we can feel in very fewer cases the absorption of heat. Now let us try to realize the events where heat is absorbed. There is a half filled glass of water at 60^{o}C, add a piece of ice in it. Of course we can realize that, with in a short time the piece of ice will melt and temperature of water will fall. Generally we use ice cubes to cool the soft drinks in this way. We have known earlier

that, water turns from liquid to solid (ice) if we remove energy from water. So it is clear that, solid water (ice) will return to liquid water, if we reinforce the removed energy (heat) to ice. Really the ice cube dipped in glass turns to liquid water by absorbing heat energy from hot water as a result temperature of hot water falls. So the ice cube converts to water absorbing heat from the system. Similarly, there may take place absorption of heat in performing chemical reactions. In this case sometimes we feel cool on touching the containers used in performing chemical reactions. Again sometimes no reaction occurs without applying heat from external sources. For example, in the reaction of edible soda and lemon juice or vinegar absorption of heat occurs. Edible soda is sodium-bi-carbonate ($NaHCO_3$). On the other hand there is citric acid in lemon juice and acetic acid in vinegar. Reaction of sodium-bi-carbonate with acid forms carbon-di-oxide, salt and water. In the reaction there occurs absorption of heat from the solution as a result we observe the solution to become cool.

$$NaHCO_{3(aq)} + CH_3COOH_{(aq)} + \text{Heat (absorbed from solution)} \longrightarrow CH_3COO^- Na^+_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

or

$$NaHCO_{3(aq)} + H^+_{(aq)} \text{ (citric acid)} + \text{Heat (absorbed from solution)} \longrightarrow Na^+ \text{ salt (sodium cytrate)} + CO_{2(g)} + H_2O_{(l)}$$

C. Calculation of heat change in chemical reactions

In performing the chemical reaction breaking of old bonds and formation of new bonds take place. Energy of different existing bonds in the chemical compounds is different. Energy is needed to break the bond and energy is evolved in bond formation. Calculation of the change of heat in a reaction is done using the equation below by evaluating the total energy required for breaking the bonds and total energy evolved in the formation of new bonds.

Change of heat in a reaction = Total energy required for breaking the old bonds - Total energy evolved in the formation of new bonds.

If the heat change is negative the reaction is exothermic and if positive the reaction is endothermic.

Calculate the heat change of the reaction below using the bond energy given in the chart.

$$CH_3CH_{3(s)} + Cl_{2(g)} \longrightarrow CH_3CH_2Cl_{(aq)} + HCl_{(g)}$$

In this reaction 1mole of C-H & 1mole of Cl-Cl bonds is broken and 1mole of C-Cl & 1mole

of H-Cl bonds is formed. Total energy required for breaking 1mole of C-H and 1mole of Cl-Cl is = (414+244) kJ = 658 kJ.

Total energy evolved in formation of 1mole of C-Cl and 1 mole H-Cl is = (326+431) kJ = 757 kJ.

So the change of heat in reaction (ΔH) =

Bond	Bond energy (kJ/ mole)
C-H	414
H-H	435
C-C	326
O-H	464
Cl-Cl	244
O=O	498
H-Cl	431

Total energy required for breaking the old bonds - Total energy evolved in the formation of new bonds

= (658-757) kJ

= -99 kJ.

Thus 99 kJ heat is evolved in the reaction.

Task: Calculate the heat change of the reactions below.

$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$

$H_{2(g)} + ½\ O_{2(g)} \longrightarrow 2H_2O_{(g)}$

$CH_{4(g)} + 2Cl_{2(g)} \longrightarrow CH_2Cl_{2(aq)} + HCl_{(g)}$

D. Energy diagram of a reaction

Absorption or emission of heat in a chemical reaction can easily be understood by energy diagram. Observe the energy diagram of exothermic and endothermic reactions in fig-8.3 and 8.4. In case of exothermic reaction the total energy of the reactants (E_1) will be greater than the total energy of product (E_2). That means $E_1 > E_2$. The excess amount of chemical energy of the reactant after consumption in the formation of products is evolved as heat energy. On the other hand, the energy diagram of endothermic reaction is opposite to the exothermic reaction.

In case of endothermic reaction the total energy of the reactants (E_1) will be less than the total energy of product (E_2). That means $E_1 < E_2$. In this case, though the total energy of reactant is less than the total energy of the product the required energy to occur the reaction is obtained from the system. That is why; if endothermic reaction is occurred, it is seen to decrease the temperature of reaction mixture or it is required to apply heat.

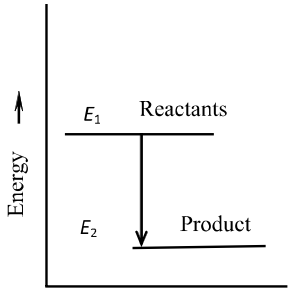


Fig 8.3: Energy diagram of exothermic reaction Here, $E_1 > E_2$

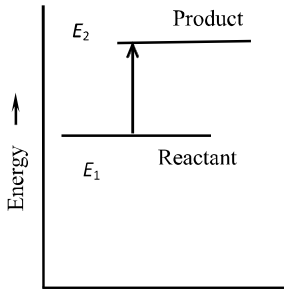


Fig 8.4: Energy diagram of endothermic reaction Here, $E_1 < E_2$

8.2 Transformation of chemical energy to heat, electricity and light energy

We see that, heat is produced on burning of any substance. Light is produced as well as heat. Both heat and light are energy, which spread as electromagnetic radiation around us. Heat energy and light energy is produced on burning of wood, coal, plants, paper, natural gas and petroleum etc. Both energies can be produced by burning safety matches and candle (Fig- 8.5). Thus what is the source of the energy of these substances? What is the meaning of burning of any substance?

Fig : 8.5 Burning candle

We know, matter is a bundle of chemically bonded atoms. On the other hand, burning is oxidation of molecules of any compound by oxygen. Thus oxidation of any molecule of any compound means the creation of oxygen added new compounds. Now consider the reaction given below- Carbon (C) of coal, Methane (CH_4) of natural gas and hydrogen molecules of hydrogen fuel react with oxygen molecules and form carbon-di-oxide gas and water. Carbons upon breaking bonds of themselves form carbon-oxygen (carbon-di-oxide) bond. Similarly, as a result of burning of methane form carbon-oxygen (carbon-di-oxide) and hydrogen-oxygen (water) bonds upon breaking carbon-hydrogen bonds. We know that the energy requirement for the formation of all bonds or molecules are not equal. Actually, the amount of energy consumed in formation of molecules or ions on burning fuel is less than the stored energy in the molecules of fuel. As a result excess energy spreas as electromagnetic radiations which we see as light or heat.

$$C_{(g)} + O_{2(g)} \longrightarrow CO_{2(g)} + \text{Heat}$$

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)} + \text{Heat}$$

$$H_{2(g)} + O_{2(g)} \longrightarrow H_2O_{(g)} + \text{Heat}$$

Electrical energy is also produced by rotating the wheels of heat engine using the heat energy evolved from burning of fuel. In our country almost all electrical energy is produced by burning fuels. On the other hand, in hydrogen fuel cells (a kind of electrolysis cell) not burning the hydrogen is converted directly to electricity by electrolysis. Chemical energy is converted to electrical energy in different types of galvanic cells such as – Daniel cell, dry cell and lead storage battery. Again the electric energy produced in galvanic cells may convert to light energy such as, lightening of torch by dry cell. In this way, converting chemical energy into different energy is made useable to man.

8.3 Use of different energy obtained from chemical energy

Fig 8.6: Harican is lighting by burning kerosene

Efficiency of work is energy. Heat is evolved on burning fuels and heat is a kind of energy. Cooking is done by natural gas.

Bricks, clay wares are burnt using heat energy. Heat energy is used in industries for melting raw materials or to make them hot in producing different substances. Huge amount of heat energy is used in industries like Iron & steel and ceramic.

Fig 8.7: Farmer is cultivating land by burning diesel in heat engine.

Different fossil fuels like- coal, petroleum and natural gas are burnt in heat engines as fuel and used in running motor vehicles, ship, airplane, rail and other engine driven vehicles. Water is lifted from depth by revolving the wheel of shallow engine by burning petroleum. We enlighten our home by burning of kerosene and wax candle. On the other hand, in modern age the most popular energy is electricity. We find the use of electricity in everywhere. Though electricity can be used in various ways, maximum electricity is produced in heat engines revolving the turbine by burning of fossil fuels. Converting chemical energy into electrical energy by electrochemical cells and battery, we use it for lighting and for operating radio, TV and fan etc.

8.4 Appropriate use of chemical energy

Source of all energy is sun. So, is the sun not indirect source of chemical energy? You have known from life cycles, plants store energy in their body from sun light by photosynthesis. Different bio-chemical compounds are produced in the plant's body from light energy and atmospheric carbon-di-oxide. Animals get energy from plants. Plants and animal decompose in soil after death. These substances under different processes for thousands of year are converted and stored in the earth as petroleum, coal and natural gas. These are called fossil fuels. We get these types of fuels in mines. The gas fields Titas, Horipur, Sangu etc. and Boropukuria coal mine are famous in our country. Do you think, we will be getting gas or coal from these mines? Really it is not. Once upon a time these will be finished. Question may arise, as plants and animals born and die regularly, why will these fossil fuels be finished then? The answer is very easy. Because we are using the fuels, that means consuming the fuels in such a rate that mine fuels are not being stored in the earth at that rate. So it can be easily assumed that, once upon a time reserve of these fuels will be finished. The subject is appropriate and it is said that reserve of these fossil fuels will be finished within the next one hundred years.

We have known earlier that, mainly fossil fuels supply the maximum of our total demand of fuels. Not only that, transformation of fossil fuels to other energy (i.e. electricity) is expensive also. Moreover chemical energy particularly fossil fuels cause different harms to environment. So, what will our role in using chemical energy? In modern time it is impossible to survive without chemical energy. But if we can ensure the limited use of chemical energy, demand on the reserve will be certainly reduced. By this we can utilize the reserve of fuel for a long time. Unfortunately we are misusing energy. We are keeping the burner enflamed, lighting lights, moving fan unnecessarily and using various decorative lighting for entertainment and using engine vehicles in poor needs. Preventing these misuses, we can ensure the long time use of fuels. On the other hand, we can prevent the worse effect of the use of chemical energy on environment. Consciousness about chemical energy use can help us to survive in the world for a long time.

8.5 Importance of purity of fuels

What is meant by pure fuels? The fuel, which on burning does not produce harmful substance for human health and environment, is called the pure fuel. Fuels particularly wood, natural gas and petroleum when burn produce carbon-di-oxide gas, water and heat. Plants absorve carbon-di-oxide gas in photo synthesis process. Certainly if we burn

these fuels in insufficient air, harmful carbon-mono-oxide gas is also produced with carbon-di-oxide gas which is dangerous for health. On the other hand, if fuel contains particularly sulfur and nitrogen containing compounds, then on burning of fuel various oxides of nitrogen and sulfur harmful to the health and environment is produced. Sulfur –di-oxide combines with atmospheric water vapor and produced sulfuric acids which cause acid rain. We can certainly realize that acid rain is an obstacle to plants and animals of environment to survive. Besides, this carbon-mono-oxide, nitrous oxide and unburn gaseous fuel (methane) comes into air from exhaust of vehicles forms various toxic gases and fumes by different chemical reaction in presence of sunlight. This is called photochemical smog. The constituent gases of photochemical smog cause dangerous corrosion to atmospheric ozone (O_3) layer. So it is very important to ensure the uses of pure fuels for safety of health and environment.

8.6 Negative effect of use of chemical energy

We have seen earlier that, the mechanism of making use of chemical energy mainly production of heat by burning the fuels with air (oxidation reaction). Though the mechanism of using of chemical energy is different is case of fuel cell and for other cases particularly in electrochemical cells and nuclear reactions. In fact maximum energy is produced by burning fuels. Now the question is that, on burning of thousands ton of fuel, where will go the produced equivalent amount of CO_2 gas and another gases particularly CO, SO_2, NO and the unused fuel emits with smoke. Certainly they are mixing with air. Noted that, some CO_2 of air is used in photosynthesis process. But unfortunately in one side we are destroying plants and on the other side increasing the use of fuel to meet the modern lifestyle. This is why amount of CO_2 is increasing usually in atmosphere day by day. Although CO_2 do not undergo any reaction with the other element of air, but heat absorbing capacity of CO_2 is high, that is CO_2 can absorb heat and can trap the heat. Again CO_2 gas stay nearer to the surface of the earth as it is heavy in weight. That is why atmospheric temperature is increasing day by day, which is called *Global Warming*. The phenomenon of this temperature increase by CO_2 gas is known as *Green House Effect* and CO_2 is called the green house gas. Due to the global worming, ice melts to water in earth poles and cause unexpected flood (Fig 8.8). On the other hand, other gases produced from the burning of fuels, polluting air by different chemical reactions and destroying the balance of elements in air and causing acid rain and photo chemical smog. Except this, these gases directly react with ozone layer and decreasing

the thickness of the layer or causing hole to the layer. In fact ozone layer acts as a filter of sun rays and prevents the various ultraviolet rays present in sunlight to enter into the earth. In the next classes we will learn in detail about the effect of these rays.

Fig 8.8: Exhaust of carbon-di-oxide from industry (left) and due to the global warming ice melts to water in earth pole (right).

8.7 Uses of ethanol as fuel.

Ethanol another name of which is alcohol is a flammable liquid chemical substance. Ethanol on burning produces heat like mineral fuels kerosene, petrol, diesel etc. So ethanol can be used in heat engine like mineral fuels and can run industries, vehicles, airplane, ship etc. Ethanol mixing with petroleum is used in heat engine as fuel in Brazil, North America and other developed countries. Almost all of the motor vehicles in America run by using 10% ethanol with petroleum. Government of Brazil makes it compulsory to use 25% ethanol in fuel. Except this, alcohol (methanol, ethanol) is used as fuel in fuel cells, known as the technology of producing useable energy in modern time and for the next generation. Certainly this question arises in mind, why to use ethanol although there is other fuel? It is said that, mineral fuels will be finished once upon a time. So it is required to think how we will produce energy. How will we run industries and vehicles? In this situation, if we can use ethanol as fuel then certainly the demand on the reserve of mineral fuel will be decreased. The interesting matter is that, ethanol is an organic chemical product which is produced from starch like corn or potato, sugarcane etc. by fermentation reaction. This is why ethanol is called bio-fuel. Now a days using new technology, production of ethanol is possible from cellulose (constituent of plants body). On the other hand it is possible to ensure the regular production of corn and plants that means ethanol by agriculture. So there is no fear of

finishing of ethanol like mineral fuels. So it is important to produce ethanol commercially and to develop technology of using it as alternative fuels.

8.8 Electrochemical cells

We have known in the above sections that, converting chemical energy into heat energy by burning of fuel can be utilized in different ways. Now we will learn how to convert chemical energy directly to electrical energy and how to do chemical reaction using electrical energy. Luigi Galvani and Alessendro Volta become able first to convert chemical energy into electrical energy. Galvani in the year 1780 and Volta in the year 1800 have understood by separate experiment that, electricity can be produced from the redox reaction which occurs spontaneously. In fact we have got battery from their invention. Thus Galvanic cell (which is known as Voltaic cell) is a kind of electrochemical cell by which electrical energy can be produced from chemical energy. On the other hand, chemical reaction can be done in electrochemical cell using electrical energy. It is called electrolysis. The cell where electrolysis is done called electrolytic cell. Electrochemical cell is composed of different small parts as electrode, salt bridge, and electrolytic solution. Different topic of electrochemical cell is discussed below.

8.9 Electrical conductor and electrode

Conductor: The materials in which electricity can pass, are called electrical conductor and the materials in which electricity can not pass, are called electrical insulator. Metal, carbon, graphite, molted salt and acid, solutions of alkali and salt etc. work as electrical conductor. Depending upon the mechanism of electrical conductivity conductors are divided into two classes such as, (1) electronic and (2) electrolytic conductor.

The conductor which passes electricity through electron flow is called electronic conductor such as, all metal and graphite. If electricity pass through ions of the conductor that is called electrolytic conductor such as, molten salt and acid, solutions of alkali and salt etc.

Electrode: Electrode is a metallic and nonmetallic electric conductor. These are called electronic conductor. Electrode connect the electronic conductor and solution (which convey ions) of electrochemical cell. Two electrodes are needed to construct a electrochemical cell. One is anode and another is cathode.

In anode; (1) Oxidation reaction occurred. (2) Electrons of anion of solution transfer to metallic rod (Anode).

In cathode; (1) Reduction reaction occurred. (2) Cations of solution accept electrons of metallic rod (Cathode).

In electrolytic cells all metallic rod or graphite rod are used as anode and cathode. In this cell the same metallic rod or different metallic rods can be used as anode or cathode. Metallic rod only works as electron conveyer and do not take part in any reaction. The metallic rod which is connected to the positive end of the battery, used in electrolytic cell, work as anode and the rod which is connected to the negative end of the battery, used in electrolytic cell, work as cathode. The method of construction of anode and cathode in Galvanic cell is different from the electrolytic cell. Electrode is constructed by placing a metallic rod into the electrolytic solution of that metal. In Galvanic cell different metallic rod is used as anode and cathode. (Anode and cathode can also be constructed by using the same metallic rod in two electrolytes of different density, you will learn about this in the next class). Anode and cathode of Galvanic cell is determined by the reactivity of metal. The more reactive metal acts as anode and the less reactive metal acts as cathode between the metal used as electrode.

Metal/Metal ion Electrode

There are different types of electrodes. Among them metal/metal ion electrode is the best. If metallic rod is dipped in the solution of that metal then it is called metal/metal ion electrode such as- Copper rod is dipped in the solution of copper sulphate, then it is called copper/copper(II) or $Cu\,|\,Cu^{2+}(aq)$ electrode. Similarly, $Ag\,|\,Ag^{+}(aq)$, $Zn\,|\,Zn^{2+}(aq)$ metal/metal ion electrodes are remarkable examples.

Electrode reaction

We have known about the metal | metal ion electrode above. We can write the electrode $Ag\,|\,Ag^{+}(aq)$ as-

$$Ag_{(s)} \rightleftharpoons Ag^{+}_{(aq)} + e^{-}$$

Metal | metal ion reactions always reversible. That is in electrode reaction metal Ag(s) converts to $Ag^{+}(aq)$ ion donating electron and dissolve in solution. On the other hand, if one electron can give to the $Ag^{+}(aq)$ ion, than $Ag^{+}(aq)$ ion will convert to metallic Ag(s). Thus electrode reaction is redox reaction. That means in any electrode reaction there will be donating or accepting of electron. But we know that oxidation-reduction occur simultaneously. If one electrode donate electron (oxidation) than, does another electrode not required to accept the electron? Actual matter is that. There are two electrodes for electrochemical reactions- anode and cathode. In electrochemical reactions the electrode

which donate electron to electrolytic substance is called cathode, again the electrode which accept electron from electrolytic substance is called anode. Electrode reaction can be spontaneous. Otherwise, electrode reaction is completed by supplying electricity to the electrode.

Anode reaction : $M \longrightarrow M^{+} + e^{-}$

Cathode reaction: $X + e^{-} \longrightarrow X^{-}$

8.10 Galvanic cell

The electrochemical cell where, electrode reaction occur simultaneously, that means no external energy is required for reaction and chemical energy is converted to electrical energy is called Galvanic cell. Daniel cell is a Galvanic cell. In Daniel cell $Cu \mid Cu^{2+}(aq)$ metal/metal ion electrode is used as cathode and $Zn \mid Zn^{2+}(aq)$ metal/metal ion electrode is used as anode. In fig 8.9 a Daniel cell is demonstrated. Copper rod is dipped in copper sulphate solution as cathode in a container; in another container zinc rod is dipped in zinc sulphate solution as anode. A U shaped tube full of inert electrolyte (KCl) solution is dipped into the two solutions to make contact with the solutions of the containers. Now, if the two electrodes are connected with wire the following oxidation-reduction reaction will happen spontaneously.

Anode reaction : $Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^{-}$

Cathode reaction : $Cu^{2+}_{(aq)} + 2e^{-} \longrightarrow Cu_{(s)}$

$Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$

That is Zn anode oxidized by donating electron, dissolves as $Zn^{2+}(aq)$ ion in solution. On the other hand $Cu^{2+}(aq)$ ion of solution will settle on the cathode as metallic Cu (s), accepting electrons from cathode. In fact the produced electrons of anode reach to cathode by wire and make electronic equilibrium. Thus, if two electrodes are connected with wire an electron flow will be created from anode to cathode. Electronic flow means current flow. Thus we have understood, if an electric bulb is connected with the wire of Daniel cell then the bulb will be enlightened. Now think how long the electronic flow will continue. Besides this, what will be the condition of mass of the Zn and Cu rod. Find out thinking yourself and write down in your exercise book.

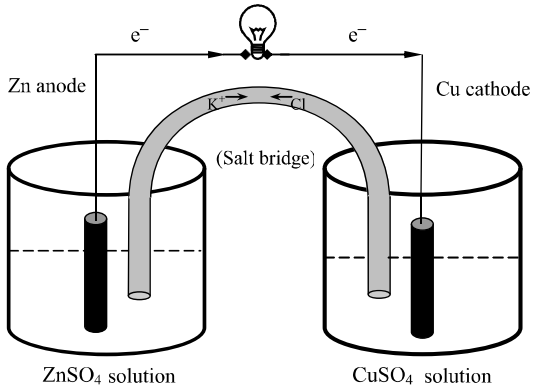


Fig 8.9: Galvanic cell

Let us now think the activity and necessity of salt bridge. We saw that, Zn^{2+}(aq) ion produced in anode and go to solution, on the other hand Cu^{2+}(aq) ion of solution settle on cathode as Cu metal. Thus in anode container there is abundance of Zn^{2+}(aq) and in cathode container there is deficit of Cu^{2+}(aq) ion. We know that, any ion (negative or positive) can not exist freely. That is a positive ion can not be produced without the presence of a negative ion and vice-e-versa. So equivalent amount of anion (sulphate ion) will be required for the Zn^{2+}(aq) ion, produced in anode, on the other hand as a result of settling of Cu^{2+}(aq) ion as Cu on the cathode equivalent amount of negative ion (sulphate ion) will be free in solution. In fact, if the equilibrium does not exists between the ions of two containers, the reaction will not occur. So, if salt bridge is added salt bridge containing positive (K^+) and negative (Cl^-) ion will remove the imbalance of positive and negative ions in anode and cathode container.

8.11 Formation of Dry cell and Mechanism of Electron Transfer

Dry cell is a kind of Galvanic cell (Fig 8.10). Commonly we call dry cell as battery. We have known about the electrochemical cell that is the Galvanic cell in the above section. Chemical energy is converted to electric energy in dry cell. The most common dry cell is Leclanchć cell. We use dry cell to light the torch, operating radio, TV remote and children's toys. Dry cell is also consist of anode and cathode as Galvanic cell. Difference is that there is no liquid electrolyte in dry cell. Now let us come to discuss the formation of dry cell and the mechanism of producing current.

Generally small jar or pot made of Zn is used as anode in dry cell. The jar is filled with manganese-di-oxide (MnO_2) and electrolytic solute. Making paste of ammonium chloride (NH_4Cl) and

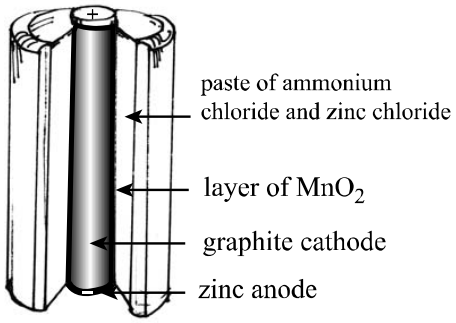


Fig 8.10: Dry cell

zinc chloride ($ZnCl_2$) with water used as electrolyte. Starch is added to condense the solution. Then filling the zinc jar with paste, cathode rod is inserted in the middle position. Carbon rod coated with manganese-di-oxide is used as cathode. If an intersection of dry cell is done, we will see the carbon rod at the center of the cell and upon that a coat of manganese dioxide and then condensed paste of starch, ammonium chloride and zinc chloride and at the outer sphere a layer of zinc plate.

We know electricity is produced by electron flow, and electron flow can be produced by accepting –donating of electron (oxidation-reduction). Let us look at the mechanism of production of electron at anode of dry cell and receiving of electron at cathode.

Anode reaction : $Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^-$

Cathode reaction : $2NH_{4+(aq)} + 2MnO_{2(s)} + 2e^- \longrightarrow 2NH_{3(aq)} + Mn_2O_{3(s)} + H_2O_{(l)}$

$$Zn_{(s)} + 2NH_4^+{}_{(aq)} + 2MnO_{2(s)} \longrightarrow Zn^{2+}_{(aq)} + 2NH_{3(aq)} + Mn_2O_{3(s)} + H_2O_{(l)}$$

In anode zinc rod is oxidized and produced two electron and zinc ion. The zinc ion will mix with paste. On the other hand, manganese–di-oxide in cathode reduced by receiving two electrons produced in anode. Ammonium ion only helps to complete the reduction process of manganese-di-oxide. Carbon rod conveys the produced electrons from anode to cathode. We know that the creation of electric flow is the flow of current. So where current is required, if we connect the dry cell, above reactions will take place and we will get current. 1.5 volt electric potential is found from dry cell.

We see that a dry cell becomes out of order within a few days that means it does not produce current. Think yourself from the above discussion, why this happens? Let us fill up the table below (Table 8.1).

Constituent of cell	Condition after use	Comments
Carbon rod	Will not be oxidized or reduced	Will not corrosion or growth. Only take part in electron convey

Constituent of cell	Condition after use	Comments
Zinc anode		
Layer of manganese dioxide		
Ammonium chloride		
Water		
Zinc chloride		
Starch		

Table-8.1: Condition of different parts of dry cell after use

All students combined examines with one old and one new dry cell and compare with the answer with in the above Table. Be careful, the chemical substance of the dry cell can not be allowed to touch anywhere of the body at no cost. At the time of doing the work, use hand gloves if necessary.

8.12 Effect of battery on health and environment

We use different types of battery such as- dry cell, mercury battery, lead-storage battery and lithium ion battery. These batteries are composed of different metal and metal ions. We have seen above that, Zn rod and MnO_2 are used to make dry cell. Zn and mercurus oxide (Hg_2O) are used in mercury cell. Again lead storage battery, which we use commonly to operate microphone is mainly composed of lead (Pb) and lead oxide (PbO). Cobalt oxide is used in lithium battery. The above mentioned metals are heavy metals. In respect to chemical properties, such heavy metal and metal compounds used in battery are toxic and carcinogenic to human body. So if we expose this battery in open air this toxic metal and metal compounds mix with soil and water and next they mix with soil and move to plants and crops. Similarly these toxic chemicals enter into the body of aquatic animals and plants. In this way, chemical used in battery destroy the balance of metallic substance of water and soil and enter into our food chain. We may be affected by different disease along with cancer if we take the food grown in the soil and water polluted by battery waste. So you would not leave the battery waste any how to the open air at no cost. Collecting the battery waste, recover the used metal and metallic compounds through proper chemical treatment and may be used to make new batteries in cyclic order. This is why, protection of environment that is health protection and financial save both will be possible.

8.13 Chemical reaction by using electricity

We have seen that, in Galvanic cell such as Daniel cell, dry cell battery anode and cathode reaction occurred spontaneously and electrical energy is produced from chemical energy. But many reactions which do not occur spontaneously that can be occurred in electrochemical cells by supplying electricity form external source. It can be said easily, as the cell connected bulb is lightened due to the production of current in Galvanic cells, on the other hand in such types of cells the source of electrical energy is to connect with cell instead of bulb. The cells where, electrode reactions are occurred by using electrical energy are called the electrolytic cells. In electrolytic cells electric energy converts to chemical energy. Electroplating in metal, purification of metal, production of new chemical compound is possible by electrolysis.

8.14 Electrolysis and mechanism of electrolysis

Formation of electrolytic cell is same as Galvanic cell, but in this case in making of cell the source of electricity (eg. battery) is connected to cell instead of electricity absorbing substance (eg. electric bulb). Electrolytic cell may be of one compartment or of two compartments. The formation of two compartments cell is same as Daniel cell. In the fig (Fig 8.11) one compartment electrolytic cell is shown. When electricity is supplied to the cell there creates a positive pole electrode (anode) and negative pole electrode (cathode). For this reason the ion present in electrolytic solution are attracted to the electrode according to their charge.

That means the negative charge ion attracts to the anode and the positive charge ion attract to the cathode. Negative ions release electron to anode (oxidation) and form new substance. On the other hand positive charge ion accept electron from cathode (reduction) and form new compound. In this way in electrolytic cell the produced electron in anode by

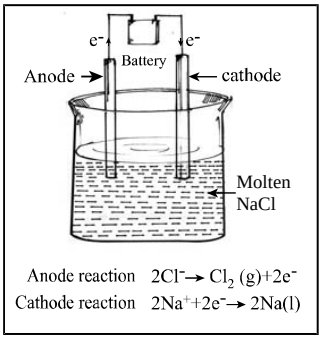


Fig 8.11: Electrolytic cell

the oxidation reaction pass through the cell to the cathode to meet the demand of electron for reduction reaction.

Anode reaction : $X^- \longrightarrow X + e^-$

Cathode reaction: $M^+ + e^- \longrightarrow M$

It is necessary to mention here that, it is not correct that on supplying current to the cell only charged ion attract to the electrode. The neutral compound present in the solution may be attracted by anode or cathode depending upon their tendency to be oxidized or reduced. In fact in electrolytic cell oxidation–reduction of neutral compound is also possible as ions. Now discuss the physical uses of electrolytic cells.

8.15 Applications of Electrolysis

Although in ancient period electrolysis was only used to coating a metal with another metal, but now in modern time the use of electrolysis is wide. The process of coating a metal with another metal by electrolysis is called the electroplating. In modern chemistry production of new chemical compound, extraction of metal from ore, production of chemical energy (fuel cell), analysis of chemical substance in laboratory, recycling and purification of matter, pollutant management etc. is done by electrolysis technique. Some apparatus used in medical science is also electrolysis technique dependent.

Coating on iron or silver with gold is possible by using electrolysis technique. Water is purified by removing unwanted ion through the use of electrolysis technique. Electricity can be produced from hydrogen fuel cell, where hydrogen molecule oxidized in anode and oxygen molecule reduced in cathode and produced water. As a result in cell electron flows from anode to cathode and we get current, even motor vehicles can run by this electricity (Fig 8.12).

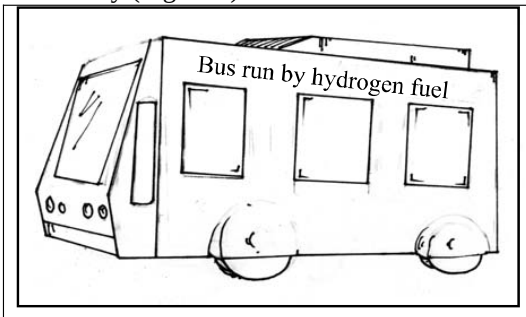


Fig 8.12: Bus run by fuel cell

Fig 8.13: Electrochemical glucose sensor

In laboratory determination of amount of one substance in different compound is possible by electrolysis such as determination of amount of arsenic in water. By treatment of waste in electrolysis cell we can protect the environment. Electrolysis dependent sensors are used to determine the amount of sugar/glucose in blood of a diabetic patient.

In the figure (Fig 8.13) determination of amount of glucose in human blood using electrolysis dependent sensor is shown. Anode and cathode is placed in the small parts touched at the finger of left hand. In fact anode and cathode is a fine layer of metal in plastic, which is made by screen printing technology. There is a small space/channel between the anode and cathode. The big part in the right hand is mainly the source of electricity (battery) and the machine to calculate the molecules taking part in reaction, occurred due to the electric supply. Thus if we think omitting the machine of calculation the rest parts are anode and cathode connect with current source. Now if we compare the parts with an electrolytic cell we will find that in making the electrolytic cell only the electrolytic solution is absent, is not it? We know different electrolytic substance such as- ion, protein etc. are present in human blood. If blood is filled in the space between the anode and cathode thus a complete electrolytic cell will be formed. In fact, filling blood in apace and supplying current from the attached source oxidized the glucose molecules in anode. On the other hand with the calculating machine attached with the cell determine the number of electron derived from the oxidation of glucose and show in the digital screen the amount of glucose in blood. The interesting matter is that it will take only one minute to determine the glucose in blood by this technique.

8.16 Electrolysis of Water

We know, water molecule is composed of 2 hydrogen atom and 1 oxygen atom. The chemical reaction of water formation is given below.

$$H_{2(g)} + \tfrac{1}{2} O_{2(g)} \longrightarrow H_2O_{(l)} + \text{Heat}$$

One molecule of hydrogen and half molecule oxygen combine to form one molecule of water. Thus on breaking of water molecule, we will get hydrogen and oxygen gas by reverse reaction.

$$2H_2O_{(l)} \longrightarrow 2H_{2(g)} + O_{2(g)}$$

The above reaction is not spontaneous. That means energy supply is required to occur the reaction. Water can be broken by electrochemical cell. The electrochemical cells are used to break the water consist of anode and cathode of chemically inert metal. Generally platinum (Pt) metal sheet is used as anode and cathode. Making some acidic solution of water with a small quantity of sulfuric acid and supplying electricity by platinum anode and cathode, the following half cell reaction occurs.

Anode reaction : $2H_2O_{(s)} \longrightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$

Cathode reaction : $4H^+_{(aq)} + 4e^- \longrightarrow 2H_{2\,(g)}$

$2H_2O_{(l)} \longrightarrow 2H_{2(g)} + O_{2(g)}$

In anode, water molecule is oxidized and produce oxygen gas, hydrogen ion and electron. On the other hand in cathode hydrogen ion is reduced and produce hydrogen gas. In fact hydrogen produced in anode reach to cathode by solution and the electron reach to cathode by the wire. It is mentionable that there is no change of sulfuric acid in the reaction, it only acts as conveyer of electricity through the solution.

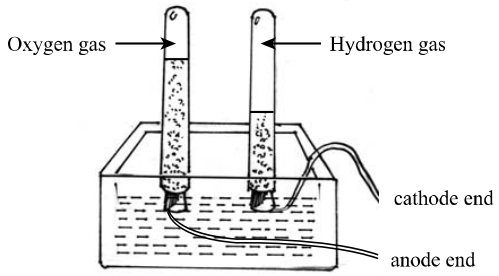


Fig 8.14: Electrolysis of water

8.17 Electrolysis of Sodium Chloride Solution

Saturated water solution of sodium chloride is called brine. Mainly chlorine gas is produced from the electrolysis of sodium chloride solution. Chlorine is commercially produced by electrolysis of sea water. In this case sea water is considered as sodium chloride solution because there is a huge amount of salt in sea water. For electrolysis dipping the anode and cathode in sodium chloride solution as usual, electricity is supplied. Mentionable that as a result of supplying electricity the anode and cathode reaction is slightly complex. As water is an electrolyte that is why when electricity is supplied to the sodium chloride solution oxidation reduction in water happen as well as sodium chloride. We will know detail about this in the next class. The main oxidation-reduction occurred in anode and cathode is discussed below.

Anode reaction : $2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e^-$

Cathode reaction : $2H_2O_{(l)} + 2e^- \longrightarrow H_{2\,(g)} + 2OH^-_{(aq)}$

$2H_2O_{(l)} + 2Cl^-_{(aq)} \longrightarrow H_{2(g)} + Cl_{2(g)} + 2OH^-_{(aq)}$

In electrolysis of water sulphuric acid is added to convey current through the solution, in this case no such addition is required. Because sodium ion (Na^+) and chloride ion (Cl^-) present in solution acts as conveyer of electricity. On supply of electricity in anode chloride ion oxidized and form chlorine gas and electron. On the other hand in cathode water molecule on reduction converts to hydroxyl ion (OH^-) and hydrogen gas.

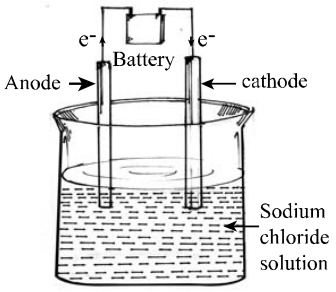


Fig 8.15: Electrolysis of sodium chloride solution

In fact electrons produced in anode reach to cathode by wire and supply the required electron for reduction of water. Hydroxyl ions produced in cathode and join together with sodium ion and remain in solution as sodium hydroxide (NaOH). Thus sodium hydroxide found as byproduct with the chlorine and hydrogen gas on electrolysis of sodium chloride.

8.18 Commercial use of electrolysis product

Different metals as sodium, aluminum, copper, zinc, iron, lead etc. are extracted from ore by electrolysis. In modern world uses of these metals are infinite. Commercial use of iron is spread everywhere. Can we think the construction of building, house, rail line, road, bridge, vehicles, airplane, ship industries furniture without iron? Besides this steel, alloy of iron is well-regarded /valued as rust preventive metal. Commercially steel is used in exchange of iron. Electric wire made of copper is widely used. Copper wire is commercially valued due to its low resistance to electricity. Aluminum is used to make airplane due to its low weight. Besides this house hold cooking wares and cooking pans are made of aluminum.

Commercially iron is made rust preventive by coating with zinc and magnesium by electroplating. Stability of iron is increased by this. When one metal is coated with another metal by electroplating it becomes very smooth. Different kinds of attractive ornaments are made by coating a easily available metal with a costly metal. Such as, brightness of silver ornament is increased by coating with gold.

Hydrogen gas that is produced from the electrolysis of water is a valuable and environment friendly fuel. The essential water and heat for the environment is produced on burning of hydrogen. Hydrogen gas is the best fuel of present time for fuel cells.

Chlorine gas that is produced from the electrolysis of sea water is used commercially as antiseptic and sodium hydroxide alkali is used as raw material in different industries.

8.19 Nuclear Reaction and Electricity Production

We have seen in case of chemical reactions that, chemical bond is formed by accepting-donating or sharing of electrons of outermost energy level. No changes of nucleus occur that means no new atom is formed rather the atoms join together and form a new compound by rearrangement of electrons of outermost energy level. In this case consider the mechanism of formation of sodium chloride (NaCl) and water (H_2O). In this section we will learn about a particular reaction where the issue of electron is absent, here new elements are formed from reactions.

We know nucleus of all elements except hydrogen is composed of two fundamental particles. The particles are neutron and proton. The nucleus of heavy elements particularly of atomic number more than 83, dissociate into smaller nucleus spontaneously. On dissociation of heavy nucleus into smaller nucleus a large amount of energy is evolved as light rays. The phenomenon is called radioactivity. Such as- pollonium-210 (Po) dissociates spontaneously and form lead-206 (Pb) and uranium-238 (U). In every case α-particles (di-positive helium-4) are produced. Again a heavy nucleus can be formed by associating smaller nucleus, such as- at high temperature (15 million ^oC) nucleus of two hydrogen atoms join together and form helium nucleus that is helium atom. Such types of reactions occur in sun. Thus we have understood that, in nuclear reaction heavy nucleus dissociate into smaller nucleus, which is called nuclear fission reaction. Again heavy nucleus can be formed by joining of smaller nucleus, which is called nuclear fusion reaction.

Radioactivity is a nuclear fission reaction. The rate of radioactivity of an element can be increased for many times. If any radioactive element is heated by a high energetic neutron, then the nucleus of the radioactive element will dissociate and form instantly many small nucleuses. Such as- 30 different elements are formed from fission reaction by heating of uranium-235 with high energetic neutron. In this reaction first produced stroncium-90 (Sr-90) and xenon-143 (Xe-143) are produced first and also two high energetic neutrons. These two neutrons will again heat the new uranium-235 (U-235) atom or stroncium-90 (Sr-90) & xenon-143 (Xe-143) and form new atoms and neutrons. In this way nuclear reaction continue like chain till the atom present there to dissociate by neutron. This is called nuclear chain reaction. In this reaction large amount of energy

is produced as well as new nucleus. In fact fission reaction is an exothermic reaction. One mole uranium-235 (U-235) produces 2.0 x 10^{13} Joule of energy by nuclear fission reaction.

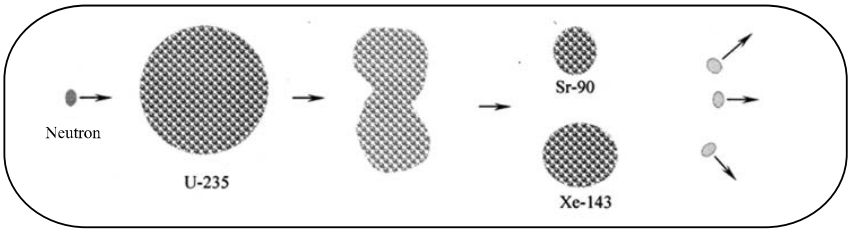


Fig 8.16: In nuclear fission reaction uranium-235 dissociate into smaller nucleus that is in atom by absorbing neutron.

So it is clear that, a large amount of energy can be produced by nuclear reaction using small amount of chemical substance. Now let us highlight a relative diagram of evolved energy by nuclear reaction and chemical reaction. 891000 Joule of energy is produced on burning 1mole methane gas. Thus to get the energy equal to the energy produced by nuclear fission reaction of uranium-235 (2.0 x 10^{13} / 891000) = 2.2 x 10^{7} mole methane gas is to be burnt.

Task: determine the volume of 2.2 x 10^{7} mole methane gas and calculate how much carbon-di-oxide will be produced on burning of that amount of methane.

Besides this, it will be possible to realize the extent of harm caused to the environment by the evolved carbon-di-oxide.

In many countries of the world electricity is produced by using the energy evolved from the fission reaction in nuclear reactor. North America produces 20% electricity of their total demand from nuclear reactor. Different kinds of nuclear reactors are used to produce electricity. Among them lighter water reactor, heavy water reactor and brider reactor is used generally.

Fig-8.17: Production of electricity by nuclear reactor. The reactor is situated in Lorraine in France

Though the production of electricity by nuclear reactor is cheap but its risk is very high. Some substances produced by fission reaction are highly radioactive; they can emit radioactivity for many years which are very harmful to environment. Besides this, accidents in nuclear reactors cause dangerous harm to environment as well as animals. Recent accident in nuclear reactor of Fukusima in Japan is remarkable one. Tsunami (flood), due to the earthquake under the sea caused great damage to the nuclear reactor of Fukusima in Japan and radioactivity spread in the environment.

8.20 Experiment of heat change in reaction and dissolving substance (in groups)

Take approximately 25mL of water in three poly bags and mark the bag with number 1, 2 and 3. Take pieces of thread to tie the bag. Now take lime (calcium oxide) in bag 1 and close the bag and tie with thread. Now observe the heat change by touching the bag. Similarly add soda (Na_2CO_3) and edible soda ($NaHCO_3$) in the bag -2 and 3 respectively. Now add lemon juice or dilute acid solution close the bag quickly and observe the change and write down the observed events in table-2.

Bag	Added solute	Observed change	Possible reaction	Type of reaction
1				
2				
3				

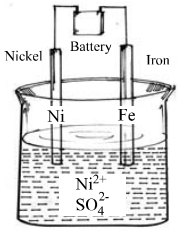
Table-8.2: Experiment of exothermic and endothermic reaction

Precaution and suggestion: (1) Better not to use acid solution, but dilute solution can be used with care. (2) Remove air at your best before closing the opening of bags. (3) Add more solute reducing the amount of water if no change is observed.

Exercise

Multiple choice questions:

1. How many kinds of conductors are there on the basis of mechanism of electrical conductivity?
   a) One b) Two
   c) Three d) Four



Mechanism of electroplating

Give the answer of the question 2 and 3 depending on the figure above.

2. What is the target of the illustrators process? For the iron to-
   a) Increase the amount
   b) Prevent corrosion
   c) Increase strength
   d) Purify

3. In the above figure
   i) Ni is corroded
   ii) Fe acts as anode
   iii) Accepting-donating of electron happened

Which one is correct?
   a) i and ii
   b) ii and iii
   c) i and ii
   d) i, ii and iii.

4. Which one of the following act as oxidant in dry cell.
   a) Zn rod
   b) MnO_2
   c) Carbon rod
   d) NH_4^+

Creative Questions:

1.

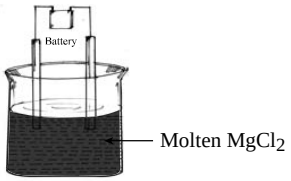
i) Petroleum + O_2 $\longrightarrow$ CO_2 + H_2O + Energy

ii) $^{238}U + {}_0n^1 \longrightarrow {}_{56}Ba + {}_{36}Kr + 3{}_0n^1$ + Energy

iii) $Zn + CuCl_{2(g)} \longrightarrow ZnCl_2 + Cu$ + Energy

a) What is electroplating?
b) Why salt bridge is used in electrochemical cell?
c) Produced energy from which one of the above reactions can be used to run vehicles.
d) Analyse the feasibility of above reactions to produce electricity in Bangladesh.

2.



a) What is metallic conductor?
b) Why is acid mixed water called electrolytic conductor? Explain.
c) Write the reaction occurs in the above cell.
d) Explain the necessity of electricity supply to the illustrator reaction.

Chapter Nine

Acid-Base Balance

Lead is extracted from the acidic residue of rejected batteries of vehicles /IPS/ solar panel in 50 furnaces on the beach of river Jamuna at Bera upozila of Pabna district. People are extremely annoyed at the toxic smoke and bad odor from the furnaces. Crops are not growing in the lands near the furnaces. Cattles are dying by eating grass. Poor labourers bring out the toxic materials by breaking batteries with bare hands. Their hands are infected.


Stack of disposed batteries

There are lead (Pb,) lead oxide (PbO_2) and dilute sulphuric acid (H_2SO_4) in the two chambers inside the plastic cover of the battery. When heat is applied to the residue and the ash of the battery sulfuric acid decomposes and produces sulphur tri oxide (SO_3) and sulphur di oxide (SO_2). Mixing of these two gases create dense foggy like situation.There is a risk of acid rain in those areas. Lead and lead compounds are highly toxic. Breaking batteries with bare hands and touching inner disposals are also harmful to health.

In USA sulphuric acid and plastics are recycled along with 97% lead of used batteries from 1997-2001 by adopting very effective pollution controlling system. Alkali and base produce salt neutralizing acid.

By the end of this chapter we will be able to-

1. explain the characteristics of acid, base and salt.	12. mention the disadvantages of using hard water.
2. identify acid, base and salts from the materials of known environment.	13. explain the financial losses due to use of hard water.
3. differentiate between basic and alkaline materials.	14. describe the causes of water pollution and the means of purification of water.
4. describe the effect of the acid and base on the usual materials.	15. mention the harms of drinking arsenic contaminated water.
5. evaluate the financial importance of the effect of acid and alkaline materials on house hold materials.	16. determine the nature of the saline water and water using in house/laboratory by measuring ph.
6. explain the concept of ph.	17. compare the nature of the compounds (acid, base) by determining the value of ph of the solution by using litmus or universal indicator
7. explain the importance of the measurement of ph.	18. show interest to use pollution free water.
8. realize the importance of the equilibrium of acid-base to maintain the environmental balance.	19. show awareness about terrible part of acid violence and able to make other conscious about it.
9. explain the cause of acid rain, hazardous effects and the way of saving from it.	20. exhibit the effect of acid and base on usual materials with experiments.
10. explain the water cycle.	21. take appropriate precaution in using acidic and basic materials.
11. explain the hardness of water.	

9.1 Acid

Have you ever tasted sour milk/curd? Have you ever felt problem in your stomach due to over eating? If the answer is yes then you have felt the chemistry of acid.

Student activity:

Acids in consumer goods

1. Make a chart of acid containing fruits and the name of the acids present in different consumer goods looking into books and papers.
2. Compare the table with other friends of the class.

You are in touch with various acids like soft drinks (carbonic acid), lemon or orange (citric acid), tamarind (tartaric acid), vinegar (acetic acid) etc. We take these acids (eat), use in cooking. All of these are sour in taste. These help in digesting your foods. Bring taste in mouth. Help to prevent diseases and fulfill the requirement of vitamin C. The walls of the stomach produce hydrochloric acid. Its moderate quantity is essential for digestion of foods. When excessive acid is produced you feel infection in stomach and throats. You should stay away from those foods which on eating produce excessive acid.

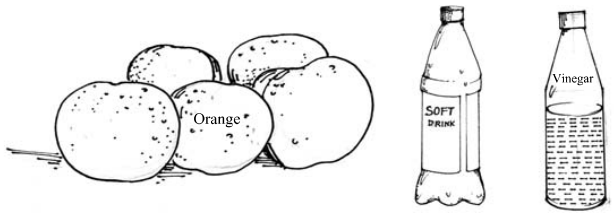


Figure 9.1 Acidic food

You will get some different types of acids in laboratory such as 1. Hydrochloric acid (HCl), 2. Sulphuric acid (H_2SO_4) and 3. Nitric acid (HNO_3).

The solution of hydrogen chloride gas is hydrochloric acid. Pure hydrochloride acid, sulphuric acid and nitric acid are colorless liquid. There is a little water in concentrated acids. We use these acids in laboratory preparing the solution with excess water.

9.2 Properties of diluted acid

1. **Taste:** Almost every acid is sour in taste.

Never try to taste any acid in laboratory

Students activities:

Test of chemical properties of dilute acid in laboratory.

2. **Litmus test:** Insert wetted red and blue litmus paper in dilute acidic solution and observe.

   Do the same experiment with dilute sulphuric acid and nitric acid. Note the result in the following table.

3. Reaction of active metals with diluted acid.

a. Take 3-5mL of dilute hydrochloric acid in a test tube.

b. Add a piece of cleaned (polishing by sand paper) magnesium ribbon in it.

Reactive metal K and Na reacts with diluted acid with explosion.
Do not test with them in laboratory

c. Hold a flaming stick at the open end of the test tube.

d. Carry out the same experiment with iron and copper dust.

e. Cary out the experiment in sulphuric acid and nitric acid in the same way.

f. Note the results in the following table.

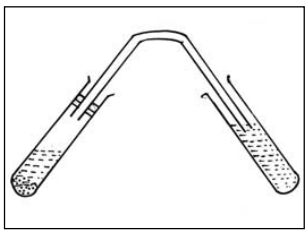


Figure 9.2 : Reaction of metals Carbonate with acid

4. Reaction of metal carbonates with acids:

a. Take 1gm sodium carbonate in a test tube.

b. Add 3-5 cm^3 of dilute hydrochloric acid in it.

c. According to the arrangement of the apparatus as in the figure pass the produced gas into the lime water.

d. Carry out the same experiment with dilute sulphuric acid and nitric acid.

e. Record the results in the following table.

5. Reactions of metal hydrogen carbonate with acids:

a. Take 1g sodium carbonate in a test tube.

b. Add 3-5cm^3 diluted hydrochloric acid in it.

c. According to the arrangement of the apparatus as in the figure, pass the produced gas into the lime water.

d. Carry out the experiment in diluted sulphuric acid and nitric acid in the same way.

e. Note the result in the following table.

6. Reactions of metal hydroxides with acids:

a. Take 3-5cm^3 diluted hydrochloric acid in a test tube.

b. Add 1g magnesium hydroxide in it.

e. Warm the solution in low flame for about 30 minutes.

f. Let the solution be cooled.

g. Carry out the same experiment in sulphuric acid and nitric acid in the same way.

h. Record the results in the following table.

7. Reaction of metal oxides with acids:

a. Take 3-5cm^3 diluted hydrochloric acid in a test tube.

b. Add 1g copper (II) oxide in it.

c. Warm the solution in low flame for about 30 minutes.
d. Let the solution be cooled.
e. Carry out the same experiment in sulphuric acid and nitric acid in the same way.
f. Record the results in the following table.

8. Electrical conductivity of diluted acid:

a. Take hydrochloric acid in a beaker in an amount of half volume of it.
b. Arraange the apparatus as in the figure.
c. Supply electricity in the circuit with the help of battery(by connecting with battery.)
d. Note down the results in the following table.

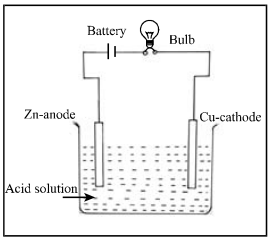


Figure 9.3 Experiment of the conductivity of acid solution

Specimen of table

Serial no	Experiment	Observation	Decision
1.			
2.			

9.3 Analysis of the results of the experiments:

A. Reaction with active metal

Metals above of the hydrogen in the series of activity of metals reacts with diluted acids produce salt and hydrogen gas.

Metal + diluted acid ⟶ Salt + Hydrogen

Such as magnesium metal reacts with diluted hydrochloric acid, sulphuric acid and very diluted nitric acid and produce hydrogen gas. It proves that the presence of hydrogen ions in dilute acids.

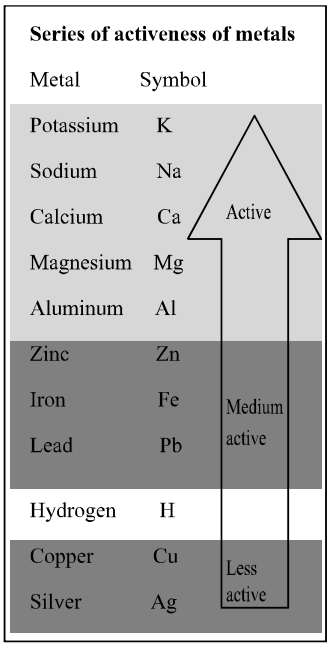
$Mg_{(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$

$Mg_{(s)} + H_2SO_{4(aq)} \longrightarrow MgSO_{4(aq)} + H_{2(g)}$

$Mg_{(s)} + 2HNO_{3(aq)} \longrightarrow Mg(NO_3)_{2(aq)} + H_{2(g)}$

These reactions can be expressed as following ionic equations.

$$Mg_{(s)} + 2H^{+}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + H_{2(g)}$$



Consumer product vinegar and lemon juice reacts with magnesium and produce hydrogen gas. Copper does not react with hydrochloric acid but react with diluted and

concentrated nitric acid and concentrated sulphuric acid. The cause of this difference is the oxidation properties of nitric acid and sulphuric acid. These acids produce atomic oxygen and react with metals in the following ways.

$2HNO_3 \longrightarrow 2NO + H_2O + 3[O]$

Medium concentrated Colourless

$2HNO_3 \longrightarrow 2NO_2 + H_2O + [O]$

Concentrated Brown Coloured

$H_2SO_4 \longrightarrow H_2O + SO_2 + [O]$

Concentrated

Produced atomic oxygen in the reaction oxidizes the metals which are less active than copper or hydrogen produce metal oxides. Metal oxides react with acids and produce acid and water. The complete reaction is expressed by adding the above mentioned oxidation reaction and acid-base neutralization reaction.

B. Reaction with metal carbonate:

Dilute acid reacts with metal carbonate and produce carbon dioxide.

Metal carbonate + diluted acid $\longrightarrow$ Salt + water + carbon dioxide

Sodium carbonate (solid or aqueous solution) reacts with dilutes acids produce carbon dioxide with bubbles.

$Na_2CO_{3\,(s\text{ or }aq)} + 2HCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

$Na_2CO_{3\,(s\text{ or }aq)} + H_2SO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + H_2O_{(l)} + CO_{2(g)}$

$Na_2CO_{3\,(s\text{ or }aq)} + 2HNO_{3(aq)} \longrightarrow 2NaNO_{3(aq)} + H_2O_{(l)} + CO_{2(g)}$

These reactions can also be expressed as following ionic equations.

$CO_3^{2-}{}_{(s\text{ or }aq)} + 2H^+_{(aq)} \longrightarrow H_2O_{(l)} + CO_{2(g)}$

Lime stone or calcium carbonate react with diluted hydrochloric acid and diluted nitric acid produce calcium salt and carbon dioxide. In the reaction of dilute sulfuric acid the reaction do not move forward up to the end due to the formation of a insoluble layer of calcium sulphate on the surface of calcium carbonate.

$CaCO_{3\,(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

$CaCO_{3\,(s)} + 2HNO_{3(aq)} \longrightarrow Ca(NO_3)_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

These reactions can be expressed as following ionic equations.

$CaCO_{3(s)} + 2H^+_{(aq)} \longrightarrow Ca^{2+}_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

C. Reaction with metal hydrogen carbonate:

Diluted acid reacts with metal hydrogen carbonate produce carbon di oxide gas.

Metal hydrogen carbonate + diluted acid $\longrightarrow$ Salt + water + carbon di oxide

Sodium hydrogen carbonate (solid or aqueous solution) produce carbon di oxide with bubble when reacts with diluted acid.

$NaHCO_{3\ (s\ or\ aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

$2NaHCO_{3\ (s\ or\ aq)} + H_2SO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)} + 2CO_{2(g)}$

$NaHCO_{3\ (s\ or\ aq)} + HNO_{3(aq)} \longrightarrow NaNO_{3(aq)} + H_2O_{(l)} + CO_{2(g)}$

These reactions can be expressed by the following ionic equation

$HCO_3^{-}{}_{(s\ or\ aq)} + H^+_{(aq)} \longrightarrow H_2O_{(l)} + CO_{2(g)}$

D. Reactions of metal hydro oxides and oxide with acid:

Metal hydro oxides and oxides are base. Acid and base react to produce salt and water. In this reaction the characteristic properties of both acid and base are abolished. This reaction is known as neutralization reaction.

Acid + metal hydroxide $\longrightarrow$ Salt + water

Acid + metal oxide $\longrightarrow$ Salt + water

In the reaction of magnesium hydro oxide with diluted hydrochloric acid produce magnesium chloride and water.

$2HCl_{(aq)} + Mg(OH)_{2(s)} \longrightarrow MgCl_{2(aq)} + 2H_2O_{(l)}$

In the reaction of dilute sulfuric acid with copper (II) produce copper (II) sulphate and water.

$H_2SO_{4\ (aq)} + CuO_{(s)} \longrightarrow CuSO_{4(aq)} + H_2O_{(l)}$

In the reaction of calcium oxide with diluted nitric acid produce calcium nitrate and water.

$2HNO_{3(aq)} + CaO_{(s)} \longrightarrow Ca(NO_3)_{2(aq)} + H_2O_{(l)}$

E. Electrical conductivity of diluted acid:

All diluted acids are electric conductor. You may carry out an experiment about electrical conductivity of dilute acid arranging the apparatus as shown in the figure.

F. The role of water in chemical properties of acid:

The characteristics of acids which you have ever known, all of them are in aqueous solution. What properties are shown by the acidic compounds in absence of water?

Touch a dry blue litmus paper on the surface of anhydrous citric acid crystal. What have you seen? No change occurred. The cause of no change is the absence of hydrogen ion in anhydrous citric acid crystal. Cytric acid gives hydrogen ion in aqueous solution. It is called ionization. Hydrogen ion in aqueous solution exhibits the characteristic properties of acids. In aqueous solution citric acid ionized partially. Ethanoic acid, carbonic acid is also ionized partially in aqueous solution.

Cytric acid + water $\longrightarrow$ Cytric acid$_{(aq)}$

Cytric acid $\longrightarrow$ $H^+_{(aq)}$ + Cytrateion$_{(aq)}$

In aqueous solution hydrogen chloride is completely ionized and produces hydrogen ions.

$HCl_{(g)}$ + water ⟶ $HCl_{(aq)}$

$HCl_{(aq)}$ ⟶ $H^+_{(aq)} + Cl^-_{(aq)}$

Pure sulphuric acid and nitric acid are colourless liquid. Here two compounds remain as molecules. Pure sulphuric acid and nitric acid do not exhibit the characteristic properties of acid, because they are not ionized that means no hydrogen ion is present there. When dissolved in water they ionized completely and produce mobile hydrogen ion and exhibit acidic characteristics. This hydrogen ion remains in movement as a result acid act as a conductor.

$H_2SO_{4(l)}$ + water ⟶ $H_2SO_{4(aq)}$

$H_2SO_{4(aq)}$ ⟶ $2H^+_{(aq)} + SO_4^{2-}{}_{(aq)}$

$HNO_{3(l)}$ + water ⟶ $HNO_{3(aq)}$

$HNO_{3(aq)}$ ⟶ $H^+_{(aq)} + NO_3^-{}_{(aq)}$

The acids which ionized partially in aqueous solution are weak acid. Similarly the bases which ionized partially in aqueous solution are weak base. All strong acids and bases ionized completely in aqueous solution. It means amount of hydrogen ions in weak acidic solution are less in respect to strong acid. Similarly amount of hydroxyl ions in wreak basic solution is less in respect to strong basic solution.

Student's activity:

Give a definition of acid on the basis of common element that present in all acids and essential ion for exhibiting characteristic properties of acids.

- How will you detect a colorless solution as acid?

9.4 Base and alkali

Basic materials are those which neutralize the acids and extinguish the characteristic properties. Generally oxides and hydroxides of metals are known as base. Any base when neutralizes any acid produces salt and water.

Acid + Base ⟶ Salt + Water

Alkali is a particular kind of base. Alkali is completely soluble in water. Sodium hydroxide, potassium hydroxide, calcium hydroxide, sodium oxide, calcium oxide etc. alkali. Aqueous solution of ammonia gas is also alkali. Whereas copper oxide, iron oxide, iron hydroxide etc. are not soluble in water. So they are base not alkali.

Alkali materials in households

Alkali materials have common uses in household cleaning work. These materials react with oils and fats and produce soap.

Some commonly used alkali and their uses are mentioned in the table bellow.

Name	Chemical Formula	Uses
Sodium hydroxide or Caustic soda	NaOH	Toilet cleaner

Name	Chemical Formula	Uses
Ammonia	NH_3	Glass cleaner
Calcium hydroxide	$Ca(OH)_2$	To white wash the wall. To eat with betel leaf

You will get so many alkalis in laboratory such as 1. Potassium hydroxide KOH, 2. Sodium hydroxide NaOH, 3. Calcium hydroxide $Ca(OH)_2$ and 4. Ammonia solution,NH_3

Never try to taste of any alkali in laboratory.

9.5 Properties of dilute Alkali

Taste: Solution of all alkali is harsh in taste and have bad odor.

Students activities

Experiment of the Chemical properties of dilute alkali in laboratory:

2. Perception: It feels slippery when it is touched (cause harm to skin)

3. Litmus test : Insert a wet red and blue litmus paper in the dilute sodium hydroxide and observe. Carry out the experiment in diluted calcium hydroxide and dilute ammonia solution in the same way. Record the results in the following table.

4. Reaction of metal ions with diluted alkali:

Use diluted sodium hydroxide, ammonium solution and salts of copper and lead with proper care.

a. Arrange 1 stand and 8 test tubes as in the figure (Fig 9.4).

b. Take $2cm^3$ nitrate solution of aluminum, calcium, lead, magnesium, iron(II), iron (III), copper(II), and zinc in those test tubes successively.

c. Add 2/3 drops of sodium hydroxide solution in each test tube and shake them and observe the changes

d. Again add more sodium hydroxide solution in each test tube and shake them until changes occur and observe.

e. Carry out the experiment by using ammonia solution in the same way.

f. Note down the results in the following table.

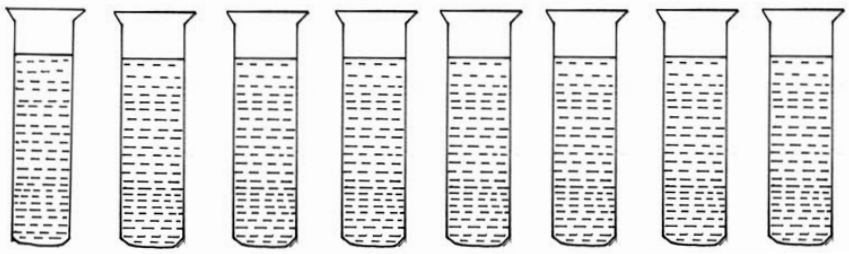


Figure 9.4 Experiment by the addition of sodium hydroxide in different salts solution

Specimen of a table

Serial no	Metal ion	Produced metal hydroxide due to the addition of NaOH(aq)	Colour of the precipitation	Colour change due to the addition of excess NaOH(aq)
1.				
2.				
3.				
4.				
5.				

5. Reactions of alkali with ammonium compounds

a. Take one spatula ammonium chloride and 2 spatula Calcium hydroxide in a mortar.
b. Mix the solids with the pestle.
c. Transfer the mixture to a test tube.
d. Heat the solution in low flame.
e. Try to take smell of the produced gas (drive the flow of the gas towards your nose with your hand)
f. Hold a piece of wet red litmus paper in the produce gas.
g. Mention the changes of litmus paper and the odor of the gas in the table.
h. Identify the produced gas.

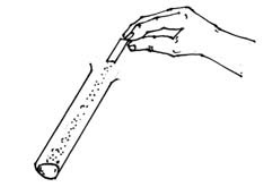


Figure 9.5 Reaction of ammonium chloride and base

Serial no	Experiment	Observation	Decision
1.			
2.			

9.6 Analysis of the obtained results:

a. The reactions of diluted alkali with metal ions:

Most of the metal hydroxides are insoluble. Metal hydroxides present in the solution will precipitate when dilute sodium hydroxide is added in the dilute solution of metal salts or ions. Some precipitate may dissolved or change color of the solution when excess sodium hydroxide is added. Compare the obtained result with the following table.

Table: Color precipitation of some common metal hydroxide and complex compounds.

Serial no	Metal ion		Produce metal hydroxide	Color of the precipitation		Changed color
1	$Ca^{2+}_{(aq)}$	Added NaOH(aq)	$Ca(OH)_2(s)$	White	Added	-
2	$Al^{3+}_{(aq)}$		$Al(OH)_{3(s)}$	White	Excess	Colourless
3	$Fe^{2+}_{(aq)}$		$Fe(OH)_{2(s)}$	Green	NaOH(aq)	-

Serial no	Metal ion	Produce metal hydroxide	Color of the precipitation	Changed color
4	$Fe^{3+}_{(aq)}$	$Fe(OH)_{3(s)}$	Reddish brown	-
5	$Cu^{2+}_{(aq)}$	$Cu(OH)_{2(s)}$	Light blue	Deep blue
6	$Zn^{2}+_{(aq)}$	$Zn(OH)_{2(s)}$	White	Colourless

N.B. $Ca(OH)_{2(s)}$ is partially soluble in water.

You can express the formation of precipitation of metal hydroxide by the following ionic equation.

$Ca^{2+}_{(aq)} + 2OH^{-}_{(aq)} \longrightarrow Ca(OH)_{2(s)}$
White precipitate

$Al^{3+}_{(aq)} + 3OH^{-}_{(aq)} \longrightarrow Al(OH)_{3(s)}$
White precipitate

$Fe^{2+}_{(aq)} + 2OH^{-}_{(aq)} \longrightarrow Fe(OH)_{2(s)}$
Green precipitate

$Fe^{3+}_{(aq)} + 3OH^{-}_{(aq)} \longrightarrow Fe(OH)_{3(s)}$
Reddish brown precipitate

$Cu^{2+}_{(aq)} + 2OH^{-}_{(aq)} \longrightarrow Cu(OH)_{2(s)}$
Light blue precipitate

$Zn^{2+}_{(aq)} + 2OH^{-}_{(aq)} \longrightarrow Zn(OH)_{2(s)}$
White precipitate

These ionic equations can be expressed as the chemical equations of the reactions of sodium hydroxides and metal salts.

$CaCl_{2(aq)} + 2NaOH_{(aq)} \longrightarrow Ca(OH)_{2(S)} + NaCl_{(aq)}$
White precipitate

$AlCl_{3(aq)} + 3NaOH_{(aq)} \longrightarrow Al(OH)_{3(s)} + NaCl_{(aq)}$
White precipitate

$FeCl_{2(aq)} + 2NaOH_{(aq)} \longrightarrow Fe(OH)_{2(s)} + NaCl_{(aq)}$
Green precipitate

$FeCl_{3(aq)} + 3NaOH_{(aq)} \longrightarrow Fe(OH)_{3(s)} + NaCl_{(aq)}$)
Reddish brown precipitate

$CuCl_{2(aq)}) + 2NaOH_{(aq)} \longrightarrow Cu(OH)_{2(s)} + NaCl_{(aq)}$
Light blue precipitate

$ZnCl_{2(aq)}) + 2NaOH_{(aq)} \longrightarrow Zn(OH)_{2(s)} + NaCl_{(aq)}$
White precipitate

Metal ions in solution undergo corresponding reactions with ammonia solution but Ca^{2+} ion dose not produce any precipitate.

B. Reactions of ammonium compounds with alkali:

Ammonium chloride, ammonium nitrate, ammonium sulphate each of these contains ammonium ion. Ammonia gas is freed when solid ammonium compounds or its solution is heated in a gentle flame.

$$2NH_4Cl_{(aq)} + Ca(OH)_{2(aq)} \longrightarrow NH_{3(g)} + CaCl_{2(aq)} + H_2O_{(l)}$$

$$NH_4Cl_{(aq)} + NaOH_{(aq)} \longrightarrow NH_{3(g)} + NaCl_{(aq)} + H_2O_{(l)}$$

These two reactions can be expressed by the following ionic equation.

$$NH_4^+{}_{(aq)} + OH^-{}_{(aq)} \longrightarrow NH_{3(g)} + H_2O_{(l)}$$

C. Reactions with acids:

Alkali solutions when react with acids produce only salt and water. You have learnt about this elaborately in acid section and in neutralization reaction section.

D. Electrical conductivity:

Hydrogen ion of acids remain in movement, whereas there is mobile hydroxyl ions in alkali. Alkali acts as a conductor due to the presence of those mobile hydroxyl ions.

E. Role of water in chemical properties of alkali

Ion is present in both potassium hydroxide and sodium hydroxide solution. In solid state ions are not in movement. When dissolved in water they ionized completely and produce mobile hydroxide ions. Only hydroxyl ions bear negative charges in the solution.

$$KOH_{(s)} + \text{Water} \longrightarrow K^+{}_{(aq)} + OH^-{}_{(aq)}$$

$$NaOH_{(s)} + \text{Water} \longrightarrow Na^+{}_{(aq)} + OH^-{}_{(aq)}$$

Ammonia gas is the combination of ammonia molecules. When dissolve in water ammonia gas reacts with water and produce ammonium ion and hydroxide ion. But small amount of ammonia dissolves in water and produce small number of hydroxide ions.

So in the ammonia solutions there are ammonia molecule, water molecule and small number of ammonium ion and hydroxide ions. The characteristic of alkali solution depends on the presence of the mobile hydroxide ions.

Alkali which ionized partially in aqueous solution are week alkali. Strong bases/alkalis are completely ionized in aqueous solution. It means the amount of hydroxide ions in the solution of weak bases are less than that of the strong bases.

Students activity:

Perform each of the followings work. Describe about one change that can be seen with bare eyes. Write the relevant ionic equation.

Iron dust is added in dilute sulfuric acid.

Solid sodium carbonate is added in diluted hydrochloric acid.

Ammonium solution is added in the solution of copper (II)sulphate.

Solve the problem:

There are four bottles without lebel, each of those contains one of the reagents mentioned bellow.

Solution of ammonia	* diluted sodium hydroxide solution
Diluted sulfuric acid	* Distilled water

How can you identify the compound in each bottle by using following chemicals and apparatus.

Solution of copper(II)chloride	* Test tube
Solid sodium carbonate	* Bunshen burner

9.7 Concentrated acid

A. Concentrated Hydrochloric acid:

Hydrogen chloride gas is highly soluble in water. When this gas dissolves in water produces hydrochloric acid. Generally in concentrated hydrochloric acid there is 35% hydrogen chloride by mass ratio. On opening the cap of the bottle of concentrated hydrochloric acid there creates slight mist and harsh odor.

B. Concentrated nitric acid:

Nitrogen dioxide (NO_2) gas when dissolves in water produce nitrious acid (HNO_2) and nitric acid (HNO_3). Generally there is 70% nitric acid in concentrated fuming nitric acid by the mass ratio. Opening the cap of the bottle of concentrated nitric acid fume on nitric acid comes out with severe odor. It is kept in brown colored bottle due to its tendency to dissociates and produce brown colored nitrogen dioxide gas. The rate of dissociation increases with the presences of light.

D. Concentrated sulfuric acid

When sulphur-tri-oxide dissolves in water it produces sulphuric acid (H_2SO_4). Generally there is 98% sulphuric acid in concentrated sulphuric acid by weight ratio.

9.8 Corrosive properties of concentrated acid and base:

Concentrated acids are very dangerous because they are corrosive. They can corrode metals, skins and cloths. Concentrated alkali/base is also corrosive and dangerous as well as acid. Sodium hydroxide is very often known as caustic soda (caustic means burning). Base is more harmful to skins and eyes in comparison to acids.

Students activities:

A. **Investigation of the corrosive properties of acids:**

Concentrated sulphuric acid is very dangerous and corrosive substance. Never add water in it. Handle with care so that your skin and cloths do not come in contact with it. If it comes in contact with any part of your body due to carelessness then clean the affected area with sufficient water and inform your teacher.

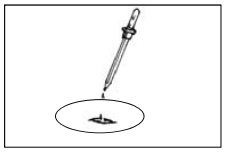


Figure 9.6 Experiment of corrosive property of acid

1. Take a filter paper in a patty dish.
2. Add a few drops of sulphuric acid on the filter paper.
3. Take some time and observe the results, note it.

B. **Investigation of the corrosive properties of alkali/base:**

Bases is also corrosive and dangerous like acids. Use it carefully so that it does not come in contact with any part of the body. If it comes in contact with any part of your body due to carelessness then clean the affected area with sufficient water and inform your teacher.

1. Take two beaker of 250 cm^3.
2. Take 50 cm^3 of distilled water in one of the beaker and 50 cm^3 concentrated sodium hydroxide in another beaker.
3. Sink one hen leg in each beaker and keep those for 1 one day.
4. After one day observe the hen leg pinching with a glass rod and note the observation in your note book.

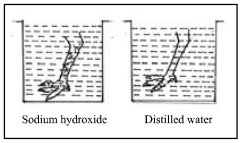


Fig 9.7 Experiment of corrosive property of base

9.9 Experiment of strong and weak acid or strong and weak base:

a. Take 50 cm^3 solution of diluted hydrochloric acid in a beaker.
b. Place two electrode as in figure (Figure 9.3) that they do not touch each other.
c. Connect one electrode by a wire with the one end of the battery and other end of the battery connect with other electrode by a wire through a torch bulb.
d. Observe the intensity of the light of torch bulb.
e. Carry out the experiment with vinegar (ethanoic acid) or citric acid.
f. Explain the difference in the intensity of the light of the bulb.
g. Carry out the same experiment with the sodium hydroxide and ammonia in the same way.

9.10 Concept of pH:

Dictionary meaning of pH is the capacity of hydrogen. The value of pH of any solution will be within 0-14.

If the value of pH of the solution is less than 7, the solution is acidic. Whereas if the value of pH of the solution is greater than 7, the solution is basic and if the value of pH of the solution is 7, the solution is neutral solution. Acidity of a solution increases according to the decreasing value of pH from 7 and alkalinity of a solution increases accordingly with the increasing value of pH from 7

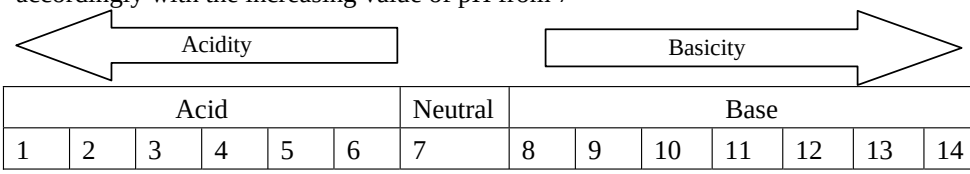


Figure: 9.8 pH Scale

1. Measurement of pH:

Generally litmus paper can be used to know the pH. Litmus paper is cheap and available. The value of pH of a solution if less than 7 the colour of the litmus paper turns to red and if it is greater than 7 the colour of the litmus paper turns to blue. The colourfull petal of flower and coloured vegetables turns to different colour in addition of acid and base. These substances indicate the presence of acid or base by changing their colours. So these are indicators.

Generally universal indicator, pH paper or pH meter is used to know the value of pH.

2. Universal indicator:

Universal indicator is the mixture of various acid and base indicators. Universal indicator turns to different colours for different value of pH. To know the value of pH of an unknown solution add few drops of universal indicator and then compare the colour of solution with the standard colour chart and determine the value of pH.

3. pH paper:

pH paper is used to know the value of pH of an unknown solution. Add a small piece of pH paper in the solution and then compare the colour of the pH paper with the standard colour chart and determine the value of pH.

pH	Type	colour
0-3	Strong acid	Red
3-7	Weak acid	Yellow
7	Neutral	Green
7-11	Weak base	Blue
11-14	Strong base	Violet

Figure 9.9 universal indicator colour chart

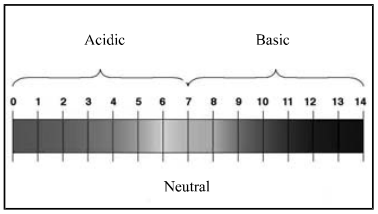


Figure 9.10 pH colour chart

4. pH meter:

pH meter is used to know the pH of an unknown solution. Inserting the electrode of the pH meter in the unknown solution the value of pH can be known directly from the digital display of the pH meter.

Student's activity:

Determining the pH value of the commonly used consumer products classify as acidic, basic and neutral.

Figure 9.11 pH meter

9.11 Importance of pH

In Agriculture: In agriculture it is very important to know the pH of the soil for cultivation. It is very important to maintain the certain pH for certain crops.

In Health Care: To digest protein in the stomach the required pH value is 2, that means acidic condition is required. For further digestion of foods in the small intestine the required pH value is 8, that means basic condition is necessary. It is essential to know the value of pH in diagnosis some diseases.

In Beauty Care: Ideal pH for body skin is 5.5. If the pH of skin remain within 5.5-6.5, it can prevent from the attack of various allergen, bacteria and environment pollutant. The softness and beauty of skin will ruin if the pH of the skin is higher or lower than the standard value. Cuticles of hair remain smooth in pH 4-6 as a result hair reflects light equally and look shiny. If the pH of hair is greater than 6 the cuticles looses their smoothness and looks dull.

9.12 Neutralization reaction and rainbow experiment:

Mixing together of acid and base produces neutral salt and water. This is called neutralization reaction. pH of the solution changes during the neutralization reaction. Water is produced as a result of the neutralization of basic ion by the acid ion so both acid and base loose their characteristic property. Neutralization reaction is very important reaction.

Acid + Base $\longrightarrow$ Salt + Water

Neutral solution is produced when sufficient amount of acid is added in any basic solution. Addition of excess acid makes the solution acidic in nature.

In rainbow experiment there occurs mainly neutralization reaction. Add a piece of a crystal of washing soda in a test tube maximum filled with water. Washing soda is basic in nature. Its chemical name is sodium carbonate. Almost fill the test tube with hydrochloric acid and add few drops of universal indicator, let it stay for two days. Express the acidity and alkalinity of the different part of the test tube by comparing with the colour chart of universal indicator.

9.13 Importance of neutralization reaction in daily life:

In digestion: Acid is produced in stomach in need of digestion. Excess acid in stomach creates irritation. To lessen that weak base like magnesium hydroxide can be taken as medicine. Other edible bases are magnesium carbonate or sodium-bi-carbonate etc. These bases neutralize the acid in stomach and produce salt, water and carbon dioxide.

In dental care: There are innumerable bacteria in human mouth. These bacteria eat the adhering part of the food in the mouth and produce acid. This acid attacks the tooth's enamels (calcium compound) and result the dental carriage. When you brush your teeth basic toothpaste neutralizes the acid inside the mouth which prevents the dental carriage.

In baking cakes: Baking powder is used in baking of cakes. Acid and base both are present in it. Baking powder is a dry mixture of the basic sodium-bi-carbonate and tartaric acid. At dry condition they do not react with each other but when water is added

neutralization reaction occur and produce carbon dioxide gas. Produced carbon dioxide gas blows up the flour. When cake is heated the production of carbon dioxide increases and expands in volume. As a result cake becomes airy and soft.

Nursing of soil in cultivation: The soil of different places is of different types. As the acidity of soil of certain places is very high or the pH value is low so the crops do not grow well. Acidity decreases by adding lime in this soil. Lime is basic material. The chemical name of it is calcium oxide. This lime neutralizes the excess acid in soil as a result increases pH. If soil is too much basic or pH is high then ammonium sulphate is added. Acidic ammonium sulphate neutralizes the excess base in soil and decreases the pH value.

Salt:

You have already known about salt. Water and salt is produced in the reactions of the acid and base. One part of the salt comes from the acid and other part comes from the base. That's why there is an acidic radical and basic radical in each salt. Generally salts are neutral in nature. Salts produced by the reaction of the equal strength of acid and base are neutral but the salt of strong acid and weak base are acidic ($FeCl_3$) and the salt of weak acid and strong base are basic (Na_2CO_3). Salts dissociate into positive ions and negative ions in aqueous solution. Some salts do not dissolve in water. Acidic and basic salts react and produce neutral salts.

$$2FeCl_{3(aq)} + 3Na_2CO_{3(aq)} \longrightarrow 6NaCl_{(aq)} + 3CO_{2(g)} + Fe_2O_{3(g)}$$

9.14 Acid rain: Naturally rain water is slightly acidic the pH of it is 5.6 because carbon dioxide and nitrogen dioxide gas remain dissolved in rain water. All living beings produces carbon dioxide during respiration and leave it to atmosphere. Any fire work and volcanic eruption causes the deposition of carbon dioxide in atmosphere. Brick fields, industries and exhaust of vehicles emit carbon dioxide.

During flushing in storm, nitrogen dioxide gas is produce in atmosphere. Nitrogen dioxide gas is also produced in the self combustion engine by burning petroleum and released into the atmosphere.

Carbon dioxide and nitrogen dioxide react with water present in air produce acid.

$$CO_{2(g)} + H_2O_{(l)} \longrightarrow H_2CO_{3(aq)}$$

$$2NO_{2(g)} + H_2O_{(l)} \longrightarrow HNO_{2(aq)} + HNO_{3(aq)}$$

Nitrous acid is very transient. It converts to nitric acid oxidized by atmospheric oxygen. During volcanic eruption sulphur dioxide and nitric oxide is produced. If the fuels of the electric power station, brick fields, industries, coal, and petroleum contain sulphur/nitrate they produce sulphur dioxide and nitric oxide which are released in the atmosphere. Sulphur dioxide reacts with atmospheric water and produces sulphurus acid. Sulphur dioxide reacts with oxygen and ozone of atmosphere and produce sulphur trioxide which reacts with atmospheric water and produces sulphuric acid.

$SO_{2(g)} + H_2O_{(l)} \longrightarrow H_2SO_{3(aq)}$

$SO_{3(g)} + H_2O_{(l)} \longrightarrow H_2SO_{4\ (aq)}$

These acids fall on the earth surface with rain. Due to acid rain the pH value of ponds and soil become 4 or less than 4. That means soil and water becomes acidic. That affects the ecosystem badly and causes extinction of many living beings.

1. Students activities:
a. Collect water at the beginning and end of rain.
b. Determine the pH of this water by using pH paper.
c. Repeat the processes for some consecutive days.
d. Make a report with your opinion and submit it to your teacher.

2. Students activities:
Write names of some risky areas in Bangladesh taking into consideration the sources of acid rain.

3. Students activities:
Present a report on the means of prevention of acid rain on the basis of above discussion.
(mentionable that sulfur free coal and petroleum is available)

9.15 Water:

Students activities:
Where water is found? [Seas, hills, sky, earth core, river-canals all these should be taken in consideration].
How is water is transferred from one place to another?
You drink water, how does plant get water?
You sweat, does plant leave water in the same way?
Draw a cycle of the rotation of water in earth; taking above matters into consideration.
Give your opinion about the change of total amount of water in earth.

Water flows over the earth surface in the remarkable part of water cycle. In this flow water comes in contact with various mineral salts. Salts dissolve in water. When rain water roll over the lime stone ($CaCO_3$), dolomite ($CaCO_3.MgCO_3$) the carbonic acid present in rain water reacts and dissolve these mineral.

Lime stone ($CaCO_3$), dolomite ($CaCO_3.MgCO_3$), react and dissolve when rain water roll over these due to the presence of carbonic acid.

$H_2O_{(l)} + CO_{2(g)} \longrightarrow Fe(OH)_{2(aq)}$

$CaCO_{3(s)} + H_2CO_{3(aq)} \longrightarrow Ca(HCO_3)_{2(aq)}$

$MgCO_{3(s)} + H_2CO_{3(aq)} \longrightarrow Mg(HCO_3)_{2(aq)}$

There are gypsum ($CaSO_4.2H_2O$) or anhydrous $CaSO_4$ in some rocks. These are slightly soluble in water. When these constituent are present in water it becomes hard. Iron ion is also a constituent of hard water.

Calcium ion present in water reacts with soap as follows

$R\text{-}COONa + H_2O \longrightarrow R\text{-}COO^- + Na^+$

Soap Stearate ion

$R = C_nH_{2n+1}$, n = 12-18

$2R\text{-}COO^- + Ca^{2+} \longrightarrow (R\text{-}COO)_2Ca$

Stearate ion Insoluble calcium stearate

Sodium ion of soap produces soluble sodium carbonate. Same reaction results when potassium is present in soap instead of sodium. Magnesium or iron of hard water gives corresponding reaction with soap. So if bi carbonates, chloride and sulphate salts of calcium, magnesium and iron remain dissolved in water do not form foam with soap.

If bi-carbonate salts of metals remain dissolved in water, the hardness of water is temporary. This type of hardness can be removed by heating. Where as, if chloride or sulphate salts of metals remain dissolved in water, then it is not so easy to remove this type of hardness. The methods of removal of permanent hardness are :

1. Soda method 2. Permutit method 3. Ion exchange resin method

In soft water there is no dissolved ion of calcium, magnesium and iron. So there form enough foam in soft water with soap. Generally water of closed place like ponds, tanks is soft. Rain water is very good soft water. When soft water is heated there is no precipitation.

Students activities:

* Compare the advantages and disadvantages of using hard water.

Clue :

Disadvantages: Washing cloths- do not form foam with soap and do not precipitate. In boiler/hot water pipe 1. Precipitate on heating, 2. More/less heat is required due to increasing thickness, 3. Expansion of the boiler body due to the change of thickness.

Advantages: Tooth and bone- constituent of hard water.

Analyse the risk and possible financial loss of using hard water in industries.

Collect water from tube well, ponds and similar other sources and wash hands using soap in those water and identify the hard and soft water on the basis of produced foam.

9.16 Water pollution:

Now a days most of the people of Bangladesh drink tube well water. In urban areas City Corporation or Municipality supply water through pipe line by purification of river water or lifting the underground water. There are dirt and various germs in supplied water due to faults or leakage in pipe line. The urban people drink this water after purification by boiling or using modern filters.

Water in river, canal, pond etc is being polluted in Bangladesh in various ways. Domestic waste, human excreta are swept by rain water and fall into this water reservoir. Hospital wastes or washing of patients cloths in water or washed with rain water polluting water. Leaking of oil from defected water vehicles is pollute river water. Fertilizers and pesticides used in cultivation all are washed by rain water and fall in the open water reservoir. Besides this industrial wastes in our country are being disposed in water without any treatment. Manganese, chromium, zinc etc. are pollutant. Heavy metals are carcinogenic to human body. Sulphuric acid from the disposals reduces the pH of the water. As a result reproductive capacity of many aquatic lives is decreasing. These make water dirty and spread bad odour.

Due to human activities many natural pollutants pollute the underground and surface water such as lifting of excess water by shallow tube well and excess digging results arsenic pollution in underground water. Greater amount of acceptance level of arsenic (acceptance level is 0.01mg/litre) is found in the tube well water of most of the areas of Bangladesh. Arsenic is a toxic element. Drinking arsenic contaminated water for a long time can cause death. By creating sore in hands-legs it reveal its first symptoms. Now public health and engineering department has marked red colour on the arsenic contaminated tube well. Arsenic contaminated water is being used in irrigation as a result open water reservoir is also being polluted and arsenic enters into food cycle.

Students activity

Make a report on the determination of causes of water pollution in your locality.

9.17 Pollution control:

In our country disposal treatment system are available in big cities. But it is not sufficient in respect of requirement. Bio gas, electric power along with organic fertilizer can be got from sewage and festering domestic disposal. Proper initiative on this regard will reduce the environment and water pollution. In rural areas ring latrine must be ensured instead of open latrine. Establishing small biogas plants using human and animal excreta and decomposable domestic disposals can provide biogas and organic fertilizer which help to reduce the expenditure of fertilizer in farming and will reduce want of fuel. If biogas plant is not possible, make a hole in one corner of your premises and dispose waste. When these disposals decompose you can use them as organic fertilizer.

It is mandatory to establish effluent treatment plant (ETP) in every industry. In no way the industrial wastes be disposed directly into the open water reservoir. You should be conscious about that. Assist directorate of environment providing information. Keep in mind that organized public consciousness and public opinion is the effective way to prevent water pollution in a country like Bangladesh.

9.18 Testing the purity of water:

Colour and odour observation: Pure water is colourless, odourless and transparent liquid. Little amount of mineral salts remain dissolved in it. If any mineral salt is dissolved in it

at a large extent it can be called polluted water. In general observation if any odour or any suspended materials in the water or any residue is found after filtration then the water is polluted.

Temperature of water: in summer it may become 30-35^{0}C and sometimes it may be 40^{0}C. If somehow the temperature of water rises by few degrees then it is said heat polluted. The water used in electric power station to cool the machineries or hot water from boiler if released directly in open reservoir of water, then heat pollution occur. Measuring the temperature of water by thermometer heat pollution of water can be detected.

pH value: If pH value of water is less than 4.5 and greater than 9.5 it will be threat to living beings. pH can be determined by using pH paper or pH meter.

BOD (Biological Oxygen Demand or Biochemical Oxygen Demand): BOD means demands of bio chemical oxygen. Water that has much BOD value is polluted one. The oxygen needed to decompose the organic matters in water in presence of air is known as BOD. You have to measure the amount of oxygen in water of a reservoir. Fill a bottle of 100ml with that water in such way that no air remains in it. Keep the bottle at 20^{0}C for 24 hours and then measure the amount of oxygen of the water in the bottle. Difference between these two will indicate the BOD.

COD (Chemical oxygen demand): COD means the chemical oxygen demand. COD is used to express total chemical matter in water. The quality of the water is analyzed by measuring the extent of organic pollutants in water (specially in rivers, canals etc). The greater value of COD means that the extent of pollution is also greater.

BOD and COD express as milligram/ liter or parts per million (ppm) unit. 1ppm = 1 mg solute in1 litre solution.

9.19 Purification of water:

Chlorination: Easy way of sterilization of water is chlorination. If certain amount of bleaching powder is added in water, produced chlorine oxidized the germs and kill them.

$$Ca(OCl)Cl + H_2O \longrightarrow Ca(OH)_2 + 2[Cl]$$

$$Germ + 2[Cl] \longrightarrow Oxidized\ germ$$

Filter the water after adding bleaching powder and it becomes drinkable.

Boiling : Water sterilized by boiling for some time (15-20 minutes), mentionable if water is contaminated with arsenic the boiling will be more harmful.

Settling: Add one spoon of alum dust $\{K_2SO_4Al_2(SO_4)_3.24H_2O\}$ in a bucket of water and allow it to settle for half an hour all the impurities/undesired product settle at the bottom. In this way insoluble pollutant can be removed.

Filtration: Now filter that can remove germs, arsenic and other pollutant is available in the market. Water from these filters is drinkable and pure. Water filtered through this can be drinkable pure water.

Assignment:

Make pH paper of your own.

Take one of the coloured vegetables such as lal shak, , red cabbages, beats or one of the coloured flowers such as china rose, red rose, dalia cut in small pieces. Boil in steam at low temperature. Insert a piece of filter paper in the extract which you obtain. Dry the paper in air and then cut it into several fine pieces. That is the pH paper made by you. To know the value of this pH paper sink it in a solution of a known pH and make a colour chart of pH range. Make pH paper with all vegetables or flowers possible by you. Select the best one to use.

Exercise

Multiple choice questions

1. Which following compound will be produced when sulphuric acid is added on lime stone?

a. CO_2 b. H_2

c. O_2 d. SO_2

2. Which of the followings is base?

a. Soft drinks b. Lemon juice

c. Vinegar d. Washing soda

3. For the presence of which one of the followings aqueous solution is basic?

a. NH_4^+ ion b. OH^- ion

c. NH_3 d. H_2O

4. Colourless solution is produced when nitric acid reacts with an unknown metal. Precipitate is formed when sodium hydroxide is added in the produced solution white precipitate is formed but dissolve it by adding extra sodium hydroxide in it. The metal is

a. Copper b. Iron

c. Lead d. Zinc

5. pH of an ethanoic acid solution is 4, to increase the pH value we have to add-

i. Ammonium solution

ii. Concentrated hydrochloric acid

iii. Solid magnesium carbonate

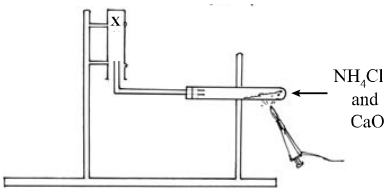
which is correct one?

a. i and ii b. i and iii

c. ii and iii d. i,ii and iii

Creative questions:

1.



a. What is the colour of NO_2 gas?
b. Will the pH of lime water be greater of less than 7? Explain.
c. Explain a chemical property of a solution of gas X.
d. What will happen if "X" gas is passed through the aqueous solution of iron salt ? write with equation.

2. The effluents that contain colour and sulphuric acid from textile mill, dyeing industries directly disposing in near water reservoir as a result those reservoir of water become unfit for aquatic life.
   a. Which acid is in tamarind?
   b. Describe your conception about the pH of the water reservoir in the illustration.
   c. Give a logical advice to control acid pollution by effluent treatment plant in textile and dying industry.
   d. Analyze the probability of acid rain in the surroundings of textile and dying industries with reactions.

Chapter Ten

Mineral Resources: Metal-Nonmetal

Bijoypur, Gopalpur of Durgapur Upazilla of Netrokona district of Bangladesh is one of the best tourism place of Bangladesh. Hill of white clay is seen here beside attractive lake. This clay rich in Kaolin or aluminium is used in ceramic industries. At the beginning the people of china used this type of clay that is why this clay is called china clay. Generally black or gray and radish clay is seen. In every cases the characteristics of clays are different. The cause of these varieties is the presence of different minerals in clay.

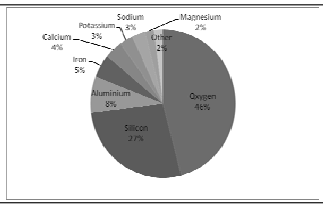
White clay hill of Bijoypur

By the end of this chapter we will be able to-

1. explain the concept of mineral resources.
2. compare among the rocks, minerals and ores.
3. find out the appropriate ways of metal extraction.
4. explain the cause of making alloys.
5. source of sulfur and reactions of formation of some important compounds of it's, description of chemical properties and analyze their use in house, industries and agriculture.
6. analyze the importance of limitation, appropriate use and recycling of minerals.
7. show sincerity in use of minerals and keenness in preserving.

10.1 Mineral resources

The earth crust is a layer of clay. The percent composition of important elements present in earth surface is shown in pie chart. Try to give the answer of the following question discussing the chart.

Which two elements are the main ingredients of earth crust? Are the two main ingredients of earth crust metal or nonmetal? Is it possible to get aluminium, iron, calcium, potassium and magnesium etc. metals free in nature? Show logic in support of your answer. [consider the chemical reactivity of metals.]	 Fig 10.1: Principle elements of earth crust

Write the name of sodium and calcium compounds which are found in nature. Sand (quartz; silicone dioxide, SiO_2), Table salt (sodium chloride, NaCl), lime stone (calcium carbonate, $CaCO_3$). Compounds of reactive metals are found in abundance in nature. On the other hand compounds of less reaction metal is found in small amount. As a result the less reactive metals such as- silver (Ag), copper (Cu), zinc (Zn), tin (Sn) and lead (Pb) etc. are valuable. Although non reactive metal gold (Au) is found free in nature but it is almost rare. This is why gold is precious. The three forths of the 98 elements found in nature are metals. Metals have some excellent characteristics. That is why the use of metal is so wide. The characteristics of metals are-

a. Struck resistance (Metals can be converted to any shape like thin sheet)
b. Malleability (Metals can be converted to thin wires)
c. Luster (metals have lustre, they scatter light)
d. Conductivity (metals are good conductors of heat and electricity)
e. Metallic sound (metals on struck emit a peculiar sound called metallic clink)
f. Melting point and boiling point (metals have high melting and boiling point)
g. Density (density of metals are higher than nonmetals)

Non metals also exist as compound in nature like metals. But some nonmetals like sulfur are found free in nature.

10.2 Rock

Most rocks are compounds of some hard particles. These particles are made by mixing of different minerals. Rocks do not remain similar always. With the weather that is temperature, rain, fog, storm, wind etc. always causes corrosion to the rocks. Lime stone (calcium carbonate) goes to sea swept by rainwater. It is deposited there and form limestone and sand stone. Sediments settle in different layers. This is why various layers are found in rocks. You will find layers in small hills. Calcium carbonate, cement like substance binds the small particles strongly and converts to stone or rocks. This rock is alluvial rock. Dead sea coral or snail-oyster shells settle in bottom and converts to calcium carbonate. Some rocks stay in deep of earth. Rocks melt at high temperature of earth. This molten rock is called magma. On cooling magma again

converts to hard rock. This rock is called igneous rock. Sometimes valuable minerals are found in this rock. Again sometimes they are even sand stone only.

10.3 Experiment of different layer formation

Take two beaker of 100 mL volume. Take 70 mL of water in each beaker. Add little amount of sand in one beaker and little amount of clay in another beaker. Mix them by stirring with a stirrer. Stop the stirring and observe the beakers. Explain the formation of the hill shown in figure considering the observation of the two beakers.

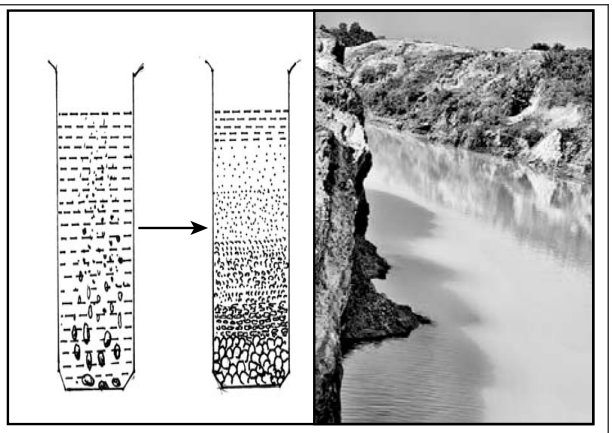


Fig 10.2: Expriment of formatiom of rock Layer formatted hill of china clay

10.4 Mineral

Though the valuable metal and non metal are found everywhere in the world but in rock piles of the earth crust or inside the earth metal or nonmetals are found as compound or as free elements. These are called minerals. Minerals are of different kinds on different context. On consideration of elements and compounds minerals are of two kinds. Such as- elemental minerals and compound minerals.

Elemental minerals: gold, diamond, sulfur etc. are found in nature as fundamental element. This is why these are fundamental minerals.

Compound minerals: All minerals except elemental minerals are compound minerals. These are found as compound.

On physical consideration minerals are of three kinds. Such as- Solid minerals, Liquid minerals and Gaseous minerals.

Solid minerals: Found as solid. Such as- magnetite, bauxite, sulfur etc.

Liquid minerals: Mercury, petroleum.

Gaseous minerals: Natural gas.

10.5 Position of mineral resources

At past bowels of earth was considered as the source of minerals. But now this concept is not considered as true. White clay or kaolin of Bijoypur of Netrokona is found in earth crust as small hill. Zircon- ore of zirconium, rutile- ore of titanium, and monanzite- ore of thorium etc. valuable minerals can be extracted from the sea shore sand of Cox’s bazaar. The mineral like hematite-ore of iron and bauxite- ore of aluminium or coal etc. are found in earth crust. For extraction of some minerals we have to go deep inside the earth by digging holes.

10.6 Ore

Metals can not be extracted economically from all minerals. The minerals from which metal can be extracted economically are called ore. The characteristic of natural ore is that their chemical constituents are well defined. Such as- magnetite is always found as pure whereas bauxite is always found as hydrated. In the mine sand, stone, clay and other needless substances are found with ore as impurities. This impurities are called mineral waste or mineral impurities or gangue.

10.7 Extraction of metal

Extraction of metal from ore is done by five steps. Such as, 1. Crushing of ores 2. Condensation of ores 3. Conversion of condensed ore to oxides 4. Conversion of metallic oxides free metals 5. Purification of metals.

1) Crushing of ores: Most of the ores are found in nature as big rocks. These big rocks are crushed to small particles so that chemical reaction can be occurred easily later on. To do this first the ores are made small pieces in joo crusher and then crushed to powder in ball crusher.

2) Condensation of ores: Clay, sand, stone, limestone and some other nonmetals are found with crushed ores as impurities. Some processes of removal of mineral impurities from ores is described below.

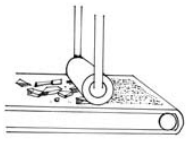


Fig 10.3: Crushing of ores

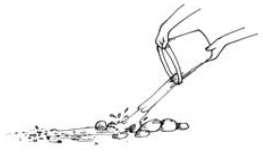


Fig 10.4: Condensation of ores

a) Separation by gravitational force: The specific gravity of metal ores and Clay, sand, stone, limestone and some other nonmetals are different. The crushed ores are stirred with adding water or washed with blowing water. Thus the light mineral impurities will wash out and ores will be condensed.

b) Oil foam flotation system: This process is generally used to condense the sulfide ores. Sulfide ores get wet easily with oil. Taking the crushed ores in big bowl added water and small amount of appropriate oil then stirred with blowing air. Sulfide ore upon wetted with oil float on water as foam. The ore is separated with foam. The mineral impurities settle at the bottom of the bowl as residues.

Experiment of oil foam flotation system:

Materials:

- Sand
- Kerosene
- Spatula
- Liquid/powder soap
- Watch glass
- A large test tube with cork
- Celcopyrite, galena or hematite ore powder.

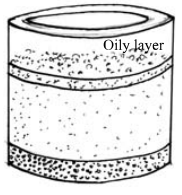


Fig 10.5 Oil foam flotation system

Process:

1. Mix equal amount of sand with one spatula of washed ore. Take the mixture in a large test tube and fill half with water.
2. Sake the test tube closing with a cork. Have the sand and ore separated?
3. Add some powder/liquid soap and a few drops of kerosene oil.
4. Again shake well the test tube closing with cork.
5. Taking some foams into watch glass with spatula and examine whether there is any ore?

Sands sink to the bottom and ores float to the surface of the test tube.

Give comments:
How will you get dry ores from the foam in a watch glass?
Will any change happen to the mixed sands?
How do you perform the experiment in better way?

c. Magnetic separation: This process is used, if either of the ores or the gangue has the magnetic property. Crushed ores are passed through a plastic conveyer belt. The outer wheel of the conveyer belt has the magnetic property.
Cromite; $FeO.Cr_2O_3$, wolframite; $FeWO_4$, Rutile; TiO_2 etc. are ores with magnetic property.

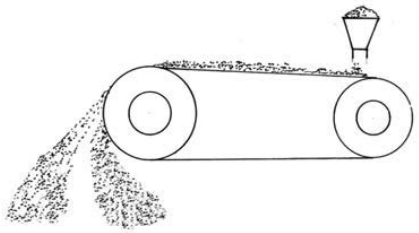


Fig 10.6: Magnetic separation

d. Chemical process: This technique is applied depending upon the characteristics of the ores. In this process the desired minerals of the ores are dissolved in a particular solution. The mineral impurities (gangue) are separated by filtration. Then the concentrated ores are collected from the solution with appropriate process. Such as- iron oxide, titanium oxide, sand etc. are found in mixture with bauxite- ore of aluminium. Adding sodium hydroxide solution with bauxite and heat to 1500-2000^oC, bauxite will be dissolved iron oxide, titanium oxide; sand etc. will not be dissolved. The mineral impurities (gangue) are removed by filtration.

$$Al_2O_3 + 6NaOH \xrightarrow{\triangle} 2Na_3AlO_3 + 3H_2O$$

If filtrate is heated adding water aluminium hydroxide will be precipitated. Heating at high temperature aluminium hydroxide will convert to alumina.

$$NaAlO_3 + 3H_2O \xrightarrow{\triangle} Al(OH)_3 + 3NaOH$$

$$Al(OH)_3 \xrightarrow{\triangle} Al_2O_3 + 3H_2O$$

3) Conversion of condensed ores to oxides:

a. Calcinations: Condensed ore are heated at temperature below the melting point in absence of air, organic substances and moisture will remove from the ore. In this process hydrated metal oxides and metal carbonates convert to metal oxides.

$CaCO_3$ (Limestone) $\xrightarrow{\triangle}$ $CaO + CO_2$

$Al_2O_3.2H_2O$ (Bauxite) $\xrightarrow{\triangle}$ $Al_2O_3 + 2H_2O$

$2Fe_2O_3.3H_2O$ (Hematite) $\xrightarrow{\triangle}$ $2Fe_2O_3 + 3H_2O$

b. Roasting: Generally roasting is applied for sulfide ores. If sulfide ores are heated at temperature below the melting point in presence of air, organic substances and moisture will remove from the ore. Mineral impurities (gangue) such as sulfur, arsenic, phosphorus etc. removed as volatile oxides.

$2ZnS$ (Zinc bland) $+ 3O_2 \xrightarrow{\triangle} 2ZnO + 2SO_2$

$2PbS$ (Galana) $+ 3O_2 \xrightarrow{\triangle} 2PbO + 2SO_2$

(**Precaution:** Produced sulfur dioxide may cause acid rain by forming acid on reaction with water vapour)

Table: Chemical reactivity of metal and metal extraction method from ion

	Metal ion	Metal extraction method
Successive increasing reactivity of metal		
Lithium	Li^+	
Potassium	K^+	
Calcium	Ca^{2+}	Electrolysis of melted ores or Salts
Sodium	Na^+	
Magnesium	Mg^{2+}	
Aluminium	Al^{3+}	
Manganese	Mn^{2+}	
Zinc	Zn^{2+}	Reduction with coke coal or carbon
Chromium	Cr^{2+}, Cr^{3+}	monoxide
Iron	Fe^{2+}, Fe^{3+}	
Lead	Pb^{2+}	
Copper	Cu^{2+}	Obtained as element or heat reduction of
Silver	Ag^+	sulfide or carbonate ores
Mercury	Hg^{2+}	
Platinum	Pt^{2+}	
Gold	Au^+	

4) **Conversion of metallic oxides into free metals:** Thousand years ago people were able to extract metal without the conception of chemical reaction. Suddenly people got metal. It is assumed that, any mineral rock was thrown in the fire and later they got metals. In this work two substances were required such as, fire and coal or carbon. Know it; ores of metals are metal oxides and metals become free in heating these metal oxides with carbon. This process is called the carbon reduction. Carbon combines with oxygen and form carbon dioxide.

$M_2O_n + nC \longrightarrow 2M + nCO$

$M_2O_n + nCO \longrightarrow 2M + nCO_2$ (Here, n = valence of the metal)

Such as,

$PbO_{(s)} + C_{(s)} \longrightarrow 2Pb_{(s)} + CO_{2(g)}$

This process is called smelting or extraction of minerals by melting. In this process the metal ion is reduced. Because here metal ion is accepting electron. So, metal extraction is a reduction process. The reduction reaction of lead ion is as follows;

$Pb^{2+} + 2e^- \longrightarrow Pb_{(s)}$

Copper, iron, zinc, manganese and chromium metals can be extracted by this process. Besides this electrolysis process is used to extract metal from the oxides of more reactive metals or metallic compounds. Principles of electrolysis

$M_2O_n \longrightarrow 2M^{n+} + nO^{2-}$

$MX_n \longrightarrow M^{n+} + nX^-$

$M^{n+} + ne^- \longrightarrow M$

Students activity:

Extraction of metallic lead from lead oxide.

Materials:

- Yellow color lead oxide.
- One piece if white paper
- Bunsen burner/spirit lamp
- Stick of safety match

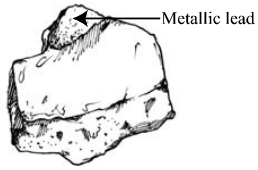


Fig 10.7: Compound of lead

Precaution: lead, lead oxide and its vapour is toxic substance. Don't touch it with bare hand. Don't take lead vapor with breath.

Process:

1. At first make the flame of burner small.
2. Burn a stick of safety match that no residues of gun powder remain.
3. Add some lead oxide to the black end of the burned stick after making it wet by dipping in water.
4. Hold the lead oxide added end of the stick to the flame of burner and observe do the small bubbles of melted lead formed.
5. Let the stick cool. Find out the lead particle putting it on a white paper. Use a magnifying glass if necessary. If no lead is found in observation repeat the step 2 to 5.

Give comments:

1. Explain the cause of wetting of the stick of safety matches with water.
2. Do any chemical reaction occur here? Give logic in support of your answer.
3. Where from the required carbon come to make free the lead?
4. Write down the equation of the reaction in formula and in description.
5. Will you get the same result if you carry out the experiment with copper, iron or zinc. Give logic in support of your answer.

Depending upon the bond energy of metallic ion or anion of ores melting or heat reduction will be required to free the metal. Strong bonds exist in the reactive metals. Inert metals exist freely so heat reduction is not required to extract these metals. Such as, Au, Ag and Pt. This is why gold and silver are found in use from the ancient time. Some metals are almost inert, metals can be

extracted from the sulfide ores of which by heat reduction like Cu. Sulfide ion oxidizes and converts to sulfur dioxide and copper ion reduces and converts to copper.

$$Cu_2S_{(s)}\text{ (celcosite)} + O_{2(g)} \longrightarrow 2Cu_{(s)} + SO_{2(g)}$$

The reaction occurs in more than one step. Such as-

$$2Cu_2S_{(s)}\text{ (celcosite)} + 3O_{2(g)} \longrightarrow 2Cu_2O_{(s)} + 2SO_{2(g)}$$

Cuprous oxide, produced form oxidation reaction reacts with un-oxidized cuprous sulfide and freed copper metals. This process is called auto reduction.

$$Cu_2S_{(s)} + 2Cu_2O_{(s)} \longrightarrow 6Cu_{(s)} + SO_{2(g)}$$

Metallic oxides are produced instead of free metals on heat reduction of sulfide ores of reactive metals.

$$2NiS_{(s)} + 3O_{2(g)} \longrightarrow 2NiO_{(s)} + 2SO_{2(g)}$$

Free metal is extracted by heat reduction of produced metallic oxide with coke coal or carbon-mono-oxide.

$$2ZnO_{(s)} + C_{(s)} \longrightarrow 2Zn_{(s)} + CO_{2(g)}\ ; \quad Fe_2O_{3(s)} + 3CO_{(g)} \longrightarrow 2Fe_{(s)} + 3CO_{2(g)}$$

In some metal extraction it is required to avoid coke coal or carbon. In these case H_2, Fe or Al is used as reductant.

$$WO_{3(g)} + 3H_{2(g)} \longrightarrow W_{(s)} + 3H_2O_{(g)}$$

Free metal is extracted by electrolysis of melted salt of highly reactive metals. Such as- Al, Na etc.

5) Purification of metals

Some mineral impurities remain with metal up to the last. Flux is added to the ores to remove mineral impurities. At high temperature metallic oxides of ores reduce and be free as metal and flux join with impurities and form metal slag. Metal slag does not dissolve in molten metal. Metal slag can easily be removed from the molten metal because of its relatively light mass. This process is called smelting.

The mineral impurities are of acidic or alkaline. Alkaline flux is added to remove acidic mineral impurities and acidic flux is added to remove alkaline mineral impurities. Such as

$$\underset{\text{Alkaline flux}}{CaO} + \underset{\text{Acidic metal impurities}}{SiO_2} \longrightarrow \underset{\text{Calciium silicate}}{CaSiO_3}$$

$$\underset{\text{Alkaline metal impurities}}{MnO} + \underset{\text{Acidic flux}}{SiO_2} \longrightarrow \underset{\text{Manganize silicate}}{MnSiO_3}$$

$$\underset{\text{Alkaline metal impurities}}{FeO(s)} + \underset{\text{Acidic flux}}{SiO_2} \longrightarrow \underset{\text{Ferous silicate}}{FeSiO_3}$$

Purification by Electrolysis:

Electrolysis is done to make the metal more pure obtained in the smelting process. Such as copper obtained in smelting process is 98% pure. On electrolysis 99.9% pure copper can be obtained. In electrolysis process chemical reaction is occurred by using electrical energy. A thick sheet of raw/impure copper is connected with the positive pole of the electric source and a thin sheet of pure copper is connected with

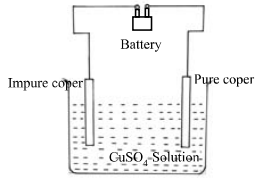


Figure 10.8 Electrolysis of copper

the negative pole of the electric source. Both the copper sheet is dipped in a tank or tub filled with copper sulphate and sulpuric acid solution. If electricity is supplied through the solution raw copper will dissolve and pure copper will settle on the pure copper sheet by reduction reaction.

$$Cu^{2+} + 2e^{-} \longrightarrow Cu_{(s)}$$

The impurities of raw copper will accumulate at the bottom of the tank as sediment. In this sediment there may have almost inert metals such as gold and silver which are recycleable. This process requires a huge amount of electricity.

Free metal can be extracted from the ores or salt of more reactive metals such as- lithium, potassium, calcium, sodium, manganese and aluminium etc. by electrolysis. Melting of salt or ores is required for this.

Student activity:

1. Melting point of sodium chloride is 801^{o}C. Melting point of mixture of 40-42% sodium chloride and 58-60% calcium chloride is almost 600^{o}C, Describe a process for extraction of sodium metal considering the above matters. To do this, the matter you have to consider.
   - Expenditure of smelting.
   - Will both the metal sodium and calcium becomes free at a time if mixture is used?
   - The context of environment pollution of the product of the reaction.
2. Melting point of aluminium oxide is 2050^{o}C. Melting point of mixture of aluminium oxide and craolite Na_3AlF_6 is between 800-100^{o}C, Describe a process for extraction of aluminium metal considering the above matters. To do this, the matter you have to consider.
   - Expenditure of smelting.
   - Will both the metal aluminium and sodium becomes free at a time if the mixture is used?
   - The context of environment pollution of the product of the reaction.
3. What harm will cause to the environment by the byproduct gas formed during the extraction of copper? Describe the means of mitigating this harm (acid rain). Give your opinion about the means, how this by product gas can be used in profitable purpose by preserving the environment.
4. Look at the figure and give answer of the question. Write the possible reaction occurred in the kiln in description and in formula. [Consider: silicon-di-oxide is present with ore as impurities, the product can react with the other reactant and product present in the reaction.

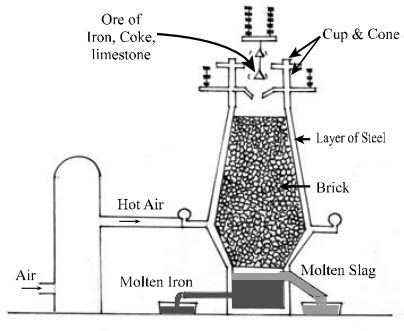


Fig. 10.9: Iron Extraction

5. Represent the possible reaction of extracting metals from the ores represent in the table. Write your logic supporting your answer in the comments column.

Metal	Ores	Extraction reaction	Comments
Mercury	Sinnabar HgS		
Zinc	Zinc bland ZnS		
	Calamine $ZnCO_3$		
Lead	Galana PbS		
Iron	Magnetite Fe_3O_4		
	Hematite Fe_2O_3		
	Limonite $Fe_2O_3.3H_2O$		
Copper	Copper pyrites $CuFeS_2$		
	Celcoisite Cu_2S		
Aluminium	Bauxite $Al_2O_3.2H_2O$		
Sodium	Brine NaCl		
Calcium	Lime stone $CaCO_3$		

10.8 Selected alloy

People first extracted the copper metal. At the ancient time they used to use copper to make ornaments, weapons and machineries. In the history of civilization the time from 5000BC to3000BC is called the copper age. As the copper was soft the weapons and machineries made of copper were not effective. If small amount of metallic tin is added with copper, the rigidity of copper increased highly. The invention of this mixture was a tremendous event. The alloy of mixture of tin and copper is bronze. The time from 3000BC to 1000BC is called the bronze age. Metal alloy is made by mixing the two molten metal. Metal alloy is more useable than metal. Such as, mixture of metallic iron and nonmetallic carbon is steel. It is considered as metal alloy. Usability of steel is more than iron. Except this stainless steel is made by mixing carbon, nickel and chromium with iron. Nickel increase the strength and chromium prevents, rusting. As pue gold is soft, copper or silver mixed alloy is used to make ornaments. Composition of some alloy and their uses are represented in table.

Metal alloy	Composition and amount	Uses
Steel	Iron 99% Carbon 1%	Rail line and wheel, engine, ship, motor vehicle, crane, war weapon, knife, scissor, watch spring, magnet, agriculture machineries
Rust less steel (stain less steel)	Iron 74% Chromium 18% Nickel 8%	Knife, fork, kitchen sink, reaction vessel of chemical industries, surgical equipments.
Brus	Copper 65% Zinc 35%	Ornaments, bearing of machineries, electric switch, handle of door, cooking ware, pan

Metal alloy	Composition and amount	Uses
Bronze	Copper 90% Tin 10%	To melt metal, machineries, plate
Duralamine	Aluminium 95% Copper 4% Magnesium, Manganese and Iron1%	Aeroplane body, bicycle parts
Gold	24 Karate 100% Gold 21 Karate 87.5% Cold copper and other metal 2.5% 22 Karate 91.67% Gold copper and other metal 8.33%	Ornaments

Symptom and cause of corrosion of some metals and metal alloy

The general cause of corrosion of metal is rusting. Metals and alloys undergo chemical reaction with the elements of the environment such as- oxygen, water etc. and corrode. The rate of this corrosion depends on the reactivity of metals. Generally reactive metal corrode faster. The colour of new copper is orange it becomes brown when kept for some days. Because a layer of copper oxide is formed on it. Certainly you have seen the cooking ware or the design of mosque or temple made of copper and brass. When they are not cleaned for few days, a green layer of copper slag is formed on these. This is a kind of salt of copper. Its composition depends on environment. Copper slag is generally mixture of copper (II) carbonate and copper (II) hydroxide [$CuCO_3.Cu(OH)_2$]. Copper slag dissolves in organic acid. So cleaning with the organic acid containing fruits (tamarind, cerambola) removing the copper slag it will regain the golden color. Gold (Au) and platinum (Pt) are inert. These do not get corrosion in thousand of years.

Iron and steel get rust on keeping a few days. Rust is raddish brown tiny flaks substance. In fact it is hydrated iron (II) oxide [$Fe_2O_3.nH_2O$]. Both water and oxygen are required for rusting in iron. If one of them is absent no rust will form. Rusting is a world wide problem. Every year all over the world almost one billion US dollar is spent to change the iron or steel structure due to rusting.

Experiment of rust formation:

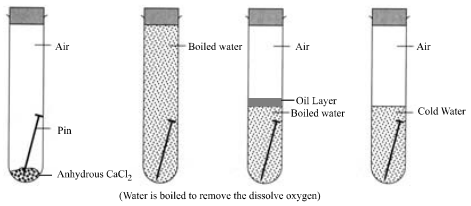


Fig 10.10 Experiment of rust formation in iron

- Take four test tube and mark with the number 1- 4.
- Arrange the test tube according to figure.

- Boil the water of no-3 test tube for 1min and add 1ml cooking oil or olive oil on the water. Air will not enter inside due to the barrier of oil.

Keep the test tube in this condition for one week.

N.B. Galvanizing is done on iron to prevent rust. Corrugated tin was thus named because it was made by coating the iron sheet with zinc and tin by galvanizing. In developed countries coating of iron with zinc and tin is done by electric process. It is called electroplating.

According to your knowledge by which processes rusting are prevented except galvanizing. Based on the observation of the experiment explain the effectiveness of the process.

10.9 Recycling of metal

The number of molecules of every element in the world is definite. It is not possible to produce fundamental elements. So every mineral is not infinite, they are finite. The resource of the metal will be finished with in 120-150 years if we use the metal at present rate. So if we extract the metal in limited amount we can get it for many years. Besides this, recycling of metal is important in solving environmental problems. It will save both money and fuel. Equal amount of aluminium can be recovered by recycling using only 5% of fuel required for extraction. Mainly aluminium, iron, copper, zinc, lead etc. are recycled. 21% of total copper used in the USA comes from recycling process. 60% of total aluminium use in Europe comes from recycling process. Metal can be recycled from the drinks can, milk pot, waste of cooking wares, parts of abandoned vehicles etc. Aluminium metal is used in strips of tablets of pharmaceutical company. Aluminium metal can be extracted by recycling these strips.

Assignment: Recycle of which metals will be cost effective from your area? Investigate considering the place of dumping of waste materials, context of environment and financial matters.

10.10 Mineral: Non metals

Not only metal but also nonmetal is found in natural mines. Coal is a mineral of carbon, Silica is a mineral of silicone, Phosphate is a mineral of phosphorous, Sulphate is a mineral of sulfur. Mineral substance is more related to the fossil chapter, so carbon is discussed there. Considering importance only sulfur mineral is discussed in this chapter.

A. Sulfur

As it is found free in nature, it is extracted directly from the mine. Sulfur mine remain at deep inside the earth. To extract from mine three one centered tube is inserted into the depth of sulfur layer. Steam of 180^{o}C temperature is passed through the outer most tube. Melting point of sulfur is 119^{o}C, so it melts when comes to the contact of steams. Hot air is passed at high pressure through the centre tube. Sulfur comes out through the middle tube due to the effect of pressure. This is called *frush* process.

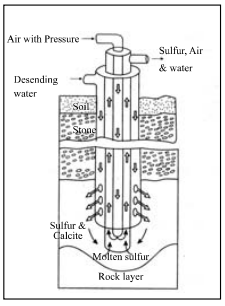


Fig. 10.11 Sulfur extraction: *frush* process

Uses of Sulfur

Sulfur is one of the important elements. The prime raw material of chemical industries sulfuric acid is made of sulfur. Sulfur is used to make different essential compounds like, vulcanizing of rubber, sulfa drugs, safety matches, gun powder, hypo of photography etc.

Compounds of sulfur: Some important compounds of sulfur are discussed below.

b. **Sulfur-di-oxide:**

Sulfur-di-oxide is a very stable compound. Sulfur di oxide is produced by burning sulfur in presence of air.

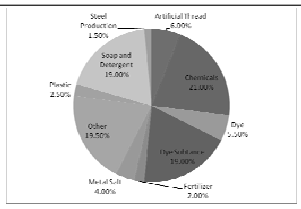
$$S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$$

Sulfur-di-oxide is a very toxic gas with acute odor. Sulfur-di-oxide is produced by burning sulfur containing coal, crude petroleum oil in presence of air. It forms sulfurous acid joining with water.

$$SO_{2(g)} + H_2O_{(l)} \longrightarrow H_2SO_{3(aq)}$$

This gas is the prime factor for acid rain. It is a major air pollutant. However sulfur-di-oxide is an important compound. It is mainly used in sulfuric acid production. Besides this it is used as anti microbes and insecticides, bleaching agent and to prevent foods from getting rotten. Onions contain profile compounds of sulfur. At the time of slicing onions sulfur-di-oxide (SO_2) is produced by dissociating this compound and comes in contact of eyes and forms sulfurous acid (H_2SO_3) reacting with eye water and irritate eyes.

c. **Sulfuric acid:**

Among all chemical substances sulfuric acid is produced and used at a large amount. The amount of sulfuric acid production and its uses is considered as a scale of economical stability and industrialization of a country. Every year several tons of sulfuric acid is produced all over the world. This acid is used as raw material in production of many substances	

Production of sulfuric acid by contact process

In normal condition sulfur-di-oxide is not oxidized by atmospheric oxygen. In contact chamber sulfur-di-oxide is oxidized to sulfur trioxide by oxygen at 400-450^{o}C temperature in presence of granular platinum or vanadium pent oxide as catalyst.

$$2SO_2(g) + O_2(g) \xrightarrow{440\text{-}500^0C,\ Pt/V_2O_5} 2SO_3(g),\ \triangle H = -197\ kJmol^{-1}$$

It is a reversible reaction. Production of sulfur tri oxide can be increased by adopting Le Chatelier's Principle. So when heat of reaction is high, yield is high. Here 45^0c is optimum temperature. In this temperature economically feasible amount of sulfur tri oxide is produced. In this reaction number of molecules in right is less than the left. Though high pressure is feasible for this reaction, but the reaction is carried out at normal atmospheric pressure. Almost 96% sulfur dioxide and oxygen converts to sulfur

tri oxide. Heat of reaction of forward reaction makes hot the reactant gas. Thus heat energy i.e. money is saved.

When water is added to sulfur tri oxide sulfuric acid is produced. But here is a problem that, a mist of fine drop of dilute sulfuric acid is formed by joining sulfur tri oxide with moisture of atmosphere, which is very difficult to condensed.

$$SO_{3(g)} + H_2O_{(l)} \longrightarrow H_2SO_{4(l)}$$

So SO3 is absorbed in 98% H2SO4 forming a fuming sulfuric acid. Fuming sulfuric acid is called oleaam. Oleaam is mixed with water to make necessary dilution.

$$H_2SO_{4(l)} + SO_{3(g)} \longrightarrow H_2S_2O_{7(l)}$$

Sulfuric acid is a dense oily liquid which is miscible with water in all proportions. When water is added to sulfuric acid it forms heat and blast. That is why sulfuric acid is added to water drop wise with stirring to make dilute. When dilution container becomes very hot the addition of acid is stopped when it becomes cold again acid is added. If the dilution container is kept in a water bath it will remain cool.

$$H_2S_2O_7(l) + H_2O(l) \rightleftharpoons 2H_2SO_4(l)$$

Sulfuric acid take part in reaction as acid, oxidant and dehydrating agent.

Student activity:

Take 2-3 ml lime water in test tube and add few drops of dilute H_2SO_4. Observe carefully. Explain the cause of change and write the possible reaction.

Take just a pinch of KI in a test tube and add few drops of concentrated H_2SO_4. Observe carefully. Explain the cause of change and write the possible reaction.

Take one tea spoon full sugar in a test tube and add few drops of concentrated H_2SO_4. Observe carefully. Explain the cause of change and write the possible reaction. You have to perform the reaction very carefully.

Above three experiments express which properties of H_2SO_4 (acid, oxidant and dehydrating agent) explain.

Explain the financial importance of sulfuric acid in Bangladesh based on the pie chart representing the various use of H_2SO_4.

Exercise

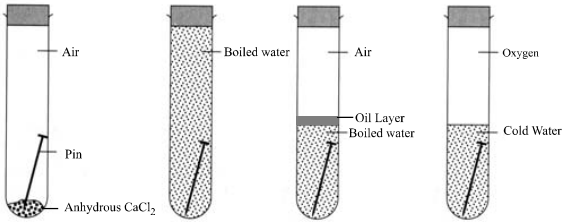
Multiple Choice Question

1. Which data of the table express the general metal?

	Melting point	Boiling point	Density		Melting point	Boiling point	Density
a)	1539	2887	7.86	b)	-219	183	0.002
c)	-133	45	0.79	d)	117	444	1.96

Answer the question no 2 and 3 from the illustrator

A group of students are investigating rust. They put four wire nail in four test tube accordingly and managed according to figure.



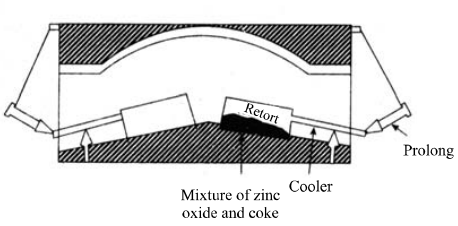
2. In which test, tube most rust will form?
   a) First b) Second
   c) Third d) Forth
3. Decisions that may be taken depending upon the experiment.
   i) Oxygen is must to form rust.
   ii) Salt act as catalyst.
   iii) No rust will form when only oxygen is present.
   Which one is correct?
   a) i and ii b) ii and iii
   c) i and ii d) i, ii and iii.
4. Which sample of gold is most hard?
   a) 18 Karate b) 21 Karate
   c) 22 Karate d) 24 Karate
5. Sulfuric acid is added to the water drop wise on dilution? Because sulfuric acid-
   i) Its hydration temperature is high.
   ii) A di-alkaline acid
   iii) A corrosive substance.
   Which one is correct?
   a) i and ii b) ii and iii
   c) i and ii d) i, ii and iii.
6. 98% sulfuric acid absorb SO_3 and added required water for dilution? Because sulfuric acid-
   i) Form deep mist with water vapor.
   ii) Huge temperature is evolved on addition of water.
   iii) A dehydrating agent.

Which one is correct?

   a) i and ii b) ii and iii
   c) i and ii d) i, ii and iii.

Creative question:

1. Zn metal is extracted taking the ZnO produced in heat reduction of calamine, in a retort as in the figure. Produced metal is purified by electrolysis.



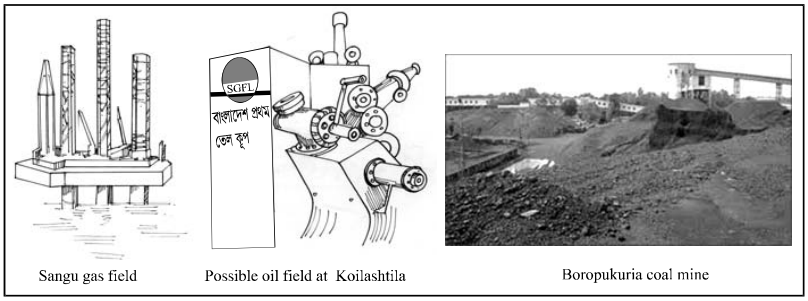
   a. Write the chemical formula of calamine.
   b. Explain the heat reduction.
   c. Explain the principal reaction occurred in retort.
   d. Why metal is extracted in three steps not in only electrolysis? Evaluate.

2. Some mineral of mixture of bauxite and calamine was found in a mine. A group of scientist in leadership of D. Tomash extracted two metals in two different way.
   a. What is called mineral?
   b. Explain ‘not every mineral is ore’.
   c. Explain the nature of oxides found in dissociation of second ore.
   d. Write with logic the cause of extraction of two metal in two different ways.

Chapter Eleven

Mineral Resources- Fossil

Recently Bangladesh Petroleum Corporation declared the invention of oil field at Koilashtila and Jointa. Before this their declaration was about the invention of oil field at Horipur. But in fact it was a gas field. Little amount of oil has been found there along with gas. There is a remarkable reserve of natural gas in the eastern part and a remarkable reserve of coal in the northern part of Bangladesh. The dead plants and corpse exist under the earth surface for 200 million years or more under high temperature and pressure they convert to coal, natural gas or mineral oils are known as fossil fuel. Fossil fuels are used in electric power plants, fertilizer industries, petrochemical industries and also used as fuel. Proper utilization of these natural sources has to ensured considering the finite resource and the right of citizens of the country.



Sangu gas field Possible oil field at Koilashtila Boropukuria coal mine

By the end of this chapter we will be able to-

(1) explain the concept of fossil fuel.
(2) explain the petroleum as a mixture of organic compounds.
(3) explain the uses of petroleum.
(4) explain the concept of hydrocarbon and classification.
(5) explain the reaction of the preparation of saturated and unsaturated hydrocarbon and will be able to differentiate them.
(6) describe the chemical reactions of the preparation of plastic materials and fibers materials as well as their uses.
(7) describe the hazards on environment of the abuse of plastic materials.
(8) explain the advantages and disadvantages of using natural gas, petroleum and coal and techniques of their uses.
(9) explain the mechanism of preparation of alcohols, aldehyde, and organic acids from hydrocarbons.
(10) explain the uses of alcohols, aldehyde and organic acids.
(11) carry out investigative work about the effect of plastic materials on environment.
(12) demonstrate the difference between organic and inorganic compounds with experiments.
(13) exhibit the consciousness about the appropriate uses of the fossil fuels.

11.1 Fossil fuel

Coal, oil and natural gas are the example of fossil fuel. In the pre historical period plants and marshland animals were concealed under the clay due to natural disaster. Clay layer prevents the decay of the dead plants and corpse. Due to the geo-logical and climate change the dead bodies of the plants and animals are trapped between two imporous rock stone layer under marshland and sand layer.

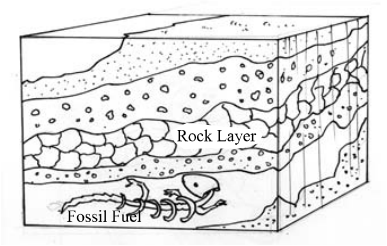


Fig 11.1 Fossil fuel at earth core

On decaying for thousand years the plants and animals bodies convert to fossil fuel under high temperature and pressure in absence of air.Plants body converts to coal. On the other hand the tiny organism of marshland converts to oil or petroleum in the same manner. If changing process continues, gaseous matter accumulates on the oil or petroleum known as natural gas.

The main constituents of all fuel are carbon and carbon compounds. Coal, petroleum and natural gas are used as fuel. Coal is a form of carbon. Petroleum is mainly the mixture of hydrocarbons, besides hydrocarbons it contain some organic compounds. Main constituent of natural gas is methane (80%), besides this natural gas contains ethane (7%), propane (6%), butane and iso-butane (4%), pentane (3%) but, so far been found natural gas in Bangladesh is 99% methane. Heat energy is obtained by burning fuel in presence of oxygen.

Task: Make a list of everyday's fuel. Why are they called fuel? Among those which are not fossil fuel?

$C + O_2 = CO_2 + heat$

$C + O_2 = CO + heat$

$CH_4 + 2O_2 = CO_2 + 2H_2O + heat$

$C_2H_6 + 2O_2 = CO_2 + 3H_2O + heat$

Product and energy is obtained by combustion of fuels in presence of oxygen. This energy can be used in various needs such as- generation of electricity, driving motor engine, flying aero plane, cooking, performing the reactions in industries.

Fuel	Color	Physical state	Main constituent
Coal	Black	Solid	Carbon
Petroleum	Black- brown	Liquid	Mixture of hydrocarbon
Natural gas	Colorless	Gas	Methane

Table 11.1 colour, physical state and main constituent of fossil fuel

Various volatile gaseous compounds come out by heating coal extracted from mine. After gas emission the residue is known as coke.

11.2 Constituents of Petroleum

Crude oil or petroleum (liquid gold) is mainly the mixture of hydrocarbon and other organic compounds. Different parts of crude oil is separated by fractional distillation to make it useable. Separation method of different parts of the crude oil is known as refining. In Bangladesh oil is refined at Eastern refinery in Chittagong. The names of the different parts of the petroleum separated in refinery on the basis of their boiling points successively are petroleum gas, petrol (gasoline), naphtha, kerosene (not that kerosene used in home as fuel), diesel oil, lubricating oil and bitumen.

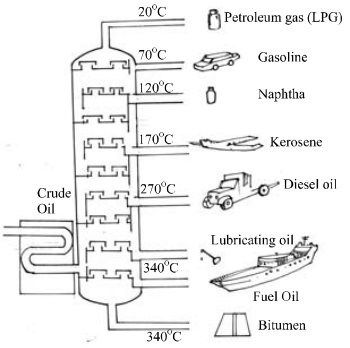


Figure 11.2 partial distillation of petroleum

11.3 Uses of different parts of petroleum

Heating the crude oil or petroleum at 400^0C and inserting at the lower end of the fractional distillation column, different part of the petroleum is collected from the different temperature region of fractionating column. The parts of the petroleum which exists as gas under 20^0C in the fractionating column is known as petroleum gas. Petroleum contains 2% petroleum gas. In this part of hydrocarbon the number of carbon is 1- 4. At beginning this gas was let to escape in atmosphere. But now it is liquefied and filled in cylinder and used as LPG in cooking and in producing required heat.

Separated part from the fractionating column at temperature region 21-70^0C is known as petrol (gasoline). Petroleum contains 5% petrol. In this part of hydrocarbon the number of carbon is 5-10. This part of petroleum is used as fuel of petrol engine (private car, micro bus)

Separated part from the fractionating column at temperature region 71-120^0C is known as naphtha. Petroleum contains 10% naphtha. In this part of hydrocarbon the number of carbon is 7-14 . This part of petroleum is used as fuel and in petrochemical industries to produce different chemical compounds and usable materials.

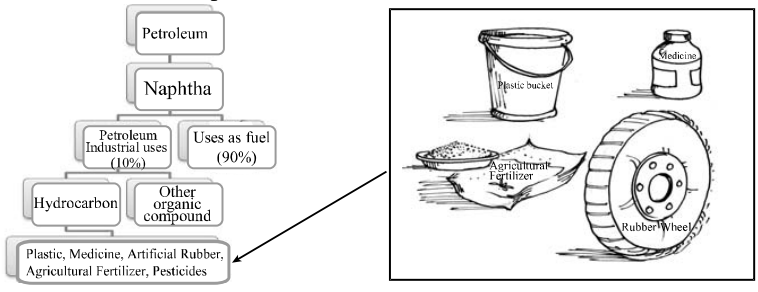


Fig. 11.3 Uses of naphtha

Separated part from the fractionating column at temperature region 121-170^{0}C is known as kerosene (paraphene; affinity less). Petroleum contains 13% kerosene. In this part of hydrocarbon the number of carbon is 11 - 16 . This part of petroleum is used as fuel in jet engine.

Separated part from the fractionating column at temperature region 171-270^{0}C is known as diesel oil. Petroleum contains 20% kerosene. In this part of hydrocarbon the number of carbon is 16 - 20. This part of petroleum is used as fuel in diesel bus engine and ship.

Separated part from the fractionating column at temperature region 271-340^{0}C has two parts known as lubricating oil and fuel oil. Faster separated part is called lubricating oil. In this part of hydrocarbon the number of carbon is 20-30. This part of petroleum is used as lubricant of engines. The lately separated part in this temperature region is fuel oil and used in ships as fuel and also as household fuel.

After separation at 340^{0}C the residue is known as bitumen. Petroleum contains 50% lubricating oil and bitumen. The number of carbon in bitumen part of hydrocarbon is more than 70. Bitumen part of petroleum is used to construct roads.

Most of the hydrocarbons used in laboratories and industries are prepared from this petroleum by different methods.

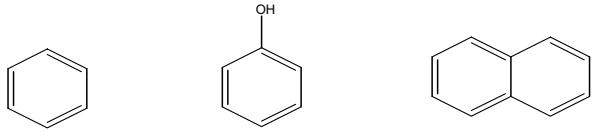
11.4 Hydrocarbons

Hydrocarbons are only the combination of carbon and hydrogen. Hydrogen and carbon atoms remain attached in it by covalent bond. Generally hydrocarbons are expressed as C_xH_y such as methane (CH_4), ethane (C_2H_6), ethene (C_2H_4), cyclohexene (C_6H_{12}), benzene (C_6H_6).

1. Classification of hydrocarbons

Hydrocarbons can be divided mainly into two classes such as aliphatic hydrocarbon and aromatic hydrocarbon.

Aromatic hydrocarbon: You use naphthalene in almirah and phenol (carbolic acid) to drive away snake which are aromatic compounds. Such as



Benzene Phenol Napthalene

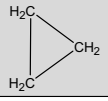
Compounds having some particular characteristics are called aromatic compounds. Aromatic compounds are generally 5, 6 or 7 membered co planer cyclic compounds. It has alternative double bond that means there is a carbon-carbon single bond and a carbon-carbon double bond in the aromatic compounds.

[You will know detail about the characteristics of aromatic compounds in next class]

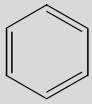
Hydrocarbons that have no aromatic characteristics are known as aliphatic hydrocarbon. There are two types of aliphatic hydrocarbon and they are– open chain hydrocarbon and other is closed chain hydrocarbon.

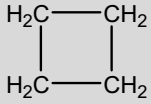
Activity: Differentiate the following hydrocarbon as open chain and closed chain and aromatic hydrocarbon.

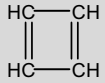
CH_3-CH_2-CH_2-CH_3



CH_3-CH_2-CH_3







Hydrocarbons that have at least two terminal carbons are known as open chain hydrocarbon such as- methane (CH_4), ethane (C_2H_6), ethene (CH_2=CH_2).

Student's activity: Write the definition of the closed chain hydrocarbon with the help of the above examples.

Open chain hydrocarbons are of two types such as *saturated* and *unsaturated* hydrocarbons. In the carbon chain of the saturated hydrocarbon carbon atoms are attached with each other with the formation of single covalent bond and rest of the valences of carbon are filled by hydrogen atoms. These are called alkane. Such as ethane (CH_3-CH_3), propane (CH_3-CH_2-CH_3) , butane (CH_3-CH_2- CH_2-CH_3) etc.

On the other hand in the carbon chain of unsaturated hydrocarbons there is at least two carbon atoms which are attached with double bond or triple bond and other valences of carbon atom are filled by hydrogen atom.

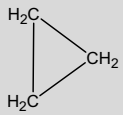
Unsaturated hydrocarbons are further divided into two classes such as alkene and alkyne. Double bonded hydrocarbons are called alkene and triple bonded hydrocarbons are called alkyne.

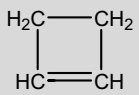
Unsaturated hydrocarbons– ethene (H_2C=CH_2), propene (H_3C-CH=CH_2), ethyne (HC≡CH), propyne (H_3C-C≡CH).

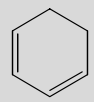
Student's activity: make a list of alkane, alkene and alkyne with the compounds mentioned in the different chapters of this book.

Closed chain aliphatic hydrocarbons are called alicyclic compounds. In the carbon chain of closed chain alicyclic hydrocarbons there may be one or more than one single bond and double bond. They are mainly divided into two types, such as – saturated alicyclic and unsaturated alicyclic hydrocarbons.

Task: Separate the following compounds as saturated and unsaturated hydrocarbons.







2. Saturated hydrocarbon (alkane):

In the carbon chains of saturated hydrocarbon the carbon atoms are attached with each other by single bond and the rest of the valences of carbon atom are filled by hydrogen. The smallest member of saturated hydrocarbon class is methane (CH_4). Petroleum is the combination of different hydrocarbons. Saturated hydrocarbons are separated from the petroleum by fractional distillation. This method is not feasible for industrial production.

Preparation: Saturated hydrocarbon (methane) is prepared from the carbon mono oxide and carbon-di-oxide in industry as well as the separation from the petroleum. The mixture of carbon mono oxide (CO) and hydrogen or carbon di oxide (CO_2) and hydrogen flown on the heated nickel catalyst produce huge amount of methane.

$$CO_{(g)} + H_{2(g)} \xrightarrow[Ni]{250^0C} CH_{4(g)} + H_2O_{(g)}$$

$$CO_{2(g)} + 4H_{2(g)} \xrightarrow[Ni]{250^0C} CH_{4(g)} + 2H_2O_{(g)}$$

Besides this, small alkane are prepared by the pyrolysis of the higher alkane obtained from the partial distillation of petroleum. Kerosene the part of petroleum was used in laboratories by pyrolysis at high temperature, in our country, before natural gas exploration. Besides this, alkanes can be prepared in laboratory from the salts of fatty acid.

Physical property: Melting point, boiling point and physical states of saturated hydrocarbon depends on the number of the carbon atom in the compound. Physical state of saturated hydrocarbon changes with the change of the number of carbon atom. Saturated hydrocarbons with carbon number 1-4 remain in gaseous state. Its boiling point is less than the room temperature. Saturated hydrocarbons with carbon number 5-15 remain in liquid state. Its boiling point is greater than the normal room temperature. Boiling point of 5 carbon atom containing saturated hydrocarbon pentane is 36^0C. Saturated hydrocarbons which have the number of carbon are 16 or more are generally solid.

Alakane	Chemical formula	Melting point	Boiling point	Physical state
Methane	CH_4	-183^0C	-164^0C	Gaseous
Ethane	CH_3-CH_3	-183^0C	-89^0C	Gaseous
Propane	CH_3-CH_2.CH_3	-190^0C	-42^0C	Gaseous
Butane	CH_3-CH_2-CH_2-CH_3	-138^0C	-1^0C	Gaseous
Pentane	CH_3-CH_2 -CH_2-CH_2-CH_3	-130^0C	36^0C	Liquid
Hexane	CH_3-CH_2 -CH_2-CH_2 CH_2-CH_3	-95^0C	69^0C	Liquid
Hexadacane	$C_{16}H_{34}$	18^0C	135^0C	Solid
Icosane	$C_{20}H_{42}$	37^0C	343^0C	Solid

Table 11.2: Melting point, boiling point and physical state of different of alkan 5

Student's activity: C_7H_{16}, C_8H_{18}, C_9H_{20} write down the possible melting point and boiling point with cause.

Chemical properties:

Alkanes are formed by strong covalent bond of carbon-carbon and carbon-hydrogen. So these compounds generally do not take part in chemical reactions. That's why these are called paraffin. Paraffin means affinity less. They do not react with acid, base, metal and oxidant. Octane (C_8H_{18}) even do not undergo reaction with sulphuric acid, sodium metal and potassium permanganate. Alkane takes part in oxidation, substitution of halogen and thermal decomposition reactions.

Combustion: Alkanes are formed by the combination of carbon and hydrogen. Both carbon and hydrogen are flammable substances. But hydrogen is more flammable in respect to carbon. Saturated hydrocarbon or Alkane reacts with excess oxygen or air and produce CO_2 and H_2O. Sufficient amount of heat energy is produced in this reaction that is why alkanes are used as fuel.

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)} + \text{heat}$$

$$C_2H_{6(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 3H_2O_{(g)} + \text{heat}$$

If the supply of oxygen is not sufficient then the combustion of Alkane does not complete. Incomplete combustion produce carbon mono oxide $CO_{(g)}$ and carbon $C_{(s)}$ instead of carbon di oxide $CO_{2(g)}$.

$$2CH_{4(g)} + 3O_{2(g)} \longrightarrow 2CO_{2(g)} + 4H_2O_{(g)} + \text{heat}$$

$$CH_{4(g)} + O_{2(g)} \longrightarrow C_{(s)} + 2H_2O_{(g)} + \text{heat}$$

Home work: Incomplete combustion causes harm to health, environment and economy- give your opinion

Halogen substitution: Halogen substitution reaction is a characteristical reaction of alkane. Methane reacts with chlorine in presence of sun light and produce methyl chloride (CH_3Cl), dichloro methane (CH_2Cl_2), trichloromethane ($CHCl_3$) and tetrachloromethane (CCl_4). One chlorine atom is replaced by one hydrogen atom in each step of the reaction and produce hydrogen chloride gas. It is chain reaction and cannot be controlled easily.

$$CH_{4(g)} + Cl_{2(g)} \longrightarrow CH_3Cl_{(g)} + HCl_{(g)}$$

$$CH_3Cl_{(g)} + Cl_{2(g)} \longrightarrow CH_2Cl_{2(g)} + HCl_{(g)}$$

$$CH_2Cl_{2(g)} + Cl_{2(g)} \longrightarrow CHCl_{3(g)} + HCl_{(g)}$$

$$CHCl_{3(g)} + Cl_{2(g)} \longrightarrow CCl_{4(g)} + HCl_{(g)}$$

Chlorine substitution reaction of Alkane is very significant to petro chemical industries. The product of this reaction CH_3Cl is used to produce different chemical substance (alcohols, aldehyde and organic acids) in industrial sector. Dichloromethane CH_2Cl_2 is

used as solvent in emulsion dye industry, trichlomethane $CHCl_3$ or chloroform is used as anesthetic and tetrachloromethane CCl_4 used as solvent in dry wash. Chlorinated hydrocarbons are toxic and toxicity depends on the number of chlorine in the compounds. Tetrachloromethane can dissolve grease and dirt easily.

Cracking:

More useable small molecules of hydrocarbon is produced by breaking large molecule of hydrocarbons and this breaking method is known as cracking. Cracking is done in two ways. If it occurs at high temperature and pressure in absence of catalyst known as thermal cracking, if it occurs at low temperature and pressure in presence of catalyst is known as catalytic cracking. Cracking process is not complete in a single reaction. Mixture of hydrocarbons and small amount of double bonded hydrocarbons are produced in this reaction. One possible reaction of this kind is

$$C_{15}H_{32} + Cl_{2(g)} \longrightarrow \underset{\text{Ethene}}{2C_2H_4} + \underset{\text{Propene}}{C_3H_6} + \underset{\text{Octane}}{C_8H_{18}}$$

Generally cracking reaction can be expressed as follows-

Long chain alkane ⟶ Mixture of small chain Alkane + Mixture of small chain alkene

Thermal cracking: If long chain Alkane are heated at high pressure (70 atm) and temperature (about 750^0C) produce mixture of small chain Alkane and alkene by breaking the bond of long chain.

Catalytic cracking: If catalyst is used to accelerate the cracking reaction then it is said Catalytic cracking or catalytic dissociation. Generally zeolites, aluminium oxide(Al_2O_3) or silicon di oxide (SiO_2) is used as catalyst. Zeolites are negatively charged alumino silicates (complex compound). It is a large lattice of aluminium, silicon and oxygen atoms. Small alkane (C_5-C_{10}) are prepared by breaking higher Alkane at comparatively low temperature (500^0C) and high pressure in presence of catalyst. In this reaction branched chain alkane and aromatic hydrocarbon (benzene) are produced. In presence of catalyst, in this reaction ethane is obtained as main alkene. Short chains Alkane are comparatively better than the long chain Alkane as fuel. So cracking reaction is a significant reaction in petroleum industries. Not only petrol fuel can be converted to diesel fuel by this reaction but also alkene and hydrogen gas can also be produced. In petrochemical industry alcohol and many other organic compounds and plastic are produced from alkene.

$$C_{18}H_{38} \longrightarrow C_6H_{14} + 6C_2H_4$$

$$C_{18}H_{38} \longrightarrow C_8H_{16} + C_{10}H_{20} + H_2$$

Other uses of Alkane: Alkane are used as fuel in different engines, to produce electricity, as lubricating oil and to produce different chemicals in chemical industries.

Besides this, long chained alkane are used to produce wax and to construct roads. Liquid and solid wax produced from alkane, mixes in a certain proportion and produces a substance like paste that can be used as ointment such as Vicks.

3. Unsaturated hydrocarbon (alkene and alkyne):

There is at least one double or triple bond in the chain of unsaturated hydrocarbon and rest of the valences of carbon is filled by hydrogen.

Unsaturated hydrocarbon with double bond is called alkene, and unsaturated hydrocarbon with triple bond is called alkyne.

A. Alkene: In alkene there is at least one double bond between two carbon atoms of the carbon and rest of the valences of carbon is filled by the hydrogen. The smallest and simple member of alkene class is ethene or ehelene ($H_2C=CH_2$).

Preparation of alkene: Little amount of the compounds of alkene class of hydrocarbon is found in nature. Most of the alkene which are used in petrochemical industries are produced by the catalytic dissociation of the higher Alkane obtained from petroleum. Dodecane is a constituent of kerosene obtained from the fractional distillation of petroleum when heated in presence of aluminium oxide and chromium oxide at 500^0C small chain close alkane and ethane are obtained.

$$C_{12}H_{26} \xrightarrow{500^0C} C_{10}H_{22} + H_2C{=}CH_2$$

$$C_{12}H_{26} \xrightarrow{500^0C} C_8H_{16} + C_4H_8 + H_2$$

When ethanol is heated in presence of aluminum oxide or dehydrated by sulphuric acid ethene is produced.

$$CH_3CH_2OH \xrightarrow[-H_2O]{H_2SO_4} H_2C=CH_2$$

$$CH_3CH_2OH \xrightarrow[-H_2O]{Al_2O_3,\ \triangle} H_2C=CH_2$$

Physical and chemical properties of alkene: Aalkene are flameable like alkane and exist in gaseous, liquid and solid state. Because of their significant chemical properties they are used in petrochemical industries. Because of the presence of carbon-carbon double bond in alkene molecule, they are chemically very reactive. Because the first bond of the double bond is although strong enough but the second one is comparatively weak. Oxidation, addition and polymerization are the characteristic reaction of the alkene.

Combustion : Alkene reacts with excess oxygen or air and produce $CO_{2(g)}$ and $H_2O_{(g)}$. Sufficient amount of heat is released from this reaction. Alkene is less combustible than Alkane because the percentage of carbon in alkene is less than Alkane.

$$C_2H_{4(g)} + 3O_{2(g)} \longrightarrow 2CO_{2(g)} + 2H_2O_{(g)} + \text{heat energy}$$

Addition of alkene: Because of the presence of carbon-carbon double bond in alkene molecule they take part in the addition reactions easily. In this reaction double bond between carbon atoms breaks and a single bond is retained.

1. Addition of hydrogen: In presence of metal catalyst (Ni) alkene reacts with hydrogen at 180-200^{0}C and produce alkane. This is called catalytic hydrogenation.

$$H_2C{=}CH_{2(g)} + H_{2(g)} \xrightarrow[Ni]{180 - 200^0C} H_3C{-}CH_{3(g)}$$

Liquid vegetable oil (where more than one bond presents) can be converted to margarine through the partial saturation with this reaction. Margarine is used to prepare butter.

2. Addition of bromine : Alkene reacts with orange-raddish coloured bromine water and produce 1,2-dibromoalkane. As a result of the reaction the colour of bromine water disappears. Unsaturated hydrocarbons can be identified by this reaction.

$$H_2C{=}CH_{2(g)} + Br_{2(g)} \longrightarrow BrH_2C{-}CH_2Br_{(g)}$$

3. Oxidation of alkene: Alkene such as ethene reacting with the dilute solution of potassium permanganate produce ethelene glycol by oxidation. In this reaction the violet colour of potassium permanganate solution disappears.

$$H_2C{=}CH_2(g) + KMnO_4(aq) \xrightarrow{H_2O} H_2C(OH){-}CH_2(OH)_{(l)}$$

4. Addition of water: At higher temperature (300^{0}C) and high pressure (60 atm) alkene reacts with water vapour in presence of phosphoric acid as catalyst and produce alcohol.

$$H_2C{=}CH_{2(g)} + H_2O_{(aq)} \xrightarrow[H_3PO_4]{300^0C,\ 60\ atm} H_3C{-}CH_2(OH)_{(l)}$$

In some countries such as in brazil alcohol is used as eco-friendly fuel. Alcohol is used as a solvent in petroleum industries in all countries. So this reaction is very significant. But industrially this reaction is not feasible. So alcohol is not produced in industry by this reaction.

Polymerization:

At high temperature (200^{0}C) and high pressure (1000 atm) innumerable alkene molecules link together and form a large molecule known as polymer and the reaction is known as polymerization reaction. Those innumerable reactant molecules which join, each of them are called monomer. All plastic materials and synthetic fibers are prepared by this reaction. Polymer obtain from ethylene molecule is known as polyethylene.

$$nH_2C{=}CH_{2(g))} \xrightarrow{200^0C,\ 1000\ atm} [-H_2C{-}CH_2{-}]_{n\,(s)}$$

B. Alkyne : In alkyne there is at least one triple bond between two carbon atoms in the carbon chain and rest of the valence of carbon is filled by the hydrogen. The smallest and simple member of this class is acetylene (HC≡CH).

Preparation of alkyne: Ethyne is produced by heating natural gas or methane at 1500^0C in presence of air. The required heat for this reaction is obtained by the partial combustion of methane. Ethyne is formed by bond breaking and bond formation in the methane molecule during the reaction.

$2CH_{4(g)} + 3/2\ O_{2(g)} \longrightarrow HC{\equiv}CH + 3H_2O_{(g)}$ + heat energy (partial combustiontion)

$2CH_{4(g)} \longrightarrow HC{\equiv}CH + 3H_{2(g)}$

Industrially ethylene gas is produced from calcium carbide. Adding water drop wise in calcium carbide ethyne or acetylene is produced.

$CaC_{2(s)} + H_2O_{(l)} \longrightarrow HC{\equiv}CH_{(g)} + Ca(OH)_2$

Physical and chemical properties of alkyne: Alkynes exist in gaseous, liquid and solid state like alkane and alkene. Two to four carbon containing alkynes are gaseous, five to eleven carbon containing alkynes are liquid and higher alkynes are solid. The alkynes are chemically very reactive but comparatively less than that of alkene. Alkyne takes part in the addition reaction with hydrogen and bromine. In the addition reaction of alkene with hydrogen and bromine produce single bonded compound by adding one molecule hydrogen or bromine, on the other hand, alkyne initially produce double bonded compound by the addition of one molecule hydrogen or bromine and next produce single bonded compound with the adition of another one molecule of hydrogen or bromine.

Task: Fill the places marked by question mark in the following reactions.

$CH{\equiv}CH \xrightarrow{H_2} ? \xrightarrow{H_2} ?$

$CH{\equiv}CH \xrightarrow{Br_2} ? \xrightarrow{Br_2} ?$

Test of unsaturation (Bromine water test):

Bromine solution is prepared by dissolving it in an organic solvent or in water which is red/brown in colour. Adding few drops of bromine solution in saturated and unsaturated hydrocarbon separately is shaken. Saturated hydrocarbons do not take part in reaction with bromine water as a result the colour of the solution remains unchanged. On the other hand unsaturated hydrocarbon (alkene, alkyne) take part in the reaction with bromine water and bromine molecule is added at the carbon-carbon double or triple bonded carbon. As a result red/brown colour of the bromine solution disappears. Differences between saturated and unsaturated hydrocarbon are made by observing the colour change of the bromine solution in the reaction.

$C_2H_{6(g)} + Br_2$(solution) $\longrightarrow$ No reaction occurred (colour of the solution is not changed)

$C_2H_{4(g)} + Br_2$(solution) $\longrightarrow$ $BrH_2C\text{-}CH_2Br$ (colour of the solution is changed)

$C_2H_{2(g)} + 2Br_2$(solution) $\longrightarrow$ $Br_2HC\text{-}CHBr_2$ (colour of the solution is changed)

In the same way the test of unsaturation can be done by using potassium permanganate solution.

11.5 Polymer: Most of our daily usual materials are polymer. Polymers are of two types. Natural and synthetic polymers. Natural polymers are cotton, rubber, rice, protein etc. and synthetic polymers are plastic materials, pen in your hand, polyester cloths etc.

A. Polymerization reaction

Innumerable molecules of the same matter or of different matters attached with each other to form a large molecule, this process is known as polymerization. Those innumerable reactant molecules which join, each of them are called monomer.

-A-A-A-A-A-A-A-A-A- -A-B-A-B-A-B-A-B-A-B-

Polymer where monomer = A Polymer where monomer = A-B

The process of polymerization of the innumerable number of molecule of same reactant is known as addition polymerization. In addition polymerization double bonded alkene react as a monomer. No small molecule is eliminated during the addition of innumerable monomers in an addition polymerization.

$$n H_2C=\underset{\displaystyle X}{\underset{|}{C}}H_{(g)} \longrightarrow -\!\left[H_2C-\underset{\displaystyle X}{\underset{|}{C}}H \right]_n$$ (X = various radicals with valence **1**)

B. Classification of polymers: On the basis of source, polymers are of two types:

1. Natural polymer: Many polymers are produced naturally, such as cellulose and starch in plants. Both of them are polymers which are formed by the combination of many glucose molecules. If we express glucose as ‘g’ or ‘glc’ the structure of starch or cellulose is -g-g-g-g-g-g-. Though they look alike, their bond formation mechanism is different. In this way a long chain is formed by the combination of more than one glucose molecule successively. Starch and glycogen deposited in animal body, is the polymer of glucose.

Protein forms the cells and tissues in your body. Protein is a polymer of amino acid. A polymer named insulin contains 22 amino acids. Astringent juice of a rubber tree is a natural polymer. Rubber is cultivated in the Hill tracks, Cox’s bazaar, Hobigonj, Sylhet and Tangail district in our country.

Plastic industries are synthesizing several times more rubber than the natural amount.

2. Synthetic polymer or plastic

It is found as hard, light, cheap and in any choiceable colour. Plastic can be melt and can be given any shape by molding. The word plastic has come from the Greek word ‘Plastikos’ means possible to melt. Many of us make paper weight by melting the rejected ball pens. It is dangerous because melting on heating or burning the plastic materials produces many toxic gases. Plastic is used to produce various products like pots for keeping foods, packet, ball pen, chair, table, motor parts, tank of water, bowl, bucket, mug etc.

All plastic materials are polymer. Chemists use the word *'plastic'* to describe some characteristic properties of polymer compounds. Innumerable small molecule attach with each other and form polymer. The small molecules are called monomer.

Plastic is produced from the polymerization of chemical substances particularly double bonded alkene, aldehyde, alcohol, amine, organic acid. To make plastic and fiber these ingredients are separated from the petroleum or produce from the petroleum.

Student's activity: Write the formula of the addition polymer from the following monomers:

$CH_2{=}CH\text{-}CH_3$	$CH_2{=}CH\text{-}Cl$	$CF_2{=}CF_2$
Propene	Venylchloride	Tetrafluroethene

At the beginning of the preparation of polymer, polymer of ethelen (polyethylene) is produced in presence of little oxygen at 200^0C temperature and 1200atm pressure. There are many branched carbon chain in that polyethylene, that is why density and melting point of polymer is low and it is soft in nature. This polyethylene is known as LDPE (low density poly ethylene). German chemist Karl Ziegler prepared polyethylene at low temperature and pressure (60^0C and 1atm) in presence of catalyst. In this polyethylene the number of branch is lesser that is why density and melting point is relatively higher. The hardness increases of this polyethylene due to the fewer number of branches. This is called high density polyethylene (HDPE).

The method of polymerization where innumerable molecule of more than one different reactant and linked together is called condensation polymerization. In condensation polymerization aldehyde, alcohol, amine and organic acid react as monomer. In the condensation polymerization small molecule like carbon di oxide (CO_2) and water (H_2O) eliminate during the combination of innumerable monomers. If two different functional groups are attached with two ends of a reactant, polymerization occurred by joining more than one molecule of that reactant. Commonly used condensation polymer is nylon. Innumerable di carboxylic acid and di amine link together at high temperature and pressure in presence of catalyst and produce nylon.

$$nHOOC\text{-}(CH_2)_4\text{-}COOH + nH_2N\text{-}(CH_2)_6\text{-}NH_2 \longrightarrow \{\text{-}OC\text{-}(CH_2)_4\text{-}CONH\text{-}(CH_2)_6\text{-}NH\text{-}\}_n + 2nH_2O$$

Natural polymers (starch, cellulose and protein) are condensation polymer. Thread can be made from the natural polymer such as cellulose, wool, and silk but thread can not be made from starch and rubber. That means natural polymers are of two types. Synthetic polymer (nylon, polyester) is used to make cloths, rope and tooth brush.

Name of the polymer	Chemical formula of monomer	Properties of polymer	Uses
Polyethylene	$H_2C{=}CH_2$	Not to cut easily durable	Plastic bag, plastic sheet

Name of the polymer	Chemical formula of monomer	Properties of polymer	Uses
Polypropene	$H_2C=CH-CH_3$	Not to cut easily, durable	Plastic rope, plastic bottle
Polyvinyl chloride(PVC)	$H_2C=CHCl$	Hard , solid and less softer than polyethylene	Water pipe, electric insulator
Polytetrafulroethene (PTFE) or Teflon	$F_2C=CF_2$	Non sticky, heat proof	Non sticky pots
Nylon	$HOOC-(CH_2)_x-COOH$ and $H_2N-(CH_2)_x-NH_2$	Glitters, durable, soft	Artificial cloths, rope, tooth brush

Table 11.3 Properties and uses of different polymers

C. Classification of plastic on the basis of the properties and uses:

Depending upon structure and thermal properties synthetic polymers (plastics) are of two types. One type of these form long thin crossed linked chain. In this type of polymer chain strong bonds form between the carbon, but their remains a weak attraction force among the neighboring chains.

These chains are able to cross over one another. As a result these polymers can be easily expanded, curved and melted on heating. These polymers are called thermoplastic. Examples- Polyethylene, polypropylene, PVC etc. Thermo plastics can be melted several times and converted to materials of different shapes. In the second type of polymer carbon atoms in the chain are attached by covalent bonds and at the same time the carbon atoms of one chain is attached strongly by hydrogen bond with the carbon atoms of neighboring chain. This type of polymer is thermosetting. Thermosetting plastic is harder and less soft than thermoplastic. On heating they turn to coal instead of melting. At this stage if the cross link of the carbon chain breaks, polymer dissociates. Thermosetting plastics are melted and shaped once; normally it is done by compression molding. Examples: Bakelite, fiber glass, synthetic reign and epoxy glue.

Student's activity: Classify the polymers you used as thermoplastic and thermosetting

D. Advantages and disadvantages of synthetic polymer or plastic:

After the second world War the use of the synthetic polymers or plastic products are increasing all over the world significantly. Now plastic materials have taken the places of usual things of woods, paper, glass and metal. The use of plastic materials is increasing instead of wood and metal product, because of various characteristics of plastic. Plastic is cheap, not corrode, do not react with chemical substances, can be

colored easily, electrically insulator, light in weight, easy to carry, durable and not damaged by weather.

Although plastic materials have wide advantages but there are some disadvantages too. The main problem of using artificial polymer or plastic is that it is not dissociate and pollute the environment. Most of the natural elements decompose by the bacteria of the soil, but plastic products do not decompose by bacteria. That is why plastic is called non biodegradable substance. In many cases plastics are destroyed by burning by which toxic gases produce (hydrogen chloride, aldehyde, hydrogen cyanide). These gases are carcinogenic and cause other diseases to human. Now scientist produce synthetic polymer which decomposes initially by sunlight (photo-degradable) and then decomposes naturally by bacteria (bio-degradable). This polymer is known as biopolymer. Most of the biopolymer is prepared from sugarcane and corn. This polymer needs 20-30 years to decompose by the bacteria. Polyethanol $\{-CH_2-CH(OH)-\}_n$ is one type of polymer which is used in hospital and dissolves in water. Solubility of polyethanol depends on the value of 'n'.

Plastic polymers are prepared from the monomers that are collected from fossil fuel. As a result the stock of limited fossil fuel is decreased. On the other hand the electricity produced from the 4% of total fossil fuel is used in manufacturing plastic products. The demand on the fossil fuel can be decreased by recycling the plastic and not using the unnecessary plastic. It is necessary to decrease the dependency on the synthetic fiber to maintain the balance of environment. Use of natural fiber can be increased including cotton, wool and jute. The land of Bangladesh is fertile, so the use of synthetic fiber can be decrease by cultivating mesta along with cotton and jute. Philippine and Indonesia spin cloths with improved yearn obtained from the leaves of pineapple and fiber of banana trees.

11.6 The preparation of alcohol, aldehyde and organic acid from hydrocarbon

The main constituent of petroleum is hydrocarbon (alkane, alkene and alkyne). All kinds of organic compounds are prepared from hydrocarbons. Saturated hydrocarbon or alkane reacts with halogens and produce alkylhalide. Alkene reacts with hydrogen bromide and produce alkyl bromide. Alkyl halides react with aqueous solution of sodium hydroxide and converts to alcohols. If produced alcohol is oxidized by strong oxidant ($K_2Cr_2O_7$ and H_2SO_4) produce firstly aldehyde/ketone and later on converts to organic acid.

$R\text{-}CH_2\text{-}CH_3 + Br_2 \longrightarrow R\text{-}CH_2\text{-}CH_2Br + HBr$

$R\text{-}CH{=}CH_2 + HBr \longrightarrow R\text{-}CH_2\text{-}CH_2\text{-}Br$

$R\text{-}CH_2\text{-}CH_2\text{-}Br + NaOH_{(aq)} \longrightarrow R\text{-}CH_2\text{-}CH_2\text{-}OH + NaBr$

$R\text{-}CH_2\text{-}CH_2\text{-}OH + [O] \longrightarrow R\text{-}CH_2\text{-}CHO$

$R\text{-}CH_2\text{-}CHO + [O] \longrightarrow R\text{-}CH_2\text{-}COOH$

R= alkyl radical
$-CH_3$, $-C_2H_5$, $-C_3H_7$ etc

Task: Alkene ⟶ Alkyl halide ⟶ Alcohol ⟶ Aldehyde/Ketone ⟶ Organic acid

Besides this method alcohol, aldehyde and organic acid can be prepared from the hydrocarbons. Alkene reacts with water vapour at 300^0C temperature and 60atm pressure in presence of phosphoric acid and produce alcohol.

$$H_2C{=}CH_{2(g)} + H_2O_{(aq)} \xrightarrow[H_3PO_4]{300^0C,\ 60\ atm} H_3C\text{-}CH_2OH_{(l)}$$

Alkyne reacts with water in presence of 2% mercuric sulphate ($HgSO_4$) and 20% sulphuric acid (H_2SO_4) produce aldehyde. Due to the toxicity of $HgSO_4$, it is descuraged in industrial uses.

$$H_2C{=}CH_2(g) + H_2O(g) \xrightarrow{HgSO_4,\ H_2SO_4} H_3C\text{-}CH_2OH(l)$$

Alkane found from petroleum, oxidized by atmospheric oxygen at high temperature and pressure, produce ethanoic acid.

$$H_3C\text{-}CH_{3(g)} + [O] \longrightarrow H_3C\text{-}COOH_{(l)}$$
$$H_3C\text{-}CH_2CH_{3(g)} + [O] \longrightarrow H_3C\text{-}COOH_{(l)}$$

11.7 Uses of alcohol, aldehyde and organic acid

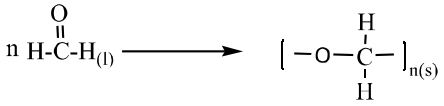
Alcohol: Methanol is a toxic chemical substance. Methanol is mainly used in the preparation of other chemical substances. In chemical industries ethanoic acid and aster of different organic acids are produced. Ethanol is mainly used as solvent in perfume, cosmetics and pharmaceutical industries. Pharmaceutical graded ethanol is used in pharmaceutical industries and rectified spirit is used in homeopathic medicine. 96% aqueous solution of ethanol is known as rectified spirit. Those substances which are not soluble in water are used by dissolving in ethanol. Ethanol is widely used in perfume industry. Ethanol is made free from odour before using in perfume. Except pharmaceuticals and food industries, rectified spirit before using in other industries is mixed with little amount of methanol to make it toxic. This is called methyleted spirit. It is used to burnish the wood and metallic furniture. Now in Brazil ethanol is used in motor engine as fuel instead of fossil fuel. Gasohol is one kind of fuel where 10-20% ethanol is mixed with petrol.

$$CH_3CH_2OH_{(l)} + 9/2\ O_{2(g)} \longrightarrow 2CO_{2(g)} + 6H_2O_{(g)} + \text{heat energy}$$

Alcohol can be prepared from starch (rice, wheat, potato and corn) by fermentation. Beside that ethanol can be obtained similarly from the molasses (by product of sugar). Karu and Karu co at Darshona in Bangladesh produce ethanol and meet the demand of the country. If we use ethanol as fuel, the demand on fossil fuel will be decreased, on the other hand environment can be kept pollution free.

Aldehyde: The use of aldehyde in industries is comparatively less. But to produce other chemical substance it is used abundantly. Methanal or the saturated aqueous solution of formaldehyde (40% by volume, 37% by weight) is known as 100% formalin which is mainly used to preserve dead animals.

Plastic materials can be made from aldehyde by polymerization reaction. Aqueous solution of lower molecular weight aldehyde (methanal) heated at low pressure produce a hard polymer known as Derlin. Derlin is used to make chair, table, bucket etc. Which would previously made by wood or metals.

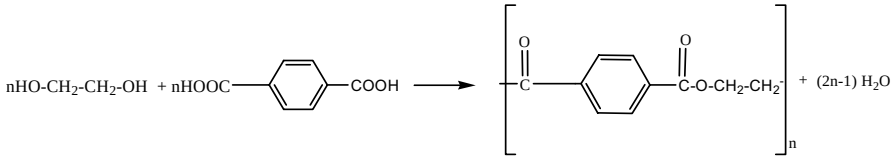


Here the number of monomer vary from five to fifty.

Condensatation polymerization reaction of formaldehyde (methanal) and urea produce urea-formaldehyde resin (melamine polymer) which is used to prepare house hold appliances like plate, drinking water pot, mug etc. Acetaldehyde is used to prepare paraldehyde which is used in producing sedative medicine.

Organic acid: Organic acids are weak compare to inorganic acids. Organic acids are edible constituent. We take organic acids as food with lemon juice (citric acid), tamarind (tartaric acid), curd (lactic acid). Having the capability of destroying bacteria organic acids are used as food preservative. 6-10% aqueous solution of ethanoic acid known as vinegar is used to preserve sauce and pickles.

Plastic is also produced from organic acid by polymerization reaction. Terilene (polyester) is a chemical fiber prepared by the condensation polymerization reaction of alcohol and organic acid and used to make cloths for pants and shirts. Here mentionable carbohydrate and oil based natural polymer is produced from alcohol and organic acid. Now the uses of polyester made cloth is decreasing day by day.



Organic acid is used to prepare perfumed like chemical.

Student's activity:

Techniques of uses of natural gas , petroleum and coal

In many cases there are sulphur, nitrogen present in natural gas, petroleum and coal. Take to consideration of the product of the reaction of these with oxygen in air

Carbon di oxide gas produces by burning natural gas, petroleum and coal. It is a green house gas.

Investigation on the effect of plastic materials on environment:

Consider the places where plastics are disposes, decomposition of plastic, possible of entering the sun light and air in the soil covered by the plastic, hindrance to root expansion of trees.

11.8 Differentiation of organic and inorganic compounds:

All the compounds you have learned in this chapter are organic. Organic compounds are formed by covalent bonding and inorganic compounds are formed by ionic bonding. But there are some organic compounds which achieve ionic characteristic. Similarly there are some inorganic compounds which achieve organic characteristic.

Student's activity: Define the organic compound.

Think: How to differentiate between organic and inorganic compounds on the basis of deference of ionic and covalent compounds. Taking some organic and inorganic compounds determine their melting point and show the differences.

Exercise

Multiple choice questions:

1. What is the percentage of ethane in natural gas?

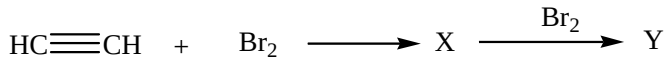
   a. 3% b. 4%

   c. 6% d. 7%

2. Which of the following compound can cause disappearance of red solution of bromine?

   a. C_3H_8 b. C_3H_8O

   c. C_3H_6O d. C_3H_4



Answer the question 3 and 4 from the above reaction.

3. What is the name of compound Y?

   a. 1,1-di bromopropane b. 2,2-di bromopropane

   c. 1,1,2,2-tetrabromopropane d. 1,2-dibromoprapene.

4. In the illustration X compound-

   i) Give addition reaction

   ii) Used to produce plastic

   iii) Less reactive than Y

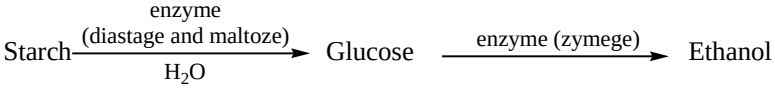
Which one of the followings is correct?

   a. i and ii b. ii and iiii

   c. i and iii d. i,ii and iii

Creative question:

1. In the month of March–June in Bangladesh huge amount of potato get rotten in Bangladesh due to lack of preservation. Ethanol can be prepared from the potato by the following reaction.



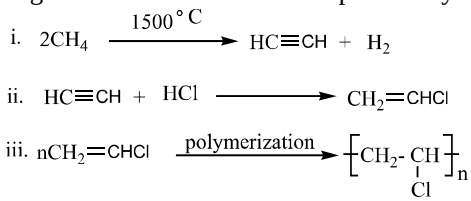
   a. What is the main constituent of petroleum?

   b. Why alkenes are more reactive than alkane? Explain.

   c. Give a description of the preparation of methane from potato.

   d. Analysis of the possibilities of using excess potato as a alternate fuel of fossil fuel.

2. A gas is converted to different product by the reactions i to iii successively.



   a. What is called hydrocarbon?

   b. Why benzene is aromatic hydrocarbon?

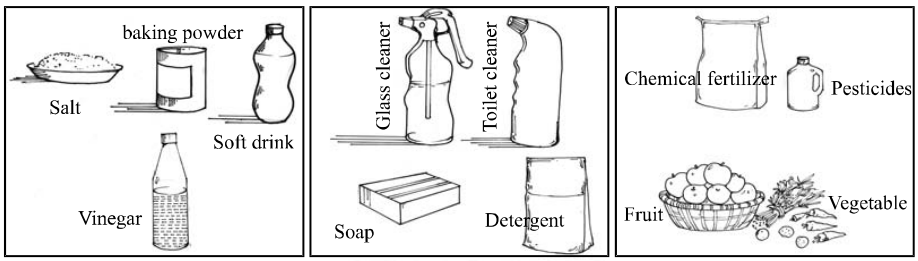
   c. What type of reaction is number ii ?

   d. Analysis the possibilities of diversification of uses of the first reactent gas in the illustration.

Chapter Twelve

Chemistry in our life

Mango is a very popular fruit in Bangladesh. People are afraid of eating fruit because calcium carbide is used to ripen them or preservatives are used. People think there is formalin in fishes, where will they go? The elements used to ripen fruits and as preservatives are chemical substances. All the chemicals used in our everyday requirement are not harmful. Every day we get up from bed with chemistry and go to bed finishing chemistry. Our foods, cosmetics, fertilizers-pesticides used to produce foods, cleaning materials etc. all are chemical substances. Realizing the importance of chemistry in our life the 100^{th} years of winning Nobel Prize in chemistry by Madam Merei Curei the international organization of chemistry and applied chemistry (IUPAC) celebrate the year 2011 as the year of chemistry. The demonstrated theme was "Chemistry is our life and Chemistry is our future".



By the end of this chapter we will be able to-

(1) explain the importance of collection, properties and uses of some house hold food materials.
(2) describe the importance of ph in determination of suitability of cosmetic materials in home.
(3) explain the preparation of household cleaning substances and mechanism of cleaning.
(4) control the ph value of soil in agriculture using appropriate compounds.
(5) explain the means of processing of agricultural products.
(6) explain the means of preservation of agricultural commodities.
(7) explain the harmful effect of chemical waste by knowing it.
(8) manufacture soap by using chemical substances.
(9) give opinion spontaneously with confidence about the appropriate use of chemical substances to prevent the pollution of soil, water and air.
(10) show interest about using health conscious commodities.
(11) show interest about using hygienic foods.
(12) exhibit the de-colorization process of bleaching powder.
(13) Show the role of baking powder in food products by experiment.

12.1 House hold Chemistry

Of course you have heard the story of *'Salty love'*. So you know food products cannot be imagined without salt. Vinegar is used to make fish-meat etc tasty and soft. Baking powder is used to blow up of cake, bread. We can not do without soft drink after taking rich or oily food.

1. Table salt or sodium chloride; (NaCl)

Huge amount of table salt or sodium chloride are dissolved in sea water. Again sufficient sodium chloride is found in underground as mineral. In our country the salt cultivators in coastal areas extract salt from sea water.

Students activity:

Make a concentrated solution of table salt in a pot. Put black polythene on a tray and pour out some solution in it, keep it in the sun for whole day. Add little solution in it everyday and keep it in the sun for whole day long. Be careful that no water can come out from the tray. Observe this for a week long.

- Explain the process of extracting salt by coastal salt cultivators on the basis of your observation.
- Observe the crystal of salt with a magnifying glass and describe the colour and size of the salt crystal.
- In rainy season keep some purified salt (pure NaCl) purified by evaporation process (in industry) in a pot, on the other pot some usually produced salt ($CaCl_2$, $MgCl_2$ mixed with NaCl) in the other pot for 2/3 days. Explain the hygroscopic property of salt on the basis of the observation.

Sodium salts meet the demand of total electrolyte in our body. Beside table salt sodium chloride is also used in the preparation of various compounds, in pharmaceutical industry, in soap industry and in dyeing industry to make the color permanent.

2. Baking powder: ($NaHCO_3$)

A very important ingredient in your kitchen is baking powder. Generally baking powder is used to blow up cake or bread. The main ingredient of baking powder is sodium hydrogen carbonate. Sodium hydrogen carbonate is produce by using lime stone, ammonia gas and table salt.

The concentrated solution of sodium chloride is known as brine. Brine is made saturated with ammonia. Lime and carbon dioxide is produced when calcium carbonate (lime stone) is heated at high temperature (600^0C). Following reactions occur when carbon dioxide passes through the ammonium saturated solution brine.

$$CaCO_3 \longrightarrow CaO + CO_2(g)$$

Lime stone — lime — carbon dioxide

Ammonium hydrogen carbonate is produced from the reaction of carbon dioxide, ammonia and water

$CO_2 + NH_3 + H_2O \longrightarrow NH_4HCO_3$

Ammonium hydrogen carbonate

Ammonium hydrogen carbonate reacts with sodium chloride in aqueous solution produce sodium carbonate and ammonium chloride.

$NH_4HCO_3 + NaCl \longrightarrow NaHCO_3 + NH_4Cl$

sodium hydrogen carbonate

Sodium hydrogen carbonate precipitated as crystal and it is then collected, dried and marked.

How sodium hydrogen carbonate blow up cake:

Sodium hydrogen carbonate (baking powder) is mixed with the flour of cake and heated. On heating sodium hydrogen carbonate dissociates to sodium carbonate, carbon dioxide and water. Carbon dioxide escaped through blowing up the flour.

$2NaHCO_3 \longrightarrow Na_2CO_3 + CO_2 + H_2O$

sodium carbonate

Sodium hydrogen carbonate ($NaHCO_3$) relieves the indigestion problem. Excess hydrochloric acid (HCl) is produced in stomach due to indigestion. Sodium hydrogen carbonate ($NaHCO_3$) neutralizes the hydrochloric acid (HCl) in stomach.

Students activity: Write the above neutralization reaction with proper symbols and chemical formula. Remember that $NaHCO_3$ is dissociated into metal and non metal ions.

One type of fungus named 'Yeast' is used in home or bakery to blow up bread. To do this initially yeast is added to a hot solution of sugar. Making knead by mixing this mixture with flour and keeping it in hot place knead begin to blow up.

The cause of blown up of knead is the respiration of yeast in presence of air. Yeast produces carbon dioxide gas during respiration with oxygen of air which helps to blow up the bread. After sufficient blown up, knead is baked in oven. Yeast dies in heat and blow up process stops.

$C_6H_{12}O_6 + 6O_2 \longrightarrow CO_2 + 6H_2O$ + heat energy

Glucose

Students activity: Mix baking powder and yeast with flour separately and keep it for some time and make cake with it. Compare the two cakes. If there is difference, explain the cause of it.

3. Vinegar

Vinegar is 5-6% aqueous solution of ethanoic acid. Ethanoic acid dissociates partially in aqueous medium. As a result small number of hydrogen ion is produced in aqueous solution. The pH value of the ethanoic acid is less then 7 yet.

$CH_3COOH \rightleftharpoons C\ H_3COO^- + H^+$

Vinegar is used to preserve food products like pickles. Bacteria is responsible for putrefing the pickles. H^+ ion of ethanoic acid of vinegar hydrolyses the protein and fat of bacteria. As a result bacteria die and pickles become safe from getting rotten. Vinegar is used to marinate (keeping fish, meat with turmeric and chili) fish, meat, which helps to break the protein and make the food soft and tasty.

Preparation of ethanoic acid: Ethanoic acid is produce in laboratory from the oxidation of the ethanol by potassium-di-chromate in presence of sulfuric acid

$$CH_3CH_2OH \xrightarrow{[O]} CH_3CHO + H_2O$$

$$CH_3CHO \xrightarrow{[O]} CH_3COOH + H_2O$$

Industrially pure ethanoic acid is synthesized from ethyene or acetylene. Heating ethyne gas (obtained from the thermal dissociation of petroleum) at 60^0C temperature passes through the aqueous solution of 2% mercuric sulphate and 20% diluted sulphuric acid. As a result ethanal is produced. Here mercuric sulphate ($HgSO_4$) and diluted sulphuric acid (H_2SO_4) acts as catalyst.

$$HC \equiv CH \xrightarrow[2\%\ HgSO_4,\ 60^0C]{20\%\ H_2SO_4} CH_3CHO + H_2O$$

Ethanoic acid is produced from oxidation of ethanol by atmospheric oxygen in presence of manganus acetate at 60^0C temperature.

$$CH_3\text{-}CHO \xrightarrow{Mn^{2+},\ 60^0C} CH_3COOH$$

30/35 years ago the rural people of our country used to make vinegar by drying date juice in sunlight and used to preserve pickles.

Students activity: Make a list of substances used in your home or by your neighbors to preserve foods. Determine the pH value of the listed substances. Explain your concept about the preservation mechanism of those substances.

4. Soft drinks

Who do not desire to drink soft drinks after eating reach foods like polao, biriani etc.?

Soft drinks are in fact the aqueous solution of carbon di oxide. Excess amount of sugar is dissolved in it. Its color and taste is changed mixing other ingredients. Carbon di oxide is dissolved in water under high pressure at cold condition. Carbon dioxide gas comes out from the solution as bubbles when temperature increases or pressure decreases. So on opening a bottle of a soft drink gas and liquid comes out with foam. That is why we feel better to drink these drinks at cold condition. Carbon di oxide dissolves in water and produce carbonic acid.

$$CO_{2(g)} + H_2O_{(l)} \longrightarrow H_2CO_{3(aq)}$$

Carbonic acid accelerates the enzymatic activities in digestion. Carbonic acid is a weak acid. A small number of molecules of carbonic acid dissociates in water.

Students activity:

1. Add water in baking powder (mixture of sodium hydrogen carbonate and tartaric acid) or add lemon juice in edible soda (sodium hydrogen carbonate) and observe. Compare your observation with the seen of the opening a cap of a soft drink bottle.

2. Make a survey among your class mates, how many of them take soft drink every day, how many of them take it time to time and how many of them take it seldom. Observe each of their health and write note. Determine the relation of drinking soft drinks to health. Submit a report on the advantages and disadvantages of drinking soft drinks.

12.2 Chemistry in cleaning works

Cleanness is a part of faith. Cleanness also expresses the personality of a man. To say about the cleaning agent we can remember toilet soap, shampoo, tooth paste, laundry soap, detergents, washing soda, bleaching powder, glass cleaner, toilet cleaner etc. On consideration of reading expedient the substances have been mentioned before or after.

1. Washing soda or soda ash

Soda ash or washing soda is produced when sodium hydrogen carbonate dissociates on heating.

$$2NaHCO_3 \xrightarrow{\triangle} \underset{\text{Sodium carbonate}}{Na_2CO_3} + CO_{2(g)} + H_2O$$

Soda ash dissolves in water. In aqueous solution soda ash converts to strong base sodium hydroxide and weak acid carbonic acid. Being a strong base sodium, hydroxide is completely ionized as Na^+ and OH^- ion in aqueous solution whereas carbonic acid being a weak acid dissociates slightly.

$$Na_2CO_{3(s)} + 2H_2O_{(l)} \longrightarrow 2Na^+_{(aq)} + 2OH^-_{(aq)} + H_2CO_{3(aq)}$$

Students activity

1. Justify the above reaction by determining the pH of the aqueous solution of soda ash by using litmus paper.

2. We take soda ($NaHCO_3$) in indigestion but not soda ash. Give your opinion on the basis of the results by determining the pH of both the solutions.

2. Toilet cleaner

Main ingredient of toilet cleaner is caustic soda; NaOH. Corrosive properties of sodium hydroxide ion play the main role in cleaning toilet. Caustic soda (NaOH) is produced by

the electrolysis of brine or concentrated solution of table salt (NaCl). In aqueous solution of sodium chloride (NaCl) there presence Na^+,H^+, Cl^-, OH^-. Among these Na^+ and H^+ are cations and Cl^-, OH are anions.

Anode reaction

$4OH^- - 4e^- \longrightarrow 2H_2O + O_2$

$Cl^- - e^- \longrightarrow Cl$

$Cl + Cl \longrightarrow Cl_2$

Cathode reaction (platinum)

$H^+ + e^- \longrightarrow H$

$H + H \longrightarrow H_2$

Cathode reaction (mercury)

$Na^+ + e^- \longrightarrow Na$

$Hg + Na \longrightarrow Na\text{-}Hg$

$Na\text{-}Hg + H_2O \longrightarrow NaOH + H_2 + Hg$

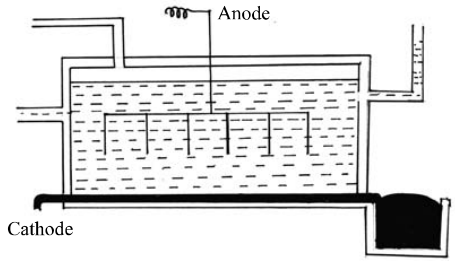


Fig 12.1: Mercury cathode cell

Student's activity

Analyze the effect on environment of the produced gas at anode, if we let the gas be exposed to the atmosphere. Explain where the gas can be used by closing.

There is a common ion in the solution of Na_2CO_3 and NaOH, mention the formula of that ion and explain the cause of the presence of that ion.

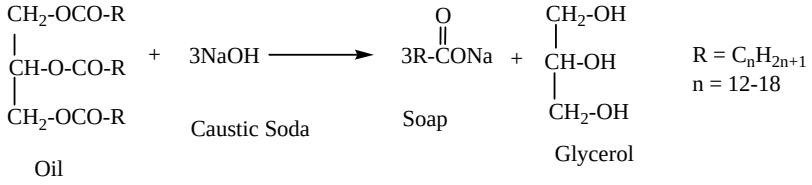
3. Soap (Toilet and laundry soap)

In ancient time in our country people used the soaked water of damping the ash of banana trees, bean herb or jujube (boroi) tree to wash cloths. Silt of river or canals or mastered oil cakes were used in bathing. It is assumed that about 2500 years ago Greeks and Romans used soap. Soap was made by the Romans by boiling the ash of the camp fire with skin, bone and the fat of animal. In the middle age soap was produced from lai by the people of England and Ireland. Lai is an alkaline liquid. Lai was prepared by soaking wood ash in water. It is used in cleaning purpose. Sometimes lai was used directly or sometimes it was boiled with animal fat to produce soap. The Egyptians made soaps from the fat of cow, buffalo, and camel even of lion. At the end of the middle age soap were made by boiling strong base caustic soda with fat. The industrial production of soap began in 1980. At the same time the production of caustic soda also began in a large scale.

Now a days there is a huge demand of soap all over the world. As a result there is an intense competition among soap manufacturer which results in increasing the quality of soap and the development of manufacturing process day by day. At present different kinds of soap is used in different needs. The main constituent of soap is fat and base.

Different fat and oil such as coconut, palm, mohua and olive oil is used in soap manufacturing. Caustic soda, caustic potash is used as base. Besides this considering using expedient different types of color and dyes are added to it.

Sodium or potassium soap is produced by hydrolysis of oil and fats with caustic soda or caustic potash. Produced sodium or potassium salt is known as soap and the reaction is known as saponification.



If sodium chloride is added in the produced mixture of the reaction then soap floats up. There is little amount NaCl, NaOH, Glycerol as impurities in the produced soap. Boiling the crude soap with water impurities dissolves. If the mixture is then cooled and water is removed and boiled again with water almost pure soap is obtained. Adding colour and fragrances in the soap and antiseptic and skin softening materials in toilet soaps, different shape is given using molds and trademark, brand etc. are engraved on it.

4. Detergent

Subsequent time of the First World War due to the scarcity of oil and fat first initiative was taken in Germany to produce soap from the byproduct of petroleum.

Detergent cleans the dirt by the same mechanism as soap. The molecular structure of detergent is different from that of soap.

Detergent is equally active in hard water also. Calcium and magnesium salts are dissolved in hard water. Calcium and magnesium ions react with soap and produce insoluble calcium and magnesium compound which floats at the upper layer of the water as film. As a result dirty clothes are not cleaned and cause the waste of soap. On the other hand, calcium and magnesium salt of detergent is soluble in water. As a result no difficulties arise in cleaning cloths in hard water.

Preparation of detergent:

a. Sodium lauryl sulphonate: Hydrolysis and hydrogenation of oil and fat produce different long chained alcohols (like lauryl alcohol). If sulphuric acid is added with the product the long chain alkyl (lauryl) hydrogen sulphate is produced. If lauryl hydrogen sulphate passes through the solution of caustic soda the detergent named lauryl sulphonate detergent is produced. Bleaching materials, fiber bighting materials and builders are mixed with the produced detergent. Detergents are marketed in the form of powder, cereal, liquids or bar.

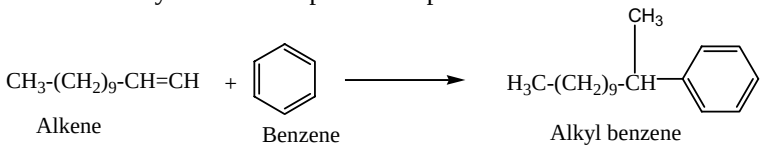
$CH_3\text{-}(CH_2)_{10}\text{-}CH_2\text{-}OH + H_2SO_4 \longrightarrow CH_3\text{-}(CH_2)_{10}\text{-}CH_2\text{-}O\text{-}SO_3\text{-}H + H_2O$

Lauryl alcohol — Sulphuric acid — Lauryl hydrogen sulphate

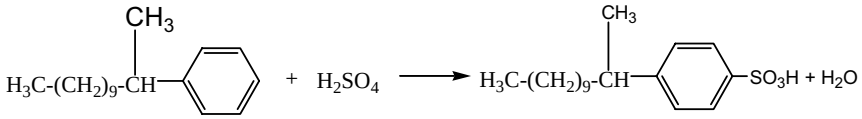
$CH_3\text{-}(CH_2)_{10}\text{-}CH_2\text{-}O\text{-}SO_3\text{-}H + NaOH \longrightarrow CH_3\text{-}(CH_2)_{10}\text{-}CH_2\text{-}O\text{-}SO_3Na + H_2O$

Lauryl hydrogen sulphate — Caustic soda — Sodium lauryl sulphonate

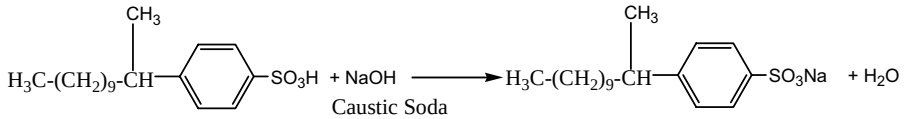
b. Sodium alkyl benzene sulphonate: Alkyl benzene is produced from the reaction of long chained alkene with benzene. If sulphuric added with the product alkyl benzene sulphonic acid is produced. If this acid is neutralized by caustic soda, a detergent known as sodium alkyl benzene sulphonate is produced.



Alkene — Benzene — Alkyl benzene



Alkyl benzene — Sulphuric acid — Alkyl benzene hydrogen sulphonate



Alkyl benzene hydrogen sulphonate — Caustic Soda — Sodium Alkyl benzene sulphonate

5. Cleaning mechanism of soap and detergent

Soap or detergents are the molecules of long chained carbon. In solvent soaps or detergent dissociate into negatively charged soap or detergent ion and positively charged sodium ion. Negatively charged end of the soap or detergent is attracted by the water. This negative end of the detergent is known as hydrophilic. The other positive end of the detergent is known as hydrophobic. The hydrophobic end dissolves in oil or grease.

When dirty clothes are damped in the water with soap and detergent then the hydrophobic part attracts the oily and greasy dirt of the clothes and dissolves in it. On the other hand hydrophilic part extends to the adjacent water layer. In this condition if clothes are rubbed or twisted the oily and grease dirt is completely covered by the hydrophilic part. A ring of negative charge ion formed around the oil and grease molecules. So they want to stay at possible maximum distance. As a result a scum of oil and grease is floated in water and washed away with water. As a result clothes become clean.

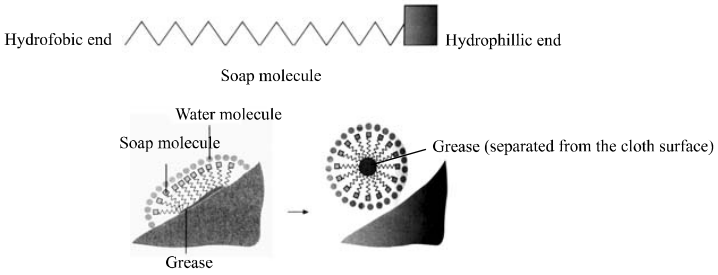


Figure 12.2: Cleaning mechanism of soap and detergent

6. Bad effects of using excess soap or detergent

Excess use of soap and detergent may destroy the color and spinning of clothes may create infection in hands skin. Soap cleans well in soft water but close the drain by the formation of dense scum. Detergent does not create such problem. Some detergents are non bio degradable. So they harm the environment in various ways.

Bio degradable compounds are dissociated by the micro organism and converts to simple compound. Non bio degradable detergents flow into river-canal, drains with water and create foam there. This foam destroys the aquatic environment. In many countries non bio degradable detergents are forbidden.

Soaps that are made of vegetable oil are bio degradable. But the disposals of used soaps in house and other places float on the surface water of river, canal, drain. So there is less possibility for these disposals to come in contact with bacteria. That is why excess use of soap is harmful to environment. So the use of soap and detergent should be reduced.

Phosphate is used in some detergents to increase the cleaning capacity of a detergent. Phosphate converts water into soft water. This phosphate comes to river, canal, drains swiping with water. Phosphates are good fertilizer to moss and other aquatic plants. As a result these plants increase rapidly. For the dissociation of extended aquatic plants at the end of life cycle consume the dissolved oxygen of water. Aquatic lives die because of insufficient dissolved oxygen. So it is necessary to control the amount of phosphate in detergent.

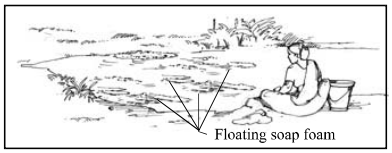


Figure 12.3 scene of cloth washing on the bank of a river

Students Task: Experiment

Preparation of soap:

Hypothesis: Soap is produced by reaction of oil or fat with alkali. pH value of the produced soap will be more than 7.

Apparatus

- Bunsen burner/spirit lamp/ kerosene cooker.
- 2 beaker 400 mL
- 2 test tube
- 1 big porcelain bowl.
- 1 stirrer.
- 1 spatula
- 1 measuring cylinder (10 mL)
- 1 funnel
- 1 filter paper

Chemicals

- Coconut oil
- Caustic soda
- Saturated solution of NaCl
- Soap from market
- Kerosene oil

Saefty measure:

- In high temperature sodium hydroxide is very corrosive substance.
  So handle with care that no accident occurs by splitting.
- Do not use the produced soap on hand or body.

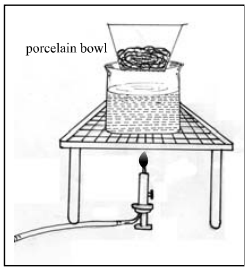


Figure 12.4 preparation of soap

Working method:

a. Prepare a steam bath in a beaker filled with water and put a porcelain bowl in it as in the figure.
b. Take 5mL coconut oil or 5g fat and 30ml Sodium hydroxide solution in the porcelain bowl.
c. Boil the mixture in steam bath for 30 minutes and stir it time to time with stirrer. Add water to maintain the deficit of water due to evaporation. At this time a sticky substance will be formed by removal of oily or fatty materials.
d. Then stop heating and let the mixture be cooled.
e. Add 50ml saturation solution of NaCl in the cold mixture and let it stay over night.
f. Next day filter the solution with filter paper and through away the filtrate and let the soap be dried.


Figure 12.5 filtration of soap

Test of the produced soap:

1. Take a test tube with one third of water and a piece of a specimen soap of yours in it. Shake it well by closing the test tube. Observe, is there any foam formed or not?
2. Add 2/3 drops kerosene in the test tube and shake it well and observe. Explain the result by considering the kerosene as grease.

3. Determine the pH value of your soap.
4. Repeat the above three steps of the experiment with soaps from the market and compare with your soap.
5. Submit a report to you teacher about the quality of your soap and the preparation method of soap.

7. Bleach

Many times there remain some dirt spots in spite of washing. This spots do not remove instead of washing with soaps or detergents. In these cases bleach is needed. Commonly used bleach in our country is bleaching powder Ca(OCl)Cl. Bleaching powder is produced when Cl_2 gas passes through the $Ca(OH)_2$ at 40^0C temperature.

$$Ca(OH)_{2(s)} + Cl_{2(g)} \longrightarrow Ca(OCl)Cl_{(s)} + H_2O_{(l)}$$

8. Spot removing technique of bleaching powder:

Bleaching powder reacts with atmospheric carbon dioxide and water and produce hypochlorus acid. Hypochlorus acid dissociates instantly and produces active oxygen. This active oxygen removes the spots by oxidation reaction. Active oxygen and HCl react and produce water and active chlorine. This active chlorine removes spots by oxidation.

$$Ca(OCl)Cl + H_2O + CO_2 \longrightarrow CaCO_3 + CaCl_2 + 2HClO$$

$$2HClO \longrightarrow 2HCl + 2[O]$$

$$2HCl + [O] \longrightarrow H_2O + 2[Cl]$$

Bleaching powder is widely used as antiseptic. Produced atomic oxygen oxidizes the protein of the germ and kills it.

9. Glass cleaner

One type of liquid is used to clean the glass of window, showcase, table, motor vehicle etc. the main element of that liquid is ammonia NH_3. Ammonia gas is produced by heating any ammonium salt with base. In laboratory ammonia gas (NH_3) is produced by heating ammonium chloride (NH_4Cl) with quick lime (CaO) or slaked lime {$Ca(OH)_2$}

$$2NH_4Cl(s) + CaO(s) \longrightarrow 2NH_3(g) + CaCl_2(s) + H_2O(g)$$

$$2NH_4Cl(s) + Ca(OH)_2(s) \longrightarrow 2NH_3(g) + CaCl_2(s) + 2H_2O(g)$$

Student's activity

Preparation of ammonia gas and test of its properties Using the apparatus and chemicals as arranged in the Figure 12.6.

Assistance : mix ammonium chloride with twice amount of slaked lime properly. Fill the reaction tube with the mixture less than half of the tube is filled with mixture keep slightly inclined the frontal part of the test tube. Think and answer.

1. Will there be any problem if the cork of the test tube and the outlet tube is not air tight?
2. Explain the importance of inclining the frontal part of the test tube on the consideration of production of water in the reaction.

3. What type of problems will arise if the reaction is carried out fully filling the test tube with the reaction mixture?
   [consider the volume, pressure, outlet path of the produced gas]
4. You have collected the gas in a dry gas jar/ test tube by holding up side down on the open end of the outlet tube. When the air filled gas jar is filled with gas, how is air removed from the jar? Compare the mass of ammonia and air.
5. How can you understand that the dry gas jar or test tube is filled with NH_3 gas? We can say in answer, hold a glass tube wetted by HCl acid in front of the open end of the gas jar or test tube. If you see there creates white smoke at the open end you will understand the tube is filled with the gas. The white gas is ammonium chloride (NH_4Cl). Write down the reaction of the production of NH_4Cl.

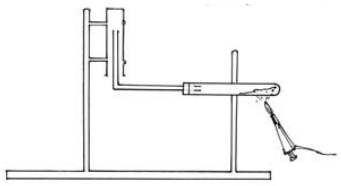


Figure 12.6 preparation and collection of ammonia gas

6. Close a gas filled test tube by your thumb and sink it into water then remove your thumb from the test tube. Observe the result. What decision can be taken from the observation?
   [where is the gas if the test tube is filled with water? Compare it with the result when sugar is mixed with water]
7. Hold a wet litmus paper in front of the open end of a gas jar or test tube filled with gas observe the result. Explain your conception about the chemical properties of the gas from the observation.
8. Where have you observed the odor of ammonia gas? One of these odory substance is used in cultivation. Present your logics in favor of the uses of these.

10. Industrial production of ammonia gas

Industrially ammonia gas is produced by Heber process. For this nitrogen N_2 and hydrogen H_2 gas is required for this. Of course you know that four fifth of the air is nitrogen. If air is cooled then nitrogen is separated as liquid.

The source of hydrogen is natural gas and water. In fact natural gas in our country is methane CH_4. Methane gas reacts with water vapor in presence of nickel as catalyst at 30atm pressure and 750^0C temperature and produces hydrogen gas and carbon-mono-oxide gas (CO). Carbon mono oxide again reduced the un-dissociated water vapor and produce hydrogen and carbon-dioxide gas (CO_2). Produced carbon dioxide gas can be separated easily as liquid on cooling. Both the gases are collected and preserved.

$$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$$
$$CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$$

Production of ammonia gas:

To produce ammonia gas in Habar process nitrogen and hydrogen gas mixture of 1:3 ratio passes over on the heated iron which act as catalyst at 450^0- 550^0C and 200-250atm pressure.

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $\Delta H = -92kJ$

It is an exothermic reaction.

Group activity:
Explain the application of Le Chatelier's principle in each reactions involved in the production of ammonia gas.

12.3 Chemistry in agriculture and industry

1. Lime stone; $CaCO_3$

Lime stone in industry: You have known that limestone is used in blast furnace in extraction of iron and in production of sodium hydrogen carbonate or edible soda industrially. It is a valuable mineral. Limestone has been found in Sunamganj and Centmartin's island in our country. This limestone is main raw material of cement industry. Lime stone is widely used as filler in colour or paint industry.

Lime stone in agriculture: Calcium carbonate reacts with any strong or weak acid and neutralization hydrogen ion in acid and produce carbon dioxide gas. For this property limestone is used to increase the pH value of water or soil.

$$CaCO_3 + 2H^+ \longrightarrow Ca^{2+} + CO_2 + H_2O$$

Crushed limestone is applied in acidic soil. It supplies the required calcium to the plants as well as increases the pH value of the soil. Water holding capacity is more in basic soil. It helps to increase the sucking of the main plant nutrients (nitrogen, phosphate and potassium). Calcium carbonate is added with food supplement to mammal animal particularly milch cows to fulfill the deficiency of calcium. Main constituent is calcium. Huge amount calcium comes out from the body of a cow with the milk.

2. Quick lime; CaO

Quick lime or calcium oxide CaO is produced when limestone is heated at high temperature.

$$CaCO_3 \longrightarrow CaO + CO_2$$

If sufficient water is added in calcium oxide then slaked lime or calcium hydroxide is produced by an exothermic reaction.

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

In acidic soil the absorption of the main plants nutrients (nitrogen, phosphate and potassium) is hindered which results in the decrease of production. Plants like legume do not grow in excess acidic soil. When pH value in water decreases water turns to acidic

and shore/septic on fishes is observed. To increase the pH value of acidic soil or water even to make basic, limestone is used. Beside that to remove the hardness of water in industry and to produce bleaching powder in industry calcium oxide is used.

3. Urea; $(NH_2)_2C=O$

2,321,000 metric ton urea is produced every year in the six industries of Bangladesh Chemical Industries Corporation. Using the full amount Bangladesh has to import urea. Beside that 100% export oriented Kafco produce 68 lac metric ton urea every year. 46% of the ingredient of the urea fertilizer is the main plant nutrient nitrogen. Urea is produced by heating liquid carbon dioxide and ammonia mixture at 130^0-150^0C.

$$CO_2 + 2NH_3 \longrightarrow (NH_2)_2C=O + H_2O$$

Dissolved urea in soil is slowly dissociated to carbon dioxide and ammonia by the influence of ureage enzyme. Ammonia dissolves in water and converts to ammonium hydroxide. Ammonium hydroxide dissociates partially in NH_4^+ and OH^- ion in solution. Plant suck up NH_4^+ ion.

$$(NH_2)_2C=O + H_2O \longrightarrow 2NH_3 + CO_2$$

$$NH_{3(l)} + H_2O_{(l)} \rightleftharpoons NH_4OH_{(aq)}$$

$$NH_4OH + + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)} + H_2O_{(l)}$$

In this reaction some ammonia evolved as gas.

Beside that urea is used in industrial production of polymer like Melamine, Formica.

4. Ammonium sulphate; $(NH_4)_2SO_4$

Ammonium sulphate is produced by the reaction of ammonia and sulphuric acid.

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

Ammonium sulphate is white crystalline substance. It exhibit acidic property in aqueous solution. If alkalinity of the soil is highly increased then ammonium sulphate is applied to control it. It provides the important nutrients nitrogen and sulphur to plants.

Assignment: Harmful effect of using excess fertilizer in cultivation.
The concerning matters are-

1. The quantity of the weed in the farming land.
2. pH value of the water reservoir of adjacent land.
3. Fertilizers are washed away by rain.
4. Growth, death and dissociation of aquatic plants. Dead plants and animals are dissociated by the oxidation of oxygen.
5. The amount of dissolved oxygen.
6. The possibility of survival of the aquatic life.

5. Chemicals in the processing of agricultural commodities

Who do not desire to buy the fruits from the market where fruits are arranged nicely in stack by stack? But all intentions of buying go away when we hear the use of chemicals

in those. Every year in the month of *ashar* and *joishtha* huge amount of mango are destroyed due to the use of calcium carbide to make them ripen. Indole acetic acid is produced naturally in the bud of the trunk of the tree and at certain stage ethelene gas is produced which helps to ripen the fruits. Transportation of ripe fruit is difficult and it creates spots on the fruits. That's why traders are interested to transport the immature fruits, then mature them artificially in sells center. In the developed countries traders apply limited amount of generated ethelene gas to bring maturity of the fruits. 0.1% ethelene gas is enough to bring maturity of the fruits in a godown. Excess ethelene weaken the human nervous system. It is harmful to eyes, skin and brain. A long term problem of supplying oxygen to brain may cause. In some places a plant hormone named ethophen is used to ripen fruits. Ethophen produce ethelene by dissociation. So in the year 2010 FDCA of USA forbade the uses of ethophen in ripen fruits. In Bangladesh calcium carbide CaC_2 is used to ripe the fruits. Calcium carbide react with water and produces acetylene and calcium hydroxide.

$$CaC_2 + H_2O \longrightarrow HC{\equiv}CH + Ca(OH)_2$$

Acetylene gas helps to ripen all fruits along with mango and banana. There is toxic arsenic and phosphorus in industrial grade CaC_2, Besides that there is similarities in properties of ethelene and acetylene. In Bangladesh using CaC_2 in fruits to make them mature is forbidden. In some countries fruit businessmen are using a chemical substance named bethylene. Any harmful effect of bethylene is not discovered till now.

Carefulness: The fruits bought from the market should be damped in a bowl of water with salt and lime for 5-7 minutes before eating then wash the fruits with clean water and dry.

Do not buy those fruits which have nail spots or some sign of damage or rotten.

6. Chemicals in preservation of agricultural commodities

Different micro organism prevent the fruit from putrefaction or delay putrefaction. For the change of colour, odour, shapes or to delay different preservatives are used in the world. It is known by the people that in our country traders use formalin unconsciously to preserve all rotenable commodities. Formalin has no effective role or do not play any role in the fruit preservation. In fact formalin is 40% aqueous solution of formaldehyde. It is effective in antibacterial and anti-fungicidal. Formalin is used to preserve dead body, specimens of biological sample and pathological tissue in laboratory.

Formaldehyde preserves or fixes tissue by creating H_2C-NH- linkage with protein or nitrogen of DNA. At lower temperature and short timed contact change is reversible but at higher temperature and long timed contact change is irreversible.

Formaldehyde is very poisonous to all animals. It is a scientifically proved carcinogen. If excess extent of formaldehyde enters the body, it results in acute pain in the stomach,

nausea, coma, kidney trouble and even can cause of death. In many countries of the world as well as Bangladesh preservation of fruits, fish-meat and other food commodities by formaldehyde is forbidden.

7. Some recommended food preservatives

Sodium benzoate and benzoic acid: In fact this two preservatives work in the same way. Benzoic acid is produced in the aqueous solution of the sodium benzoate. It is found naturally in alubukhara, palm, cinnamon, matured olive and in apple. It prevents yeast, molds and some bacterias. It is very effective below the pH 4.5. Its recommended acceptable dosage is 0.1% sodium benzoate. Benzoic acids derivative para methylbenzoic acid and para methoxybenzoic act as food preservative. Certain amount of sodium benzoate is used in processed foods like tomato sauce, pickles, chanachur, chips etc .

Potassium sorbate, sodium sorbate and calcium sorbate: These salts when dissolved in water produce sorbic acid. This is very effective within pH 6.5 it also kill yeast, molds and other bacteria. Its recommended acceptable dosage is also 0.1% .

Sodium benzoate and sorbate is used together in some foods for better safety. If any preservative is used it is mandatory to mention their name in the ingredient list.

Students activities

Keep oil, vinegar, lemon juice, salt, concentrated solution of sugar, water and a piece of a fruit or vegetable in separate pot and observe these for 7 days. Describe which of them can be used as preservatives on the basis of your observation.

12.4 Industrial disposal and environment pollution

In Bangladesh tannery, paint and pesticides industrial effluect containing the heavy metal Lead (Pb), mercury (Hg), and cadmium (Cd) are exposed open or closed water reservoir. These ions are very toxic even in trace level. These ions enter the human body by food chain through protein of animals and plants and do the harm to human body and hinders the proper activity of protein. The effect of heavy metal in human body is dangerous. This can cause damage in nervous system, kidney, liver and can cause otism and even death.

If heavy metal ions are not removed from the industrial disposal they enters into the food chain. It means heavy metal ion deposits in fish from polluted water, in crops or vegetables by irrigation of polluted water and to poultry and flesh of cattle from the polluted water and foods.

It is difficult to determine these heavy ions in low concentration solution. It is very difficult and expensive to remove these from water.

Disposals of soap and detergent industries contain huge amount of caustic soda which increase the pH of water and cause bad effect on the aquatic life and plants.

Students activity

1. If there is any industry in your area, what type of metal isexposed in the open water reservoir with effluent, know it and write a report on the harmful affect of metal ions. Take help from your teacher and internet.
2. Describe how you will inspire the owner of the industry and will create public opinion in establishment of effluent treatment plant.
3. Write the names of the elements from the level of the pesticides used by the farmer in your locality and which elements are polluting environment write report about it.

Exercise

Multiple choice questions:

1. What is the ratio of hydrogen and nitrogen in ammonia gas production?
   a. 1:2 b. 1:3
   c. 2:1 d. 3:1
2. Which of the following accelerate the activity of enzyme?
   a. H_2O b. NaCl
   c. H_2CO_3 d. CH_3COOH
3. Which is applicable in the production of NaOH by electrolysis?
   a. diluted solution of NaCl b. Melted NaCl
   c. platinum electrode d. mercury electrode
4. $NH_3 + H_2SO_4 \rightarrow$
   i. A neutralization reaction.
   ii. Product is a important nutrient of plants.
   iii. The pH of the aqueous solution of the product is greater than 7.

Which one is correct?

   a. i b. i and ii
   c. ii and iii d. i, ii and iii

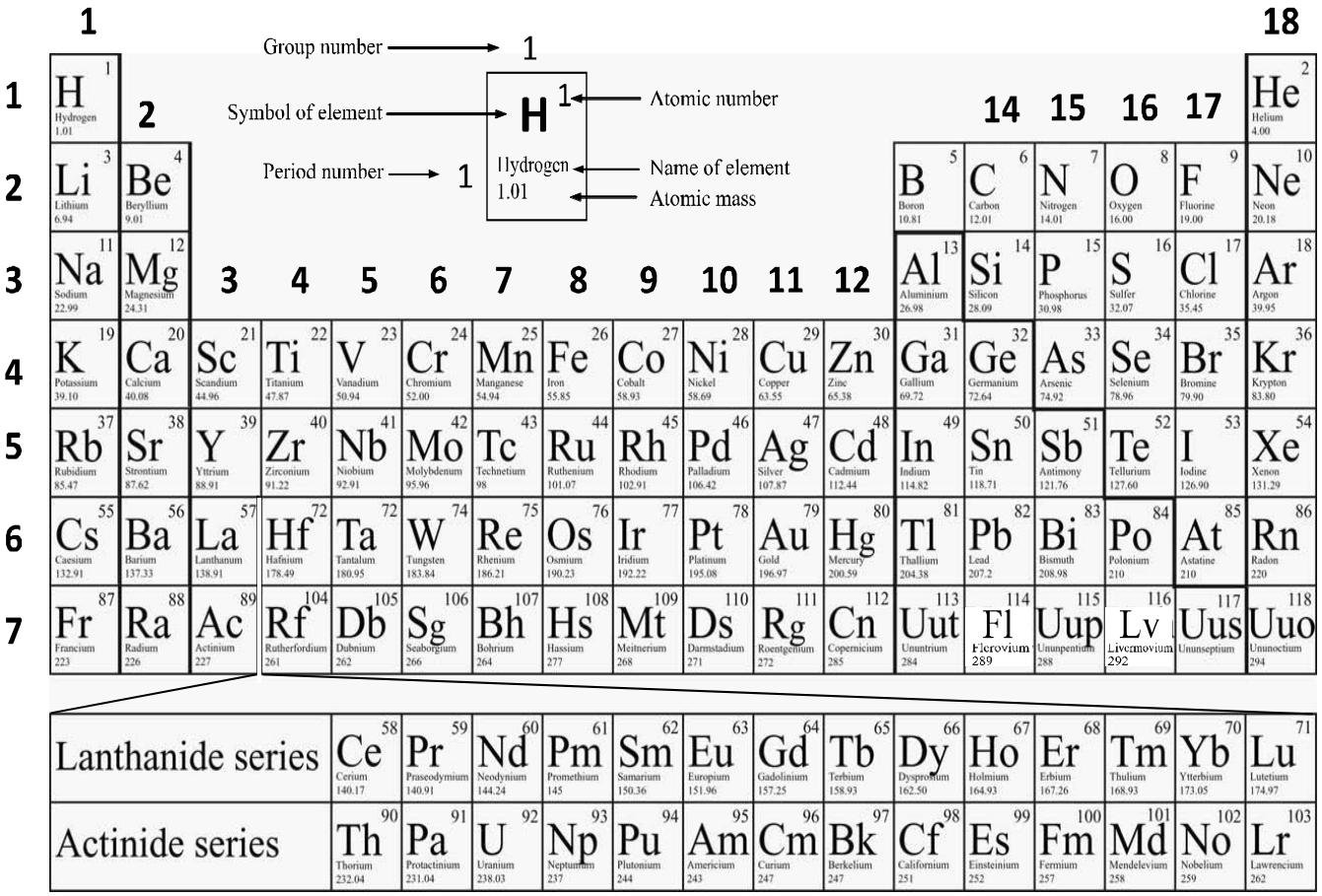
Creative questions:

1. Dr. Chandra's maid servant is taking rest due to her indigestion. Suddenly the fridge is being out of order Dr. Chandra becomes worried with uncooked fish, meat, salt, baking powder and vinegar which she bought from market. In the mean time maid servant is feeling better by taking baking powder secretly. Knowing this Dr. Chandra instructed her not to take it in future.
   a. what is the main constituent of glass cleaner?
   b. what is the role of air in ammonia industry in our country?

c. To take immediate action Dr.Chandra asked her maid to preserve fish, meat by using which one of the illustrate? Explain.
d. Explain the chemistry with reaction about the cure of indigestion of the maid servent in the illustrate.

2. At the beginning of the year Srijony and Srabonty started to go school wearing new dress of same fabrics. To wash their clothes both of their mother use soap but Srabonty's mother add two spoon of vinegar in a bucket of water and wash the cloth again with it. At this srabonty's cloth looks brighter than Srijony's.
   a. Write the chemical formula of bleaching powder?
   b. Why lime is added in the boundary shrimp cultivation time to time?
   c. Explain the technique of the washing the mentioned school dress.
   d. Explain with logic about the cause of the brightness of the Srabonty's dress in the illustrator.

Period Table



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	H 1 Hydrogen 1.01																	He 2 Helium 4.00
2	Li 3 Lithium 6.94	Be 4 Beryllium 9.01											B 5 Boron 10.81	C 6 Carbon 12.01	N 7 Nitrogen 14.01	O 8 Oxygen 16.00	F 9 Fluorine 19.00	Ne 10 Neon 20.18
3	Na 11 Sodium 22.99	Mg 12 Magnesium 24.31											Al 13 Aluminium 26.98	Si 14 Silicon 28.09	P 15 Phosphorus 30.98	S 16 Sulfer 32.07	Cl 17 Chlorine 35.45	Ar 18 Argon 39.95
4	K 19 Potassium 39.10	Ca 20 Calcium 40.08	Sc 21 Scandium 44.96	Ti 22 Titanium 47.87	V 23 Vanadium 50.94	Cr 24 Chromium 52.00	Mn 25 Manganese 54.94	Fe 26 Iron 55.85	Co 27 Cobalt 58.93	Ni 28 Nickel 58.69	Cu 29 Copper 63.55	Zn 30 Zinc 65.38	Ga 31 Gallium 69.72	Ge 32 Germanium 72.64	As 33 Arsenic 74.92	Se 34 Selenium 78.96	Br 35 Bromine 79.90	Kr 36 Krypton 83.80
5	Rb 37 Rubidium 85.47	Sr 38 Strontium 87.62	Y 39 Yttrium 88.91	Zr 40 Zirconium 91.22	Nb 41 Niobium 92.91	Mo 42 Molybdenum 95.96	Tc 43 Technetium 98	Ru 44 Ruthenium 101.07	Rh 45 Rhodium 102.91	Pd 46 Palladium 106.42	Ag 47 Silver 107.87	Cd 48 Cadmium 112.44	In 49 Indium 114.82	Sn 50 Tin 118.71	Sb 51 Antimony 121.76	Te 52 Tellurium 127.60	I 53 Iodine 126.90	Xe 54 Xenon 131.29
6	Cs 55 Caesium 132.91	Ba 56 Barium 137.33	La 57 Lanthanum 138.91	Hf 72 Hafnium 178.49	Ta 72 Tantalum 180.95	W 74 Tungsten 183.84	Re 75 Rhenium 186.21	Os 76 Osmium 190.23	Ir 77 Iridium 192.22	Pt 78 Platinum 195.08	Au 79 Gold 196.97	Hg 80 Mercury 200.59	Tl 81 Thallium 204.38	Pb 82 Lead 207.2	Bi 83 Bismuth 208.98	Po 84 Polonium 210	At 85 Astatine 210	Rn 86 Radon 220
7	Fr 87 Francium 223	Ra 88 Radium 226	Ac 89 Actinium 227	Rf 104 Rutherfordium 261	Db 105 Dubnium 262	Sg 106 Seaborgium 266	Bh 107 Bohrium 264	Hs 108 Hassium 277	Mt 109 Meitnerium 268	Ds 110 Darmstadium 271	Rg 111 Roentgenium 272	Cn 112 Copernicium 285	Uut 113 Ununtrium 284	Fl 114 Flerovium 289	Uup 115 Ununpentium 288	Lv 116 Livermovium 292	Uus 117 Ununseptium	Uuo 118 Ununoctium 294

Lanthanide series	Ce 58 Cerium 140.17	Pr 59 Praseodymium 140.91	Nd 60 Neodynium 144.24	Pm 61 Promethium 145	Sm 62 Samarium 150.36	Eu 63 Europium 151.96	Gd 64 Gadolinium 157.25	Tb 65 Terbium 158.93	Dy 66 Dysprosium 162.50	Ho 67 Holmium 164.93	Er 68 Erbium 167.26	Tm 69 Thulium 168.93	Yb 70 Ytterbium 173.05	Lu 71 Lutetium 174.97
Actinide series	Th 90 Thorium 232.04	Pa 91 Protactinium 231.04	U 92 Uranium 238.03	Np 93 Neptunium 237	Pu 94 Plutonium 244	Am 95 Americium 243	Cm 96 Curium 247	Bk 97 Berkelium 247	Cf 98 Californium 251	Es 99 Einsteinium 252	Fm 100 Fermium 257	Md 101 Mendelevium 258	No 102 Nobelium 259	Lr 103 Lawrencium 262

2013

Academic Year

9-10 Chemistry

শিক্ষাই দেশকে দারিদ্র্যমুক্ত করতে পারে

– মাননীয় প্রধানমন্ত্রী শেখ হাসিনা

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সব সময় নিজের দোষগুলোর প্রতি দৃষ্টি রাখ

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