Chemistry Part – 2

CHEMISTRY PART – II

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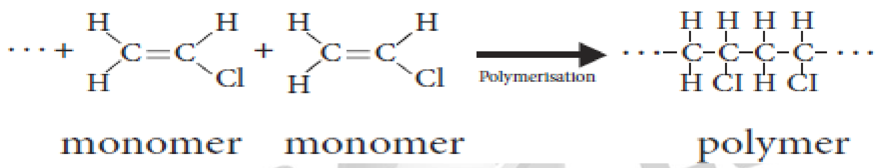
Carbon and Nitrogen Compounds

7th term -3
Unit - 3. Polymer Chemistry

What Are Polymers?

Th e word 'Polymer' is of Greek origin. 'Poly' means many and 'mer' means basic smaller unit. Polymers are very long chains made of repeating smaller molecules called 'monomers' that are joined together by covalent bonds and the process is called polymerization. Th e diagram below shows how repeating monomers join to form a polymer:

Polyvinyl Chloride (PVC) is a common plastic used for water pipes. Th e monomer and polymers of PVC is shown below.



Polymer

Polymers can be classified into natural and synthetic polymers. Can you imagine that your body produces and you are made up of natural polymers? Th e most familiar polymers that we use in our daily life are man-made and synthetic.

Natural Polymers

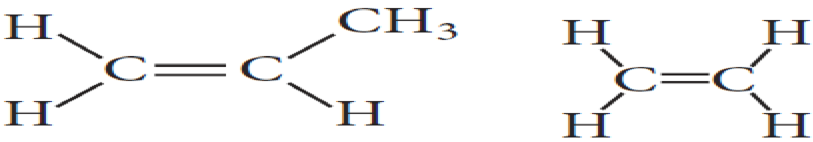
Natural polymers are found in living systems that include proteins and carbohydrates in our bodies and cellulose in wood and paper. They play a very important role in living things to provide structural materials and molecules needed for life processes.

Protein polymers are made from amino acid monomers (20 different kinds of amino acids). Different combinations of the amino acid monomers create many different protein polymers. Examples of protein polymers include DNA, enzymes, silk, skin, hair, fingernails, feathers and fur.

Examples of carbohydrate polymers include cellulose, chitin and lignin found in plants. Cellulose is made of sugar molecules and is the main component of cotton used in clothing. Chitin is found in the cell walls of fungi such as mushrooms and exoskeletons of insects such as crabs and spiders. Lignin consists of a network of polymers and is important in giving structure to plants.

Synthetic Polymers

Synthetic polymers are man-made polymers produced by using raw materials from petroleum oil and gas. Plastics are synthetic polymers. When oils and gases are processed to make petrol, ethylene and propylene monomers are removed as byproducts byproducts. We have already seen that polymer such as the Poly Vinyl Chloride (PVC) is made up of many monomers joined together. Ethylene and propylene are the building block monomers that make up many different types of plastics.



Based on the nature of the monomers, the way they are arranged in the polymer and the characteristics of final polymer.

There are grouped into different categories such as fibres, plastics, proteins. Let us study about few of them in the following sections.

Fibres

We wear clothes, use bags, rope, blankets, etc. in our daily life. They are made of fibres. Once upon a time, people used natural fibres such as cotton and wool. Nowadays, we use a lot of synthetic fibres. All natural and synthetic fibres are polymers.

Observe the difference between the natural and synthetic fibres:

Natural Coconut Rope vs. Nylon Fishing rope

Natural and Synthetic Fibres

Fibres are long strands of polymers interwoven to form linear, string-like structures. Fibres that are obtained from plant or animal sources are called natural fibres. Examples include cotton, coconut fibre, hair, wool and silk. Fibres that are made using raw materials from petroleum are synthetic fibres. Examples include polyester, acrylic and nylon. Historically, humans used natural plant fibres and animal fur for shelter, clothing and protection from the weather. Today, a large variety of natural fibres are still grown and processed such as cotton, silk, and wool. Natural fibres can be spun into filament, thread or rope. Then they can be woven, knitted, matted or bonded and are used to make clothing, containers, insulation material and many other products we use in our daily life. Three main sources of natural fibres are: (i) Animal (e.g.) wool and silk.

The discovery of making synthetic fibres out of petrochemicals has replaced the use of many natural fibres. Synthetic fibres such as nylon, polyester and acrylic are used to make many different plastic items you use in your daily life such as clothing, blankets, tooth brushes and stuffing in cushions.

Types and Uses
Silk: Natural Fibre

Natural silk fibres are obtained from boiling the cocoons of silk worms from specific species of moths. There are four types of natural silk: Mulberry silk, Tasar silk, Muga silk and Eri silk. Most of the mulberry silk worldwide is produced in India. Silk is one of the strongest natural fibres and has many uses such as clothing, carpets and parachutes.

Rayon: A Semi-synthetic Fibre

In the 19th century scientists were successful in producing the first artificial silk known as rayon. The first rayon factory in India was established in Kerala in 1946. Rayon is a man-made fibre, but it is not considered fully synthetic as it is made out of natural cellulose collected from wood pulp. The cellulose that is collected from wood or bamboo pulp is treated with several chemicals. First sodium hydroxide is added followed by carbon disulphide. The cellulose dissolves in the chemicals added to it and produces syrup called Viscose. Viscose is forced through a spinneret (a device made of metal plates with very tiny holes) into a solution of dilute sulphuric acid. This produces silk-like threads that are cleaned with soap and dried. This new fibre is called rayon.

Some types of rayon are made from the short cotton fibres left on cottonseeds after ginning. Rayon is cheaper than silk, can be woven like natural silk fibre and can be dyed in a wide variety of colours. It can be mixed with cotton to make bed sheets or with wool in the production of carpets and home furnishing products. Rayon is also found in sanitary products, diapers, bandages and gauze for dressing wounds.

Nylon: Synthetic Fibre

Nylon is the first fully processed synthetic fibre. It was popular during the Second World War for the use of parachutes and rope materials for climbing. Nowadays, nylon has replaced natural silk in many textiles, and has become one of the most commonly used synthetic fibres.

Nylon fibre is strong, elastic and light. It islustrous and easy to wash, which has made it popular for the clothing industry We use many products made from nylon such as socks, ropes, tents, toothbrushes, car seatbelts, sleeping bags, curtains, etc. Nylon thread is actually stronger than a steel wire.

Do You Know?

Nylon is very strong and can be used for rock climbing!

Nylon is a plastic polymer made of chemical units called polyamides. olyamides are made with monomers – hexamethy lenediamine and adipic acid. Solid chips of these polyamides are melted and forced through a heated spinneret which has very, very tiny holes.

Polyester and Acrylic:
Synthetic Fibres

Polyester is another synthetic fibre. It can be drawn into very fine fibres that can be woven like any other yarn. Polyester is sold in the name of polycot, polywool, terrycot, etc. Polycot is a mixture of polyester and cotton; Polywool is a mixture of polyester and wool. PET (Polyethylene Terephthalate) is a very familiar form of polyester. It is used for making water and soda bottles, utensils, films and wires amongst many other useful products. Many of the clothes we wear are made out of polyester fibres. Fabrics made from this fibre do not get wrinkled easily and are easy to wash making polyester fabrics suitable for dress materials.

We wear sweaters and use shawls and blankets in the winter. Many of these are not made from natural wool although they appear to resemble wool. These are prepared from another type of synthetic fibre called acrylic. The wool obtained from natural sources is quite expensive, where as clothes made from acrylic are relatively cheap because they are a byproduct of the production of plastics. They are available in a variety of colours. Synthetic fibres are more durable and affordable which has contributed to their widespread use.

Advantages of Synthetic Fibres

Do you ever think about why some of your clothing does not need ironing and looks bright and colourful for many years? This is because they are made from synthetic fibres such as polyester and the advantages are that they do not wrinkle easily and they keep their colour and brightness for a much longer time than natural fibres such as cotton.

A lot of materials such as fishing nets are made from synthetic fibres. One of the main advantages of using synthetic fibres such as nylon, is that they are stronger than many natural fibres such as silk or wool. For example a trampoline is made of woven synthetic fibres. These fibres are strong and elastic which gives it the properties to bounce.

Drawbacks of Synthetic Fibres

We have already learned that it is safer to use cotton clothing instead of synthetic clothing when a person is cooking or working in a laboratory. This is because one disadvantage of synthetic fibres such as polyester is that they are not heat resistant and catch fire easily. In summer it is better to wear clothing that is made out of cotton materials rather than synthetic.

This is because most synthetic fibres absorb very little moisture and do not allow air circulation making them hot and uncomfortable to wear.

If you could recall that we already found out that synthetic fibres are made out of petrochemicals and last in the environment for a very long time. The disadvantage is that they break down into very small pieces called microplastics which cause pollution to soil and water bodies such as rivers, lakes and oceans.

Plastics

Ask yourself what is the first plastic thing you touched today! Maybe it was your alarm clock or the filling in your pillow or the synthetic clothes that you were wearing. Almost everything around us today is plastic. You have seen water and oil in polythene pouches. Right! In the past, people used to bring milk, oil and other liquids from a shop in vessels made of materials such as metal and glass. Think about what the containers, buckets, mugs, chairs and tables used in the past were made of? What do we use today to make many of these products?

Plastic as a material has taken over and replaced metal and wood which were previously used. Plastics have also replaced many glass items. If we continue to write the list of everyday items that are made of plastic, it will be endless! Why is plastic so popular? What are the different uses of plastic? What are the various types of plastics? Let us now learn about plastics:

Plastics have helped us to make advancements in technology, building, healthcare, transport and food safety. Plastics have completely occupied our life because of their characteristic qualities. Plastics have many positive qualities such as lightweight, strong and they can be moulded into complex shapes. They are also flexible and waterproof and some plastics are even UV resistant. Plastics are also cheap and convenient for us to use. Now that you have discovered why plastics are so popular, let us find out more about the different uses of plastics.

Uses of plastics

There are different types of plastics that are excellent materials when they are used for the right application. For example, let us take a syringe that is made from a type of plastic called polypropylene. These syringes do not have to be sterilized and reused; hence they provide a high standard of hygiene and eliminate the risk of spreading diseases.

Just as plastic is a material that can be used for a good application, it can also be used for the wrong application. Think about the different items you use that are plastic. For example, a You use this bag for a very short time and then throw it in a dustbin. Many of these carry bags do not get recycled and they litter and pollute our environment for a long time.

If you want to learn more about plastic which is used for the wrong application then you can refer to the Government of Tamil Nadu's ban on one-time use and throwaway plastics (Environment and Forests Department, T.N. G.O. No: 84, dated 25/06/2018, with effect from 1st January 2019).

Types of plastics

Th e plastics we use in our daily life are also made up of polymers. All plastics do not have the same type of arrangement of units. In some articles, the arrangement of a monomer is linear, and in some other items, the arrangement of articles is cross-linked. Depending on the type of arrangement, we have two main types of polymers – thermoplastics and thermoset. Let us see what these are!

Thermoplastics: Polyethylene (also called polythene) is an example of a plastic. It is used for making polythene carry bags which are commonly used. When you burn a polythene carry bag, it melts and turns into liquid along with the production of an offensive odour, a bright flame and soot. Another example is a **PET (Polyethylene Terephthalate)** bottle, when we fill it with boiling water, it gets deformed. Plastics which can be easily softened and bent when heated are known as thermoplastics. These plastics can be modified and turned into another plastic item through the process of recycling.

Thermoset: On the other hand, there are some plastics, which once they are moulded, cannot be softened through heating them. These are called thermosetting plastics. Bakelite and melamine are some examples of thermosetting plastics. Bakelite is a poor conductor of heat and electricity. It is used for making electrical switches and handles of various utensils. Melamine resists fi re and can tolerate heat. It is used for making floor tiles and fabrics that resist fire.

Resin code of plastics

Now that you have learnt about the differences between Thermoplastic and Thermosetting polymers, let us find out more about the different types of plastics that you use in your daily life. Plastics are very useful in our daily life but some types contain dangerous chemicals. Did you know that there are many different types of plastics?

You can tell these plastics apart by searching for a resin code. Th e resin codes are a universal way of categorising different types of plastic, which helps us separate plastics so that it is easier to recycle them. How can you identify the resin code? Where can you find the resin code on a plastic item?

Look at the chasing arrow triangle-shaped symbol on the bottom of a bottle, on the brand label sticker or on the lid of a container. What number is marked in the centre of the triangle? What letters (acronym) are below this? Th is is what we call a resin code.

If the number is 1 within the chasing arrow triangle and/or has the acronym PET or PETE, then it is a type of plastic which is called PET. Now that you have found out that the bottle has a specific resin code, let us see what gives the bottle and other plastic products certain qualities. Different chemicals (additives) are added to plastic to give them various qualities and characteristics, for example flexibility, strength, soft ness or transparency. There are some chemicals that are used in plastics that are dangerous for our health, animals and the environment. For example, Polyvinyl Chloride- PVC resin code #3 has heavy metals such as cadmium and lead which are toxic chemical which are harmful to your health. Polystyrene- PS resin code #6 has styrene which is a toxic chemical known to cause cancer.

Look at the resin code chart on the previous page to find out more about the different types of plastic, what are common items and which plastics are safe and unsafe for us, animals and the environment.

Look at the resin code chart to find out more about the different types of plastic, the common items and the plastics that are safe and unsafe for us, animals and the environment.

Impacts of plastics

Plastics are cheap, light weight, strong and durable and have contributed to a range of advances and benefits to our modern life. But the increase in the use of plastics, particularly the one-time use and throwaway plastics has serious impacts on the environment, animals and our health.

We have seen garbage dumps with different plastics. One big problem with plastics is that they do not decompose or biodegrade. This leads to large amounts of waste that will not disappear and end up accumulating and polluting the environment.

A lot of one-time use plastic such as polythene bags and food packaging that are thrown away are responsible for littering the environment and clogging drains. Standing water breeds mosquitoes that can spread diseases such as malaria, dengue and chikungunya and also lead to flooding.

Why do you think some animals eat plastic? Many animals confuse plastic for food and eat it by accident. When left over food is thrown away it is often packed in plastic. Animals smell the leftover food and eat the plastic by accident. For example animals in urban areas, particularly cows, often eat polythene plastic bags by accident as they contain food waste. Can you imagine the consequences?

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A lot of the plastic waste we use such as plastics bags, bottles and straws end up in the oceans. Plastics in the ocean are exposed to sunlight, water and the physical movement of the waves, which breaks it down in tiny pieces called microplastics. Some microplastics are also found in household products. Examples are microbeads that can be found in toothpaste, face wash and body scrubs. Microbeads are washed down in drains and end up in the soil, rivers, lakes and the ocean Microbeads are washed down in drains and end up in the soil, rivers, lakes which cause pollution.

Many birds eat plastic items and small pieces of plastic, which are covered in algae. Once in the stomach of animals, plastics cannot be digested and this decreases the amount of space for food and can lead to starvation. In
2015, plastics were found in 90% of seabirds.

We have already read that Government of Tamil Nadu has banned one-time use and throwaway plastics such as plastic carry bags, plates, straws and water pouches. This is an indication that important efforts are taking place to reduce negative consequences of plastics on the environment.

PLA Plastics

Can you see how much plastic litter pollutes our environment? How nice would it be if a material that had similar qualities to plastic could be biodegradable, be absorbed by the soil and give nutrients to the soil!
Yes, scientists have thought about alternatives to synthetic plastics and have found Poly Lactic Acid (PLA) –a substitute for some types of plastics. Poly Lactic Acid or polylactide is compostable and bioactive thermoplastic.
This polymer is obtained from plant starch such as corn, sugarcane and pulp from sugar beets. PLA is a biodegradable material. It is useful for making food packaging, garbage bags and disposable table ware.

Various methods of disposing plastics

Plastics are everywhere! Our increasing consumption and production of plastic waste needs a solution. Let us find out more about how and where plastic waste is disposed of and the better methods of disposing plastics.

Organic waste such as the peels of vegetables, fruits and food remains can get broken down by bacteria in the soil to create a rich source of nutrients in the form of compost. A material that gets decomposed through natural processes and action by bacteria is called biodegradable.

Plastics do not decompose by natural processes and action of bacteria and are therefore not biodegradable. It is important for us to separate our biodegradable and non-biodegradable waste and dispose of them separately. A lot of the plastic produced globally is designed to be used only once and thrown away, creating a large amount of plastic waste. Plastic waste ends up being recycled, incinerated, landfilled, dumped or ends up littering our environment. It is estimated that from all the plastic waste ever produced, 79% is in landfills, dumps or in the environment, 12% has been incinerated and only a small 9% is recycled.

Let us learn more about what happens with the plastic waste. One way to look at plastic disposal is the 5R Principle – Refuse, Reduce, Reuse, Recycle and Recover. We have already learned about the waste pyramid and how the different methods of waste disposal can be seen in terms of the best option to the least favourable in this order: Refuse (Avoid), Reduce, Reuse, Recycle, Recover (Compost and Incinerate) and Landfill.

Refuse (Avoid)

The best thing to do is to avoid using plastic products. One-time use throwaway plastics can often be avoided. For example, we can carry cotton or jute bags when we go shopping and say no when a shopkeeper offers us a plastic bag.

Reduce

Reducing the amount of plastic we use is important. Before buying a plastic product we can check to see if there are any substitutes or alternatives that can be used. If we use fewer plastics, we will create less plastic waste.
However, even if we try to reduce the amount of plastics we use and throw away, it is impossible to stop using plastics completely.

Reuse

If possible products made of plastics can be used again and again. For example, if we have a plastic bag in good condition, instead of throwing it away we can use it again the next time we go for shopping. If we have a plastic product and if you do not feel like using it again, we can give it to others instead of throwing it out.

Recycle

It is better to recycle plastic waste. Separating plastic waste and making sure it gets recycled is good as it turns waste materials into something new. Then it will not be thrown away in landfills, open dumps or ending up as litter in the environment. Many thermoplastics can be recycled. They can be softened by heating and can be made into another article by recycling, but thermosetting plastics cannot be recycled. Recycling of plastics is challenging and it is important to know that plastics cannot be recycled forever. There are so many different types of plastics, which are often mixed together making it difficult to separate them back into the original material. Every time plastic is melted and recycled it loses quality, this is called 'downcycling'. Recycling of plastic waste cannot be the only solution to plastic pollution.

Recover (Compost And Incinerate)

Solid waste can be converted into resources such as electricity and compost through thermal and biological means. Burning plastics in a large furnace or in the open is bad for the environment. Open burning releases toxic pollutants into the air and soil, which are harmful to our health, animals and the environment. Burning plastics at high temperatures in incinerators and trapping the gases and collecting the toxic ash is widely used to produce energy. This is often seen as a positive way to deal with plastic waste. However, burning plastics releases super toxic gases, and the remaining ash contains toxic chemicals and heavy metals. Burning of plastics is not a good solution, as we end up wasting non-renewable resources and produce super toxic chemicals that are difficult to store or dispose safely.

Landfill

Plastic waste often ends up in landfills that are huge holes where waste is buried to keep it separate from the environment. This is the most common way for plastics to be disposed of around the world. Plastics make up 7-13% of waste that is sent to landfills on a global scale. Plastics in landfills can still lead to pollution of the air, soil and groundwater. Over time landfills can degrade, and the toxic chemicals in certain plastics can leak out into the environment.

Biodegradable plastics

The concept of biodegradable plastics or bio-plastics was first introduced in the 1980s. Based on the nature of degradation, there are two main types of plastics: degradable plastic and compostable plastic.

Degradable plastics are made from petroleum oil or gas which is the same as conventional plastics. The difference is that they have a chemical or additive added to them to make them breakdown faster than conventional plastics when they are exposed to sunlight, oxygen or water. What do you think will happen to degradable plastics? Degradable plastics breakdown into tiny pieces called microplastics and these stay in our environment for a very long time. It is very important to understand that degradable plastics do not breakdown completely in the environment! Scientists have found that microplastics in the ocean are really bad and it is likely that these tiny pieces in the soil are also harmful.

Compostable plastics are derived from renewable resources such as corn, sugar cane, avocado seeds or shrimp shells. Compostable plastics can be broken down completely by microbes and turned back into food for plantscarbon dioxide, methane, water and other natural compounds.

Plastic Eating Bacteria

In 2016, scientists from Japan tested different bacteria from a bottle recycling plant and found that Ideonellasakaiens is 201-F6 could digest the plastic used to make single-use drinks bottles that are made of polyethylene terephthalate (PET). The bacteria works by secreting an enzyme known as 'PETase', that breaks down plastic into smaller molecules. These smaller molecules are then absorbed by the bacteria as a food source. The working of the enzyme is diagrammatically shown below:

Although the discovery of the bacteria breaking down plastics is seen as a potential solution to the plastic pollution – it is still very complex! A big issue is the scale of the plastic pollution problem. We consume and produce such large quantities of plastics and this is only increasing. The scale of the bacteria breaking down plastics is much slower and will therefore not solve the crisis we are facing.

Another limitation is that it is restricted to PET resin code #1 plastics, which currently is one of the most recyclable plastics worldwide. It will not be a feasible solution to the issue of the large quantities of non-recyclable low-grade plastics which are polluting the environment. That is why it cannot be the solution to plastic pollution on its own!

Glass – Types And Uses

Glass can be found wherever we look; a glass window or glass mirror or glass light bulb. Glass is one of the world's oldest and most versatile human created materials. Glass is the only material that can be recycled over and over again without losing its quality. Glass is bit of a riddle. It is hard enough to protect as, but it shatters with incredible ease. It is made from opaque sand, yet, it is completely transparent. Most surprisingly, it behaves like a solid material, but it is also a sort of weird liquid in disguise!

Glass is prepared by heating (SiO_2) silicondi- oxide until it melts, say to about 1700◦C and Sodium Carbonate is added to it. Then it is cooled down really fast. When SiO_2 silicondi- oxide melts, the silicon and oxygen atoms break out of their crystal structure. If we cooled it slowly, the atoms would slowly line up back into their crystalline arrangement. But if we cool the liquid fast enough, the atoms of the silica will be halted in their tracks, they won't have time to line up, and they will be stuck in any old arrangement, with no order to the arrangement of the atoms. We call materials like this as amorphous. At this stage, glass is linear in arrangement inorganic in nature and has a structure very similar to glass and they are considered as polymers.

In a commercial glass plant, sand is mixed with waste glass (obtained from recycling collections), soda ash (sodium carbonate) and limestone (calcium carbonate) and heated in a furnace. The soda ash reduces the sand's melting point and produces a kind of glass that would dissolve in water. The limestone is added to stop that happening. The end product is called soda-lime-silica glass. It is the ordinary glass we see all around us.

Usually, other chemicals are added to change the appearance or properties of the finished glass. For example, iron and chromium based chemicals are added to the molten sand to make green-tinted glass.

Oven-proof borosilicate glass (widely sold under the trademark PYREX) is made by adding boron oxide to the molten mixture.

Adding lead oxide makes from a sandwich or laminate of multiple layers of glass and plastic bonded together.

Toughened glass used in car winds hields is made by cooling molten glass very quickly to make it much harder.

9th book
Unit – 15 Carbon and its Compounds

Compounds of Carbon – Classification

Carbon is found both in free state as well as combined state in nature. In the pre-historic period, ancients used to manufacture charcoal by burning organic materials. They used to obtain carbon compounds both from living things as well as non-living matter. Thus, in the early 19th century, Berzelius classified carbon compounds based on their source as follows:

Organic Carbon Compounds: These are the compounds of carbon obtained from living organisms such as plants and animals. e.g. Ethanol, cellulose, Starch.

Inorganic Carbon Compounds: These are the compounds containing carbon but obtained from non-living matter. e.g. Calcium Carbonate, Carbon Monoxide, Carbon dioxide.

Organic Compounds of Carbon

There are millions of organic carbon compounds available in nature and also synthesized manually. Organic carbon compounds contain carbon connected with other elements like hydrogen, oxygen, nitrogen, sulphur etc. Thus, depending on the nature of other elements and the way in which they are connected with carbon, there are various classes of organic carbon compounds such as hydrocarbons, alcohols, aldehydes and ketones, carboxylic acids, amino acids, etc. You will study about organic carbon compounds in your higher classes.

Inorganic Compounds of Carbon

As compared to organic compounds, the number of inorganic carbon compounds are limited. Among them oxides, carbides, sulphides, cyanides, carbonates and bicarbonates are the major classes of inorganic carbon compounds. Formation, properties and uses of some of these compounds are given in Table 15.1.

Special Features of Carbon

The number of carbon compounds known at present is more than 5 million. Many newer carbon compounds are being isolated or prepared every day. Even though the abundance

Inorganic carbon compounds

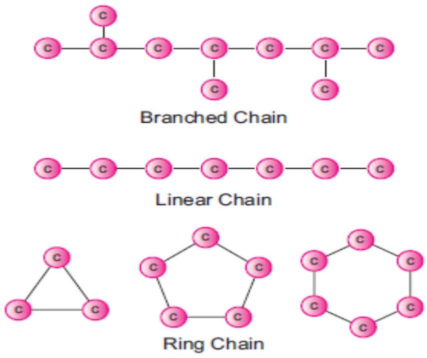
Compounds	**Formation**	**Properties**	**Uses**
Carbon monoxide	Not a natural	Colourless,	Main component

(CO)	componentof air. Mainly added to atmosphere due to incomplete combustion of fuels.	odourless, highly toxic, sparingly soluble in water.	of water gas (CO+H2). Reducing agent.
Carbon dioxide (CO_2)	Occurs in nature as free and combined forms. Combined form is found in minerals like limestone, magnesite. Formed by complete combustion of carbon or coke.	Colourless, odourless, Tasteless Stable, highly soluble in water, takes part in photosynthesis.	Fire extinguisher, preservative for fruits, making bread, to manufacture urea, carbonated water, nitrogenous fertilizers, dry ice in refrigerator
Calcium Carbide (CaC_2)	Prepared by heatingcalcium oxide and coke.	Greyish black solid.	To manufacture graphite and hydrogen. To prepare acetylene gas for welding.
Carbon disulphide (CS_2)	Directly prepared from Carbon and Sulphur	Colourless, inflammable, highly poisonous gas.	Solvent for sulphur. To manufacture rayon, fungicide, insecticide
Calcium Carbonate ($CaCO_3$)	Prepared by passing Carbondioxide into the solution of slaked lime	Crystalline solid, insoluble in water.	Antacid
Sodium bicarbonate ($NaHCO_3$)	Formed by treating sodium hidroxide with carbonic acid (H2CO3)	White crystalline substance, sparingly soluble in water	Preparation of sodium carbonate, baking powder, antacid

of carbon is less, the number of carbon compounds alone is more than the number of compounds of all the elements taken together. Why is it that this property is seen in carbon and in no other elements? Because, carbon has the following unique features.

Catenation

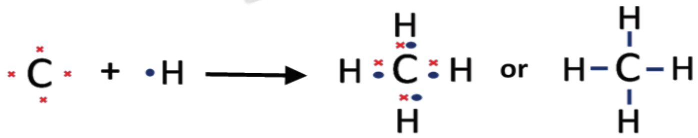
Catenation is **binding of an element to itself or with other elements through covalent bonds** to form open chain or closed chain compounds. Carbon is the most common element which undergoes catenation and forms long chain compounds. Carbon atom links repeatedly to itself through covalent bond to form linear chain, branched chain or ring structure.



This property of carbon itself is the reason for the presence of large number of organic carbon compounds. So organic chemistry essentially deals with catenated carbon compounds. For example, starch and cellulose contain chains of hundreds of carbon atoms. Even plastics we use in our daily life are macro molecules of catenated carbon compounds.

Tetravalency

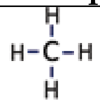
Another versatile nature of carbon is its tetravalency. The shell electronic configuration of carbon is 2,4 (Atomic no: 6). It has four electrons in its outermost orbit. According to Octet Rule, carbon requires four electrons to attain nearest noble gas (Neon) electronic configuration. So carbon has the tendency to share its four electrons with other atoms to complete its octet. This is called its tetravalency. Thus, carbon can form four covalent bond with other elements. For example, in methane, carbon atom shares its four valence electrons with four hydrogen atoms to form four covalent bonds and hence tetravalent.



Multiple Bonds

As seen above, the tetravalent carbon can form four covalent bonds. With this tetravalency, carbon is able to combine with other elements or with itself through single bond, double bond and triple bond. As weknow, the nature of bonding in a compound is the primary factor which determines the physical and chemical characteristics of a compound. So, the ability of carbon to form multiple bonds is the main reason for the existance of various classes of carbon compounds. Table 15.2 shows one of such classes of compounds called 'hydrocarbons' and the type of bonding in them.

Hydrocarbon

Type of bond	Example	Class of the Compound
Single Bond	 Methane	Alkane
Double Bond	 Ethene	Alkane
Triple Bond	H-C ≡ C-H Ethene	Alkane

When one or more hydrogen in hydrocarbons is replaced by other elements like O, N, S, halogens, etc., a variety of compounds having diff erent functional groups are produced. You will study about them in your higher class.

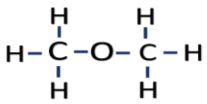
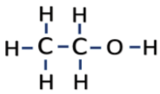
Isomerism

Isomerism is another special feature of carbon compounds especially found in catenated organic compounds. Let us consider the molecular formula of an organic compound C2H6O. Can you name the compound? You can't. Because the molecular formula of an organic compound represents only the number of diff erent atoms present in that compound. It does not tell about the way in which the atoms are arranged and hence its structure. Without knowing the structure, we can't name it.

A given molecular formula may lead to more than one arrangement of atoms. Such compounds are having different physicaland chemical properties. _ is phenomenon in which the **same molecular formula may exhibit different structural arrangement** is called isomerism. Compounds that have the same molecular formula but different structural formula are called isomers (Greek, isos = equal, meros = parts).

The given formula C_2H_6O is having two kinds of arrangement of atoms as shown below.

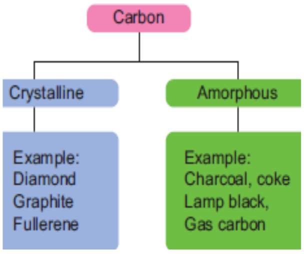
(a) CH_3-CH_2-OH (b)CH_3-O-CH_3

Both the compounds have same molecular formula but different kind of arrangements. In compound 'a', the oxygen atom is attached to a hydrogen and a carbon. It is an alcohol. Whereas in compound 'b', the oxygen atom is attached to two carbon atoms and it is an ether. These compounds have different physical and chemical properties. You will study about isomerism in detail in higher classes.

Allotropy

Allotropy is a property by which an element can exist in more than one form that are physically different and chemically similar. The different forms of that element are called its allotropes. The main reason for the existence of allotropes of an element is its method of formation or preparation. Carbon exists in different allotropic forms and based on their physical nature they are classified as below.



(a) Crystalline forms of Carbon

Diamond:

- In diamond, each carbon atom shares its four valence electrons with four other carbon atoms forming four covalent bonds.

Here the atoms are arranged in repeated tetrahedral fashion which leads to a three dimensional structure accounting for its hardness and rigidity.

Graphite:

- In graphite, each carbon atom is bonded to three other carbon atoms through covalent bonds in the same plane.
- This arrangement forms hexagonal layers which are held together one over other by weak Vander Waals forces.
- Since the layers are held by weak forces, graphite is softer than diamond.

Fullerene:

- The third crystalline allotrope of carbon is fullerene. The best known fullerene is Buckminster fullerene, which consists of 60 carbon atoms joined together in a series of 5- and 6- membered to form spherical molecule resembling a soccer ball. So its formula is C60.
- This allotrope was named as Buckminster fullerene after the American architect

Difference between Diamond and Graphite

Diamond	Graphite
Each carbon has four covalent bonds.	Each carbon has three covalent bonds.
Hard, heavy and transparent	So , slippery to touch and opaque.
It has tetrahedral units linked in three	It has planar layers of hexagon units.

dimension.	
It is a non-conductor of heat and electricity.	It is a conductor of heat and electricity.

Buckminster **fuller**. Because its structure reminded the framework of **dome shaped halls** designed by Fuller for large international exhibitions, it is called by the pet name **Bucky Ball**. A large family of fullerenes exists, starting at C20 and reaching up to C540.

(b) Amorphous forms of carbon

In amorphous form of carbon, carbon atoms are arranged in random manner. These form of carbon are obtained when wood is heated in the absence of air. E.g., charcoal

Physical properties of Carbon and its compounds

- Carbon is a non-metal found in various allotropic forms from soft powder to hard solid.
- All the allotropic forms of carbon are solids whereas its compounds exist in solid, liquid and gaseous state.
- Amorphous forms of carbon and graphite are almost black in colour and opaque. Diamond is transparent and shiny.
- Its amorphous forms have low melting and boiling point compared to crystalline forms.
- Carbon is insoluble in water and other common solvents. But some of its compounds are soluble in water and other solvents. e.g., Ethanol, CO_2 are soluble in water.

Chemical properties of Carbon and its compounds

Elemental carbon undergoes no reaction at room temperature and limited number of reactions at elevated temperatures. But its compounds undergo large number of reactions even at room temperature.

Oxidation – (Reaction with oxygen)

Carbon combines with oxygen to form its oxides like carbon monoxide (CO) and carbon dioxide (CO_2) with evolution of heat. Organic carbon compounds like hydrocarbon also undergo oxidation to form oxides and steam with evolution of heat and flame. This is otherwise called combustion.

$2C(s) + O_2(g) \rightarrow 2CO(g) + \text{heat}$
$C(s) + O_2(g) \rightarrow CO_2(g) + \text{heat}$
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + \text{heat}$

Reaction with steam

Carbon reacts with steam to form carbon monoxide and hydrogen. This mixture is called water gas.

$C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$

Reaction with sulphur

With sulphur, carbon forms its disulphide at high temperature.
$C(s) + S(g) \rightarrow CS_2(g)$

Reaction with metals

At elevated temperatures, carbon reacts with some metals like iron, tungsten, titanium, etc. to form their carbides.

Tungesten + Carbon → Tungesten carbide

Carbon compounds in everyday life

It is impossible to think of our daily life without carbon compounds. Over time, a large number of carbon compounds have been developed for the improvement of our lifestyle and comfort. They include carbon-based fuels, carbon nanomaterials, plastics, carbon filters, carbon steel, etc.

Even though carbon and its compounds are vital for modern life, some of its compounds like CO, cyanide and certain types of plastics are harmful to humans. In the following segment, let us discuss the role of plastics in our daily life and how we can become aware of the toxic chemicals that some plastics contain.

Plastics – Catenated long chain carbon compounds

Plastics are a major class of catenated organic carbon compounds. They are made from long chain organic compounds called 'polymer resins' with chemical additives that give them different properties. Different kinds of polymers are used to make different types of plastics. Plastics are everywhere. They are convenient, cheap and are used in our everyday life. Plastics have changed the way we live. They have helped improve health care, transport and food safety. Plastics have allowed many breakthroughs in technologies such as smartphones, computers and the internet. It is clear that plastic has given our society many benefits. But these benefits have come at a cost.

Drawbacks of plastics

- Plastics take a very long time to fully break down in nature.

- The microbes that break down plastic are too few in nature to deal with the quantity of plastics we produce.
- A lot of plastic does not get recycled and ends up polluting the environment.
- Some types of plastics contain harmful chemical additives that are not good for human health.
- Burning of plastics releases toxic gases that are harmful to our health and contribute to climate change.
- One-time use and throwaway plastics end up littering and polluting the environment.
- In order to know which plastics are harmful, you will need to learn the secret 'language' of plastics (resin codes).

Identifying different types of plastics

(a) The resin codes

Look at the following pictures. One is a plastic sachet in which milk is distributedto consumers and the other is a plastic food container. Observe the code shown on it (circled). Do you know what this code means? It is called a '**resin code**'. The resin code represents the type of polymer used to make the plastic.

(b) Need for resin codes

Plastics should be recycled or disposed of safely. Certain types of plastics should be avoided so that they do not end up polluting the environment or harming our health. Each plastic is composed of a different polymer or set of molecules. Different molecules do not mix when plastics are recycled, it is like trying to recycle paper and glass together. For this reason, they need to be separated. The resin codes of plastics were designed in 1988 and are a uniform way of classifying the different types of plastic which help recyclers in the sorting process.

(c) Find in the resin code on plastic items

The secret resin codes are shown as **three chasing arrows in a triangle**. There is a **number in the middle or letters under the triangle** (an acronym of that plastic type). This is usually difficult to find. It can be found on the label or bottom of a plastic item.

The resin codes are numbered from 1 to 7. Resin codes #1 to #6 each identify a certain type of plastic that is often used in products. Resin code #7 is a category which is used for every other plastic (since 1988) that does not fit into the categories #1 to #6. The resin codes look very similar to the recycling symbol, but this does not mean that all plastics with a code can be recycled.

(d) **Where will the resin code be shown on plastic items?**

- Flip a plastic item to find the resin code on the bottom.
- Sometimes the bottom of plastic item will only have an acronym or the full name of that plastic type.
- If you do not find it on the bottom, search for the code on the label.
- Some plastics do not have a code. The company did not follow the rules and you do not know if it is safe to use.

Harmful effects of plastics

Plastics in our everyday life can be harmful for two reasons. The first reason is that some types of plastic contain chemicals that are harmful to our health. The second reason is that a lot of plastics are designed to be used just for one time. This use and throwaway plastic causes pollution to our environment.

(a) Harmful plastics

There are three types of plastic that use toxic and harmful chemicals. These chemicals are added to plastics to give them certain qualities such as flexibility, strength, colour and fire or UV resistance. The three unsafe plastics are: PVC (resin code #3), PS (resin code #6 also commonly called Thermocol) and PC/ABS (resin code #7).

PVC – Polyvinyl Chloride plastics

• Heavy metals (cadmium & lead) are added to PVC.
• Phthalates (chemical additive) copy our hormones.
• Burning PVC releases dioxins (one of the most toxic chemicals known to humans).
PS – Polystyrene plastics
• Styrene is a building block of this plastic and may cause cancer.
• It takes very long time to break-down (100- 1 million years).
• Higher amounts of toxic styrene leak into our food and drinks when they are hot or oily. PC – Polycarbonate plastics
• PC plastic contains BisphenolA (BPA).
• BPA leaks out of PC products used for food and drinks.
• BPA increases or decreases certain hormones and changes the way our bodies work.

ABS – Acrylonitrile Butadiene Styrene

• Styrene causes problems for our eyes, skin, digestive system and lungs.
• Brominated Flame Retardants (BFRs) are often added.
• Studies show that toxic chemicals leak from this plastic.

(b) One-time use plastic

Use and throwaway plastics cause short and long-term environmental damage. Half of all the plastic made today is used for throwaway plastic items. These block drains and pollute water bodies. One-time use plastic causes health problems for humans, plants and animals. Some examples are plastic carry bags, cups, plates, straws, water pouches, cutlery and plastic sheets used for food wrapping. **Figure 15.5** One-time use plastic items These items take a few seconds to be made in a factory. You will use them for a very short time. Once you throw them away, they can stay in our environment for over a 1,000 years causing plastic pollution for future generations. We need rules and laws to protect people and the environment from plastic pollution.

New rules to make Tamil Nadu plastic free

As we know, the Government of India is progressively taking various legal initiatives to stop plastic pollution by making some

provisions and amendments in the Environment (Protection) Act, 1988. With reference to this act, Government of Tamil Nadu has taken a step forward to ban the usage of some kind of plastic items (Environment and Forests Department, T.N. G.O. No: 84, dated 25/06/2018).

As per the government order cited above, the Tamil Nadu Government has banned the usage of one-time use and throwaway plastics from 1st January 2019. This excellent legislation is designed to protect Tamil Nadu from plastic pollution.

Rules which ban the production, storage, supply, transport, sale and distribution of one-time use plastics are extremely effective. They are successful because they target all sections of society–manufacturer, supplier, shopkeeper and customer. This progressive initiative taken by the State of Tamil Nadu leads by example for the rest of the nation.

You can find below some key aspects of the new rules along with science-based facts why these items have been banned in Tamil Nadu.

Banned items

Plastic carry bags

- Globally we use 2 million plastic bags each minute.
- 97% of plastic bags do not get recycled.
- Animals eat plastic bags by accident as they contain food. A cow was found with over 70 kilos of plastic in its stomach.

Plastic plates

- Dirty plastics (like a used plate) are difficult to recycle.
- Most of the one-time use plates are made from Polystyrene (resin code # 6) which is harmful to our health.
- Plates will be used for just 20 minutes but stay in the environment for over a 1,000 years.

Water pouches

- Water pouches are often littered, increasing plastic pollution.
- The blue print (ink) on the clear plastic pouch decreases the recycling value.
- Once a water pouch is used, it is difficult to recycle as it contains leftover water and gets covered in dirt.

Plastic straws

- Plastic straws are too light and small to be recycled.
- Straws are one of the top 10 items which are found in the plastic pollution in oceans.
- 90% of seabirds have ingested plastics such as straws.

Plastic sheets

- Plastic sheets used on top of plates get dirty and cannot be recycled.
- More chemicals leak from plastic into food when it is hot, spicy or oily.
- Animals such as cows, goats, and dogs eat plastic by accident because it smells like food.

Role of students in the prevention of plastic pollution

You play a very important role and have the power to minimise plastic pollution. Ask yourself, is this plastic safe or harmful plastic? If it is not a harmful plastic type, is it a one-time use plastic item? These questions and the science-based knowledge will help you to reduce unnecessary plastic pollution.

What can you do to prevent plastic pollution?

- As a student, you can share your scientific knowledge on plastics and their effects with your parents, relatives and friends to make them aware of plastic pollution.
- You can help by teaching them how to avoid harmful plastics by searching for the resin codes.
- You can educate them about the new rules and how important it is to stop one-time use plastics.

Practice in your daily life

- Do not litter the environment by throwing plastic items.
- Do not use Thermocol (resin code #6 PS) for your school projects.
- Do not use one-time use or throwaway plastics like plastics bags, tea cups, Thermocol plates and cups, and plastic straws.
- Do not burn plastics since they release toxic gases that are harmful to our health and contribute to climate change.
- Burning PVC plastic releases dioxins which are one of the most dangerous chemicals known to humans.
- Do not eat hot or spicy food items in plastic containers.
- Segregate your plastic waste and hand this over to the municipal authorities so that it can be recycled.
- Educate at least one person per day about how to identify the resin codes and avoid unsafe plastics (resin code #3 PVC, #6 PS and #7 ABS/PC).

10th book
Unit – 11 CARBON AND ITS COMPOUNDS

GENERAL CHARACTERISTICS OF ORGANIC COMPOUNDS

Everything in this world has unique character, similarly organic compounds are unique in their characteristics. Some of them are given below:

- Organic compounds have a high molecular weight and a complex structure.
- They are mostly insoluble in water, but soluble in organic solvents such as ether, carbon tetrachloride, toluene, etc.
- They are highly inflammable in nature
- Organic compounds are less reactive compared to inorganic compounds. Hence, the reactions involving organic compounds proceed at slower rates.
- Mostly organic compounds form covalent bonds in nature.
- They have lower melting point and boiling point when compared to inorganic compounds
- They exhibit the phenomenon of isomerism, in which a single molecular formula represents several organic compounds that differ in their physical and chemical properties
- They are volatile in nature.
- Organic compounds can be prepared in the laboratory

CLASSIFICATION OF ORGANIC COMPOUNDS BASED ON THE PATTERN OF CARBON CHAIN

Organic chemistry is the chemistry of catenated carbon compounds. The carbon atoms present in organic compounds are linked with each other through covalent bonds and thus exist as chains. By this way, organic compounds are classified into two types as follows:

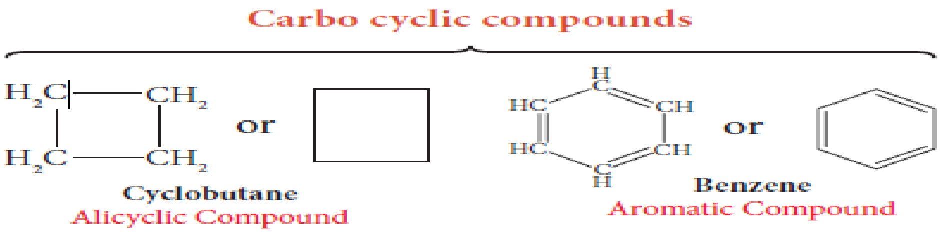
1. **Acyclic or Open chain compounds:**

   These are the compounds in which the carbon atoms are linked in a linear pattern to form the chain. If all the carbon atoms in the chain are connected by single bonds, the compound is called as saturated. If one or more double bonds or triple bonds exist between the carbon atoms, then the compound is said to unsaturated.

CH3-CH2-CH3 **Propene** **Unsaturated compound**	**CH3-CH=CH2** **Propane** **Saturated compound**

2. **Cyclic Compounds:**

Organic compounds in which the chain of carbon atoms is closed or cyclic are called **cyclic compounds.** If the chain contains only carbon atoms, such compounds are called **carbocyclic compounds.** If the chain contains carbon and other atoms like oxygen, **compounds.** Carbocyclic compounds are further subdivided into **alicyclic** and **aromatic compounds.** Alicyclic compounds contain one or more carbocyclic rings which may be saturated or unsaturated whereas aromatic compounds contain one or more benzene rings (ring containing alternate double bonds between carbon atoms). E.g.



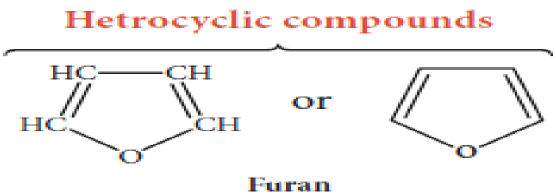
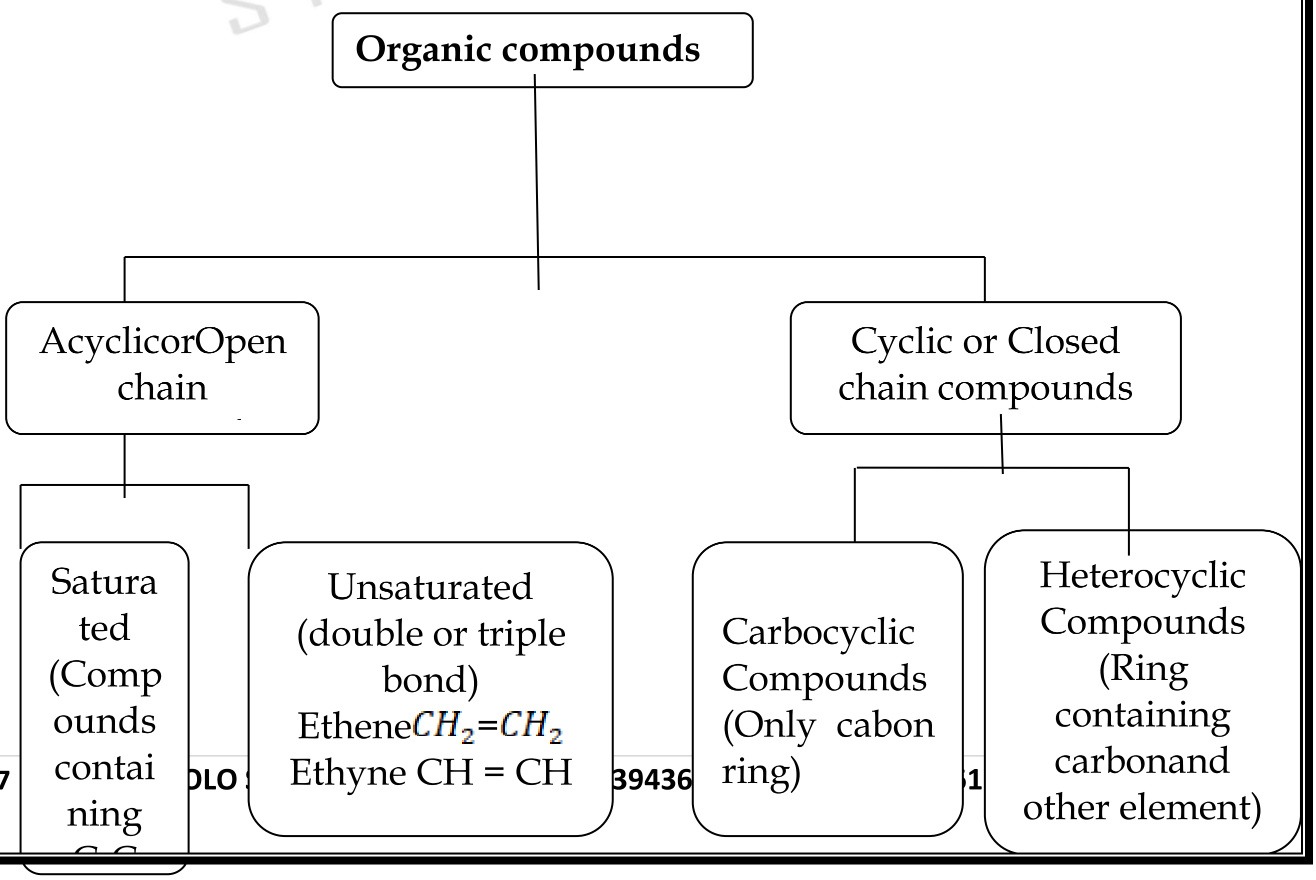
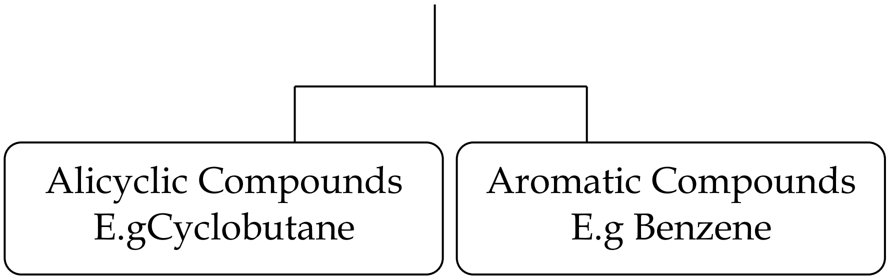


Figure 11.1 depicts the classification of organic compounds based on the pattern of carbon arrangements and their bonding in organic compounds:





Classification of organic compounds

CLASSES OF ORGANIC COMPOUNDS (BASED ON THE KIND OF ATOMS)

Other than carbon, organic compounds contain atoms like hydrogen, oxygen, nitrogen, etc., bonded to the carbon. Combination of these kinds of atoms with carbon gives different classes of organic compounds. In the following section, let us discuss various classes of organic compounds.

Hydrocarbons

The organic compounds that are composed of only carbon and hydrogen atoms are called **hydrocarbons.** The carbon atoms join together to form the framework of the compounds. These are regarded as the parent organic compounds and all other compounds are considered to be derived from hydrocarbons by replacing one or more hydrogen atoms with other atoms or group of atoms. Hydrocarbons are, further, sub divided into three classes such as:

(a) Alkanes: These are hydrocarbons, which contain only single bonds. They are represented by the general formula **C_nH_{2n+2}** (where n = 1,2, 3, ……). The simplest alkane (for n=1) is methane (CH_4). Since, all are single bonds in alkanes, they are saturated compounds.

(b) Alkenes: The hydrocarbons, which contain one or more C=C bonds are called alkenes. These are unsaturated compounds. They are represented by the general formula **C_nH_{2n}.** The simplest alkene contains two carbon atoms (n=2) and is called ethylene (C_2H_4).

(c) Alkynes: The hydrocarbons containing carbon to carbon triple bond are called **alkynes.** They are also unsaturated as they contain triple bond between carbon atoms. They have the general formula **C_nH_{2n-2}.** Acetylene (C_2H_2) is the simplest alkyne, which contains two carbon atoms. Table 11.1 lists the first five hydrocarbons of each class:

Hydrocarbons containing 1to 5 carbon atoms

No. of carbon	Alkane (C_nH_{2n}	Alkene (C_nH_{2n})	Alkyne (C_nH_{2n} -

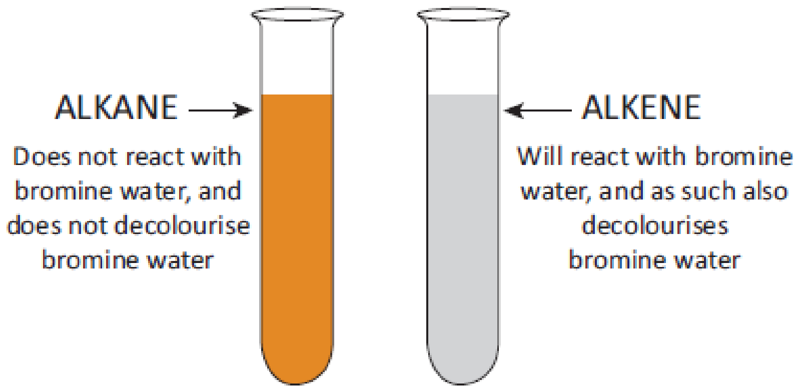
atoms	+ 2)		2)
1	Methane (CH_4)	-	-
2	Ethane (C_2H_6)	Ethene (C_2H_4)	Ethyne (C_2H_2)
3	Propane (C_3H_8)	Propene (C_3H_6)	Propyne (C_3H_4)
4	Butane (C_4H_{10})	Butene (C_4H_8)	Butyne (C_4H_6)
5	Pentane (C_5H_{12})	Pentene (C_5H_{10})	Pentyne (C_5H_8)

Characteristics of hydrocarbons:

- Lower hydrocarbons are gases at room temperature E.g. methane, ethane are gases.
- They are colourless and odourless.
- The boiling point of hydrocarbons increases with an increase in the number of carbon atoms.
- They undergo combustion reaction with oxygen to form CO_2 and water.
- Alkanes are least reactive when compared to other classes of hydrocarbons.
- Alkynes are the most reactive due to the presence of the triple bond.
- Alkanes are saturated whereas alkenes and alkynes are unsaturated.
- They are insoluble in water.

Test to identify saturated and unsaturated compounds:

- Take the given sample solution in a test tube.
- Add a few drops of bromine water and observe any characteristic change in colour.
- If the given compound is unsaturated, it will decolourise bromine water.
- Saturated compounds do not decolourise bromine.



ADDITION OF BROMINE WATER TO ALKANES AND ALKENES

Test to identify unsaturated compounds

Classification of organic compounds based on functional groups

The structural frameworks of organic compounds are made of carbon and hydrogen, which are relatively less reactive. But, the presence of some other atoms or group of atoms makes the compounds more reactive and thus determines the chemical properties of the compound. These groups are called **functional groups.**

A functional group is an atom or group of atoms in a molecule, which gives its characteristic chemical properties.

The chemical properties of an organic compound depend on its functional group whereas its physical properties rely on remaining part of the structure. Carbon to carbon multiple bonds (C=C, C C) also are considered as functional groups as many of the properties are influenced by these bonds. Other functional groups include atoms of halogens, –OH, –CHO, –COOH, etc.

For example, ethane is a hydrocarbon having molecular formula C2H6. If one of its hydrogen is replaced by –OH group, you will get an alcohol. Leaving the functional group, the rest of the structure is represented by '**R'.** Thus an alcohol is represented by 'R-OH'

$CH_3 - CH_3 CH_3 - CH_2 -$ OH ← Functional Group

Ethane Ethanol

HydrocarbonAlcohol

A series of compounds containing the same functional group is called a **class of organic compounds.** Table 11.2 shows various classes or families of organic compounds and their functional groups:

Classes of organic compounds based on functional group

Class of the compound	Functional group	Common Formula	Examples
Alcohols	–OH	R-OH	Ethanol, CH_3CH2_2OH
Aldehydes	O || −C−H	R-CHO	Acetaldehyde, CH_3CHO
Ketones	O || −C−	R–CO-R	Acetone, CH_3COCH_3

Carboxylic acids	O | | −C−OH	R-COOH	Acetic acid, CH_3COOH
Ester	O | | −C−OR	R-COOR	Methyl acetate, CH_3COOCH_3
Ether	–O–R	R-O-R	Dimethyl ether, CH_3OCH_3

HOMOLOGOUS SERIES

Homologous series is a group or a class of organic compounds having same general formula and similar chemical properties in which the successive members differ by a - CH2 group.

Let us consider members of alkanes given in Table 11.1. Their condensed structural formulas are given below:

Methane - CH4
Ethane - CH3CH3
Propane - CH3CH2CH3
Butane - CH3(CH2)2 CH3
Pentane - CH3(CH2)3 CH3

If you observe the above series.you can notice that each successive member has one methylene group more than the precedent member of the series and hence they are called homologs.

Characteristics of homologous series

- Each member of the series differs from the preceding or succeeding member by one methylene group (–CH2) and hence by a molecular mass of 14 amu.
- All members of a homologous series contain the same elements and functional group.
- They are represented by a general molecular formula. e.g. Alkanes, CnH2n + 2.
- The members in each homologous series show a regular gradation in their physical properties with respect to their increase in molecular mass.
- Chemical properties of the members of a homologous series are similar.
- All the members can be prepared by a common method.

NOMENCLATURE OF ORGANIC COMPOUNDS

Why do we need nomenclature?

In ancient days, the names of organic compounds were related to the natural things from which they were obtained. For example, the formic acid was initially obtained by distillation of 'red ants'. Latin name of the red ant is 'Formica'. So, the name of the formic acid was derived from the Latin name of its source Later, the organic compounds were synthesized from sources other than the natural sources. So scientists framed a systematic method for naming the organic compounds based on their structures. Hence, a set of rules was formulated by IUPAC **(International Union of Pure and Applied Chemistry)** for the nomenclature of chemical compounds.

Components of an IUPAC name

The IUPAC name of the any organic compound consists of three parts:

i. Root word
ii. Prefix
iii. Suffix

These parts are combined as per the following sequence to get the IUPAC name of the compound:

(i) Root word: It is the basic unit, which describes the carbon skeleton. It gives the number of carbon atoms present in the parent chain of the compound and the pattern of their arrangement. Based on the number of carbon atoms present in the carbon skeleton, most of the names are derived from Greek numerals (except the first four). Table 11.3 shows the root words for the parent chain of hydrocarbons containing 1to10 carbon atoms:

Root words of hydrocarbons

No. of carbon atoms	Root word
1	Meth-
2	Eth-
3	Prop-
4	But-
5	Pent-
6	Hex-
7	Hept-
8	Oct-
9	Non-
10	Dec-

(ii) Prefix: The prefix represents the substituents or branch present in the parent chain. Atoms or group of atoms, other than hydrogen, attached to carbon of the parent chain are called substituents. Table 11.4 presents the major substituents of organic compounds and respective prefix used for them:

Prefix for IUPAC Name

Substituent	**Prefix used**
-F	**Fluoro**
-Cl	**Chloro**
-Br	**Bromo**
-I	**Iodo**
-NH2	**Amino**
-CH3	**Methyl**
-CH2CH3	**Ethyl**

(iii) Suffix

The suffix forms the end of the name. It is divided into two parts such as

(a) Primary suffix and

(b) Secondary suffix.

The primary suffix comes after the root word. **It represents the nature in carbon to carbon bonding of the parent chain**. If all the bonds between the carbon atoms of the parent chain are single, then suffix **'ane'** has to be used. Suffix **'ene'** and **'yne'** are used for the compounds containing double and triple bonds respectively. The secondary suffix describes the functional group of the compound.

Suffix for IUPAC Name

Class of the Compound	Functional group	Suffix used
Alcohols	−OH	-ol
Aldehydes	−CHO	-al
Ketones	O || −C−	-one
Carboxylic acids	−COOH	-oic acid

IUPAC rules for naming organic compounds:

- **Rule1:** Identify the longest chain of carbon atoms to get the parent name (root word).
- **Rule 2:** Number the carbon atoms of the parent chain, **beginning at the closest end of the substituent or functional group**. These are called **locant numbers**. *If both functional group and substituent are present, then the priority will be given to the functional group*.
- **Rule 3:** In case of alkenes and alkynes, locate the double bond or triple bond and use its locant number followed by a dash and a primary suffix. The

carbon chain is numbered in such a way that the multiple bonds have the lowest possible locant number.

- ❖ **Rule 4:** If the compound contains functional group, locate it and use its locant number followed by a dash and a secondary suffix.
- ❖ **Rule 5:** When the primary and secondary suffixes are joined, the terminal 'e' of the primary suffix is removed.
- ❖ **Rule 6:** Identify the substituent and use a number followed by a dash and a prefix tospecify its location and identity.

IUPAC Nomenclature of hydrocarbons – Solved examples

Let us try to name, systematically, some of the linear and substituted hydrocarbons by following IUPAC rules:

Example 1:CH3-CH2-CH2-CH2-CH3

Step 1: It is a five- carbon chain and hence the root word is 'Pent'. (Rule 1)
Step 2: All the bonds between carbon atoms are single bonds, and thus the suffix is 'ane'.
So, its name is Pent + ane = Pentane

Example 2:

CH3
|
CH3−CH−CH2−CH2−CH3

Step 1: The longest chain contains five carbon atoms and hence the root word is 'Pent'.
Step 2: There is a substituent. So, the carbon chain is numbered from the left end, which is closest to the substituent. (Rule 2)

CH3
|
CH3−CH−CH2−CH2−CH3

Step 2: All are single bonds between the carbon atoms and thus the suffix is 'ane'.
Step 3: The substituent is a methyl group and it is located at second carbon atom. So, its locant number is 2. Thus the prefix is '2-Methyl'. (Rule 6).
The name of the compound is
2-Methyl + pent +ane = 2-Methylpentane

Example 3:
CH3
|
CH2

|
CH3– CH– CH2– CH2– CH2 – CH3

Step 1: The longest chain contains seven carbon atoms and hence the root word is 'Hept'.
Step 2: There is a substituent. So, thecarbon chain is numbered from the end, which is closest to substituent. (Rule 2)

1CH_3
|
2CH_2
|
$CH_3 - CH - CH_2 - CH_2 - CH_2 - CH_3$
3 4 5 6 7
CORRECT

CH_3
|
CH_2
|
$CH_3 - CH - CH_2 - CH_2 - CH_2 - CH_3$
1 2 3 4 5 6
WRONG

Step 2: All are single bonds between the carbon atoms and thus the suffix is 'ane'.
Step 3: The substituent is a methyl group and it is located at third carbon. So, its locant number is 3. Thus the prefix is '3-Methyl'. (Rule 6)
Hence the name of the compound is **3-Methyl + hept + ane = 3 –Methylheptane**

Example 4: CH3-CH2-CH2-CH=CH2
Step 1: It is a 'five- carbon atoms chain' and hence the root word is 'Pent'. (Rule 1)
Step 2: There is a carbon to carbon double bond. The suffix is 'ene'.
Step 3: The carbon chain is numbered from the end such that double bond has the lowest locant number as shown below: (Rule 3)

5 4 3 2 1
CH3-CH2-CH2-CH=CH2

Step 4: The locant number of the double bond is 1 and thus the suffix is '-1-ene'. So, the name of the compound is **Pent + (-1-ene) = Pent-1-ene**

IUPAC Nomenclature of other classes – Solved examples
Example 1: CH3-CH2-CH2-OH

Step1: The parent chain consists of 3 carbon atoms. The root word is 'Prop'.
Step 2: There are single bonds between the carbon atoms of the chain. So, the primary suffix is 'ane'.
Step 3: Since, the compound contains – OH group, it is an alcohol. The carbon chain is numbered from the end which is closest to –OH group. (Rule 3)

3 2 1
CH3− CH2− CH2− OH

Step 4: The locant number of –OH group is 1 and thus the secondary suffix is '1-ol'.
The name of the compound is **Prop + ane + (1-ol) = Propan-1-ol**
Note: Terminal 'e' of 'ane' is removed as per Rule 5

Example 2: CH3COOH
Step1: The parent chain consists of 2 carbon atoms. The root word is 'Eth'.
Step 2: All are single bonds between the carbon atoms of the chain. So the primary suffix is 'ane'.
Step 3: Since the compound contains the–COOH group, it is a carboxylic acid. The secondary suffix is 'oic acid'
The name of the compound is Eth + ane + oic acid) = Ethanoic acid
Table 11.6 lists IUPAC names homologs of various classes of organic compounds

Test yourself:
Obtain the IUPAC name of the following compounds systematically:

(a) CH3CHO
(b) CH3CH3COCH3
(c) ClCH2-CH2-CH2-CH3

ETHANOL (CH3CH2OH)

Ethanol is commonly known as alcohol. All alcoholic beverages and some cough syrups contain ethanol. Its molecular formula is C2H5OH. Its structural formula is

Ethanol
H H
| |
H-C-C-O-H
| | C_2H_5OH
H H

No. of carbons atoms	IUPAC Name			
	Alcohols	Aldehydes	Ketones	Carboxylic acid
1	**Methanol (CH3OH)**	**Methanal (HCHO)**	**-**	**Methanoic acid (HCOOH)**
2	**Ethanol (CH3CH2OH)**	**Ethanal (CH3CHO)**	**-**	**Ethanoic acid (CH3COOH)**
3	**Propanol (CH3CH2CH2OH)**	**Propanal (CH3CH2CHO)**	**Propanone CH3COCH3**	**Propanoic acid CH3CH2COOH**
4	**Butanol CH3CH2CH2CH2H**	**Butanal CH3CH2CH2CO**	**Butanone CH3COCH2CH3**	**Butanoic acid (CH3CH2CH2COOH)**
5	**Pentanol(CH3CH2CH2CH2 CH2OH)**	**Pentanal(CH3CH2CH2CH2CHO)**	**Pentanone(CH3COCH2CH2CH3)**	**Pentanoic acid (CH3CH2CH2CH2COOH)**

Manufacture of ethanol

Ethanol is manufactured in industries by the fermentation of molasses, which is a by-product obtained during the manufacture of sugar from sugarcane. Molasses is a dark coloured syrupy liquid left after the crystallization of sugar from the concentrated sugarcane juice. Molasses contain about 30% of sucrose, which cannot be separated by crystallization. It is converted into ethanol by the following steps:

(i) Dilution of molasses

Molasses is first diluted with water to bring down the concentration of sugar to about 8 to 10 percent.

(ii) Addition of Nitrogen source

Molasses usually contains enough nitrogenous matter to act as food for yeast during the fermentation process. If the nitrogen content of the molasses is poor, it may be fortified by the addition of ammonium sulphate or ammonium phosphate.

(iii) Addition of Yeast

The solution obtained in step (ii) is collected in large 'fermentation tanks' and yeast is added to it. The mixture is kept at about 303K for a few days. During this period, the enzymes invertase and zymase present in yeast, bring about the conversion of sucrose into ethanol.

invertase

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{} C_6H_{12}O_6 + C_6H_{12}O_6$$

Sugar glucose fructose

zymase

$$C_6H_{12}O_6 \xrightarrow{} 2C_2H_5OH + 2CO_2$$

Glucose or fructose ethanol

The fermented liquid is technically called **wash**.

(iv) Distillation of 'Wash'

The fermented liquid (i.e. wash), containing 15 to 18 percent alcohol, is now subjected to fractional distillation. The main fraction drawn is an aqueous solution of ethanol which contains95.5% of ethanol and 4.5% of water. This is called rectified spirit. This mixture is then refluxed over quicklime for about 5 to 6 hours and then allowed to stand for 12 hours. On distillation of this mixture, pure alcohol (100%) is obtained. This is called absolute alcohol.

Yeast and Fermentation: Yeasts are single–celled microorganisms, belonging to the class of fungi. The enzymes present in yeasts catalyse many complex organic reactions. Fermentation is conversion of complex organic molecules into simpler molecules by the action of enzymes. E.g. Curdling of milk

---

Physical properties

i) Ethanol is a colourless liquid, having a pleasant smell and a burning taste.
ii) It is a volatile liquid. Its boiling point is 780 C (351K), which is much higher than that of its corresponding alkane, i.e. ethane (Boiling Point = 184 K).
iii) It is completely miscible with water in all proportions.

Chemical Properties

(i) Dehydration (Loss of water)

cu

$CH_3CH_2OH \xrightarrow{573k} CH_3CHO + H_2 \uparrow$

When ethanol is heated with con H_2SO_4 at 443K, it loses a water molecule i.e. dehydrated to form ethene.

conc H_2SO_4

$CH_3CH_2OH \rightarrow CH_2 = CH_2 + H_2O$

Ethanol 443k ethane

(ii) **Reaction with sodium**:

Ethanol reacts with sodium metal to form sodium ethoxide and hydrogen gas.

$2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2 \uparrow$

Sodium ethoxide

(iii) **Oxidation:**

Ethanol is oxidized to ethanoic acid with alkaline $KMnO_4$ or acidified $K_2Cr_2O_7$

$K_2Cr_2O_7 / H^+$

$CH_3CH_2OH \rightarrow CH_3COOH + H_2O$

2[O]ethanoic acid

During this reaction, the orange colour of $K_2Cr_2O_7$ changes to green. Therefore, this reaction can be used for the identification of alcohols.

(iv) **Esterification:**

The reaction of an alcohol with a carboxylic acid gives a compound having fruity odour. This compound is called an **ester** and the reaction is called esterification. Ethanol reacts with ethanoic acid in the presence of conc. H_2SO_4 to form ethyl ethanoate, an ester.

conc H_2SO_4

$C_2H_5OH + CH_3COOH \rightarrow CH_3COOC_2H_5 + H_2O$

Ethanol Ethanoic acid Ethyl ethanoate

(v) **Dehydrogenation:**

When the vapour of ethanol is passed over heated copper, used as a catalyst at 573 K, it is dehydrogenated to acetaldehyde.

Ethanol Acetaldehyde

vi) **Combustion:**

Ethanol is highly inflammable liquid. It burns with oxygen to form carbon dioxide and water.

❖

Uses of ethanol

Ethanol is used

- ❖ in medical wipes, as an antiseptic.
- ❖ as an anti-freeze in automobile radiators.
- ❖ for effectively killing micro organisms like bacteria, fungi, etc., by including it in many hand sanitizers.
- ❖ as an antiseptic to sterilize wounds in hospitals.
- ❖ as a solvent for drugs, oils, fats, perfumes, dyes, etc.

C2H5OH + 3O22CO2 + 3H2O →

Ethanol Carbondioxide

to enhance the flavour of food extracts, for example vanilla extract; a common food flavour, which is made by processing vanilla beans in a solution of ethanol and water

in the preparation of methylated spirit (mixture of 95% of ethanol and 5% of methanol) rectified spirit (mixture of 95.5% of ethanol and 4.5% of water), power alcohol (mixture of petrol and ethanol) and denatured spirit (ethanol mixed with pyridine).

ETHANOIC ACID (CH_3COOH)

Ethanoic acid or acetic acid is one of the most important members of the carboxylic acid family. Its molecular formula is C2H4O2. Its structural formula is

```
    H  O
    |  ||
 H--C--C—OH
    |
    H
```

Manufacture of ethanoicacid

Ethanoic acid is prepared in large scale, by the oxidation of ethanol in the presence of alkaline potassium permanganate or acidified potassium dichromate.

KMnO4/OH-

CH3CH2OH2[O]CH3COOH + H2O →

Ethanol Ethanoic acid

Physical Properties

(i) Ethanoic acid is a colourless liquid having an unpleasant odour.
(ii) It is sour in taste.
(iii) It is miscible with water in all proportions.

Chemical Properties

(i) **Reaction with metal:** Ethanoic acid reacts with active metals like Na, Zn, etc., to liberate hydrogen and form sodium ethanoate.

$2CH_3COOH + Zn \rightarrow (CH_3COO)_2Zn + H_2 \uparrow$

$2CH_3COOH + 2Na \rightarrow 2CH_3COONa + H_2 \uparrow$

ii) Reaction with carbonates and **bicarbonates:** Ethanoic acid reacts with sodium carbonate and sodium bicarbonate, which are weaker bases and liberates CO_2, with brisk effervescence.

$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + CO_2 \uparrow + H_2O$

Uses of ethanoic acid

Acetic acid, in lower concentration, is used as a food additive, a flavoring agent and a preservative.

Ethanoic acid is used

- in the manufacture of plastic.
- in making dyes, pigments and paint.
- in printing on fabrics.
- as a laboratory reagent.
- for coagulating rubber from latex.
- in the production of pharmaceuticals.

ORGANIC COMPOUNDS IN DAILY LIFE

Organic compounds are inseparable in human life. They are used by mankind or associated at all stages of life right from one's birth to death. Various classes of organic compounds and their uses in our daily life as follows:

Hydrocarbons

- Fuels like LPG, Petrol, Kerosene.
- Raw materials for various important synthetic materials.
- Polymeric materials like tyre, plastic containers.

Soap

Soaps and the Detergents are materials that are used by us for cleaning purposes because pure water alone cannot remove all types of dirt or any oily substance from our body or clothes. They contain ‘surfactants’, which are compounds with molecules that line up around water to break the ‘surface tension’. Both of them having a different chemical nature. Soap is a cleaning agent that is composed of one or more salts of fatty acids. Detergent is a chemical compound or a mixture of chemical compounds, which is used as a cleaning agent, also. They perform their cleaning actions in certain specific conditions. You will learn more about this in detail, in the following units

Soaps are sodium or potassium salts of some long chain carboxylic acids, called fatty acids. Soap requires two major raw materials: i) fat and ii) alkali. The alkali, most commonly used in the preparation of soap is sodium hydroxide. Potassium hydroxide can also be used. A potassium-based soap creates a more water-soluble product than a sodium-based soap. Based on these features, there are two types of soaps:

A. HARD SOAP

Soaps, which are prepared by the ***saponification of oils or fats with caustic soda*** (sodium hydroxide), are known as hard soaps. They are usually used for washing purposes.

B. SOFT SOAP

Soaps, which are prepared by the ***saponification of oils or fats with potassium salts***, are known as soft soaps. They are used for cleansing the body.

Manufacture of soap
KETTLE PROCESS:

This is the oldest method. But, it is still widely used in the small scale preparation of soap. There are mainly, two steps to be followed in this process.

i) Saponification of oil:
The oil, which is used in this process, is taken in an iron tank (kettle). The alkaline solution (10%) is added into the kettle, a little in excess. The mixture is boiled by passing steam through it. The oil gets hydrolysed after several hours of boiling. This process is called Saponification

ii) Salting out of soap:
Common salt is then added to the boiling mixture. Soap is finally precipitated in the tank. After several hours the soap rises to the top of the liquid as a 'curdy mass'. The neat soap is taken off from the top. It is then allowed to cool down

Effect of hard water on soap

Hard water contains calcium and magnesium ions (Ca2+ and Mg2+) that limit the cleaning action of soap. When combined with soap, hard water develops a thin layer (precipitates of the metal ions) called 'scum', which leaves a deposit on the clothes or skin and does not easily rinse away. Over time, this can lead to the deterioration of the fabric and eventually ruin the clothes. On the other hand, detergents are made with chemicals that are not affected by hard water.

Detergents

Development of synthetic detergents is a big achievement in the field of cleansing.These soaps possess the desirable properties of ordinary soaps and also can be used with hard water and in acidic solutions. These are salts of sulphonic acids or alkyl hydrogen sulphates in comparison to soap, which are salts of carboxylic acids. The detergents do not form precipitates with Ca2+ and Mg2+ present in hard water. So, the cleansing action of detergents is better than that of soaps.

Preparation of detergents

Detergents are prepared by adding sulphuric acid to the processed hydrocarbon obtained from petroleum. This chemical reaction result in the formation of molecules similar to the fatty acid in soap. Then, an alkali is added to the mixture to produce the 'surfactant molecules', which do not bond with the minerals present in the hard water, thus preventing the formation of their precipitates. In addition to a 'surfactant', the modern detergent contains several other ingredients. They are listed as follows:

i) Sodium silicate, which prevents the corrosion and ensures that the detergent does not damage the washing machine.
ii) Fluorescent whitening agents that give a glow to the clothes.
iii) Oxygen bleaches, such as 'sodium perborate', enable the removal of certain stains from the cloth.
iv) Sodium sulphate is added to prevent the caking of the detergent powder.
v) Enzymes are added to break down some stains caused by biological substances like blood and vegetable juice.
vi) Certain chemicals that give out a pleasant smell are also added to make the clothes fragrant after they are washed with detergents.

Cleansing action of soap

A soap molecule contains two chemically distinct parts that interact differently with water. It has one polar end, which is a short head with a carboxylate group (–COONa) and one non-polar end having the long tail made of the hydrocarbon chain. The polar end is hydrophilic (Water loving) in nature and this end is attracted towards water. The non-polar end is hydrophobic (Water hating) in nature and it is attracted towards dirt or oil on the cloth, but not attracted towards water. Thus, the hydrophobic part of the soap molecule traps the dirt and the hydrophilic part makes the entire molecule soluble in water.

When a soap or detergent is dissolved in water, the molecules join together as clusters called 'micelles'. Their long hydrocarbon chains attach themselves to the oil and dirt. The dirt is thus surrounded by the non-polar end of the soap molecules (Figure 11.3). The charged carboxylate end of the soap molecules makes the micelles soluble in water. Thus, the dirt is washed away with the soap.

Advantages of detergents over soaps

Detergents are better than soaps because they:

- ❖ can be used in both hard and soft water and can clean more effectively in hard water than soap.
- ❖ can also be used in saline and acidic water.
- ❖ do not leave any soap scum on the tub or clothes.
- ❖ dissolve freely even in cool water and rinse freely in hard water.
- ❖ can be used for washing woollen garments, where as soap cannot be used.
- ❖ have a linear hydrocarbon chain, which is biodegradable.
- ❖ are active emulsifiers of motor grease.
- ❖ do an effective and safe cleansing, keeping even synthetic fabrics brighter and whiter.

Biodegradable and Non-biodegradable detergents:

a) Biodegradable detergents:
They have straight hydrocarbon chains, which can be easily degraded by bacteria.

b) Non-biodegradable detergents:
They have highly branched hydrocarbon chains, which cannot be degraded by bacteria.

Disadvantages of Detergents

1. Some detergents having a branched hydrocarbon chain are not fully biodegradable by micro-organisms present in water. So, they cause water pollution.
2. They are relatively more expensive than soap.

Comparison between soap and detergents

Soap	**Detergent**
It is a sodium salt of long chain fatty acids.	It is sodium salts of sulphonic acids.
Th e ionic part of a soap is –COO–Na+.	Th e ionic part in a detergent is –SO–3Na+.
It is prepared from animal fats or vegetable oils	It is prepared from hydrocarbons obtained from crude oil.
Its effectiveness is reduced when used in hard water.	It is effective even in hard water.
It forms a scum in hard water.	Does not form a scum in hard water.
It has poor foaming capacity.	It has rich foaming capacity.
Soaps are biodegradable.	Most of the detergents are non-biodegradable.

Have you noticed the term "TFM" in soap

TFM means TOTAL FATTY MATTER. It is the one of the important factors to be considered to assess the quality of soap. A soap, which has higher TFM, is a good bathing soap.

FERTILIZERS

1. **Nitrogenous Fertilizers**: These type of fertilizers generally supply nitrogen to the soil. Examples: Ammonium sulphate [$(NH_4)_2S0_4$], Calcium ammonium nitrate (CAN, basic calcium ammonium nitrate $Ca(N0_3)_2CaO$, Calcium cyanamide CaNCN, urea etc.

2. **Phosphorous Fertilizers:** These fertilizers provide phosphorous to the soil. Examples : Super phosphate of lime, triple super phosphate, phosphate slag, Ammoniated phosphates, Nitro phosphate

3. **Potash Fertilizers**: These fertilizers provide potassium to the plant. Examples: potassium chloride, potassium sulphate, Potassium nitrated etc.

4. **NP Fertilizers**: These fertilizers contain two elements i.e., sodium and phosphorus. These are formed by mixing together both the fertilizers. Example: dihydrogen ammoniated phosphate ($NH_4H_2P0_4$), calcium superphasphate [$Ca(H_2P0_4)_2$ $2Ca(N0_3)_2$].

5. **NPK or complete fertilizers**: These of type of fertilizers provide all the three essential elements viz nitrogen, Phosphorus and potassium to the soil. It is obtained by mixing all the three types of fertilizers in suitable propartions.

Nitrogenous fertilizers

1. **Ammonium sulphate or sindri fertilizers ($(NH_4)_2S0_4$).** It is prepared by manufactured at **sindri fertilizer factory Bihar**. Hence it is called sindri fertilizers. This fertilizer contains **24-25% ammonia** which is converted to nitrates in the soil by nitrifying bacteria.

   $2NH_3 + H_2O + CO_2 + CaSO_4 \rightarrow (NH_4)_2 SO_4 + CaCO_3$ - ppt

   Ammonia Soluble

2. **Calcium ammonium nitrate (CAN)(Nangal Ferilizer)**

   [$Ca(N0_3)_2$ NH_4 $N0_3$]. It is manufactured in the following manner.

   (i) **Production of ammonia** : Haber's process

(ii) Production of nitric acid: It is obtained by Ostwald's process. This process ammonia is mixed with air in the ratio of 1: 10 by volume. In this process nitric Oxide (NO) is produced.

$$4NH_3 + 5O_2 \text{ (from air)} \rightarrow 4NO + 6H_2O$$

(iii) Formation of NH_4NO_3:

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

Ammonium nitrate

(iv) Formation of CAN pellets: The concentrates solution of NH_4ON_3 is stirred with finally powdered lime stone.

$$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$$

$$Ca(NO_3)_2 + NH_4NO_3 \rightarrow Ca(NO_3)_2\ NH_4NO_3$$

(v) CAN is very hygroscopic hence to protect it from atmospheric moisture the pellet of CAN are stirred with concentrated solution of finely powdered soap stone (Sodium silicate). The pellets are then dried and packed in polythene bags.This fertilizers is manufactured in Mangal (Punjab) and Rourkela.CAN **contains 20% nitrogen**. It can be directly assimilated by plants, It is highly soluble in water.

3. Calcium Cyanamide ($CaCN_2$). This compound is a derivate of cynamide (H_2CN_2). It is manufactured by the action of air on lime stone and coal. The lime stone is burnt in kilns to obtain lime (CaO). A mixture of lime and coal is heated in an electric furnace at 2500°C to produce calcium carbide (CaC_2) It is finely powdered and then heated in a cylindrical electric furnace at 1000°C in the atmosphere of nitrogen, when $CaCN_2$ is produced.

$$\underset{\text{Lime stone}}{CaCO_3} \xrightarrow{\text{Heat}} CaO + CO_2$$

$$CaO + 3C \xrightarrow[2500°C]{\text{Heat}} CaC_2 + CO$$

$$CaC_2 + N_2 \xrightarrow[1000°C]{\text{Heat}} \underset{\text{Grey Calcium Cynamide}}{CaCN_2} + C + heat$$

It is sparingly soluble in water. This ammonia is converted into nitrates by nitrifying bacteria.

4. **Urea (carbamide NH_2CONH_2).** It is an excellent nitrogenous fertilizer and is manufactured by reacting ammonia and carbon-di-oxide.

$$CO_2 + 2NH_3 \rightarrow NH_2COONH_4$$

Ammonium Carbamate

$$NH_2\,COONH_4 \rightarrow NH_2CONH_2 + H_2O$$

Urea

Urea separate as dry powder and contains 47% of nitrogen. Urea has the higher nitrogen content than other fertilizers. It cost of production is less and it can be used in all types of crops and soils.

Phosphate Fertilizers

Super phosphate of lime [$Ca(H_2PO_4)_2 + 2(CaSO_4\ 2H_2O)$].

It is a mixture of calcium dihydrogen phosphate $Ca(H_2PO_4)$ and dihydrate calcium sulphate (gypsum) $CaSO_4\ 2H_2O$. It contains about **16-20 % of P_2O_5**.

$$Ca_3(PO_4)_2 + 2H_2SO_4 + 4H_2O \rightarrow Ca(H_3PO_4)_2 + 2(CaSO_4.2H_2O) + heat$$

Calcium di hydrogen + gypsum Phosphate

Supper Phosphate of Lime

1. **Double and Triple Superphosphates**

Triple phosphate is prepared by treating rock phosphate with phosphoric acid in a mixer.

$$Ca_3(PO_4)_2 + 4H_3PO_4 \rightarrow 3CaH_4(PO_4)_2$$

2. **Phosphatic Slag**

This Slag is obtained as a byproduct in the manufacture of steel and is a double salt of tricalcium phosphate and calcium silicate.

3. **Ammoniated phosphate**

It is prepared action of calcium phosphate, sulphuric acid and ammonium sulphate. It contains about 12% of nitrogen and **50.5% of P_2O_5.**

$$Ca_3(PO_4)_2 + (NH_4)2SO_4 + 2H_2SO_4 \rightarrow 2NH_4H_2PO_4 + 3CaSO_4$$

Potash fertilizers

1. **Potassium chloride**. It is found in nature as Sylvine (KCl) and carnallite (KCl.MgCl. $6H_20$). It is extracted from carnallite by boiling with the mother liquor from previous operation. Carnallite dissolves where as

other impurities are not dissolved and can be filtered off. It is a white crystalline solid and is fairly soluble in water.

2. **Potassium sulphate (K_2SO_4)**. It is manufacture from naturally occurring mineral eg. schonite.

$$K_2SO_4 . MgSO_4 .6H_2O + 2KCl \rightarrow 2K_2SO_4 + MgCl_2 + 6H_2O$$

3. **Potassium nitrate or Nitre or Indian- Saltpetre (KNO_2)**: Crude Nitre occurs as an efflorescence on the surface of the earth in tropical countries. It is obtained from a mixture of child % petre ($NaNO_2$) and potassium chloride (KCl).

$$NaNO_2 + KCl \rightleftharpoons KNO_2 + NaCl$$

Ill Effects Of Fertilizers

1. **Micronutrient loss and imbalance**

Most of the chemical fertilizers used in modern agriculture have **Nitrogen, Phosphorous and Potassium** which are essential **primary macronutrients**. **Calcium , Magnesium and Sulphur** are **secondary macronutrients**. Excessive use of these fertilizers cause deficiency [of **micro nutrients** viz., zinc, copper molybdenum, boron etc., in the soil which affect the productivity if the soil.

2. **Nutrient Toxicity**

Higher doses of fertilizers produces toxicity which jffect the normal growth and development of plants

3. **Deteriorates soil Quality**

Indiscriminate and unscientific use of these fertilizer can deteriorate the soil quality.

4. **Impairs water quality**

These fertilizers applied in the field otter, leach deep into the soil and ultimately contaminate the ground water. For example: From nitrogenous fertilizers the nitrates get concentrated in the water and if the concentration **exceeds 25 mg/**l they became the cause of serious health hazard called **"Blue baby syndrome" or metha emoglobinemia.**

5. **Causes Environmental Pollution**

Excessive uses of fertilizers have caused irrepairable damage to the environment. The unused quantity of fertilizers escapes into the hydrosphere or atmosphere. The applied nitrogen escapes into the atmosphere in the form of harmful gases like ammonia, nitrous oxide etc.

6. **Effect of fertilizers on crop yield and quality**

   Excessive nitrogen decreases the phosphate content in leaves and grain. Excessive amount of nitrate fertilizers can cause acute poisoning in livestock. Sodium nitrate fertilizers contain sodium per chlorate as an impurity which has strong adverse effect on germination of several crops. Sodium nitrate fertilizers scorches the young leaves of vegetable crops and potato.

7. **Eutrophication**

   Excessive and prolonged use of nitrogen and phosphorous fertilizers in the field causes water pollution. The excessive fertilizers are washed off with water and reach water bodies causing over nourishment of these water bodies like lakes. This process is known as eutrophication (eu = more, trophic = nutrition) Due to eutrophication the lakes get invaded by **algal blooms.** These cause diminished oxygen content in the water and it affects the aquatic life severely.

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5. PESTICIDES

Pesticides are legally classed as "Economic poisons" and are defined-., as "any substance used for controlling, preventing, destroying, repelling or mitigating any pest"

Lists the various pesticides

S.No	Pesticide Class	Functions
1	Insecticide	Controls Insects
2	Herbicide	Kills Weeds
3	Fungicide	Kills Fungi
4	Rodenticide	Kills Rodents
5	Bactericide	Kills Bacteria
6	Algicide	Kills Algae
7	Molluscicide	Kills Snails,Slugs, Mussels,Oyesters
8	Avicide	Controls or repels birds
9	Slimicide	Controls Slimes
10	Piscicide	Controls Fish
11	Ovicide	Destroys Eggs

Insecticides

The control of insect pests affecting agricultural crops, domestic animals and man has been of considerable economic importance to mankind since the beginning of civilization.

1. **The Arsenic Compounds**
   Arsenic Oxides: Arsenic tri oxide As_2O_3, Arsenic pentoxide or Arsenic acid As_2O_5.
   Calcium Arsenates: $Ca_3 (AsO_4)_2]_3 Ca(OH)_2$
   Lead Arsenates: $PbHASO_4$

Magnesium Arsenates: Mono magnesium ortho Arsenate $MgH_4(AsO_4)_2$, Secondary magnesium ortho Arsenate $MgHAsO_4$ and Tri magnesium ortho Arsenate $Mg_2(AsO_4)_2$.

2. **Fluorine Compunds**
Sodium Fluoride(NaF): The first Fluorine compound used against cockroaches. It is also used as **Herbicide.**
Zinc Fluoride (ZnF_2): Used as wood Preservative.
Calcium Fluorspar, magnesium, Strontium, Copper, barium and lead fluorides are tested against **mosquito larvae**.
    - Sodium and Potassium fluosilicate Na_2SiF_6 and K_2SiF_6 areused against **mosiquito larvae.**
    - Sodium aluminum fluosilicate, Sodium fluo aluminates Na_3AlF_6

3. **Boron Compounds.**
    (i) **Boric acid (H_3BO_3)** has been used as an ingredient of cock roach baits and to kill housefly larvae in manure.
    (ii) **Borax($Na_2B_4O_7$. $10H_2O$)**: It is used as fly preventive in manure and ant poison
    (iii) Barium and Calcium borates.

4. **Mercury Compounds**
Metallic mercury has been found to function as a fumigant.
    (i) **Mercuric chloride $HgCI_2$** It has been used as fungicide and Bacteriacide.
    (ii) **Mercuric oxide HgO**
    (iii) **Ethyl mercuric chloride(C_2H_5 HgCl),Ethyl mercuric Iodide – (C_2H_5HgI)** and **Ethyl mercuric Phosphate .**
    (iv) **Phenyl mercuric salts (C_6H_5HgX):** Acetate, Benzoate, Phthalate, Salicylate, Gluconate.
    (v) **Hydroxy mercuri chlorophenol, Hydroxy mercuricresol**.

5. **Copper Compounds**
(i)Bordeaux mixture($CuSo_4$+ $Ca(OH)_2$)
Solution made up of **copper sulphate, quick lime and water** in fixed ratios. It is used as Fungicide.
(ii) Burgundy mixture:
It is known as soda Bordeaux and is prepared by the reaction of copper sulphate, pentohydrate and sodium carbonate solution.

6. **Suphur Compounds**
'Sulphur dioxide (S02) is used as household fumigant.

Some Important Herbicides

Some Important Herbicides are **2, 4 D** (2, 4 dichlorophenoxy acetic acid), **2, 4, 5-T** (2, 4, 5 tri-chlorophenoxy acetic acid) ,atrazine, picioram, propazine.

Some Important Rodenticides

Some Important Rodenticides are Strychnine, Arsenic, Zinc Phosphate, warparin, sodium fluoro acetate, thalium phosphorus, ANTU (alpha naphthyl urea) and Norbromide.

Oil Exploration

8th book
Unit – 15 - CHEMISTRY IN EVERYDAY LIFE

Hydrocarbon

Hydrocarbons are the organic compounds consisting of hydrogen and carbon atoms. They are combustible and produce large amount of heat energy along with carbon dioxide and water vapour, on burning. Hence, many hydrocarbons are used as fuels.

Sources of Hydrocarbons

Hydrocarbons occur naturally and they are found in fossil fuels like crude oil, natural gas and coal. About 300 million years ago plants and animals died and they were buried on the ocean floor. Overtime they were covered by silt and soil layers.

Then they were buried deep inside the earth and compressed through temperature and pressure and converted to fossil fuels like oil and natural gas. These fuels are found in porous rocks which lie below large bodies of water, especially oceans. By drilling these rocks hydrocarbons can be extracted. Hydrocarbons are present in different trees and plants also.

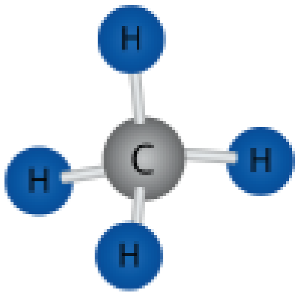
Properties of Hydrocarbons

Among all the chemical compounds hydrocarbons have some unique properties. Some of them are given below.

- Most of the hydrocarbons are insoluble in water.
- Hydrocarbons are less dense than water. So they fl oat on top of water.
- Most hydrocarbons react with oxygen to produce carbon dioxide and water.
- Hydrocarbons can be gases (e.g. methane and propane), liquids (e.g. hexane and benzene) or waxes (paraffin).
- Hydrocarbons are capable of making bonds with one another. This property is known as catenation. Due to this property they form more number of complex molecules.

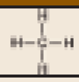
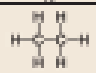
Types of Hydrocarbons

In hydrocarbons carbon and hydrogen atoms are linked together through different chemical bonds. Depending on the bond between these atoms there are number of hydrocarbons. The four general classes of hydrocarbons are: alkanes, alkenes, alkynes and arenes. Some of the common hydrocarbons are methane, ethane, propane, butane and pentane. Methane is the simplest hydrocarbon in which four hydrogen atoms are linked with one carbon atom. It is a colourless, odourless and inflammable gas. It is an eco-friendly fuel because it does not produce any harmful products. It is used as a fuel in electricity generation. Methane is also known as marsh gas as it is present in marshes. Dead and decaying plants and animals release methane gas. It is a renewable source of energy. Sewage sludge can also be decomposed by microorganisms to produce methane gas along with impurities like carbondioxide and hydrogen sulphide. After removing these impurities, methane gas can be used as an efficient fuel.



Structure of methane

Make a model using clay and match sticks for the following hydrocarbons.

Name	Formula	Structure
Methane	CH_4	
Ethane	C_2H_6	
Propane	C_3H_8	
Butane	C_4H_{10}	
Pentane	C_5H_{12}	

Propane is an odourless and highly inflammable gas. It is heavier than air. It is liquefied through pressurisation and commonly used as LPG (Liquefied Petroleum Gas) along with butane. Propane is used as fuel in heating, cooking, and vehicles. Propane can also be used as refrigerants.

Propane is used in LPG cylinders. Since it is an odouress gas, any leakage cannot be detected. Hence, a chemical by name Mercaptan is mixed with LPG to help in detection of any leakage of LPG.

Butane is a gas at room temperature and atmospheric pressure. They are highly flammable, colorless gases that quickly vaporize at room temperature. Butane is used as a fuel gas and propellant in aerosol sprays such as deodorants. Pure forms of butane can be used as refrigerants. Butane is also used as lighter fuel for a common lighter or butane torch. Pentanes are liquids with low boiling point. They are used as fuels and solvents in the laboratory. They are also used to produce polystyrene.

Natural Gas

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane along with other higher alkanes and a small percentage of carbon dioxide, nitrogen and hydrogen sulphide (H_2S). If thenatural gas contains lower hydrocarbons like methane and ethane, it is called dry gas. If higher hydrocarbons like propane and butane are also present in the gas, it is called wet gas.

Natural gas is always found above the oil in the oil wells. This gas is trapped inside the small spaces in underground rocks called reservoirs. Conventional natural gas can be extracted through drilling wells. Natural gas can also be found in reservoirs with oil and is extracted along with oil. This is called associated gas.

Natural gas is a fossil fuel used as a source of energy for heating, cooking and electricity generation. Natural gas occurs in Tripura, Rajasthan, Maharashtra, Andhra Pradesh (Krishna, Godavari Basins) and Tamil Nadu (Cauveri Delta). It is also formed by the decomposition of organic matter in marshy areas and waste sewages. The natural gas formed by this way contains mainly methane.

Uses of Natural Gas

- Natural gas is used as an industrial and domestic fuel.
- It is used in thermal power stations.
- It is used as fuel in vehicles as an alternative for petrol and diesel.
- When heated it decomposes and forms hydrogen and carbon. Hydrogen thus formed is used in the manufacture of fertilizers.
- It is used to manufacture chemicals, fabrics, glass, steel, plastics and paints.
- It is also used in electricity generation.

Moderate temperature and humidity is needed to keep paintings and other ancient artifacts from being destroyed by environmental factors. Thus natural gas is used in museums to protect the monuments.

15.2.2 Advantages of Natural Gas

- It produces lot of heat as it is easily burnt.
- It does not leave any residue.
- It burns without smoke and so causes no pollution.
- This can be easily supplied through pipes.
- It can be directly used as fuel in homes and industries.

Compressed Natural Gas

When the natural gas is compressed at high pressure, it is called Compressed Natural Gas (CNG). Nowadays it is used as fuel in automobiles. The primary hydrocarbon present in CNG is methane (88.5%). Natural gas is liquefied for shipping in large tankers. This is called Liquefied Nitrogen Gas (LNG). CNG is stored at high pressure whereas LNG is stored in ultra cold liquid form. CNG has the following properties.

- It is the cheapest and cleanest fuel.
- Vehicles using this gas produce less carbon dioxide and hydrocarbon emission.
- It is less expensive than petrol and diesel.

The average composition of CNG.

Constituents	Percentage
Methane	88.5
Ethane	5.5
Propane	3.7
Butane	1.8
Pentane	0.5

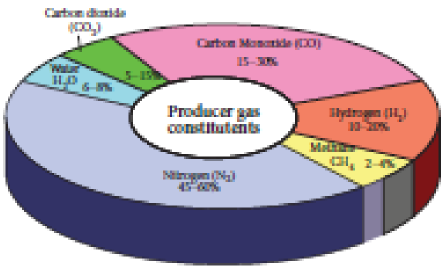
Other Gases

Apart from natural gas, there are some other gases used as fuel. Producer gas, coal gas, bio gas and water gas are some of them.

Producer Gas

Producer gas is a gaseous mixture of carbon monoxide and nitrogen. It is produced by passing air mixed with steam, over red hot coke at a temperature of 1100 ˚C. It is used as an industrial fuel for iron and steel manufacturing.

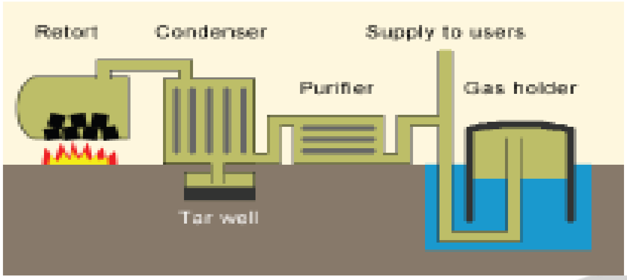
Producer gas is known by different names in different countries. It is referred as Wood gas in USA and as Suction gas in UK.



Composition of Producer Gas

Coal Gas

It is a mixture of gases like hydrogen, methane and carbon monoxide obtained by the destructive distillation of coal. Heating coal in the absence of air is called destructive distillation. It is used in heating open hearth furnace in the manufacture of steel. It is also used as a reducing agent in certain metallurgical operations.



Production of coal gas

Water Gas

It is a gaseous mixture of carbon monoxide and hydrogen. It is made by passing steam over incandescent coke at a temperature of 1000°C.

$$C_{(g)} + H_2O_{(g)} \xrightarrow{1000^o C} CO_{(g)} + H_{2(g)}$$

It is also called as syngas or synthesis gas as it is used to synthesize methanol and simple hydrocarbons. It is used as an industrial fuel also.

Bio Gas

Bio-gas is a mixture of methane and carbon dioxide. It is produced by the decomposition of plant and animal waste which form theorganic matter. The breaking down of organic matter in anaerobic condition (ie. in the absence of oxygen) leads to the formation of biogas. It is an example for renewable source of energy.

Coal and its types

Coal is one of the fossil fuels. It is a mixture of free carbon and compounds of carbon containing hydrogen, oxygen, nitrogen and sulphur. Three hundred million years ago, some plants grew into giant ferns and mosses. These plants got buried into the bottom of the soil. They slowly started to decompose and formed a dense, sponge like material called peat. Over time peat was compressed due to high temperature and pressure and coal was formed. As coal contains mainly carbon, the slow process of conversion of dead vegetation into coal is called carbonization.

Extraction of Coal

Coal is extracted from the coal beds found below the surface of the earth. Coal found inside the earth is broken into pieces by explosivesand brought above. Depending on the depth of the coal bed, coal is extracted in two ways.

Surface mining

If the coal beds lie within 22 feet of the earth's surface, the top soil is removed and coal is dug out. This is called surface mining.

Underground mining

In some places, coal beds are found very deep inside the earth. In that case underground tunnels are made to get this coal. This is called underground mining or deep mining.

Coal reserves can be found in about 70 countries worldwide. The largest coal reserves are available in United State, Russian, China, Australia and India. The US is the internationalleader in coal reserves, with nearly 30% of the world's supply. Coal mining was started in India in 1774. India now ranks third among the coal producing countries in the world. USA and China have two third of the world's coal reserve.

Types of Coal

Coal is classified into four main categories based on the amounts of carbon it contains and the heat energy it can produce. They are lignite, sub bituminous, bituminous and anthracite. Among these four types anthracite is the most desirable one due to its high heat content.

Lignite

Lignite is a brown colored coal of lowest grade. It has least content of carbon. The carbon content of lignite is 25 – 35%. Lignite contains a high amount of water and makes up almost half of our total coal reserves. It is used for electricity generation. The other uses include generating synthetic natural gas and producing fertilizer products.

Sub bituminous

When lignite becomes darker and harder over time sub-bituminous coal is formed. Sub bituminous coal is a black and dull coal. It has higher heating value than lignite and contains 35-44% carbon. It is used primarily as fuel for electricity power generation. This coal has lower sulfur content than other types and burns cleaner.

Bituminous

With more chemical and physical changes, sub-bituminous coal is developedinto bituminous coal. Bituminous coal is dark and hard. It contains 45-86% carbon. It has high heating value. It is used to generate electricity. Other important use of this coal is to provide coke to iron and steel industries. By-products of this coal can be converted into different chemicals which are used to make paint, nylon, and many other items.

Anthracite

It is the highest grade coal. It is hard and dark black in colour. It has a very light weight and the highest heat content. Anthracite coal is very hard, deep black and shiny. It contains 86-97% carbon and has a heating value slightly higher than bituminous coal. It burns longer with more heat and less dust.

Uses of coal

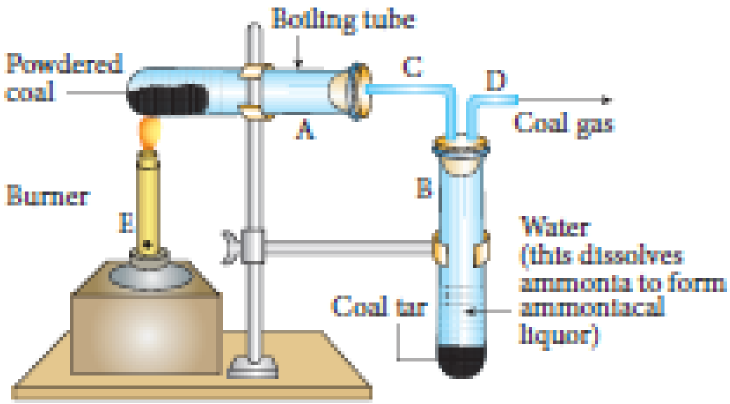
- Coal is used to generate heat and electricity.
- It is used to make derivatives of silicon which are used to make lubricants, water repellents, resins, cosmetics, hair shampoos, and toothpaste.
- Activated charcoal is used to make face packs and cosmetics.
- Coal is used to make paper.
- Coal helps to create alumina refineries.
- Carbon fibre which is an extremely strong but lightweight material is used in construction, mountain bikes, and tennis rackets.
- Activated carbon, used in filters for water and air purification and in kidney dialysis machines is obtained from coal.

Products obtained from coal

Coal when heated in the absence of air does not burn but produces many by-products. This process of heating coal in the absence of air is called destructive distillation of coal. Thousands of different products have coal or coal by-products as their components. Some of them are soap, aspirins, solvents, dyes, plastics, and fibres, such as rayon and nylon. The main by products obtained during destructive distillation are coke, coal tar, ammonia and coal gas.

Destructive Distillation of Coal

The destructive distillation of coal can be carried out in the laboratories. The apparatus is as shown in



Fractional Distillation

Finely powdered coal is taken in a test tube and heated. At a particular temperature coal breaks down to produce coke, coal tar, ammonia and coal gas. Coal tar is deposited at the bottom of the second test tube and coal gas escapes out through the side tube. The ammonia produced is absorbed in the water, forming ammonium hydroxide. Finally a black residue called coke is left in the first tube.

Coke:

Coke contains 98% carbon. It is porous, black and the purest form of coal. It is a good fuel and burns without smoke. It is largely used as a reducing agent in the extraction of metals from their ores. It is also used in making fuel gases like producer gas and water gas which is a mixture of carbon monoxide and hydrogen.

Coal tar:

Coal tar is a mixture of different carbon compounds. It is a thick, black liquid with unpleasant smell. The fractional distillation of coal tar gives many chemical substances like benzene, toluene, phenol and aniline. They are used in the preparation of dyes, explosives, paints, synthetics fibers, drugs, and pesticides. Another product obtained from coal tar is naphthalene balls which are used to repel moth and other insects.

Coal Gas:

Coal gas also known as town gas is mainly a mixture of gases like hydrogen, methane and carbon monoxide. The gases present in coal gas are combustible and hence, it is an excellent fuel. It has high calorific value.

Ammonia:

The other by product obtained from coal is ammonia. It is used for making fertilizers such as ammonium sulphate, ammonium superphosphate etc.

It is also known as Black Diamond owing to its precious nature. On destructive distillation, 1000 kg of coal gives 700 kg of coke, 100 litres of ammonia, 50 litres of coal tar and 400 m3 of coal gas.

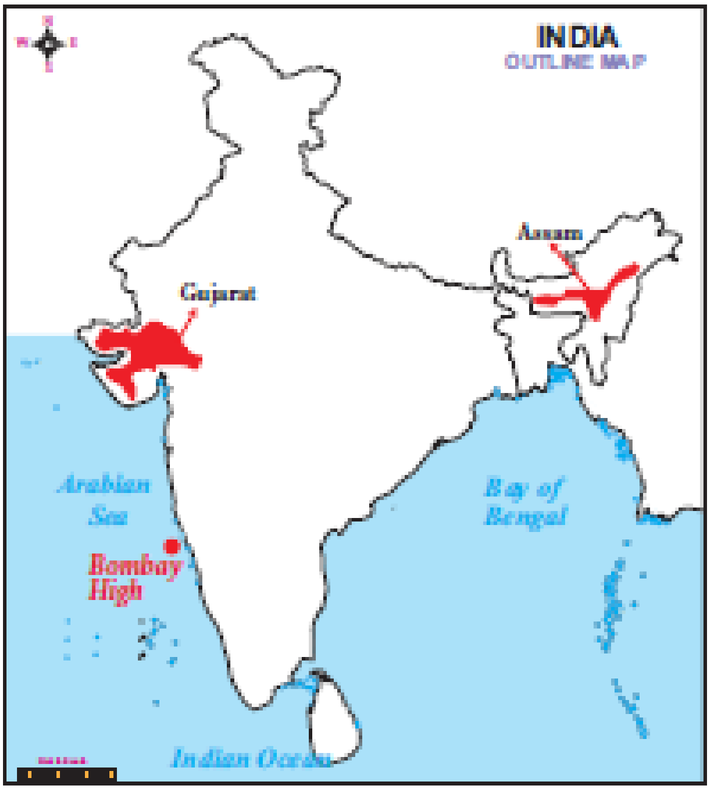
Petroleum

The term 'petroleum' is derived from the latin words 'petra' meaning rock and 'oleum' meaning oil. It is a fossil fuel formed from the remains of ancient marine organisms through death and decay. Petroleum is a complex mixture ofhydrocarbons that occur in Earth in liquid, gaseous, or solid form. The term petroleum commonly denotes the liquid form, crude oil. But technically petroleum also includes natural gas and bitumen, a solid form. The natural gas and the crude oil constitute the primary fossil fuels.

Ancient cultures used crude oil for binding materials. It was also used as a sealant for waterproofing various surfaces.

Occurrence of Petroleum

The chief petroleum producing countries are U.S.A, Kuwait, Iraq, Iran, Russia and Mexico. In India, petroleum is found in



Places where petroleum is extracted

Assam, Gujarat, Maharashtra (Mumbai), Andhra Pradesh (Godavari and Krishna basin) and Tamil Nadu (Cauveri Basins). By drilling through the earth the crude oil is pumped out from the well as a black liquid.

The first oil well in the world was drilled in Pennsylvania, USA in 1859. The second oil well was drilled in Makum, Assam, India in 1867.

Refining of crude petroleum

Thecrude petroleum obtained from the well is a dark colored viscous liquid which contains many impurities such as water, solid particles and gases like methane and ethane. To make it useful for different purposes, it must be separated into various components. The process of separating petroleum into useful by-products and removal of undesirable impurities is called refining. The steps involved in this process are given below.

Separation of water

The crude oil obtained from the oil wells will have salt water mixed with it. As the first step the water is removed from the crude oil.

Removal of sulphur compounds

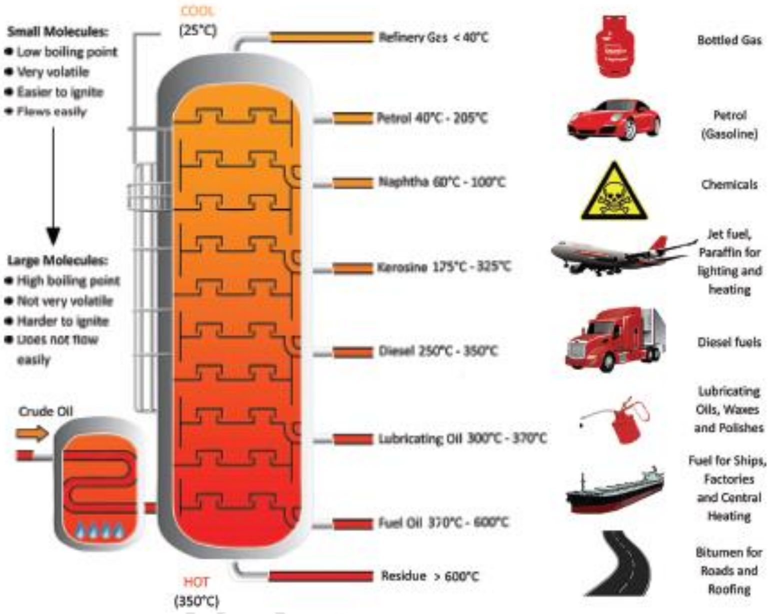
The crude oil will have harmful sulphur compounds as impurities. In this step these impurities are removed.

Fractional distillation

Petroleum is a mixture of various constituents such as petroleum gas, petrol, diesel, kerosene, lubricating oil, paraffin wax, etc. The process of separation of various constituents or fractions of petroleum is done by fractional distillation in fractionating columns. The process of heating a mixture of liquids having different boiling points and then separating them by cooling is called fractional distillation.
Crude petroleum is first heated to about 400°C in a furnace. As the vapours of crude oil move up the tower, the various fractions condense according to their boiling point ranges. The various fractions of petroleum obtained are tabulated below. Many useful substances are obtained from petroleum and natural gas. These are termed 'petrochemicals'. These are used in the manufacture of detergents, fibres, and other man-made plastics like polythene. Hydrogen gas obtained from natural gas, is used in the production of fertilizers. Due to its great commercial importance, pertoleum is also called 'black gold'.

Uses of Petroleum
Products obtained from crude oil have a number of uses.

- Liquefied Petroleum Gas or LPG is used in houses as well as in the industry.
- Diesel and petrol are used as fuels for vehicles. It is also used to run electric generators.
- Petrol is used as a solvent for dry cleaning.
- Kerosene is used as a fuel for stoves and also in jet planes.
- Lubricating oil reduces wear and tear and corrosion of machines.
- Paraffin wax is used to make candles, ointments, ink, crayons, etc.
- Bitumen or asphalt is mainly used to surface roads.



Extraction of Petroleum

Fuel

Any substance that can produce heat and energy on burning is called fuel. We use this heat for various purposes such as cooking, heating and many industrial and manufacturing purposes. Some of the fuels that we use in our daily life are wood, coal, petrol, diesel and natural gas.

Types of fuel

Fuels are classified into different types according to their physical state. They are classified into solid, liquid and gaseous fuels.

Solid fuels

Fuels like wood and coal are in solid state and they are called solid fuels. This type of fuel was the first one to be used by man. These fuels are easy to store and transport. The production cost is also very low.

Liquid fuels

Most of the liquid fuels are derived from the fossil remains of dead plants and animals petroleum oil, coal tar and alcohol are some of the liquid fuels. These fuels give more energy on burning and burn without ash.

Gaseous fuel

Coal gas, oil gas, producer gas and hydrogen are some of the gaseous fuels. These fuels can be easily transported through pipes and they do not produce pollution.

Characteristics of fuel

An ideal fuel should have the following characteristics.

- It should be readily available
- It should be easily transportable
- It should be less expensive
- It should have high calorific value
- It should produce large amount of heat
- It should not leave behind any undesirable substances

Efficiency of Fuel

Any fuel contains carbon as its main constituent. During the combustion of fuel carbon combines with oxygen and liberates large amount of heat. It is expected that a fuel liberates maximum amount of heat in the short time. The efficiency of a fuel can be understood from the following terms.

Specific Energy

Specific energy is the amount of energy produced by unit mass of a fuel. It is defined as the energy per unit mass. It is used to measure the stored energy in certain substances. Its unit is Jkg-1.

Calorific Value

It is the quantity of heat produced by the complete combustion of fuel at constant pressure and normal conditions. It is measured in terms of 125kg-1.

Calorific value of fuel

Fuel	Calorific Value (KJ/kg)
Cow dung cake	6000 – 8000
Wood	17000 – 22000
Coal	25000 – 33000
Petrol	45000
Kerosene	45000
Diesel	45000
Methane	50000
CNG	50000
LPG	55000
Biogas	35000 – 40000
Hydrogen	150000

Octane Number

Octane number denotes the amount of octane present in petrol. The fuel having high octane number is called as an ideal fuel.

Cetane Number

Cetane Number measures the ignition delay of the fuel in diesel engine. When cetane number is higher the ignition delay is shorter. The fuel with high cetane number is called as the ideal fuel.

Difference between Octane number and Cetane number

Octane Number	Cetane Number
Octane rating is used for petrol	Cetane rating is used for diesel
It measures the amount of octane present in petrol.	It measures the ignition delay of the fuel in diesel engine.
Octane number of petrol can be increased by adding benzene or toluene.	Cetane number of diesel can be increased by adding acetone.
The fuel with high octane number has low cetane number	The fuel with high cetane number has low octane number.

Alternative Fuel

The natural resources in the world have been used by man in a rapid way and so very soon they will be exhausted. The traditional fuel that we use today including petroleum are non renewable and they would be depleted soon. It is estimated that coal will last for 148 years, petroleum for 40 years and natural gas for 61 years. So we need to find alternative sources of energy. More over fossil fuels emit harmful gases like carbon dioxide, carbon monoxide and sulfur dioxide which pollute the atmosphere. Burning fossil fuels also cause temperature rise in the earth's atmosphere. Many believe that fuel which does not cause pollution is needed to enhance the quality of our environment. Some of the alternative fuels are given below.

Bio diesel

Bio diesel is a fuel obtained from vegetable oils such as soya bean oil, jatropha oil, corn oil, sunflower oil, cotton seed oil, rice-bran oil and rubber seed oil.

Hydrogen - The future fuel
Hydrogen could be the best alternative fuel in the future. It is a clean fuel as it gives out only water while burning. Moreover, it has the highest energy content. It does not pollute air.

Wind energy

Wind energy is obtained with the help of wind mills. When wind blows, they rotate the blades of the wind mills and current is produced in the dynamo. Wind mills are mostly located at Kayathar, Aralvaimozhi, Palladam and Kudimangalam in Tamil Nadu.

Gobar Gas

Gobar gas is obtained by the fermentation of cow dung in the absence of air (anaerobic conditions). It mainly contains methane and a little ethane. It is widely used in rural areas for cooking and operating engines.

Solar Energy

Sun is the first and foremost energy source that makes life possible on our earth. Solar energy is the only viable fuel source of non depleting nature for, sun provides a free and renewable source of energy. It is the renewable type of energy without endangeringthe environment. It is the potential source to replace the fossil fuel in order to meet the needs of the world. With the advancements in science and technology, solar energy has become more affordable, and it can overcome energy crisis. Solar energy is a clean energy. With the minimum efforts maximum energy can be harnessed using various equipments.

Applications of Solar Energy

Solar energy has wider applications in various fields.

- ❖ It is used in solar water heater.
- ❖ It is used in drying of agricultural and animal products.
- ❖ It is used in electric power generation.
- ❖ It is used in solar green houses.
- ❖ It is used in solar pumping and solar distillation. It is used for solar cooking and solar furnaces also.