CHEMISTRY

Standard

X

PART-2

Government of Kerala
Department of Education

State Council of Educational Research and Training (SCERT) Kerala

2016

The National Anthem

Jana-gana-mana adhinayaka jaya he
Bharatha-bhagya-vidhata,
Punjab-Sindh-Gujarat-Maratha
Dravida-Utkala-Banga
Vindhya-Himachala-Yamuna-Ganga
Uchchala-Jaladhi-taranga
Tava subha name jage,
Tava subha asisa mage,
Gahe tava jaya gatha.
Jana-gana-mangala-dayaka jaya he
Bharatha-bhagya-vidhata,
Jaya he, jaya he, jaya he,
Jaya jaya jaya jaya he!

Pledge

India is my country. All Indians are my brothers and sisters.

I love my country, and I am proud of its rich and varied heritage. I shall always strive to be worthy of it.

I shall give my parents, teachers and all elders respect, and treat everyone with courtesy.

To my country and my people, I pledge my devotion. In their well-being and prosperity alone lies my happiness.

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Dear children,

As students of Class X, the highest class in a high school you are at the portals of the higher secondary education. This 'Chemistry' text has accordingly, been designed to cater to the demands of the next academic level.

The text provides opportunities for student's active participation in the classrooms. We have tried to organise these activities giving due emphasis to the level of your competence through investigative learning.

Scientific activity, while enabling social progress, must also uphold eco-friendly values. This should happen at deeper levels of any science enquiry and activity. The text has tried to incorporate such ideologies to the possible extent and to discuss emerging areas like Green Chemistry.

The initial units focus on explaining peculiarities of elements related to their electronic configuration, identifying the relationship between mass of substances and their number of molecules and also identifying the significance of mole concept in chemistry.

Following this, discussions on the rate of reactions and equilibrium and chemical reactivity of metals and their stages of production are made.

Exposing the students to the basic concepts of Organic Chemistry, the book has introduced naturally occuring and man made materials including medicines, polymers etc. which are inevitable to human progress.

It is the duty of each one of you to assimilate ideas in this text, carry out the activities effectively and attain your goal. Hope that your journey be fruitful in this through active interactions and appropriate activities.

Wishing you the best...

Dr P.A. Fathima
Director, SCERT

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THE SYMBOLS USED IN THE TEXTBOOK


Additional Information
(Need not be assessed)


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5 Production of Metals

The metal age is a significant period in the history of human civilisation. Gold, an inactive metal, is found in nature in the free state. The discovery of this metal dates back to the stone age. Later, the invention and use of brass, an alloy of copper, marked the beginning of the brass age. It took much longer for isolating iron from natural sources to make weapons. The discovery of electricity led to the production of reactive metals like aluminium, potassium, sodium etc.

So many are the metallic objects we use! It is the unique properties of each metal that are made use of here. For example, it is the electrical conductivity of copper and aluminium that is utilised in electric wires.

The thermal conductivity of aluminium is utilised in cooking utensils made of aluminium. Find out instances in which the physical properties of metals like hardness, ductility, malleability, metallic lustre are utilised.

Have you thought of how these widely used metals are produced?

The chemically reactive metals are found in the combined state (Table 5.1) while the relatively unreactive metals (platinum, gold etc.) are found in the free native state in the earth's crust. Elements or their compounds, occurring naturally and obtained by mining are called **minerals**. There can be several minerals containing the same metal. For example, bauxite ($Al_2O_3.2H_2O$), cryolite (Na_3AlF_6) and clay ($Al_2O_3.2SiO_2.2H_2O$) are some of the minerals containing aluminium. But all minerals are not used for the extraction of metals.

What are the characteristics possessed, by minerals that are used for the extraction of metals?

- Abundance
- Easily separable
- High metal content
-

A mineral from which a metal is economically, easily and quickly extracted, is called the **ore** of the metal.

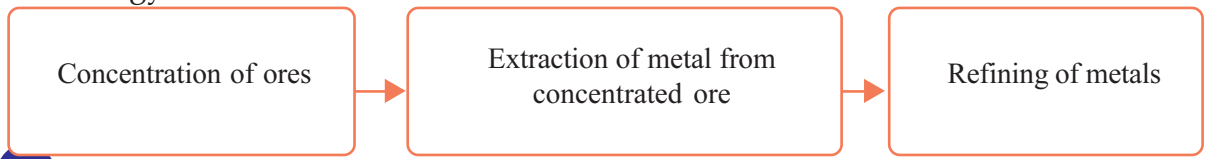
Among the minerals of aluminium, bauxite possesses these properties. Hence bauxite is the ore of aluminium. All ores are minerals, but are all minerals ores?

Examine the table showing certain metals, and the name and chemical formula of their ores (Table 5.1).

Metal	Ore	Chemical formula
Aluminium	Bauxite	$Al_2O_3.2H_2O$
Iron	Haematite, Magnetite	Fe_2O_3 Fe_3O_4
Copper	Copper pyrites Cuprite	$CuFeS_2$ Cu_2O
Zinc	Zinc blende, Calamine	ZnS $ZnCO_3$

Table 5.1

Metallurgy involves all the processes leading to the separation of a pure metal from its ore. There are three important stages in metallurgy.



I Concentration of Ores

The process of removing the impurities **(gangue)** from the ore obtained from the earth's crust is termed concentration of the ore. Depending on the nature of the ore and the impurities, there are different methods of concentration. The concentrated ore will have a higher metal content and will be more or less free from impurities. First, the ore is powdered **(pulverisation)**. Different methods are used to concentrate the powdered ore.

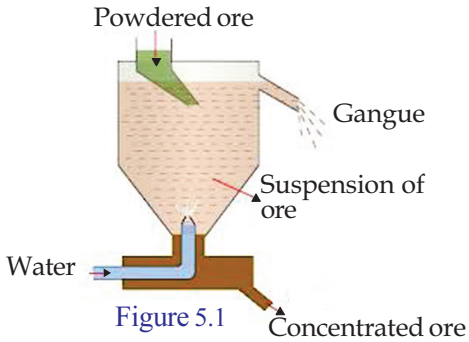


Figure 5.1

1. Levigation or Hydraulic Washing

When the impurities are lighter and the ore particles are heavier, the lighter impurities are removed by washing in a current of water (Figure 5.1). e.g. concentration of oxide ores, concentration of the ores of gold.

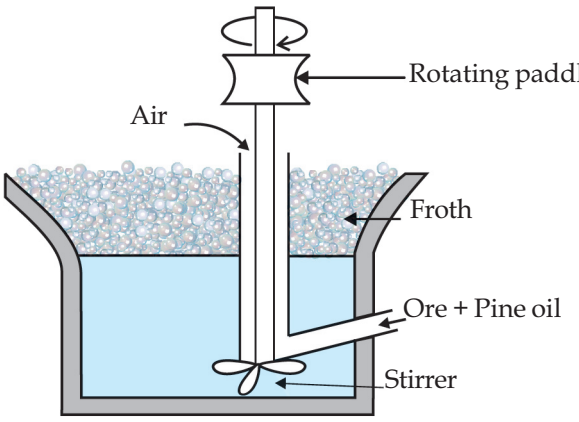


Figure 5.2

2. Froth Floatation

This process is used when the impurities are heavier and the ore particles are lighter (Figure 5.2). Usually sulphide ores are concentrated by this method. A mixture of the powdered ore, water and pine oil is strongly agitated by passing compressed air. As a result of this, the ore particles which are made wet by the pine oil stick to the froth of the oil formed during the mixing process and float on the surface of water. But the heavier impurities get wet by water and sink to the bottom. The froth that floats on water contains the ore. The ore is separated from the froth. e.g. concentration of copper pyrites.

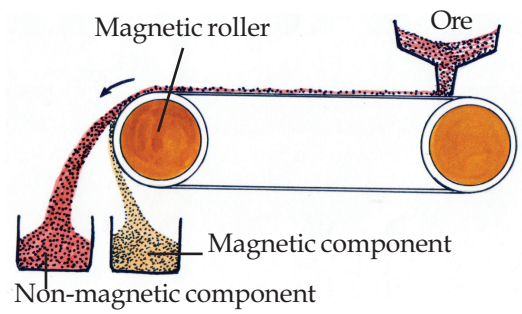


Figure 5.3

3. Magnetic Separation

If either the ore or the impurity is magnetic in nature, concentration is done by this method (Figure 5.3). The powdered ore is fed into a conveyer belt moving over a magnetic wheel to separate the magnetic substance. This method is used for the concentration of the ore of iron, magnetite and also to separate the magnetic impurity, iron tungstate from tin stone, the non - magnetic ore of tin.

4. Leaching

On adding the ore to a suitable solution, a chemical reaction takes place and the ore dissolves in the solution. The insoluble impurities are filtered off. The pure ore is separated from the filtrate by a chemical reaction. Bauxite, the ore of aluminium is concentrated by this method.

Certain properties of metallic ores and the impurities present in them are tabulated. Identify the appropriate method of concentration and complete Table 5.2.

Properties of ores	Properties of the impurities present in the ore	The method of concentration to be used
High density	Low density	.....
Magnetic in nature	Non-magnetic nature	.....
Low density	High density	.....
Aluminium ores that get dissolved in a solution	Insoluble in the same solution	.....

Table 5.2

II Extraction of Metals from Concentrated Ore

There are two stages in this.

a) Conversion of concentrated ore into its oxide.

b) Reduction of the oxide.

a) Conversion of Concentrated Ore into its Oxide

i) Calcination: Calcination is the process of heating the concentrated ore at a temperature below its melting point to remove the volatile impurities. When subjected to calcination, impurities like water, organic matter and other volatile impurities are expelled from the ore. Metal carbonates and hydroxides decompose to form oxides. Oxygen will not take part in the reaction.

e.g. $ZnCO_3$ ore is converted to ZnO by calcination

ii) Roasting: Roasting is the process of heating the concentrated ore at a temperature below its melting point in a current of air. During roasting, the ore gets converted into its oxide. When the concentrated ore is subjected to roasting, the water present in it is removed as vapour. Other impurities like sulphur, phosphorus and organic matter are oxidised and expelled. The sulphide ore combines with oxygen to form oxide. e.g. Cu_2S ore is converted to Cu_2O by roasting.

b) Reduction of the Oxide

The process of extraction of metal from the oxide is reduction. Suitable reducing agents can be used for this purpose. Carbon monoxide is used as the reducing agent to extract iron from haematite, and carbon to extract zinc from zinc oxide.

$$Fe_2O_3\,(s) + 3CO\,(g) \rightarrow 2Fe\,(s) + 3CO_2\,(g)$$

$$ZnO\,(s) + C\,(s) \rightarrow Zn\,(s) + CO\,(g)$$

Electricity is used as the reducing agent to extract highly reactive metals like sodium, potassium and calcium from their ores.

III Refining of Metals

The metal obtained by reduction may contain other metals, metal oxides and small quantities of non metals as impurities. Refining of metals is the process of removal of these impurities to get the pure metal.

Depending on the nature of metals and the impurities present in them , different methods are used for the refining of metals. Note some methods that are discussed below.

a. Liquation

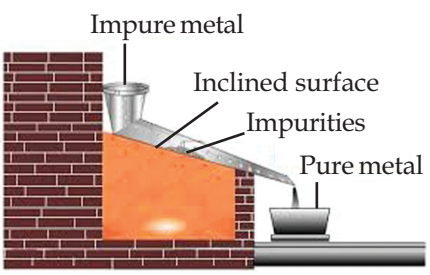


Figure 5.4

Low-melting metals like tin and lead may contain other high-melting metals or metal oxides as impurities.

On heating such metals on the inclined surface of a furnace, the pure metal melts and flows down leaving the impurities behind (Figure 5.4). This process is termed liquation.

b. Distillation

This method is used for the refining of metals with low boiling points such as zinc, cadmium and mercury. When the impure metal is heated in a retort, the pure metal alone vapourises. The vapours can be condensed to get the pure metal. This method is termed distillation.

c. Electrolytic Refining

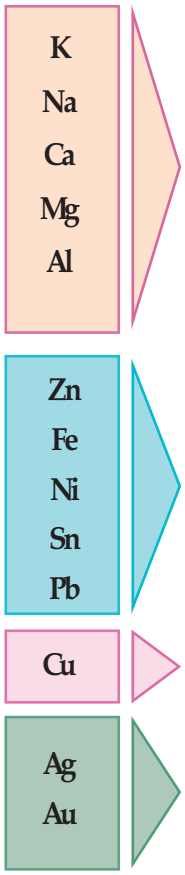
Electrolytic refining is the process of refining a metal by the electrolysis of a solution of the salt of the metal, using a small piece of pure metal as the negative electrode and the impure metal as the positive electrode. The pure metal from the

positive electrode dissolves in the electrolyte and gets deposited on the negative electrode. Metals like copper and silver are refined using this method.

The Chemistry of Metallurgy

We have seen some general principles of metallurgy so far.

Now, let us examine how widely used metals like iron, aluminium and copper are extracted. Examine Table 5.3, showing the relation between the reactivity series of metals and their extraction.



The metal is separated by the electrolysis of molten compounds of metals.

Metal oxides are reduced by carbon/carbon monoxide.

Metal is separated by auto oxidation and reduction of the metal sulphide.

Found in free state in nature.

Table 5.3

The less reactive metals were discovered first and the more reactive metals later. Can you find the reason for this on the basis of the process used for the extraction of metals from their compounds?

- Do metals have the tendency to lose electrons or gain electrons?

- Is the tendency to lose electrons the same for different metals?

Are the metals seen as positive ions or negative ions in their compounds?

- -

If so, which of the two, oxidation or reduction, must be used to separate the metals from their compounds? Why?

- -

The necessity to use a reducing agent during the extraction of a metal must be evident to you by now. Electricity, carbon and carbon monoxide are examples of reducing agents.

Electricity, the strongest reducing agent, is used to extract sodium from sodium chloride. What is the reason for this?

Prepare a note based on its position in the reactivity series.

Watch the video & animation 'blast furnace' in the page 'Metals' of 'Chemistry for Class X' in School Resources of IT @ School Edubuntu for more details.

The reducing agent used for extracting iron from its oxide ore, haematite is carbon monoxide.

- Are the less reactive metals such as gold and platinum found in the free state or in the combined state in nature?

  -

You have now understood that, different types of reducing agents should be used for the extraction of metals from their ores, on the basis of the reactivity of the metal.

> Electricity, the strongest reducing agent is used to extract highly reactive metals from their ores. In the case of comparatively less reactive metals, the reducing agents used are carbon, CO etc. Metals with very low reactivity are found in free state in nature.

Industrial Production of Iron

Now let us see how iron is manufactured.

- Which is the principal ore of iron?

  -

- This ore will contain earthly impurities. What are the concentration methods used to remove these impurities?

  -

First, haematite is finely powdered.

- If the powdered ore is heavier than the impurities, which concentration method will be used?

The lighter impurities will be washed away in a current of water. The ore so obtained is subjected to roasting. During roasting, impurities like sulphur, arsenic, phosphorus etc. are removed as their gaseous oxides. Water is also expelled along with this. But, silicon dioxide (sand) will be present in it in large quantities.

A mixture of the roasted haematite, coke and lime stone ($CaCO_3$) is fed into a blast furnace (Figure 5.5).

Blast furnace is a huge steel furnace lined inside with a refractory material, which can withstand high temperature. A blast of hot air at 1000 °C is sent into the tower from the bottom. At the same time the mixture containing haematite falls into the furnace from the top.

Let us take a look at the chemical reactions taking place inside the blast furnace.

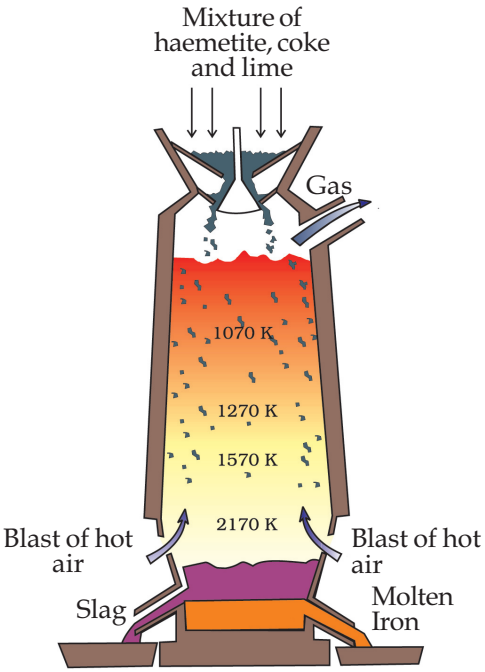


Figure 5.5

The calcium carbonate $CaCO_3$ mixed with the haematite decomposes at high temperature.

$$CaCO_3\,(s) \rightarrow CaO\,(s) + CO_2\,(g)$$

The calcium oxide (CaO) formed here combines with silicon dioxide (SiO_2) the main impurity of the ore in the hot lower region of the furnace to form calcium silicate ($CaSiO_3$). This melts into a liquid. Substances, which help in removing impurities that are difficult to separate (**gangue**) as separable molten material (**slag**) are called **flux**.

Here, the impurity in the ore, i.e. silicon dioxide (SiO_2) is the gangue. The chemical used to remove the gangue, i.e. calcium oxide (CaO) is the flux, and calcium silicate ($CaSiO_3$) formed by the reaction between gangue and flux is the slag. The molten slag flows towards the bottom of the furnace. See the chemical equation.

$$CaO\,(s) + SiO_2\,(s) \rightarrow CaSiO_3\,(s)$$
$$\text{flux} + \text{gangue} \rightarrow \text{slag}$$

When copper is extracted from the copper sulphide ore, the gangue present in it is FeO which is basic in nature. This is removed, by heating it with the flux SiO_2 which is acidic in nature. The flux reacts with gangue and gets separated as the slag, ferrous silicate.

$$SiO_2 + FeO \rightarrow FeSiO_3$$
Flux Gangue Slag

Slag, which is lighter floats over molten iron. CaO, a substance which is basic in nature is chosen as the flux because the gangue silicon dioxide (SiO_2) is acidic in nature.

Given below are the other reactions taking place along with the formation of slag.

At the bottom of the blast furnace, coke combines with the oxygen in the hot current of air.

$$C(s) + O_2(g) \rightarrow CO_2(g) + \text{heat}$$

Here the temperature rises upto 1800 °C. The CO_2 which rises up along with the hot air current is reduced by coke.

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

- The temperature in this part of the furnace will be less than the temperature in the lower region. What may be the reason? Analyse the chemical equation and identify.

- -

The carbon monoxide which reaches the middle of the furnace reacts with iron oxide (Fe_2O_3) to produce iron.

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$$

- Does CO act as an oxidising agent or a reducing agent here?

- -

The iron formed in this manner moves down the furnace, gets heated up, melts and is collected as a molten liquid at the bottom of the furnace. Molten slag which is lighter floats over the heavier molten iron. These can be easily separated. The molten iron obtained here has 4% carbon and other impurities like manganese silicon, phosphorus etc. This is called **pig iron**.

Pig iron, mixed with scrap iron and coke, is melted in a special furnace to make **cast iron**.

Cast iron contains nearly 3% carbon. Molten cast iron expands a little on solidification. This is why molten cast iron is poured into moulds to form different shapes. Though these objects are hard, they break on bending.

Figure 5.6

Comparatively pure raw iron is known as **wrought iron**. This is made by purifying cast iron. This contains 0.2 - 0.5% carbon and traces of phosphorus and silicon.

Different types of steel can be prepared by varying the amount of carbon from 0.1 to 1.5%.

Alloy steels are prepared by adding other metals to steel. See the name, composition, properties and uses of different types of alloy steels given in tabular form (Table 5.4). Alloy steels have properties different from those of steel.

Alloy steels	Components	Properties	Uses
Stainless steel	Fe, Cr, Ni, C	Strong	For the manufacture of utensils, parts of vehicles
Alnico	Fe, Ni, Al, Co	Magnetic in nature	For the manufacture of permanent magnets
Nichrome	Fe, Ni, Cr, C	High resistance	For making heating coils

Table 5.4

Examine the table and find out two alloy steels having the same components but different properties. What may be the reason for the wide difference in their properties. Is it the difference in the proportion of the component elements? Note down your conclusion.

- -

Different types of alloys are prepared by changing the component elements and also by varying the proportion of the component elements.

Charles Martin Hall
(1863 - 1914)

Extraction of Aluminium

What are the purposes for which we utilise the various properties of aluminium?

- Metallic lustre - Reflectors
- Electrical conductivity - _ _ _ _ _ _ _ _ _ _ _ _ _
- Thermal conductivity - _ _ _ _ _ _ _ _ _ _ _ _ _

Paul Heroult
(1863 - 1914)

Do you know how this metal which was once even costlier than gold,was transformed into the common man's metal by the Hall-Heroult process?

You know that the ore of aluminium is bauxite ($Al_2O_3.2H_2O$). The chief impurity present in it is silicon dioxide (SiO_2). The first stage

is the concentration of bauxite. The different stages in this process can be studied with the help of a flow chart (Figure 5.6).

When impure bauxite is mixed with hot concentrated NaOH solution, aluminium oxide dissolves in it to form sodium aluminate.

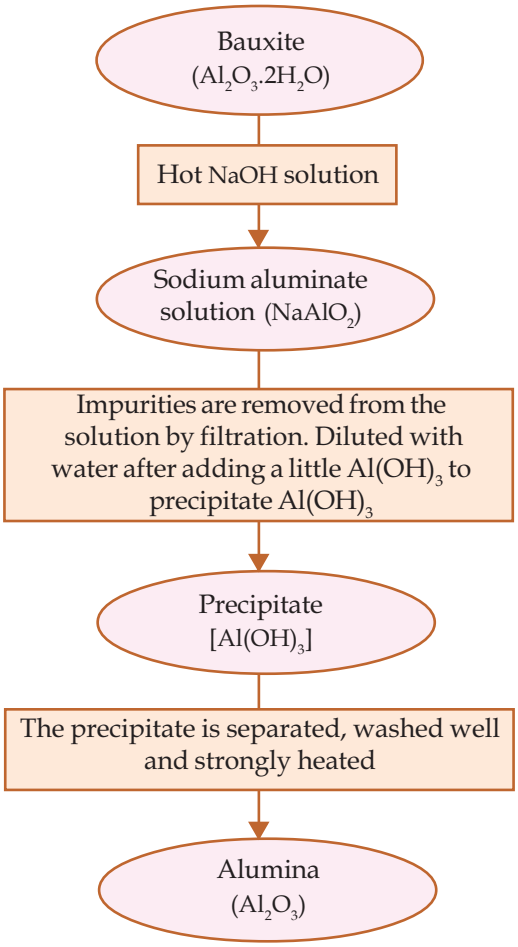


Figure 5.6

See the equation of the chemical reaction that takes place on heating $Al(OH)_3$.

$2Al(OH)_3\,(s) \rightarrow Al_2O_3\,(s) + 3H_2O\,(l)$

How is aluminium separated from the alumina thus obtained?

Iron was separated by using CO as the reducing agent in the blast furnace. Is it sufficient to use CO to separate aluminium, which is more reactive than iron, from alumina?

- -

Aluminium is extracted using electricity, the strongest reducing agent.

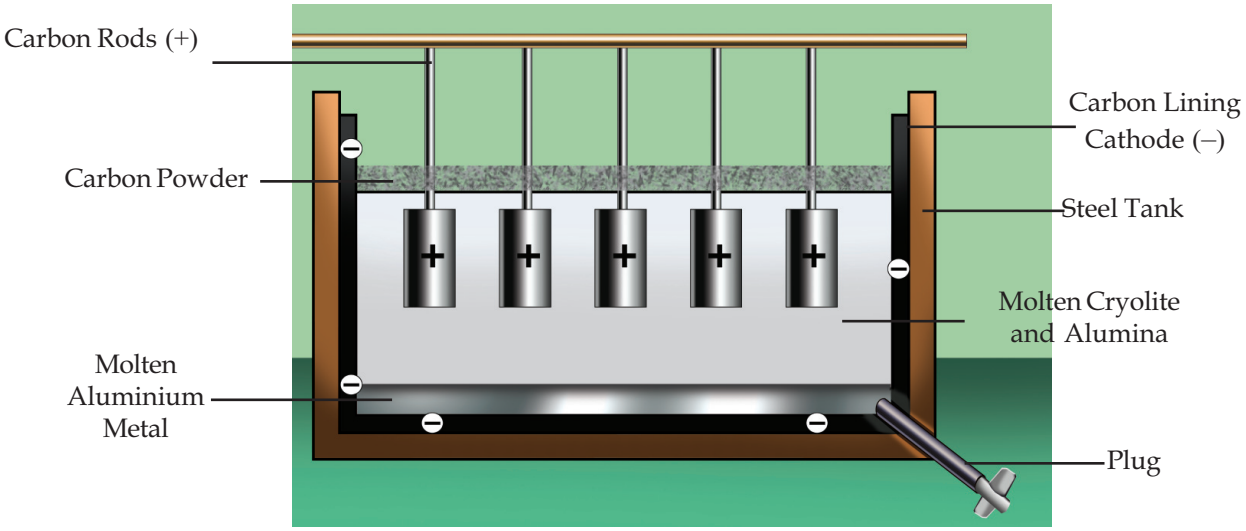


Figure 5.7

The alumina (Al_2O_3) obtained by concentration of bauxite is mixed with cryolite (Na_3AlF_6) and subjected to electrolysis. See Figure 5.7. The melting point of alumina is very high. Cryolite is added to alumina to reduce its melting point and increase its electrical conductivity. When electricity is passed through this mixture, it gets heated, cryolite melts and alumina dissolves in it.

- What are the ions present in alumina?

  -

- Where is aluminium liberated when alumina is electrolysed?

  At the anode or cathode?

  -

Let us write the equation of the chemical reaction taking place here.

$$Al^{3+} + 3e^- \rightarrow Al$$

Thus, pure aluminium is produced at the cathode.

What is the reaction at the anode?

$$2O^{2-} \rightarrow O_2 + 4e^-$$

- Can you find out the reason why the carbon blocks in this cell are replaced from time to time?

  -

Refining of Copper

Copper is a metal which is widely used for electrical purposes. The copper used must be quite pure for it to be a good conductor.

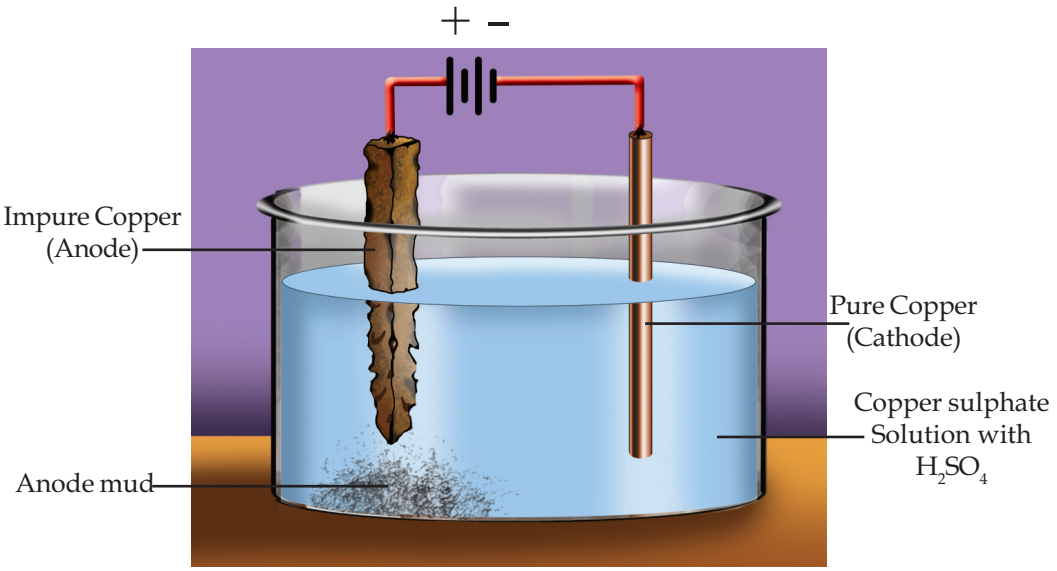


Figure 5.8

The copper isolated from the ore is not pure. It is refined by the electrolytic method. See Fig. 5.8.

For refining copper industrially, a thin plate of pure copper is used as the negative electrode and a big piece of copper, which is to be refined is used as the positive electrode. The electrolyte used is aqueous copper sulphate solution mixed with H_2SO_4.

See the reactions taking place at the two electrodes during electrolysis.

At the positive electrode :

$$Cu \rightarrow Cu^{2+} + 2e^{-} \text{ (Oxidation)}$$

At the negative electrode :

$$Cu^{2+} + 2e^{-} \rightarrow Cu \text{ (Reduction)}$$

As oxidation takes place at the positive electrode, it is the anode, and the negative electrode where reduction takes place is the cathode.

At which electrode is copper deposited during the process? (Put '✓' against the correct one.)

Anode ☐ Cathode ☐

The impurities get deposited below the anode. This is known as **anode mud**. This will contain costly metals (e.g. gold). Hence this process is profitable. The pure copper is removed from the cathode after a few days.

Significant Learning Outcomes

The learner

- identifies minerals, ores and gangue and explains them.
- explains the process that takes place at different stages of metallurgy.
- finds and suggests the method suitable for the concentration of each ore from among the methods such as hydraulic washing, froth floatation, magnetic separation and leaching.
- selects the appropriate method by understanding the difference between calcination and roasting in the process of convertion of ores into oxide and the peculiarity of the ores to be used.
- selects the method for refining of metals from different methods such as liquation, distillation, electrolyte refining etc. on the basis of the nature of impurities and metals.
- explains the different stages in the industrial production of iron.
- identifies the properties of alloy steels.
- explains the concentration of the ores of aluminium and the production of aluminium.
- explains the method of refining of copper.

Let Us Assess

1. Which of the properties of metals is utilized in the following instances?
   - Aluminium utensils are used for cooking.
   - Copper is used for making vessels.
   - Gold wires are used in ornaments.

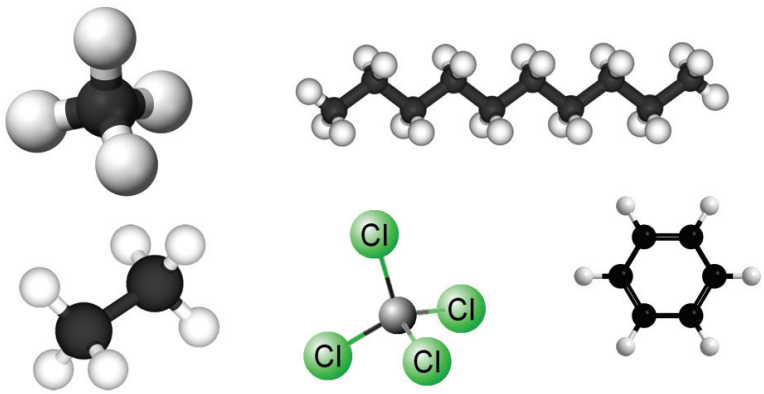
2. What are the factors to be considered while selecting minerals for the extraction of metals?
3. Write the different stages involved in metallurgy.
4. What are the different methods for the refining of metals?
5. How is iron extracted?
6. Write the uses of the following:
   - Pig iron
   - Cast iron
   - Alnico
7. Explain the process of producing alumina from bauxite.
8. Explain the method of obtaining pure aluminium from alumina by electrolysis. In this process the carbon rods are replaced from time to time. Why?
9. Explain what is anode mud.

Extended Activities

You know that metals can be separated from molten compounds of metals by electrolysis.

Find out how metals like Na, Ca and Mg are extracted.

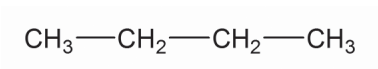
6 Nomenclature of Organic Compounds



Just think about the diversity of hydrocarbons.

We know thousands of compounds that are formed by the combination of carbon atoms. How difficult will it be to distinguish these compounds by giving names!

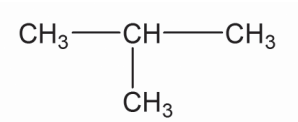
Let us write the structural formula of butane.



- What is its molecular formula?

- -

Now look at another structural formula of C_4H_{10}.



You know that pentane (C_5H_{12}) is a hydrocarbon with five carbon atoms. How many structural formulae can be written for it?

Complete Table 6.1 given below.

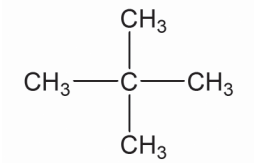
Structural formula	Molecular formula
$CH_3—CH_2—CH_2—CH_2—CH_3$	.....
.....	C_5H_{12}
	.....

Table 6.1

- You are familiar with the name of the first compound among these. Try writing it.

- -

Can this name be given to the second and third compounds with the same molecular formula?

These compounds differ in their chemical as well as physical properties. How can these compounds be named so as to identify them correctly?

For this purpose **the International Union of Pure and Applied Chemistry (IUPAC)** has framed certain rules.

Aren't you familiar with the method of writing the names of open chain hydrocarbons without branches?

What are the points to be considered mainly while doing this?

- Number of carbon atoms.
- Nature of bond between the carbon atoms.

Let us see how the IUPAC name is written for the compound.

$CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$

How many carbon atoms are present in it?

What is the type of bond existing between them?

Since there are six carbon atoms, the word root used is 'hex' and since there are only carbon-carbon single bonds, the suffix 'ane' is added.

Word root + ane

Thus, this compound can be named as **hex + ane = hexane**.

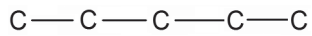
Similarly, represent the structures of octane and decane and complete Table 6.2.

Compound	Number of carbon atoms	Molecular formula	Structural formula
Octane	8	.....	.....
Decane	10	.....	.....

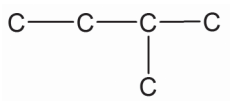
Table 6.2

For more understanding open 'Chemistry for Class X' in 'School Resources' of IT @ School Edununtu and play the animation 'Organic samyuktangal-namakaranam' from the page 'Organic samyuktangal-namakaranavum isomerisavum'.

Nomenclature of Branched Hydrocarbons

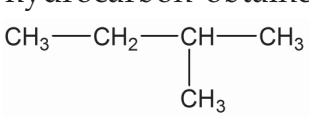


This chain contains 5 carbon atoms. See another chain with the same number of carbon atoms.



What change has occurred to the carbon chain here? Isn't it clear that a carbon atom has formed a branch?

Shall we write the structural formula of the hydrocarbon obtained by adding hydrogen atoms to this carbon chain?

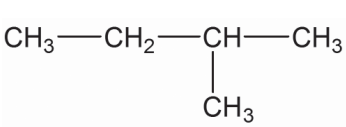


According to the IUPAC rules of nomenclature, the longest chain (with the maximum number of carbon atoms) should be considered as the main chain and the remaining are treated as branches. The position of the branches can be found out by numbering the carbon atoms in the main chain.

Numbering of the carbon atoms in the chain should be done in such a way that the carbon atom carrying the branch gets the lowest number.

Let's see how an IUPAC name is given to the compound shown here.

See the two ways in which numbering is done in the carbon chain.



Alkyl Radical

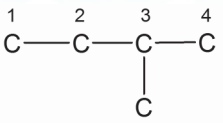
In saturated hydrocarbons, all valancies of carbon atoms are satisfied by hydrogen. When a hydrogen atom is removed, it changes to a reactive group of atoms. These are radicals. The radical formed by the removal of hydrogen atom from methane is the methyl radical.

$CH_3—$

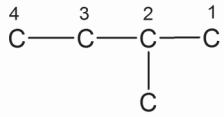
Similarly, $CH_3—CH_2—$ is named an ethyl radical and

$CH_3—CH_2—CH_2—$ is named a propyl radical.

In general, they are known as alkyl radicals and are represented as R—



(1)



(2)

Which of these chains has the lowest number for the carbon atom carrying the branch? :

Number of carbon atoms in the main chain :

Word root :

Suffix :

Name of the alkyl radical coming as branch :

Position of the branch :

IUPAC name = 2-Methylbutane

Position number of branch + hyphen + name of radical + word root + suffix

A hyphen (—) is used to separate numerals and alphabets while writing the IUPAC name.

Write IUPAC names to the given hydrocarbons by identifying the longest chain and the position of branch (Table 6.3).

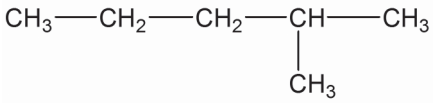
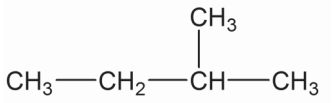
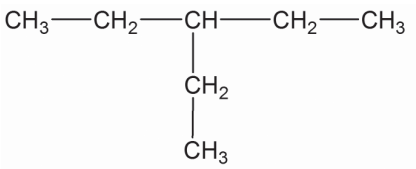
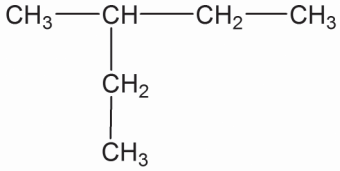
Compound	Number of carbon atoms in the longest chain	Name of branch	Position of branch	IUPAC name
	.....	.....	.....	.....
	.....	.....	.....	.....
	.....	.....	.....	.....
		.....	.....	.....

Table 6.3

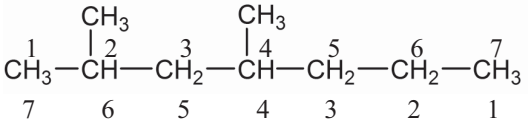
Nomenclature of hydrocarbons with more than one branch

If the same branch appears more than once in a carbon chain, the number of branches are to be indicated using prefixes like di (two), tri (three) etc.

If more than one branch is present, as per rule, numbering should be done either from left to right or from right to left so as to get the lowest number for the branch coming first in the longest chain.

For more understanding open 'Chemistry for Class X' in 'School Resources' of IT @ school Edubuntu, animation page 'Organic samyuktangal-namakaranavum isomerisavum' and play 'Organic samyuktangal-mamakaranam'

For example



Number of carbon atoms in the main chain : 7

Number of branches : 2

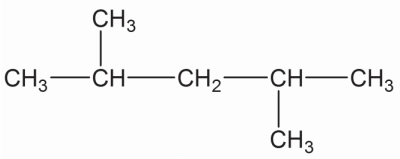
Position of the first branch while numbering from left to right : 2

Position of the first branch while numbering from right to left : 4

Correct way of numbering : left to right

IUPAC name : 2,4-Dimethylheptane.

Some structural formulae are given below. Name them.



Number of carbon atoms in the main chain :

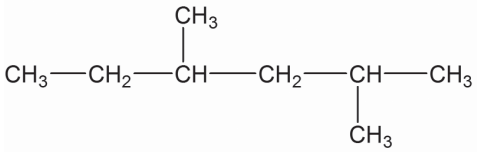
Number of branch/branches :

Position of the first branch while numbering from left to right :

Position of the first branch while numbering from right to left :

Is there any change in the position number? :

IUPAC name :

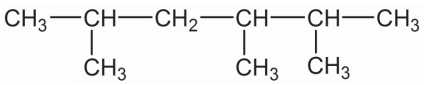


Number the carbon atoms in the main chain of the compound given above. Put a '✓' against the correct position numbers of the branches.

2, 4	
3, 5	

- IUPAC name. _

Note the compound given below.



Number the longest chain of this compound from left to right and from right to left.

In both cases, isn't the position number of the first branch the same?

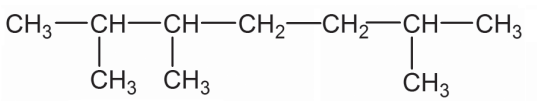
- Which is the second branch? _
- When does this branch get the lowest number? Put a '✓' mark against the correct one.

While numbering from left to right ☐

While numbering from right to left ☐

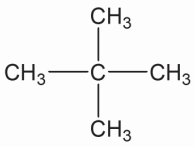
IUPAC name : 2, 3, 5-Trimethylhexane

Write the IUPAC name of the compound given below.



_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

If a carbon atom has two identical branches, the number of their position should be repeated.



See the compound given.

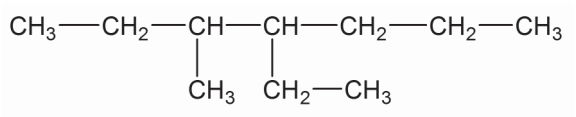
Number of branches present in this compound :

Names of the branches :

Position numbers of branches :

IUPAC name : 2,2-Dimethylpropane

If different radicals are present as branches, names of the radicals should be written in alphabetical order while naming.

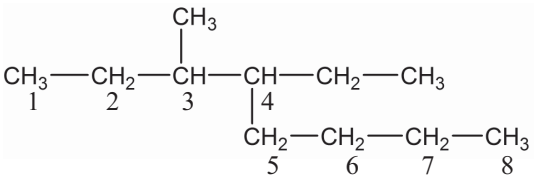


- What are the branches present in this compound?

- - - - - - - - - - - - - - - - - - -

Let us see what is the name of this compound.

4-Ethyl-3-methyheptane.



In the longest chain of this compound,

- how many carbon atoms are present? :
- how many branches are present? :
- which are those branches? :
- position of the branches :
- IUPAC name :

Can you represent the structure of a compound if its IUPAC name is given?

- How can the structure of 2,3-dimethylbutane be written?

- -

- How many carbon atoms are present in its main chain?

- -

- Let us represent the main chain.

C—C—C—C

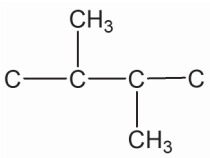
- Which are the branches?

- -

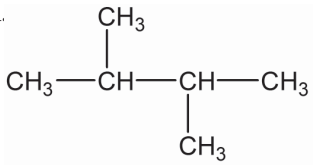
- What are their positions?

- -

Let us write the structural formula by including the branches to the main chain.



Now, let us complete the structure by filling all the valancies of carbons with hydrogen.



In the same way, write the structures of some other compounds also.

Complete Table 6.4 given below.

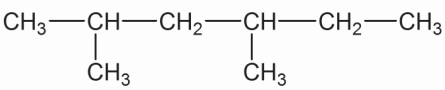
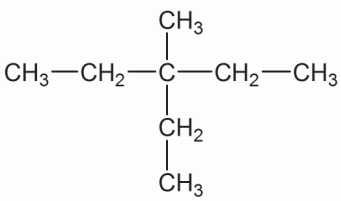
Compound	IUPAC name
	.....
.....	2,3,3-Trimethylpentane
.....	3,3-Diethylpentane
	.....

Table 6.4

Nomenclature of Unsaturated Hydrocarbons

Classify and tabulate the following compounds into alkanes, alkenes and alkynes (Table 6.5).

C_5H_{10} , C_6H_{10} , C_2H_4 , C_5H_{12} , C_6H_{12} , C_7H_{12} , $C_{10}H_{22}$, C_4H_{10} , C_4H_8 , C_4H_6

Alkane	Alkene	Alkyne

Table 6.5

- Can you write the structural formula of the compound C_2H_4?

- -

Replace the 'ane' in the IUPAC name of the alkane with 'ene'.

Alk + ene = alkene, The IUPAC name of C_2H_4 is ethene.

One of the structural formulae of C_4H_8 is given below.

$CH_2{=}CH{-}CH_2{-}CH_3$

Notice the position numbers given to the carbon atoms.

$\overset{1}{CH_2}{=}\overset{2}{CH}{-}\overset{3}{CH_2}{-}\overset{4}{CH_3}$ (Structure 1)

$\overset{4}{CH_2}{=}\overset{3}{CH}{-}\overset{2}{CH_2}{-}\overset{1}{CH_3}$ (Structure 2)

While numbering the carbon atoms, during IUPAC naming, the carbon atoms linked by double bond should be given the lowest position number.

Accordingly, it is in structure (1) that position numbers are given in this manner.

If so, what will be the IUPAC name of the compound $CH_2{=}CH{-}CH_2{-}CH_3$?

But-1-ene

- If so, what will be the structural formula of But-2-ene?

  -

Which relation can you see between these two?

While naming hydrocarbons containing a double bond, numbering should be done in such a way that the carbon atoms linked by double bond gets the lowest number.

Word root + position of double bond + suffix.

- Which of the following is the IUPAC name of the compound $CH_3{-}CH_2{-}CH{=}CH{-}CH_3$? Tick (✓) the correct one.

  Pent-3-ene ☐

  Pent-2-ene ☐

Alkynes can also be named in this fashion. Add the suffix 'yne' while writing IUPAC names. Alk + yne = Alkyne.

$CH{\equiv}CH$ Ethyne

$CH_3{-}C{\equiv}C{-}CH_3$ But-2-yne

How many hydrocarbons can be written by changing the position of triple bond in this compound? Try to write their IUPAC names.

Word root + position of triple bond + suffix

For more experience open 'Chemistry for Class X' in 'School Resources' of IT @ School Edubuntu, animation page 'Organic samyukthangal namakaranavum isomerisavum' and play 'Organic samyukthangal-namakaranam'.

Functional Groups

Carbon and hydrogen are not the only elements present in organic compounds. There are other atoms and groups of atoms present in the place of hydrogen atoms in organic compounds. For example methanol is a compound in which a hydrogen atom in methane is replaced with an –OH group. Similarly, the compound H–COOH which has one carbon atom is called methanoic acid.

The chemical and physical properties of methane are quite different from the chemical and physical properties of methanol and methanoic acid.

> The presence of certain atoms or groups imparts certain characteristic properties to compounds. They are called functional groups.

Let us familiarise ourselves with some of the functional groups.

1. Hydroxyl Group (– OH)

The presence of an –OH group in the carbon chain is the reason for the important properties of methanol. Therefore –OH group can be considered as a functional group.

The IUPAC names of compounds with hydroxyl function group end in 'ol'. Alcohols are compounds with one or more –OH as functional group.

The naming of alcohols is done by replacing 'e' from the name of the corresponding alkane with 'ol'.

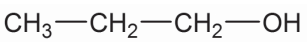
Alkane - e + ol → Alkanol

Ethane - e + ol → Ethanol

For example,

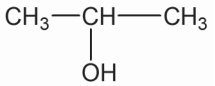
Methanol Ethanol

See the compound given below.



- Write the molecular formula _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

What about the compound given below?



- Write the molecular formula _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

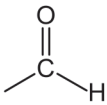
What is the difference between the two?

Here, the position of functional group changes.

Therefore, while writing IUPAC names of these compounds shouldn't the position of functional group be added? The carbon atom carrying the functional group should be given the lowest number. Here the first compound can be called propan-1-ol.

- Then try to write the IUPAC name of the second compound.

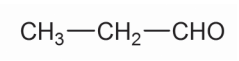
_ _

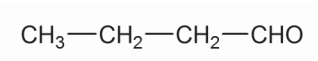
2. Aldehyde Group ( or —CHO)

Compounds with —CHO functional group are called aldehydes. IUPAC names of aldehydes end in 'al'.

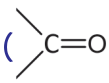
Alkane - e + al → Alkanal

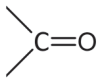
Ethane - e + al → Ethanal

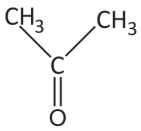
 Propanal

 Butanal

If the functional group contains a carbon atom that carbon atom should be treated as part of the main chain.

3. Keto Group ( or -CO-)

Ketones are compounds with  as the functional group.

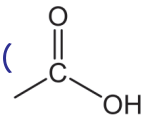
Example: 

The IUPAC names of ketones are written by terminating the name of the main chain with the suffix 'one'.

Alkane - e + one → Alkanone

The IUPAC name of compound $CH_3—CO—CH_3$ is propanone. i.e. propane - e + one.

The IUPAC name of the compound $CH_3—CH_2—CH_2—CO—CH_3$ is pentan-2-one. Did you notice that the position of functional group is also considered while naming?

4. Carboxylic Acid ( or —COOH)

Compounds with functional group —COOH are known as carboxylic acids. While writing IUPAC names of these compounds, the name of the main chain is terminated with the suffix 'oic acid'.

Alkane - e + oic acid → Alkanoic acid.

Vinegar is a carboxylic acid. Its formula is

$CH_3—COOH$

The IUPAC name of this compound is ethanoic acid.
That is, **Ethane - e + oic acid → Ethanoic acid**

$H—COOH$ Methanoic acid

$CH_3—CH_2—COOH$ Propanoic acid

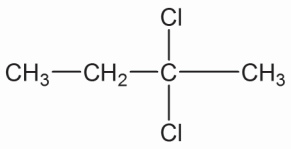
The naming is done after counting the carbon atom in the functional group as a part of the main chain.

Halo Group

Organic compounds with functional groups, fluoro (–F), chloro (–Cl), bromo (–Br) and iodo (–I) are called halo compounds. The method of giving IUPAC names to these compounds is given below.

The position of halo group + - + name of halo group + name of parent alkane.

$CH_3—CH_2—CH_2—Cl$ 1-Chloropropane



2, 2-Dichlorobutane

Alkoxy Group (—O—R)

Ethers are compounds with an alkoxy group. Let us see their IUPAC names.

$CH_3—CH_2—O—CH_2—CH_3$ Ethoxyethane

$CH_3—O—CH_2—CH_3$ Methoxyethane

That is, ethers are named as alkoxyalkanes.

Here among the alkyl radicals on either side of the —O— group the longest alkyl group is taken as alkane and the other as alkoxy group.

Amino Group ($—NH_2$)

Compounds carrying an $–NH_2$ group are known as amines. See the IUPAC names of compounds containing $–NH_2$ as the functional group.

$CH_3–NH_2$ Methanamine

$CH_3–CH_2–NH_2$ Ethanamine

'amine' is added in the place of 'e' in alkane.

$CH_3—CH_2—CH_2—NH_2$ Propan-1-amine

- Can you write the structural formula of propan-2-amine?

- -

The names of the functional groups such as chloro (–Cl), bromo (–Br), nitro ($–NO_2$) etc. are given as prefixes in the IUPAC name of the compound.

Based on the above discussion, complete Tables 6.6 and 6.7.

Functional group	Structure of compound	IUPAC name
.....	$CH_3—CH_2—CH_2—OH$	.....
.....	$CH_3—CH_2—CH_2—OH$	.....
— CO —	.....	.....
—O—R	.....	.....

Table 6.6

Compound	IUPAC name
$CH_3—CH_2—CH_2—CH_2—OH$	.....
.....	Butanoic acid
$CH_3—CHO$	.....
.....	Propanone

Table 6.7

Isomerism

See the two compounds given below.

For more practice visit 'Chemistry for Class X' in 'School Resources' of IT @ school Edubuntu and open animation page of 'Organic samyukthangal-namakaranavum isomerisavum' and play the interactive animation on Isomerism.

$CH_3—CH_2—CH_2—OH$

$CH_3—\underset{\displaystyle OH}{\underset{|}{CH}}—CH_3$

- What are the similarities between these two compounds?

  _

Molecular formula : _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Functional group : _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

- What is the difference between them?

  _

These compounds have the same molecular formula. But the position of the functional group differ. These compounds are different even though they have the same molecular formula. They are called **Isomers**. These compounds differ in their chemical and physical properties.

> Compounds having same molecular formula but different chemical and physical properties are called Isomers. The phenomenon is called Isomerism.

In the examples given above, the isomers differ in their structural formulae. Let us examine some other examples in which the structural formulae are different.

Examine the two compounds given below.

$CH_3—CH_2—CH_2—CH_3$ $\qquad$ $CH_3—\underset{\displaystyle CH_3}{\underset{|}{CH}}—CH_3$

- Try to write the molecular formula. Can't you write the IUPAC names of these compounds?
- What is the difference between them? _ _ _ _ _ _ _ _ _ _ _ _ _ _

- Do they have the same chain structure?

Compounds with the same molecular formula but possess a difference in the chain structure are called **'Chain Isomers'**.

- What are the functional groups in $CH_3—CH_2—OH$ and $CH_3—O—CH_3$.

  -

- Try to write down their molecular formula. - - - - - - - - - - -

  Are they isomers? Their IUPAC names are respectively ethanol and methoxymethane.

Compounds having same molecular formula, but having a difference in their functional groups, are known as **'Functional Isomers'**.

See another example. Given below is the structural formula of propanone.

$CH_3—CO—CH_3$

See the structural formula of an aldehyde with the same molecular formula.

$CH_3—CH_2—CHO$

- Which type of isomerism is seen in them?

  -

Haven't you understood that functional isomers exist as a result of having different functional groups in compounds with the same molecular formula?

Examine the two compounds which you have already seen.

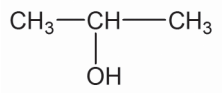
$CH_3—CH_2—CH_2—OH$

$CH_3—\underset{\displaystyle OH}{\underset{|}{CH}}—CH_3$

See the position of their functional group —OH. Isn't it different?

See their IUPAC names.

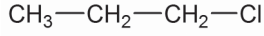
$CH_3—CH_2—CH_2—OH$ Propan-1-ol



Propan-2-ol

These are position isomers.

If the position of the functional group is different in two compounds having the same molecular formula and the same functional group then, they are **Position Isomers**.

- Try to write down all possible position isomers of the compound  .

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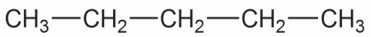
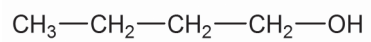
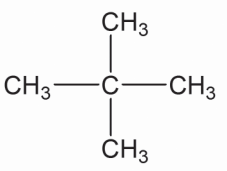
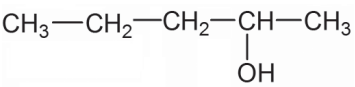
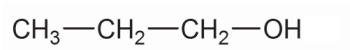
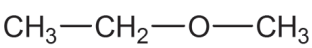
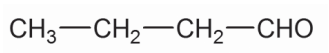
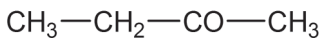
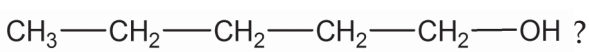
- Examine the compounds given below and find out the isomeric pairs. To which type do they belong?

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

- How many position isomers are possible for the compound  ?

Which functional group is present in one of its functional isomers? Can't you write its structure and IUPAC name?

- -

- How many chain isomers are possible for the compound $CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$? Write them down.

- -

- The structural formulae of various compounds are given. Tabulate them into different pairs of isomers. You can write their IUPAC names also. Write the functional group in each of them.

1. $CH_3—CH_2—CH_2—CHO$
2. $CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$
3. $CH_3—CO—CH_2—CH_3$
4. $CH_3—CH(CH_3)—CH_2—CH_2—CH_3$
5. $CH_3—CH_2—O—CH_3$
6. $CH_3—CH_2—CH_2—OH$

Isomerism in Alicyclic Compounds

- What is the IUPAC name of the compound $CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$? Write its molecular formula?

- -

- The molecular formula of an alkene with the same number of carbon atoms is C_6H_{12}? Can you write a structural formula for this compound?

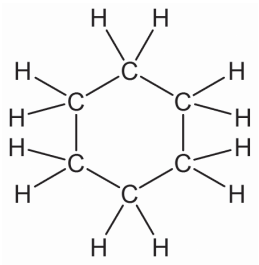
- -

- What is its IUPAC name?

- -

Try to find out other structural formulae.

The structural formula of an alicyclic compound with six carbon atom is given below.



Its IUPAC name is cyclohexane.

Isn't the molecular formula of this cyclic compound the same as that of hexene mentioned above?

That is, the chain compound hexene and the cyclic compound cyclohexane are isomers. Try to find out the other cyclic isomers of this compound.

Similarly, compounds with molecular formula C_5H_{10} and C_4H_8 have cyclic and chain isomers. Find out and write their structures and IUPAC names.

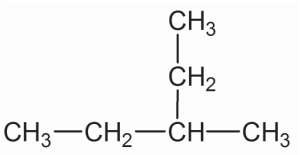
Significant Learning Outcomes

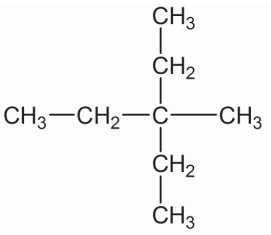
The learner

- constructs structural formulae of various hydrocarbons, and writes different structural formulae of compounds with the same molecular formula.
- writes the IUPAC names of straight chain hydrocarbons by knowing the number of carbon atoms in them.
- writes the IUPAC names of alkanes containing a methyl radical as branch.
- writes the IUPAC names of hydrocarbons with more than one methyl radical as branches.
- writes the IUPAC names of hydrocarbons with methyl and ethyl radicals as branches.
- writes the IUPAC names of alkanes, alkenes and alkynes.
- recognises the functional groups, identifies and writes the functional groups in a given set of compounds.
- writes the different structural formulae of compounds with same molecular formula.
- identifies different functional groups in compounds with the same molecular formula and writes them as functional isomers.
- writes the IUPAC names of functional isomers.
- writes cycloalkanes as the isomers of alkenes.
- draws the structures of some cyclic compounds like cyclohexane and cyclopentane.

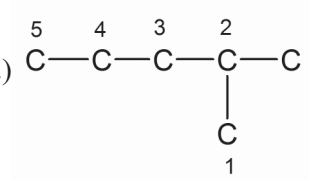
Let Us Assess

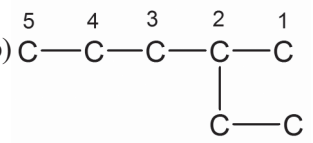
1. Mark the main chains in the compounds given below.

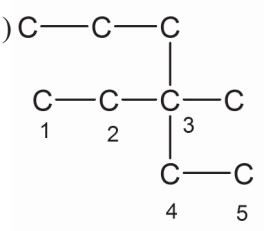


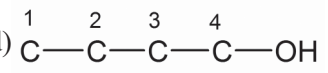


2. See how the carbon chains are numbered. Correct the wrong ones.

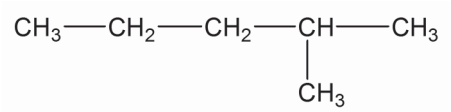
a) 

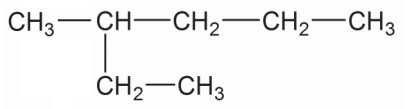
b) 

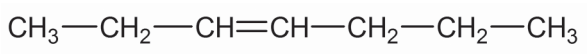
c) 

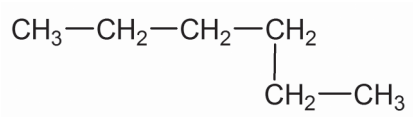
d) 

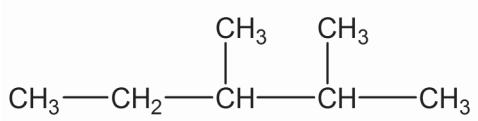
3. Write down the IUPAC names of the compounds given.

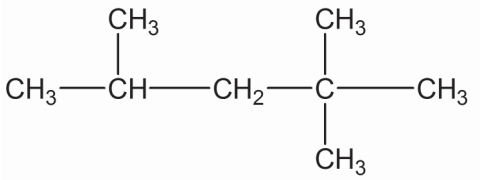
a. 

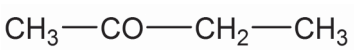
b. 

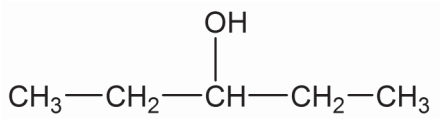
c. 

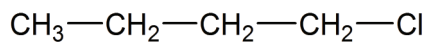
d. 

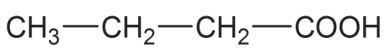
e. 

f. 

g. 

h. 

i. 

j. 

4. Write down the structural formulae of compounds given below.
   a. 3-ethyl-2-methylhexane
   b. But-2-ene
5. Write down the structural formula of the compound C_5H_{10}. Also write the structural formula of one of its isomers which is an alicyclic compound.

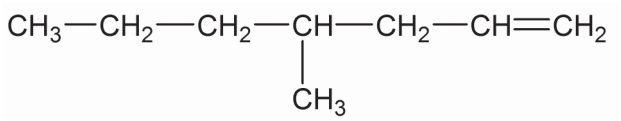
Extended Activities

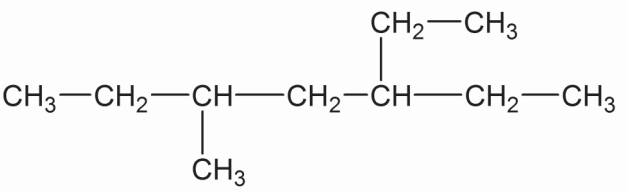
1. Given below are certain hints about a hydrocarbon.
   - The molecular formula is C_5H_{10}.
   - Has a methyl radical as branch.

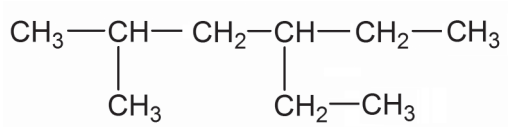
a) Write three possible structural formulae of this compound.

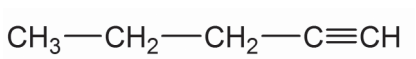
b) Write the IUPAC names of these structural formulae.

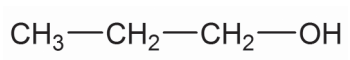
2. Write down the IUPAC names of the compounds given below.

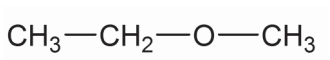
a) 

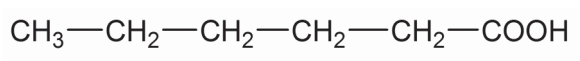
b) 

c) 

d) 

e) 

f) 

g) 

3. Write the structural formulae of all possible isomers of the compound with molecular formula $C_4H_{10}O$. Identify the different isomer pairs from them and find the type of isomerism to which each pair belongs.

4. Find three pairs of isomers from the compounds given below. Identify the type of isomerism to which each pair belongs.

a) Propan-1-ol

b) 2,2,3,3-Tetramethylbutane

c) Octane

d) Propan-2-ol

e) Methoxyethane

5. The structural formulae of two organic compounds are given.

(i) $CH_3—O—CH_2—CH_3$ (ii) $CH_3—CH_2—CH_2—OH$

a) What are the IUPAC names of these compounds?

b) Write one similarity and one difference between these two compounds.

c) What is this phenomenon known as?

6. Write down the structural formulae of the following compounds.

a) Cyclopentane

b) Cyclobutene

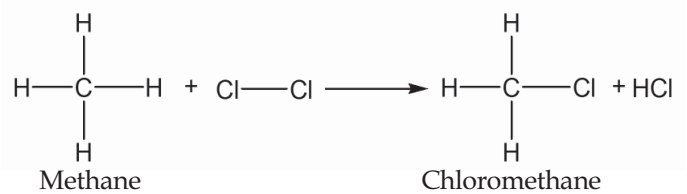
7 Chemical Reactions of Organic Compounds

Organic chemistry is the study of different hydrocarbons; the different compounds obtained from them and their chemical reactions. The various substances that we use in different fields of daily life are the contributions of organic chemistry. There are different types of organic compounds such as medicines, polymers and fuels. These are obtained through different chemical reactions. Let us familiarise some of such basic chemical reactions.

Substitution Reactions

Examine the different stages of the reaction of methane (CH_4) with chlorine in the presence of sunlight (Figure 7.1).

Stage 1



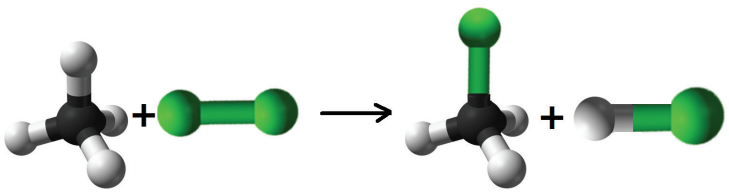


Figure 7.1

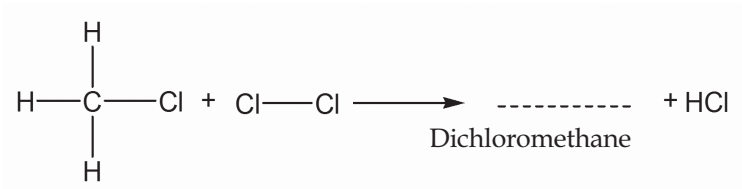
Here, one hydrogen atom of methane is replaced by chlorine atom, isn't it?

Think of this process being continued…

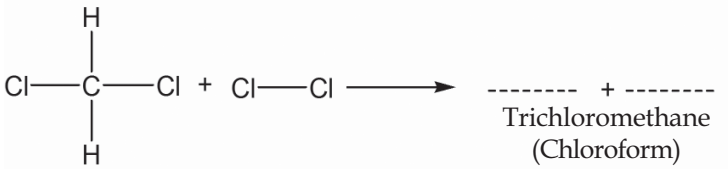
For further details open 'Chemistry for Class X' in 'School Resources' of IT @School Edubuntu and watch the video 'Adesarasapravarthanangal' from the page 'Organic samyuktangal rasapravarthanangal'.

Complete stages 2, 3 and 4 in the respective order.

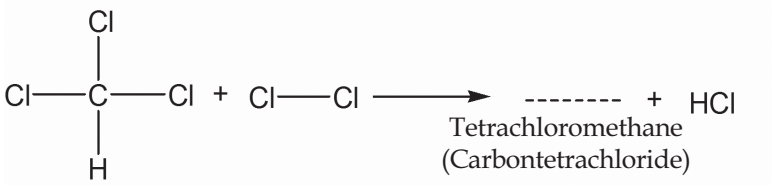
Stage 2



Stage 3



Stage 4



When methane reacts with chlorine each hydrogen atom of methane is replaced successively by chlorine atoms. As a result, a mixture of CH_3Cl (chloromethane), CH_2Cl_2 (dichloromethane), $CHCl_3$ (trichloromethane) and CCl_4 (carbon tetrachloride) is formed. Such reactions are called **substitution reactions**.

Reactions in which an atom or a group in a compound is replaced by another atom or a group are called substitution reactions.

- What are the compounds formed when $CH_3 — CH_3$ (ethane) undergoes substitution reaction with chlorine? Write them.

  -

Addition Reactions

- Write the formulae of ethane and ethene.

  -

- What is the peculiarity of the carbon - carbon bond in ethene?

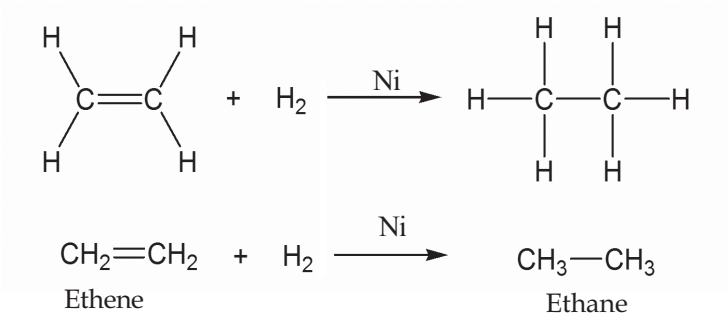
  -

You know that ethene is an unsaturated compound due to the presence of the carbon - carbon double bond.

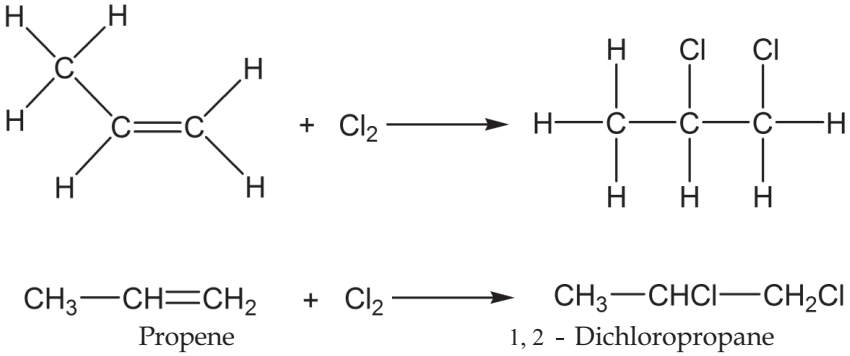
When unsaturated compounds take part in chemical reactions they tend to form saturated compounds.

Let us examine a chemical reaction of ethene molecule.

The chemical reaction in which ethene reacts with hydrogen at high temperature in the presence of the catalyst nickel (Ni) is given.



Let us examine another similar reaction.



- Which hydrocarbon is the reactant here?

  -

- Is the product saturated or unsaturated?

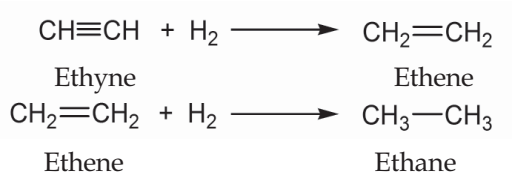
  -

Identify the products in the following addition reactions and complete Table 7.1.

Chemical reaction	Product	IUPAC name of the product
$CH_2=CH_2 + Cl_2$	.....	.....
$CH_2=CH_2 + HCl$	.....	.....
$CH_3–CH=CH_2 + H_2$	.....	.....
$CH_3–CH=CH–CH_3 + HBr$	.....	.....

Table 7.1

Similarly, take note of the balanced chemical equation for the reaction of the alkyne, ethyne with hydrogen.

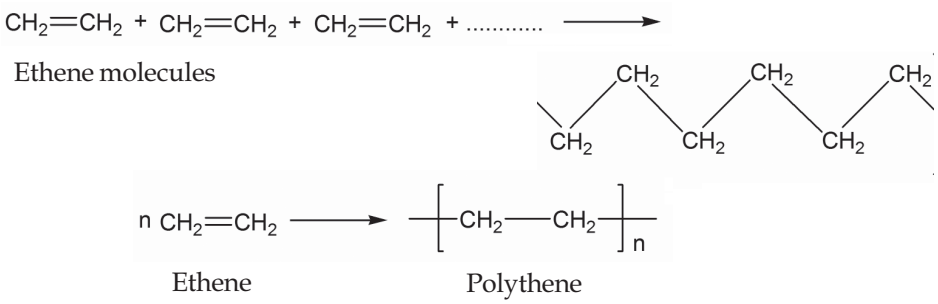


Reactions in which unsaturated organic compounds with double bond or triple bond react with other molecules to form saturated compounds are called **addition reactions**.

Polymerisation

You have learned that ethene molecules undergo addition reaction to form saturated compounds.

Consider the reaction in which a large number of ethene molecules combine under high pressure and temperature in the presence of a catalyst. The product formed here is polythene.



See the pictorial representation of this reaction (Figure 7.2).

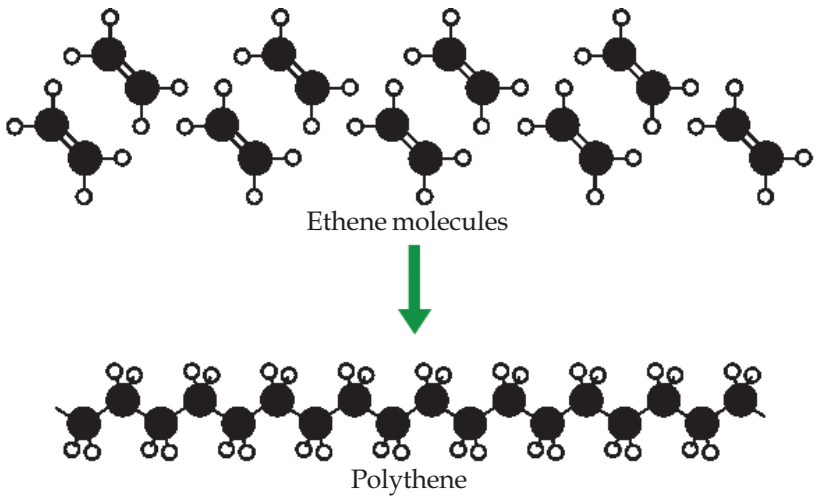
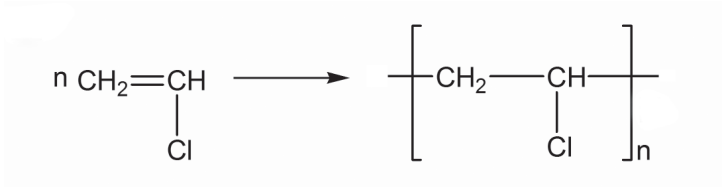


Figure 7.2

Polymerisation is the process in which a large number of simple molecules combine under suitable conditions to form complex molecules. These molecules are called polymers.

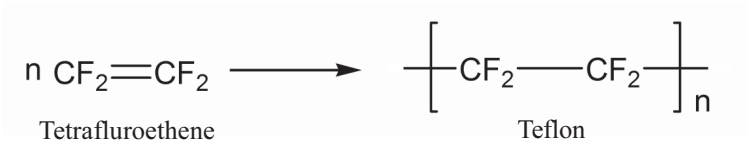
The simple molecules which combine in this manner are called **monomers**. We use a number of natural and man-made polymers in our daily life.

PVC (Polyvinylchloride) is a polymer commonly used for making pipes. It is formed by the polymerisation of a large number of chloroethene (vinylchloride) molecules.



Vinylchloride — Polyvinylchloride (PVC)

Teflon is a polymer which is familiar to us. It is used as a coating on the inner surface of non-stick cookware. Its monomer is tetrafluoroethene. Consider the equation which shows the polymerisation process taking place here.



Tetrafluroethene — Teflon

Table 7.2 given below includes some familiar polymers and their monomers. Complete the table suitably.

Monomer	Polymer	Use
. . . . .	PVC	. . . . .
Ethene	. . . . .	. . . . .
Isoprene	Natural rubber (Polyisoprene)	. . . . .
. . . . .	Teflon	. . . . .

Table 7.2

Combustion of Hydrocarbons

Most of the hydrocarbons are used as fuels. Kerosene, Petrol, LPG etc. are some among those substances.

When hydrocarbons burn they combine with the oxygen in the air to form CO_2 and H_2O along with heat and light. This process is called **combustion**.

$$\underset{\text{Methane}}{CH_4(g)} + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) + \text{Heat}$$

You might have understood that hydrocarbons are used as fuels because of the exothermic nature of the combustion process.

- Can you write the balanced chemical equation for the combustion of the fuel butane (C_4H_{10})?

Thermal Cracking

Some hydrocarbons with high molecular masses, when heated in the absence of air undergo decomposition to form hydrocarbons with lower molecular masses. This process is called **thermal cracking**.

Different products are made in this way.

Propane is one of the simplest hydrocarbons which has the capacity to undergo thermal cracking.

Examine the equation for the thermal cracking of propane.

$$\underset{\text{Propane}}{CH_3 - CH_2 - CH_3} \rightarrow \underset{\text{Ethene}}{CH_2 = CH_2} + \underset{\text{Methane}}{CH_4}$$

When hydrocarbons with larger number of carbon atoms undergo thermal cracking, there are different possibilities for the cleavage of the carbon chain. The products formed as a result of thermal cracking depend on the nature of the hydrocarbons getting cracked, their temperature and pressure. See another example given below (Figure 7.3).

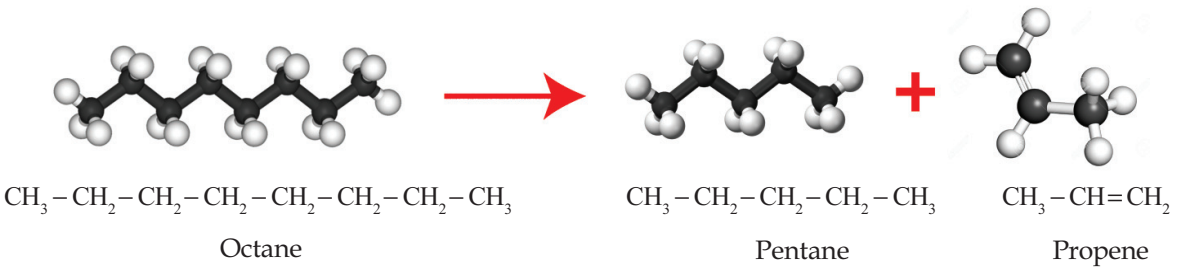


Figure 7.3

When saturated hydrocarbons are subjected to cracking the product formed contains both saturated and unsaturated hydrocarbons.

Butane is the main constituent of LPG. Butane can be prepared by the cracking of higher hydrocarbons.

Plastic wastes, which are hydrocarbon polymers can be converted to simpler hydrocarbons by thermal cracking. This helps to control pollution to some extent.

Complete Tables 7.3 and 7.4 containing chemical reactions of hydrocarbons.

$CH \equiv CH + H_2$	⟶	.....
$CH_3Cl + Cl_2$	⟶	..... + HCl
.....	⟶	$+CH_2-CH_2+_n$
CH_4 + ...	⟶	$CO_2 + H_2O$
..... + H_2	⟶	CH_3-CH_3

Table 7.3

Match Columns A, B and C suitably.

Reactants (A)	Products (B)	Name of the reaction (C)
$CH_3–CH_3 + Cl_2$	$CO_2 + H_2O$	Addition reaction
$C_2H_6 + O_2$	$CH_2=CH_2$	Thermal cracking
$nCH_2=CH_2$	$CH_2=CH_2 + CH_4$	Substitution reaction
$CH_3–CH_2–CH_3$	$CH_3–CH_2Cl + HCl$	Polymerization
$CH\equiv CH + H_2$	$+CH_2—CH_2+_n$	Combustion

Table 7.4

Some Important Organic Compounds

Now, let us familiarise ourselves with some organic compounds.

1. Alcohols

Consider the two compounds given below.

$CH_3–OH$, $CH_3–CH_2–OH$

Can you write the IUPAC names of these two compounds?

- -

Among these, methanol is known as **Wood spirit** and ethanol as **Grape spirit**. Alcohols are organic compounds containing the –OH functional group.

a. Methanol (CH_3OH)

Methanol is a highly poisonous substance used as a solvent in the manufacture of paint and as a reactant in the manufacture of varnish and formalin. Hence its industrial preparation is very important.

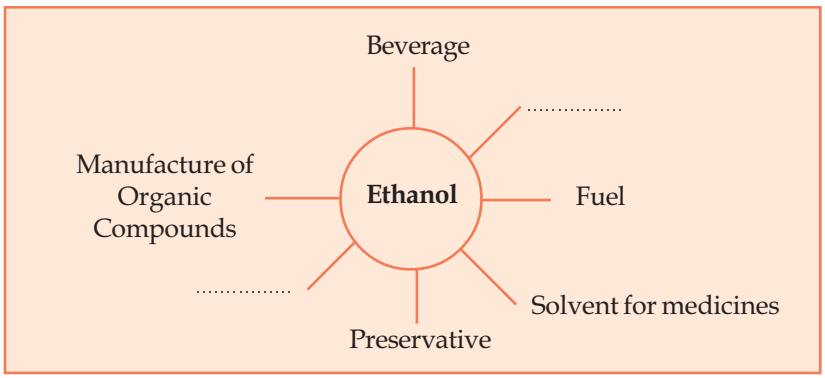
Methanol is industrially prepared by treating carbon monoxide with hydrogen in the presence of catalysts.

$$CO + 2H_2 \xrightarrow[573\,K,\ 200\,atm]{\text{Catalyst}} \underset{\text{Methanol}}{CH_3—OH}$$

b. Ethanol (CH_3CH_2OH)

Ethanol is an alcohol which is extensively used for industrial purposes.

Ethanol is used as an organic solvent and in the manufacture of various organic compounds and paints. It can be used as a fuel by itself or in combination with other compounds. Complete the following word web including more uses of ethanol.



Industrial Preparation of Ethanol

Molasses is the concentrated solution of sugar (mother liquor) left behind after the separation of sugar crystals during the manufacture of sugar. Ethanol is manufactured by fermenting diluted molasses by adding yeast. Here the reactions occur in the presence of the enzymes present in yeast. Within a few days it changes to ethanol in the presence of the enzymes invertase and zymase present in yeast.

For more clarification, open 'Chemistry for Class X' in 'School Resources' of IT@SchoolEdubuntu and watch the video 'Ethanol' from the page 'Organic Samyuktangal-rasapravarthanangal'.

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

Sucrose (Sugar) — Glucose — Fructose

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} 2C_2H_5\text{-}OH + 2CO_2$$

Ethanol

The ethanol thus obtained will be about 8 - 10% strong. It is known as **'wash'**. This is subjected to fractional distillation to get 95.6% strong ethanol solution known as **'rectified spirit'**. Poisonous substances are added to ethanol meant for industrial purposes to prevent its misuse as a beverage. This product is known as **'denatured spirit'**. 99.5% ethanol is known as **'absolute alcohol'**. A mixture of absolute alcohol and petrol, known as **'power alcohol'** is used as fuel in automobiles. Ethanol is also manufactured from starchy substances like barley, rice, tapioca etc.

2. Carboxylic Acids

These are compounds containing –COOH functional group. Don't you know the IUPAC names of compounds like CH_3–COOH and CH_3–CH_2–COOH?

See Table 7.5 given below containing the names and structures of some carboxylic acids.

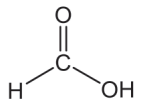
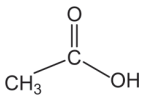
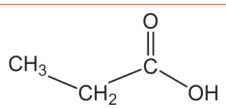
Formula	Structural formula	IUPAC name	Common name
H—COOH		Methanoic acid	Formic acid
CH_3—COOH		Ethanoic acid	Acetic acid
CH_3—CH_2—COOH		Propanoic acid	Propionic acid

Table 7.5

Most of the substances obtained from nature contain carboxylic acids. Carboxylic acids containing twelve or more carbon atoms are called **fatty acids**. Acetic acid is formed when fruits are subjected to fermentation. About 5 - 8% strong acetic acid (ethanoic acid) is known as **vinegar**. Carboxylic acids are usually prepared by the oxidation of alcohols. Vinegar can be prepared from ethanol in this way.

Industrial Preparation of Ethanoic Acid

There are different methods for the manufacture of ethanoic acid. Ethanoic acid can be manufactured by treating methanol with carbon monoxide in the presence of catalyst.

$$\underset{\text{Methanol}}{CH_3 — OH} + CO \xrightarrow{\text{Catalyst}} \underset{\text{Ethanoic acid}}{CH_3 — COOH}$$

Similarly, acetic acid of low concentration known as vinegar is also obtained when ethanol is subjected to fermentation in the presence of air using the bacteria acetobactor.

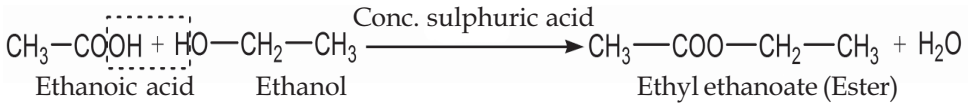
Can you list the uses of ethanoic acid?

- In the manufacture of rayon
- In the rubber and silk industry
-

3. Esters

Esters are obtained by the reaction between alcohols and carboxylic acids. Esters have the pleasant smell of fruits and flowers. Oils and fats are esters formed by the reaction between glycerol with fatty acids such as palmitic acid and stearic acid. Soaps are the salts formed when these react with alkalies.

The ester ethyl ethanoate is formed when ethanoic acid and ethanol react in the presence of concentrated sulphuric acid. The equation for this reaction is given below.



From the structural formulae of esters isn't it clear that their functional group is — COO—?

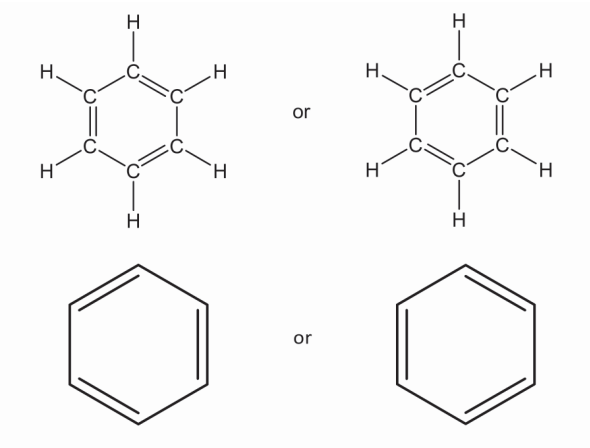
Examine the given structural formulae and select the esters. You may also identify the chemicals required for their manufacture.

1. $CH_3–CH_2–COO–CH_3$
2. $CH_3–CH_2–COOH$
3. $CH_3–CH_2–CO–CH_3$
4. $CH_3–OH$
5. $CH_3–CH_2–CH_2OH$
6. $CH_3–COOH$
7. $CH_3–CH_2–CH_2–COO–CH_3$

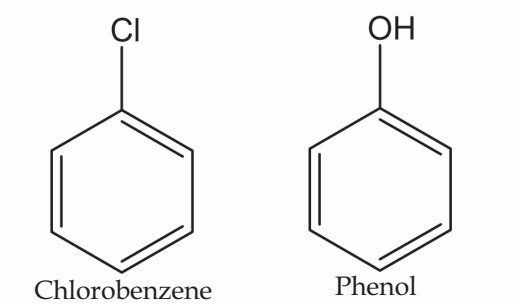
4. Aromatic Compounds

Benzene is the simplest aromatic compound.

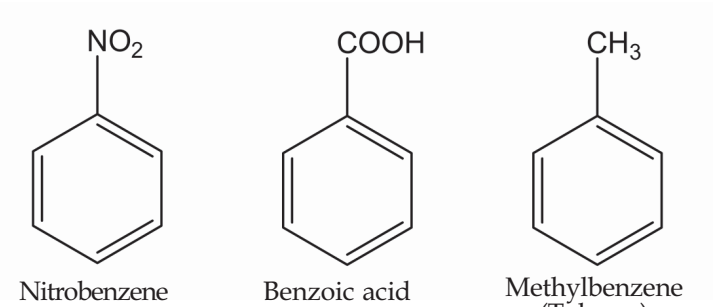
See the structure of benzene with molecular formula C_6H_6 represented in different ways.



All aromatic compounds have the ring structure. There are double bonds between alternate carbon atoms. See the structures of different aromatic compounds given below which are formed when the hydrogen atom of benzene is replaced by different functional groups.



Chlorobenzene Phenol



Nitrobenzene Benzoic acid Methylbenzene (Toluene)

These compounds have immense chemical and industrial significance. Many useful substances can be prepared from them. Coal tar obtained by the distillation of coal in the absence of air is the source of aromatic compounds.

Significant Learning Outcomes

The learner

- writes the substitution reactions of hydrocarbons like methane and ethane.
- writes the chemical formulae and IUPAC names of the products formed by the addition reactions of unsaturated hydrocarbons.
- cites examples for various polymerization reactions.
- suggests examples for thermal cracking.
- writes the chemical equations for the stages of manufacture of ethanol.

- explains the different uses of ethanol.
- writes the chemical equations for the manufacture of compounds with functional groups – COOH and – COO –.
- draws the structures of aromatic compounds like benzene, chlorobenzene, methyl benzene, benzoic acid etc.

Let Us Assess

1. Given below are two chemical equations.

   a. $CH_2 = CH_2 + H_2 \rightarrow A$

   b. $A + Cl_2 \xrightarrow{\text{Sunlight}} B + HCl$

   Identify the compounds 'A' and 'B'. Name these reactions.
2. Name the important chemical reactions of hydrocarbons. Give one example for each.
3. Write the chemical formula of propane. Write the names and structural formulae of two compounds that may be formed during its substitution reaction with chlorine.
4. Complete the equation for the following chemical reaction. Name this reaction.

   $CH_3 - CH_2 - CH_2 - CH_3 + \ldots O_2 \rightarrow$ _____ + _____
5. Which of the given molecules can form polymers?

   Butane, Propane, Propene, Methane, Butene

Extended Activities

1. You are familiar with different chemical reactions of hydrocarbons. Identify the situations in daily life in which these are used.
2. List the different uses of ethanol. Prepare an essay on its adverse effects on human body and the related social issues when it is used as a beverage.
3. You know how to make soap, don't you? Try to prepare soaps of different colours and fragrance. Prepare a short note on the chemistry of soaps.

8 Chemistry for Human Progress

Man marched towards progress utilizing different substances obtained from nature, understanding their peculiarities and consequently creating new substances. Chemistry is the branch of science which helps man in his development and rapid progress in every field of life such as agriculture, industry, health care, food, shelter, clothing, decoration, transport, research etc.

Isn't the situation in the picture familiar to you? Have you ever thought of the significance of the warning "Highly Inflammable" on tanker lorries carrying petroleum products? This is due to the peculiar nature of the petroleum product in the tank. What do you know about petroleum products?

Petroleum

The crude oil or petroleum obtained by mining from the depths of earth is a mixture of different hydrocarbons.

Petroleum is a mixture of hydrocarbons formed when the remains of marine creatures are subject to chemical transformation over the years. Traces of organic compounds containing nitrogen, oxygen and sulphur are found along with this.

Some of the components obtained during the fractional distillation (Figure 8.1) of petroleum and their uses are given in Table 8.1.

Fractional Distillation of Petroleum

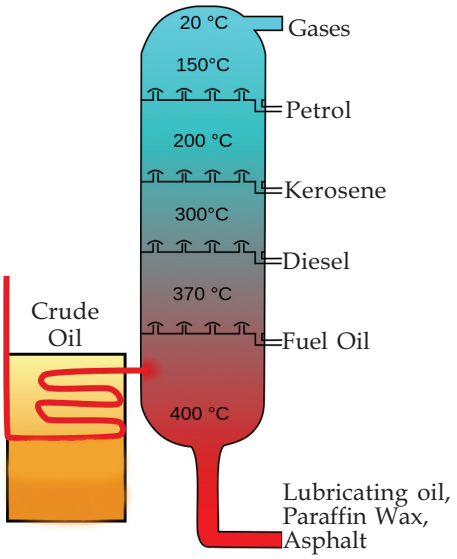


Figure 8.1

Components	Number of carbon atoms present in the hydrocarbons	Uses
Uncondensed gases	$C_1 - C_4$	Domestic/Industrial fuel
Petrol	$C_5 - C_9$	Motor fuel
Kerosene	$C_{10} - C_{16}$	Domestic fuel
Diesel	$C_{16} - C_{18}$	Diesel engine fuel
Petroleum jelly (Vaseline), Grease	$C_{18} - C_{22}$	Lubricant, Manufacture of cosmetics
Paraffin wax	$C_{22} - C_{30}$	Manufacture of Wax, Boot polish, Wax paper, Tarpaulin etc.
Bitumen	Above C_{30}	Road tarring

Table 8.1

Uncondensed gases obtained during fractional distillation can be condensed under suitable conditions and used for different purposes.

- Is the number/range of carbon atoms in fuels like petrol, diesel, kerosene etc. the same?

The number of carbon atoms in the carbon chain and the structure of the chain are the important factors which influence the properties of fuels.

Liquified Petroleum Gas (LPG)

Don't you know that butane is the major constituent of LPG, the widely used fuel for cooking?

Butane can be separated from the uncondensed gases obtained from petroleum and can be converted to LPG.

LPG can also be prepared by separating butane from the gaseous byproducts obtained when hydrocarbons with a large number of carbon atoms are subjected to thermal cracking.

For example, consider the balanced chemical equation for the thermal cracking of heptane.

$$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3 \rightarrow CH_3—CH_2—CH_2—CH_3 + CH_3—CH=CH_2$$

Heptane → Butane + Propene

Liquified Petroleum Gas (LPG) is obtained when butane gas is liquefied under high pressure.

- What are the products obtained when hydrocarbons are subjected to combustion?

CO_2 as a Result of Combustion

When 1 kg methane is burnt, 2.75 kg CO_2 reaches the atmosphere. If it is 1kg butane, 3.03 kg of CO_2 will be formed. As the number of carbon atoms in hydrocarbons increases, the amount of CO_2 formed by their combustion also increases.

- Consider the balanced chemical equation for the combustion of butane.

$$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

Similarly, a large amount of carbon dioxide is released into the atmosphere when all organic fuels undergo combustion. Just think of the changes that may arise in the environment due to the considerable increase in the amount of carbon dioxide in the atmosphere. Due to the incomplete combustion of fuels, carbon monoxide, which is a poisonous gas, may also reach the atmosphere.

Conduct a seminar in the class on how excessive consumption of fuels affect the environment.

Petrochemicals

The chemicals prepared from the hydrocarbons that are separated from petroleum are generally known as **petrochemicals**. These include some components obtained by the fractional distillation of petroleum and the substances prepared from them. Various substances such as paints, plastic, ointment, creams etc. are obtained from petrochemicals. The role of petroleum products in their manufacture can be understood from Table 8.1.

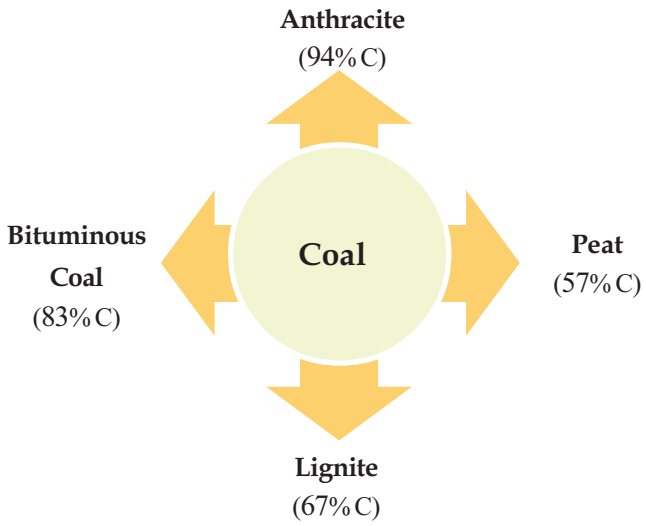
Coal

Like petroleum, coal is also a fossil fuel obtained from the depths of the earth.

Coal is formed as a result of the carbonisation on the remains of plants.

> The process by which the remains of plants transform into coal in the absence of air under high temperature and pressure is known as carbonisation.

Carbon is the major component of coal obtained from nature. Examine the figure given below showing different forms of coal and the carbon content of each.



- Which form of coal has the highest carbon content?

  -

- Which form has the lowest carbon content?

  -

Coal was used as a fuel in locomotives and for domestic purposes till a few decades back. It is also used for the manufacture of producer gas, water gas, graphite, synthetic petrol, coke, coal tar and aromatic compounds.

Now, can you imagine how useful are the fossil fuels like petroleum and coal ?

Analyse Table 8.2 given below.

Production and Consumption of Petroleum in India

Million Metric Ton (MMT)

Crude Oil	2011 - 12	2012 - 13	2013 - 14
• Production	38.09	37.86	37.79
• Consumption	201.12	219.21	222.50

Table 8.2

This data reveals that in India, in recent years, the production of crude oil has been decreasing while its consumption has been increasing, isn't it? If they are not available proportionate to their consumption, won't they have to be imported?

Discuss in the class how the import and export of crude oil influence the various sectors of the concerned countries.

- Finance
- Employment
- Industry
-

What will be the situation if non-renewable fuels like petroleum and coal get exhausted due to excessive consumption?

Isn't it essential to restrict their excessive consumption? We have to think of alternate energy resources. Suggest some methods to make people aware of this.

- Poster making
- Awareness classes
-

Medicines

The role of medical science and medicines in promoting health and enhancing life span is unique. The contribution of Chemistry in the progress of different fields of medical science and research is very important.

Aren't you familiar with some of the medicines? You might have noticed the different types of medicines in medical stores.

What are the purposes for which medicines are used?

- Diagnosis
- Prevention of disease
-

Which are the different branches of medicine based on the nature of treatment?

- Ayurveda
- Allopathy
- Homeopathy
-

See Table 8.3 which contains a few types of allopathic medicines used in treatment of diseases and their functions.

Medicine for Diagnosis

Different medicines are used in Allopathy for diagnosis. For example, barium sulphate oral suspension is used in X - ray, MRI scans etc. and iomeprol containing iodine is used in CT scan studies. The amount of glucose in urine can be obtained using Benedict solution. Technetium 99 is used in gamma ray scanning.

Type	Function
Analgesics	To relieve pain
Antipyretics	To lower body temperature
Antacids	To reduce acidity
Antiseptics	To control micro organisms
Antibiotics	To destroy the disease causing micro organisms and prevent their growth

Table 8.3

Some of the antipyretic medicines and their chemical names are given in Table 8.4 .

Medicine	Chemical name
Aspirin	2-Acetoxybenzoic acid
Paracetamol	4-Acetamidophenol

Table 8.4

Don't you know that different medicines that we use contain chemicals? Check the labels of different medicines, identify the chemicals and list them.

-
-
-

Have you noticed doctors recording the age and weight of the patient in the prescription before suggesting the medicine? Why is it necessary?

It is advisable to take medicines following the directions of doctors, who prescribe them after considering the health condition of the patient.

Do you know that sometimes self treatment may lead to the worsening of diseases? What are the other situations in which the health condition of the patient worsens even when medicines are taken?

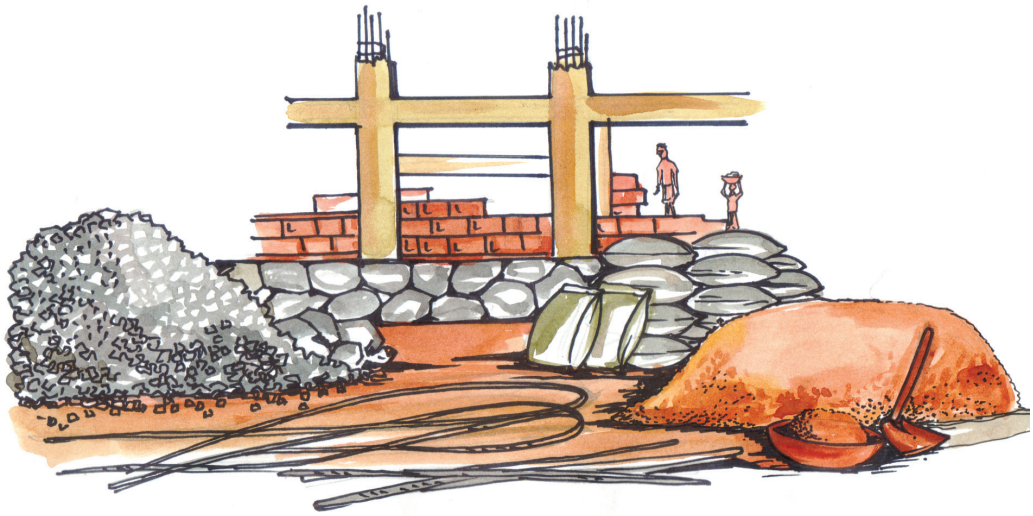
- Irregularity in using medicines as per the timings prescribed by the doctors
- Taking medicines even after the prescribed period
- Taking medicines prescribed for another person
-

Some medicines are obtained from nature while others are prepared from chemicals. Whatever be the type of medicine, its scientific use will help to improve the health of a patient. What happens if the use is not scientific? Organize a debate in your class.

Cement

The transition in the field of construction from huts made of wood and logs to buildings made of mud walls and stone walls underwent a revolutionary progress with the invention of cement. The contribution of cement can be seen in the construction of buildings, but also in the modern forms of bridges, dams, roads, etc.

Haven't you noticed the increase in the number of buildings around us? Cement is the substance that brought about a phenomenal change in the field of building construction.



Cement is manufactured in large scale using the rotary kiln (Figure 8.2). The pictorial representation of the important process taking place here is given in Figure 8.3.

The rotary kiln for the manufacture of cement
Figure 8.2

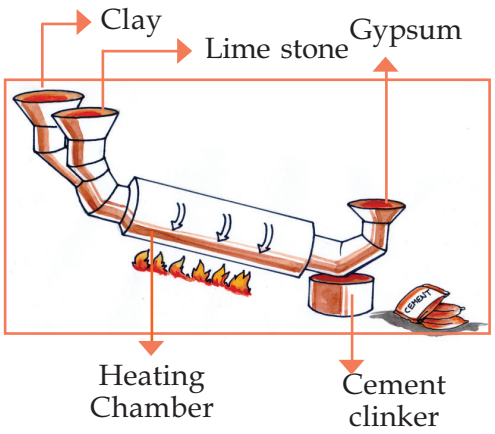


Figure 8.3

- What are the raw materials used for the manufacture of cement?

  -

Cement clinker is obtained when powdered lime stone and clay are heated in a rotary kiln. It is mixed with gypsum and then powdered and stirred to get cement. Cement is a complex mixture of silicates and aluminates of calcium.

What are the materials used as mixtures for the purposes given below, related to building construction? Complete Table 8.5.

Use	Mixture	Substances required
For plastering	Cement mix	Water, Cement, Sand
For concreting the roof	Reinforced concrete	Metal, Steel/Iron bars, ----, ------, ------
For setting the floor	Concrete	Metal, Sand, ------, ------

Table 8.5

You might have noticed workers wearing gloves and pantaloons while concreting buildings. What can be the reason for this?

- -

The process in which cement combines with water and sets into a hardened mass is known as setting of cement. Since it is an exothermic reaction, a large amount of heat energy is liberated when the cement mixture gets hardened. What can be its adverse effects? How can we overcome these? Prepare notes after discussing with those working in the field of construction.

The setting time of different types of cement is different. It is made possible by mixing specified quantities of gypsum during the time of manufacture.

If cities and villages continue to be crowded with concrete buildings, demolision of them at a later stage will accumulate the debris of building materials. Discuss how this debris may affect the ecosystem.

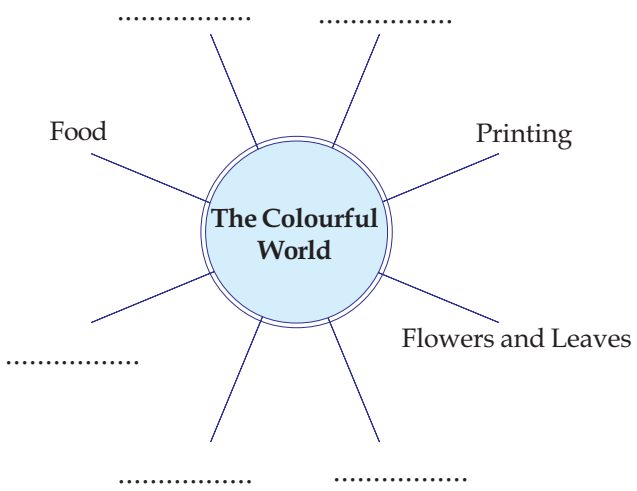
The World of Colours

For more clarity, open 'Chemistry for Class X' in 'School Resources' of IT @ School Edubuntu and view the video 'Cement' from the page 'Rasathanthram nithya jeevithathil'.

Can we think of a world without colours?

What are the situations in which we identify the presence of colours?

Complete the sun diagram given below.



There are natural as well as artificial colouring materials around us.

In ancient days coloured plant pigments were used to impart colours to threads for clothing, historical art forms, palaces, pictures, murals etc.

Dyes and pigments are chemical substances which help to impart colour to other objects.

Colours obtained from plants such as Alizarin Red and Indigo Blue are natural dyes. Organic compounds benzene, aniline, phenol etc. are used in the manufacture of synthetic dyes. Cadmium sulphide (CdS), Lead chromate ($PbCrO_4$) etc. are examples of pigments.

The constituents used for colouring clothes, paper, leather, plastics, ink, cosmetics, food items etc. contain different dyes and pigments. Nowadays there are methods to get a combination of desired colours using computer aided technology.

Glass Globes that Changed the World

Glass globules obtained from the ash while cooking in hearths in the Egyptian deserts, changed man's perspective of the world. Lenses, plane glasses and glass laminates redefined vision. The progress in the field of space science and astronomy has been very significant, with the advent of lenses of telescopes made out of scratching glass pieces. It is none other than glass which brightened the dark rooms of buildings.

Glass

Glass is quite an accidental invention in the history of mankind. The world of microscopic particles was made visible to us through microscopes after the emergence of lenses.

We use different types of glasses these days. List the different areas in which glasses are used.

- Wind shield glass of motor vehicles
- Lenses in spectacles
- Screens of smart phones
- Optic fibres
-

Different types of glasses and the constituents used for their manufacture are given in Table 8.6.

Glasses	Constituents	Uses
Soda-lime glass/Soda glass/Soft glass	Silicon dioxide (SiO_2) Sodium carbonate (Na_2CO_3) Calcium carbonate ($CaCO_3$)	Window panes Mirrors
Hard glass	Silicon dioxide (SiO_2) Potassium carbonate (K_2CO_3) Calcium carbonate ($CaCO_3$)	Laboratory equipments Factory equipments/ Kitchen utensils
Borosilicate glass	Boron oxide (B_2O_3) Aluminium oxide (Al_2O_3) Silicon dioxide (SiO_2)	Laboratory equipments Cookware
Flint glass/Optical glass/ Lead glass	Silicon dioxide (SiO_2) Potassium carbonate (K_2CO_3) Lead oxide (PbO)	Lenses, Prisms

Table 8.6

Analyse the table and prepare a short note on different types of glasses, their constituents and uses.

We can prepare glass articles of different shapes by moulding or blowing liquid glass obtained by heating the required constituents at a specified temperature.

Glass is a mixture of silicates.

Haven't you seen glasses of different colours? The colour is due to the presence of some compounds added along with the raw materials during the manufacture of glass.

The colour given by some compounds of transition elements to glass are given below. Expand the list by identifying more examples.

- Ferric ion → Yellow
- Chromium/Ferrous ion → Green
- Cobalt oxide → Blue
- Manganese dioxide → Purple
-

Photosensitive Glass

Some glasses turn dark when high intense light falls on them. They become more transparent as the intensity of light decreases. This is caused by the addition of light sensitive chemicals during their manufacture. When light falls on the window shield of glasses of some vehicles, they appear dark. These are called photo sensitive glasses.

Green Chemistry

Science has developed various instruments and various types of chemicals for reducing labour, improving the comforts of life and for healthcare as a result of the progress that mankind has achieved. Many substances used or produced in all these activities may cause environmental hazards. For example, materials used for making useful commodities and the waste materials we dump cause pollution in a large scale. Can you point out such situations? List them.

-
-
-

A branch of Chemistry has emerged which addresses the pollution caused in such situations and controls the production of poisonous chemicals and products thereby reducing the adverse effects on nature and environment. This is **Green Chemistry**.

Green chemistry is based on certain principles which limit the number of reactant atoms and molecules in chemical processes to the required definite proportion, thereby reducing the amount of hazardous by-products to the minimum.

Some of the important goals of green chemistry are given below. Discuss them in your class and expand the list.

- to convert hazardous chemicals into useful and harmless substances.
- to produce eco - friendly products.
- to reduce pollution.
- to minimise the use of poisonous products.
-

Green chemistry has lent a helping hand to nature and life by accepting the unparalleled position of chemistry in the progress of mankind, and by reducing the adverse effects on nature caused by human intervention without hindering progress.

Present a seminar in class on the feasibility and essentiality of green chemistry.

Significant Learning Outcomes

The learner

- lists the fuels obtained from petroleum based on the number of carbon atoms in their hydrocarbon chain.
- explains the different methods in which liquefied petroleum gas (LPG) can be prepared.
- defines petrochemicals and explains the importance of petroleum in the manufacture of different petrochemicals.
- describes how coal is formed under earth and classifies the different forms of coal based on the amount of carbon in them.
- identifies that many medicines are made of different chemicals.
- identifies how self-medication adversely affects health.
- explains the manufacture and uses of cement.
- describes the constituents used to impart colour to materials.
- describes the constituents in the manufacture of different types of glasses.
- lists the different uses of glass.
- identifies the compounds which give colour to glass.
- identifies the significance of green chemistry and applies it in daily life.

Let Us Assess

1. The balanced chemical equation for the thermal decomposition of heptane is given.

$$C_7H_{16}(l) \rightarrow C_4H_{10}(g) + C_3H_6(g)$$

   a) Which of these components can be used as LPG?

   b) In which state is the component collected and stored?

2. The characteristics of some components of petroleum are given. Match them appropriately.

A	B
Component	**Use**
1. Diesel 2. Petrol 3. Kerosene 4. Grease	• Lubricant • Fuel in diesel engines • Motor fuel • To light lamps • To make wax

3. Prepare a short note on petrochemicals.
4. List the important uses of coal. Name the form of coal with the highest carbon content.
5. Describe how coal is formed?
6. Which constituents form the basis of the variety of colours in the world of colours? What are their characteristics?
7. How are glasses manufactured? What are the raw materials needed for hard glass and borosilicate glass?
8. Which are the compounds used for imparting the following colours to glass?
   - Green
   - Yellow
   - Blue

Extended Activities

1. Butane obtained by the thermal decomposition of higher hydrocarbons can be liquefied to get LPG. Identify examples for such possible situations.
2. Clay is an important constituent in the manufacture of cement. Find other substances for the manufacture of which clay is used.
3. Glass is the substance which changed the very appearance of the world. Enquire and prepare short notes on the different situations in modern facilities where glass is being used.

4. Visit a nearby primary health centre and prepare a short note on medicines used for different purposes and the chemical components in them.
5. Chlorine is used as a bleaching agent during the manufacture of paper. Environmental pollution can be controlled if ozone is used instead of chlorine. Identify the contributions of green chemistry in similar situations.
6. Prepare a write-up on 'Self-treatment and Health'.
7. Prepare a short note on the manufacture and uses of cement.
8. Conduct a survey by observing the buildings in your surroundings and list those buildings which are made of environment-friendly materials.