

CHEMISTRY

Standard X

Part II



Government of Kerala
Department of General Education

State Council of Educational Research and Training (SCERT) Kerala

2019

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,

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 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.

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. Some basic concepts in Organic Chemistry are discussed in this textbook.

The educational portal 'Samagra' and the QR Code incorporated textbook make the classroom learning process effortless and stimulating. National Skills Qualification Framework (NSQF), Disaster management techniques relevant to contemporary issues and the ICT possibilities are considered in this textbook.

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 J. Prasad
Director, SCERT

CONSTITUTION OF INDIA

Part IV A

FUNDAMENTAL DUTIES OF CITIZENS

ARTICLE 51 A

Fundamental Duties- It shall be the duty of every citizen of India:

- (a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
- (b) to cherish and follow the noble ideals which inspired our national struggle for freedom;
- (c) to uphold and protect the sovereignty, unity and integrity of India;
- (d) to defend the country and render national service when called upon to do so;
- (e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;
- (f) to value and preserve the rich heritage of our composite culture;
- (g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;
- (h) to develop the scientific temper, humanism and the spirit of inquiry and reform;
- (i) to safeguard public property and to abjure violence;
- (j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievements;
- (k) who is a parent or guardian to provide opportunities for education to his child or, as the case may be, ward between age of six and fourteen years.



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THE SYMBOLS USED IN THE TEXTBOOK



Additional Information
(Need not be assessed)



ICT Possibilities for Concept Clarity



Let Us Assess



Extended Activities

5

Compounds of Non - Metals



Are you familiar with the chemicals shown in the picture?

These chemicals have utmost importance in the agricultural and industrial sectors. Hence they are produced in large quantities. We shall familiarise ourselves with the methods of production and properties of some of these chemicals.

Ammonia (NH_3)

Ammonia is an important raw material for the production of nitrogenous fertilisers which are essential for the growth of plants.

How can we prepare ammonia in the classroom? Let's do an experiment.

Take a little ammonium chloride (NH_4Cl) in a watch glass and add a little calcium hydroxide ($\text{Ca}(\text{OH})_2$) to it. Stir well.

Can you sense any smell?

Show wet blue and red litmus papers over the watch glass one by one. Which litmus paper shows a colour change?

Is the gas acidic or basic?



Look at the figure showing the preparation of ammonia in the laboratory (Figure 5.1).

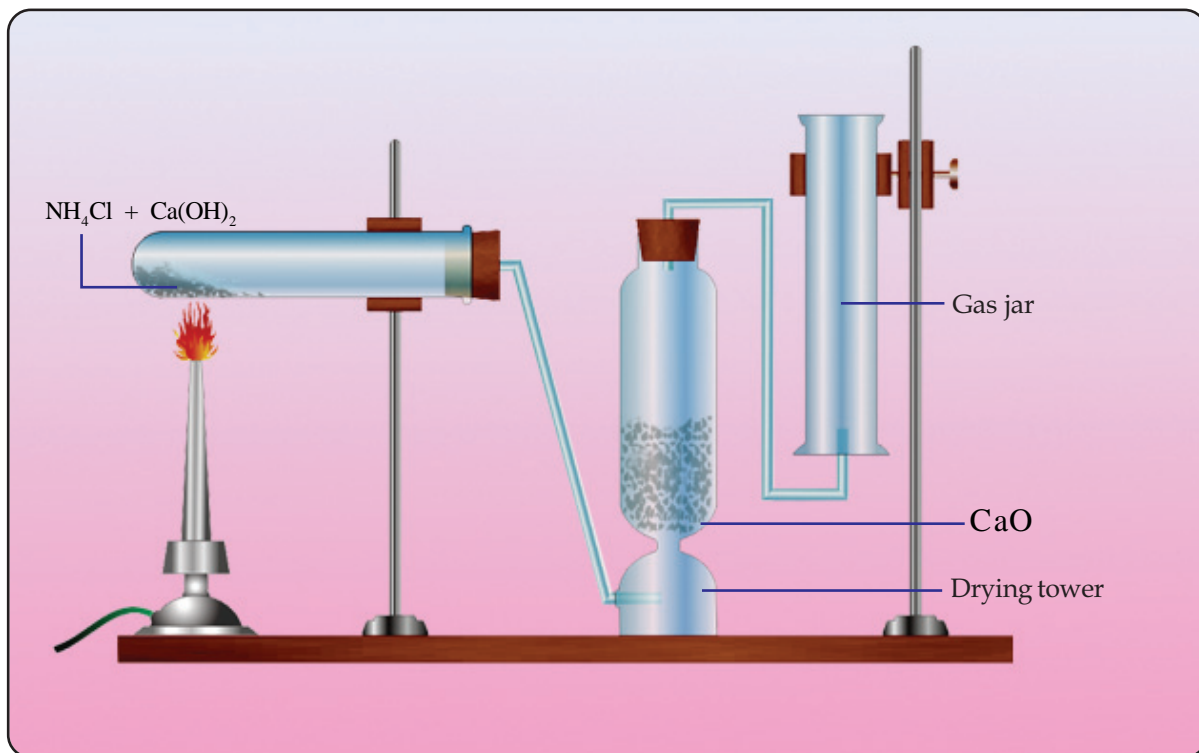
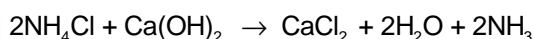


Figure 5.1



Open Chemistry for Class X in School resources of IT@School Edubuntu and see the video 'Ammonia Nirmanam' from the page 'Chila Aloha Samyiktangal'.



Why is ammonia gas passed through quick lime (CaO)?

It is passed through a drying tower containing quick lime (CaO) to remove the moisture present in it.

Note that the gas jar used for collecting ammonia is kept inverted.

- What may be the reason for collecting ammonia in this manner?
- What is your inference about the density of ammonia from this?

Let's do an experiment using ammonia gas.

Collect dry ammonia in a round bottomed flask.

Arrange the apparatus as shown in the figure (Figure 5.2). Dip the jet tube in the beaker containing water, in which some phenolphthalein is added. Using a syringe add a few drops of water into the flask in which ammonia is taken.

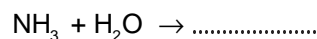
What do you observe?

What inference can be made about the solubility of ammonia in water? Why does water rush into the flask?

Why does water entering the flask change its colour? -----

Which property of ammonia is responsible for this change in colour? -----

Complete the chemical equation given below and find the product obtained when ammonia is dissolved in water.



Put a tick mark (✓) to those which are applicable to ammonia in Table 5.1 given below.

Colour	Yes/No
Odour	Pungent smell/No smell
Nature	Acidic/Basic
Solubility in water	Less/Very high
Density of Ammonia	Less than that of air/More than that of air

Table 5.1

- When an Ammonia tanker leaks, water is sprayed to reduce its intensity. What is the reason for this?

A highly concentrated aqueous solution of Ammonia is called Liquor ammonia. Ammonia gas can be liquified easily by applying pressure. Liquified ammonia is known as liquid ammonia.

Some uses of ammonia are given below.

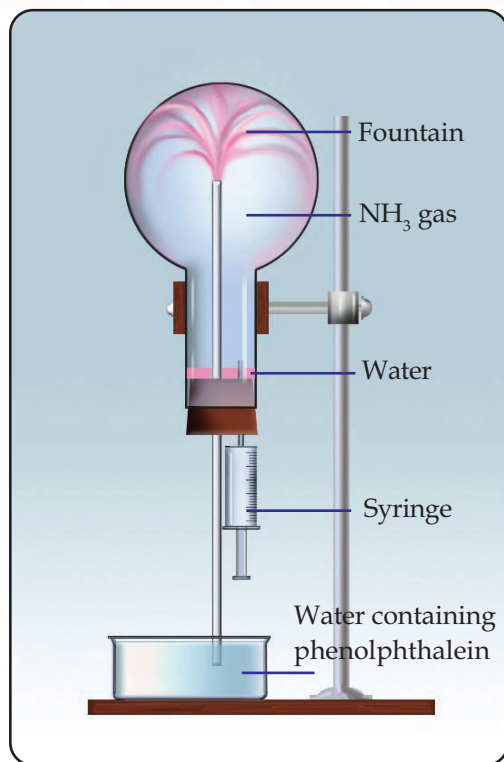
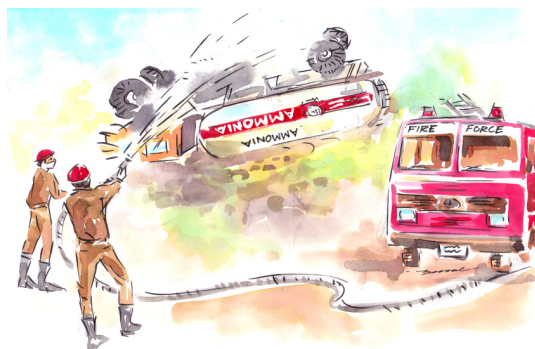


Figure 5.2



Open Chemistry for Class X
in School Resource of
IT@School Edubuntu
& see the video





Open chemistry for class X in school resources of IT@school Edubuntu and see 'nitrogenum hydrogenum upayogichu ammonia nirmanam'



Open Chemistry for class X in School resources of IT@School Edubuntu & see the video "Ammonia plant"

- For the manufacture of chemical fertilisers like ammonium sulphate, ammonium phosphate, urea etc.
- As a refrigerant in ice plants.
- To clean tiles and window panes.
- -----

Take some ammonium chloride (NH_4Cl) in a boiling tube and heat it. Don't you sense a peculiar smell?

- Which is the gas evolved here?

- Show a wet red litmus paper on the mouth of the boiling tube. What change can you observe?



Haber process



Fritz Haber
(1868 - 1934)

The Haber process was invented by the German Scientist Fritz Haber in 1912, for preparing ammonia on an industrial basis. Nitrogen and

hydrogen taken in the ratio 1:3, are made to combine at a very high pressure (200 atm) and a temperature of 450°C to produce ammonia. Spongy iron is used as the catalyst. Ammonia is an important compound used in large quantities to produce chemical fertilizers. It was through the green revolution that our country ensured food security and achieved self sufficiency in food production. One of the major principles of the green revolution was the use of chemical fertilizers.

This change indicates the basic nature of the gas.

Haven't you made it sure that this gas with pungent smell and the basic nature is ammonia?

Keep the litmus paper for some more time at the mouth of the boiling tube and then observe its colour change.

- What is the change occurred?

The wet litmus paper has changed again to red colour due to the presence of the hydrogen chloride (HCl) gas. When ammonium chloride (NH_4Cl) is heated. Lighter NH_3 comes out first then the denser HCl comes out.

- Write the chemical equation of this reaction.

Haven't you noticed the white powder sticking to the sides of the test-tube? It is ammonium chloride. It is formed due to the reaction between NH_3 and HCl gases which come out.

Let us do another experiment to make this clear. A glass rod dipped in concentrated hydrochloric acid is shown inside a jar which is filled with ammonia gas.

What have you observed?

Complete the chemical equation and find out the product.



Take a glass tube. Place a piece of cotton dipped in HCl at one end and another piece dipped in ammonia solution at the other end of the glass tube, such that these are well inside the glass tube. Close both ends of the glass tube tightly using corks. Observe the changes inside the glass tube.

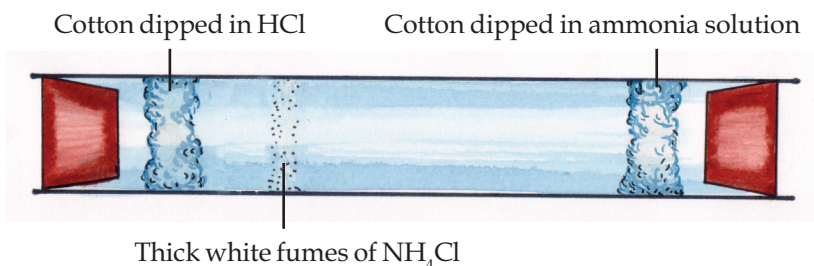


Figure 5.3

Do you observe the thick white fumes? It is due to the combination of HCl gas and NH_3 gas. Heat the region of the glass tube where the white powder of ammonium chloride has been stuck.

- What happens to the white powder on heating?

See the chemical equations for the decomposition of ammonium chloride while heating and the recombination of products formed.

- $\text{NH}_4\text{Cl} (\text{s}) \rightarrow \text{NH}_3 (\text{g}) + \text{HCl} (\text{g})$
- $\text{NH}_3 (\text{g}) + \text{HCl} (\text{g}) \rightarrow \text{NH}_4\text{Cl} (\text{s})$

We can combine these equations into



The sign " \rightleftharpoons " indicates that the reaction takes place in both directions.

(This sign " \rightleftharpoons " is to be read as reversible)



Watch the video of the reaction between ammonia and hydrogen chloride from the page 'Some Non-metallic Compounds', opening 'Chemistry for Class X' in 'School Resources' of IT @ School Edubundu.

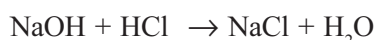
Reactions taking place in both directions are called **reversible reactions**.

In a reversible reaction the reaction in which the reactants change to products is called the **forward reaction** and that in which the products change back to reactants is called the **backward reaction**.

Examine the chemical equations given below and write the forward and backward reactions in each.

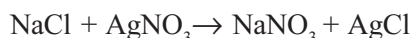
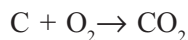
- $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
- $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$
- $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$

Are these chemical reactions similar to those we have already studied? See the chemical equation of the neutralisation reaction between sodium hydroxide and hydrochloric acid.



Such chemical reactions in which reactants give products, but the products do not give back the reactants are called irreversible reactions.

More examples:



Chemical Equilibrium

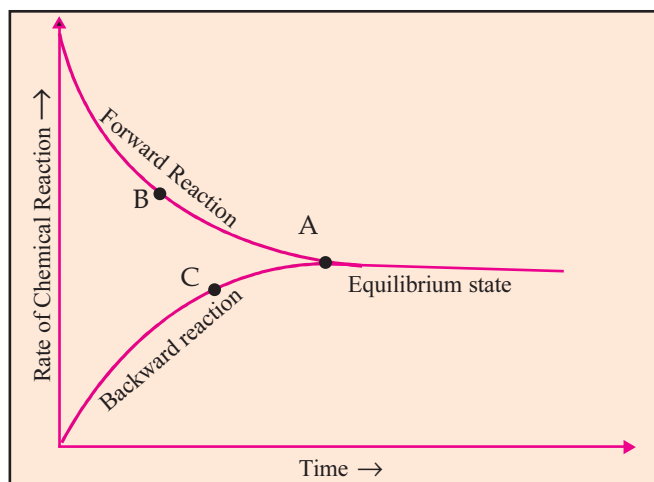


Figure 5.4

Try to find answers to the given questions by analysing the graph of the reversible process (Figure 5.4).

- What happens to the rates of forward and backward reactions as time progresses?

- Identify the point at which the rates of both forward and backward reactions become equal?

Chemical equilibrium is the stage at which the rate of the forward reaction becomes equal to the rate of the backward reaction in a reversible chemical reaction.

The characteristics of equilibrium identified through the experimental observations conducted so far are given below:

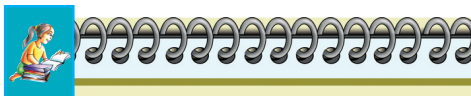
- At the equilibrium both the reactants and the products coexist.
- The rates of forward and backward reactions become equal at equilibrium.
- Chemical equilibrium is dynamic at the molecular level.
- Chemical equilibrium is attained in closed systems.

We have seen that in all systems in equilibrium, both reactants and products coexist. At equilibrium forward and backward reaction occur simultaneously at the same rate. That is why chemical equilibrium is said to be dynamic at the molecular level.

The scientist Le Chatelier proposed an important principle related to chemical equilibrium.

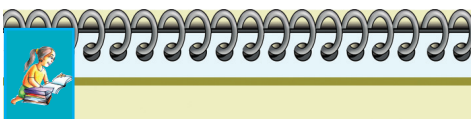
Le Chateliers' Principle

When the concentration, pressure or temperature of a system at equilibrium is changed, the system will readjust itself so as to nullify the effect of that change and attain a new state of equilibrium.



Closed System

Closed system is one in which nothing new is added to a system or nothing is removed from the system. Equilibrium is possible only in a closed system.



Chemical Equilibrium is Dynamic Equilibrium

A system reaches equilibrium not because the reaction stops but because the rates of forward and backward reactions become equal. Even at equilibrium, the reactant molecules react to form product molecules and product molecules react to form reactant molecules. Hence chemical equilibrium is said to be dynamic equilibrium at the molecular level.

Influence of concentration on Equilibrium

Ammonia is industrially prepared by Haber process. Its chemical equation is given below:



It is a reversible reaction, isn't it? Suppose the concentration of the reactant nitrogen is increased. According to Le Chatelier's principle, the system rearranges by converting the increased amount of reactant into products. If so,

- The rate of which reaction increases when the concentration of nitrogen is increased?
Forward reaction/backward reaction (Put ✓ mark)
- What will happen if the concentration of ammonia is increased?

- What will be the effect, if the ammonia produced is removed continuously from the system?

Complete the Table 5.2 by writing the effect of the change in concentration in the system at equilibrium.

Action	Change of concentration	Change in rate
• More hydrogen is added	• Increases the concentration of reactant.	• Rate of forward reaction increases.
• More ammonia is added	• Increases the concentration of the product	•
• Ammonia is removed	• Decreases the concentration of the product.	•
• More nitrogen is added	• Increases the concentration of the reactant.	•

Table 5.2

Pressure and Chemical Equilibrium

You know that pressure has a significant influence in the case of gases only.

Let us examine the influence of pressure in the manufacture of ammonia.



- In this equation what is the total number of moles of the reactant molecules?

- What about the products?

Here, both reactants and products are gases.

Forward reaction : 4 mole reactant molecules → 2 mole product molecules (volume decreases)

Backward reaction : mole product molecules → mole reactant molecules (volume)

In a gaseous system, decrease in the number of molecules helps to decrease the pressure.

According to Le Chateliers' principle, when pressure of a system at equilibrium is increased the system will try to attain equilibrium by reducing pressure.

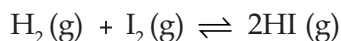
- In the manufacture of ammonia, the reaction in which direction results in the decrease in the number of molecules?

-
- What happens when the pressure of the system is increased?

-
- What happens if the pressure of the system is decreased?

-
- In the manufacture of ammonia, why is a high pressure of 150-300 atm used?

Analyze the chemical equation for the gaseous reaction given below:



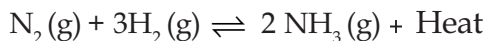
- What is the total number of moles of reactants?

-
- What about the products?

Here there is no change in the number of moles of the reactants and the products.

In a reversible reaction if there is no change in the number of gaseous molecules in the reactant and product side, pressure will not have any effect on the chemical equilibrium.

Temperature and Equilibrium



Which is the endothermic reaction in this?

Forward reaction/Backward reaction

On increasing the temperature, the system tries to reduce it by increasing the rate of endothermic reaction. As a result the product ammonia decomposes to form N_2 and H_2 . Hence, according to Le Chateliers' principle, for the formation of a larger amount of NH_3 , the temperature has to be reduced. But at low temperature the number of molecules having threshold energy will be less. Therefore the rates of forward and backward reactions get very much reduced, the system will take more time to reach equilibrium. Hence in the manufacture of ammonia, 450°C is taken as the optimum temperature.

Catalyst and Chemical Equilibrium

You know that positive catalysts are substances which increase the rate of reactions. In reversible reactions, there are forward and the backward reactions. Catalyst cannot increase the rate of only one among these. Then, what is the function of a catalyst in a reversible reaction? Catalyst increases the rates of both the forward and backward reactions to the same extent. As a result the system reaches equilibrium at a faster rate. Once equilibrium has been reached, the rate of chemical reaction can be controlled by altering other factors.

Is it beneficial to add a catalyst in a system which has already attained equilibrium? Try to find out the answer.

Sulphuric Acid (H_2SO_4)

Sulphuric acid is a chemical of utmost importance in industry. Let us make an idea of the various uses of sulphuric acid by analysing the word web given below.

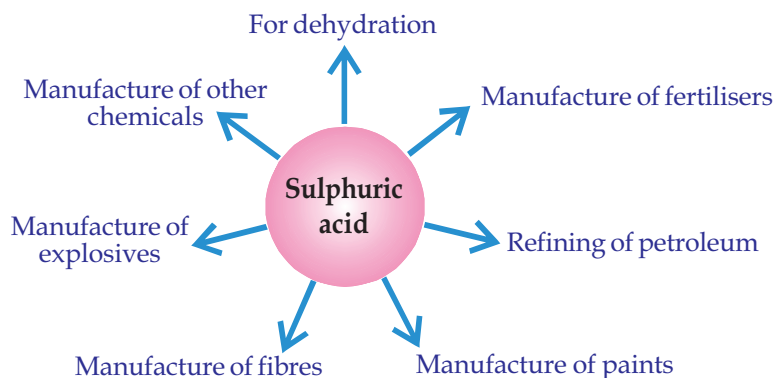


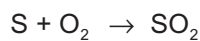
Figure 5.5

Now you can understand why sulphuric acid is called the king of chemicals.

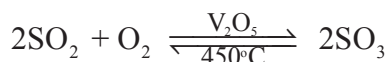
Industrial Preparation of Sulphuric Acid

Sulphuric acid is industrially prepared by the **Contact Process**. Let us examine the different stages in the contact process.

Sulphur is burnt in oxygen to produce sulphur dioxide.



The SO_2 thus formed is allowed to combine with oxygen in the presence of vanadium pentoxide (V_2O_5) as catalyst to produce sulphur trioxide.



SO_3 is now dissolved in concentrated sulphuric acid.



The product thus formed is known as Oleum. Sulphuric acid is produced by dissolving Oleum in water.



Sulphuric acid is formed also by the direct dissolution of sulphur trioxide in water. Still, sulphur trioxide is not directly dissolved in water. Why?

The dissolution of sulphur trioxide in water is an exothermic process. It may turn sulphuric acid initially formed into fine fog like particles (smog) which will hinder further dissolution.



Open chemistry for class X in school resources of IT@school Edubuntu and see the video 'Sulphuric acid'

That is why sulphur trioxide is dissolved in concentrated sulphuric acid to make oleum.

Complete the flow chart.



Physical properties

- Colourless
- Comparatively high viscosity
- Highly corrosive
- Denser than water
- Dissolves in water

Chemical properties

Take 5mL water in a test tube and slowly add concentrated sulphuric acid to it. Touch the bottom of the test tube. What do you feel?

Is the reaction exothermic or endothermic? _ _ _ _ _

While diluting sulphuric acid, the acid should be added to water in very small quantities, stirring it. If water is added to the acid, it will result in spurting and may cause burns to our body, as the reaction is highly exothermic.

Dehydrating nature

Take some sugar in a watch glass and add a few drops of concentrated sulphuric acid. Observe the changes. Molecular formula of sugar is $C_{12}H_{22}O_{11}$, isn't it? Analyze the chemical equation of this experiment.



- What are the constituent elements of sugar?
- Which is the black substance in the product formed?
- What is the ratio of hydrogen and oxygen in sugar?
- Which is the substance that absorbed hydrogen and oxygen from sugar in the ratio as in water?

Concentrated sulphuric acid has the ability to absorb chemically combined water, or hydrogen and oxygen from substances in the ratio corresponding to that of water. This process is known as dehydration. Concentrated sulphuric acid is a strong dehydrating agent.

Complete the table by involving the activities given below.

No.	Activity	Observation
1.	Dropping Con. H_2SO_4 on a cotton cloth.	.....
2.	Adding Con. H_2SO_4 to glucose taken in a small beaker.	.....
3.	Adding Con. H_2SO_4 to a watch glass in which CuSO_4 crystals are taken.	.....

Table 5.3

Dehydrating properties of H_2SO_4 are shown in all the above activities.

Drying nature

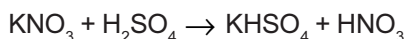
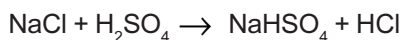
Drying agents are substances capable of absorbing the moisture present in a substance.

Concentrated sulphuric acid is used as a drying agent in the preparation of Cl_2 , SO_2 and HCl .

Why is concentrated sulphuric acid not used as a drying agent in the preparation of ammonia?

Reaction with salts

Concentrated sulphuric acid forms hydrogen chloride on reaction with chlorides and nitric acid on reaction with nitrates. Chemical equations of these reactions are given below.



Concentrated sulphuric acid can displace volatile acids from their salts.

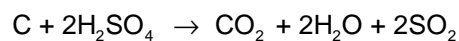
This method is employed in the preparation of hydrochloric acid, nitric acid etc.

Oxidising nature

Concentrated sulphuric acid reacts with metals and non metals and oxidises them.

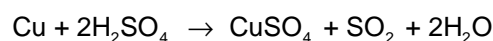
Add concentrated sulphuric acid to a test tube containing a small quantity of carbon. Heat it. What do you observe?

Analyse the chemical equation and find the reason for your observation.



- What is the oxidation state of elemental carbon?
- What about the carbon in carbon dioxide?
- Was carbon oxidised or reduced in this reaction?
- Which is the oxidising agent?

See the reaction between concentrated sulphuric acid and copper.



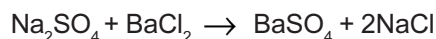
Is copper oxidised or reduced in this case?

Think about it relating the oxidation states of elemental copper and the copper in copper sulphate.

Which is the oxidising agent in this reaction? Which is the reducing agent?

Identification of sulphate ions

Take a little sodium sulphate solution in a test tube and add three or four drops of Barium chloride (BaCl_2) solution to it. Due to the reaction, a white precipitate is formed. Add four or five drops of diluted hydrochloric acid to it. Write down the observation. Analyse the given chemical equation.



- Which substance is soluble in water among the products?
- Which substance is the white precipitate?
- Does the white precipitate dissolve when dilute hydrochloric acid is added to it?

Write down the observation in the table given below, when 1mL Barium chloride solution is added to the solutions given in the table.

No.	Solution	By adding BaCl_2 solution	When dilute HCl is added to this
1	MgSO_4	.....	.....
2.	ZnSO_4	.....	.....

Table 5.4

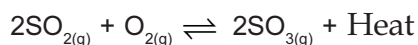
Sulphate salts react with Barium chloride to form a white precipitate of Barium sulphate. It is not soluble in dilute hydrochloric acid.





Let us assess

- In which of the following reversible reactions the change in pressure does not influence the equilibrium? What is the reason?
 - $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$
 - $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
- What is the use of applying high pressure during the formation of ammonia from nitrogen and hydrogen?
- $\text{C}(\text{s}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2(\text{g})$
 - Identify the reactants and products.
 - Products are frequently removed from the system. What happen to the system? Explain the reason.
- $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g}) + \text{Heat}$
In this reaction how do the following changes influence the amount of the product?
 - Decrease in temperature
 - Increase in pressure
 - Increase in the concentration of oxygen
- $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) + \text{Heat}$
 - What change is to be made in pressure to get maximum yield of the products.
 - What is the change in concentration required for increasing the rate of the forward reaction?
- The chemical equation of one of the different stages of manufacturing sulphuric acid by contact process is given below. Find out the influence of the following factors in the reaction given below.



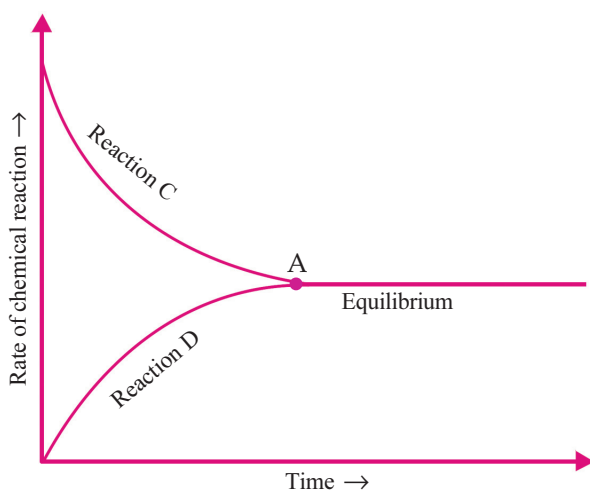
- Increase the amount of oxygen
- Pressure is increased
- Catalyst vanadium pentoxide (V_2O_5) is added
- SO_3 is removed

7. Calcium oxide (CaO) is used as drying agent in the preparation of Ammonia in laboratory. Can concentrated H_2SO_4 be used as drying agent instead of CaO? Justify your answer.
8. Which property of sulphuric acid is shown in the following situations.
 - a) During the preparation of chlorine the gas is passed through concentrated H_2SO_4 .
 - b) Wooden cupboards appeared to be burnt, when concentrated sulphuric acid happened to fall on it.



Extended Activities

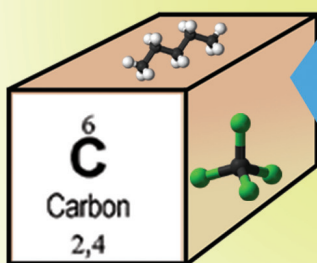
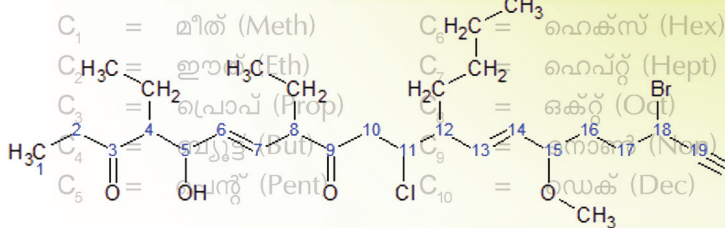
1. The graph for the reaction $\text{N}_2 (\text{g}) + 3\text{H}_2 (\text{g}) \rightleftharpoons 2\text{NH}_3 (\text{g})$ is given below.



- a) Identify and write reactions C and D.
 - b) What happens to the position of point A in the graph when a catalyst is used? Redraw the graph.
2. It is often said that the production of sulphuric acid is a bench mark of the industrial development of a country. Prepare a note based on the various uses of sulphuric acid.
 3. Fill half of a beaker of capacity 50 mL with sugar. Add concentrated sulphuric acid so that the sugar is immersed in it. Observe the changes. What are the products formed? Which property of sulphuric acid is revealed here?

6

Nomenclature of organic compounds and isomerism

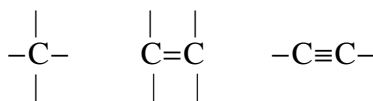



You have understood the position and importance of the element carbon in the periodic table. Carbon is a component in a variety of compounds. The very high ability for catenation and its ability to form different types of chemical bonds with other elements make it different from other elements. You also know organic chemistry is the branch of chemistry that deals with the carbon compounds.

Let us familiarise the structure of different types of organic compounds, the method of IUPAC nomenclature etc.

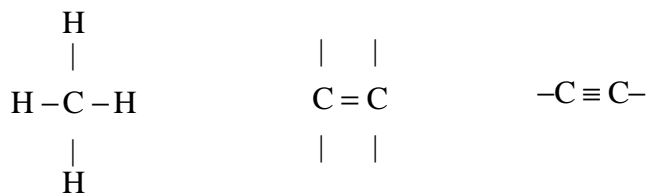
The valency of carbon is four.

Look at the representation given below.



The given structures indicate the valency of carbon. Imagine that hydrogen atoms are added to these structures.

Complete the given structures.



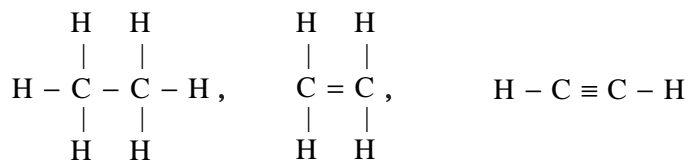
Certain organic compounds and their molecular formulae are given here.

Structure of the Compound	Molecular formula
$ \begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{H}-\text{C}-\text{C}-\text{H} \\ | \quad | \\ \text{H} \quad \text{H} \end{array} $	C_2H_6
$ \begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \\ \text{H} \quad \text{H} \end{array} $	C_2H_4
$\text{H}-\text{C}\equiv\text{C}-\text{H}$	C_2H_2

Table 6.1

What are the characteristics of the compounds given in the table?

- They are hydrocarbons
- There are compounds having single bond, double bond and triple bond between the carbon atoms.



The structure of these compounds can also be written in condensed way as CH_3-CH_3 , $\text{CH}_2=\text{CH}_2$, $\text{CH}\equiv\text{CH}$. Such a representation is known as condensed formula.

The open chain hydrocarbons having only single bond between the carbon atoms are included in the **Alkane** category.

In alkanes, as all the four valencies of each carbon atom are satisfied by single bonds, they are known as **saturated hydrocarbons**.

Complete the table given below.

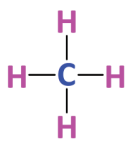
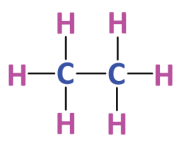
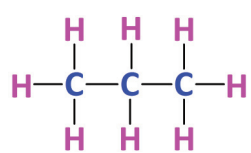
Number of Carbon atoms	Structure of Alkanes	Condensed formula	Molecular formula
1		CH ₄	CH ₄
2		CH ₃ - CH ₃	C ₂ H ₆
3		CH ₃ - CH ₂ - CH ₃	C ₃ H ₈
4	CH ₃ - CH ₂ - CH ₂ - CH ₃	.....
5	C ₅ H ₁₂

Table 6.2



IUPAC

IUPAC (International Union of Pure and Applied Chemistry) is an international organisation that strives to carry forward the new trends in the field of chemical sciences happening worldwide and thereby contribute to the application of chemistry for the service of mankind. This organisation, founded in 1919, has its headquarters at Zurich in Switzerland. IUPAC takes the lead role in the naming of elements and compounds, standardisation of atomic weights and physical constants, recognising new terms in chemistry etc.



- What is the relationship between the number of atoms of carbon and hydrogen in alkane?
- If an alkane contains 'n' carbon atoms, how many hydrogen atoms will be there?
- If so, can you deduce a general formula for alkanes?

Analyse the molecular formula of CH_4 and C_2H_6

- What is the difference between the number of carbon atoms and hydrogen atoms in CH_4 and C_2H_6 ?
- Is the difference same in the case of C_2H_6 and C_3H_8 ?

What is the difference between the molecular formulae of any two successive alkanes?

A series of such compounds is called a homologous series.

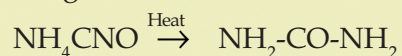
See the characteristics of a homologous series.

- The members can be represented by a general formula.
- Successive members differ by a $-\text{CH}_2-$ group.
- Members show similarity in chemical properties.
- There is a regular gradation in their physical properties.



Are organic compounds biocompounds?

Once it was believed that organic compounds could be produced only from plant or animal based substances. But in 1828, the German Scientist Friedrich Wohler prepared the organic compound urea from an inorganic compound named ammonium cyanate. This paved the way for the preparation of a large number of organic compounds from inorganic substances.



Hydro carbons having double bond or triple bond between carbon atoms are commonly known as **unsaturated hydrocarbons**.

Hydro carbons having a double bond between any two carbon atoms are considered as **Alkenes**.

Complete the table given below (Table 6.3).

No of Carbon atoms	Structure of the Alkene	Condensed formula	Molecular formula
2		$\text{CH}_2 = \text{CH}_2$	C_2H_4
3		$\text{CH}_2 = \text{CH} - \text{CH}_3$	C_3H_6
4
5	$\text{CH}_2 = \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$	.....

Table 6.3

- Analyse Table 6.3 and find the number of hydrogen atoms in an alkene with 'n' carbon atoms.
- If so, can a general formula of alkenes be deduced? Try to write it.

Check whether the alkenes given in the above table are members of a homologous series.

Look at the structure of a hydrocarbon carrying a triple bond between two carbon atoms (Figure 6.1).



Figure 6.1

Hydrocarbons having a triple bond between any two carbon atoms are named as **alkynes**.

Complete the table 6.4.

No of Carbon atoms	Structure of the alkyne	Condensed formula	Molecular formula
2	$\text{H} - \text{C} \equiv \text{C} - \text{H}$	$\text{CH} \equiv \text{CH}$	C_2H_2
3	$\begin{array}{c} \text{H} \\ | \\ \text{H} - \text{C} \equiv \text{C} - \text{C} - \text{H} \\ | \\ \text{H} \end{array}$	$\text{CH} \equiv \text{C} - \text{CH}_3$	C_3H_4
4	$\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{H} - \text{C} \equiv \text{C} - \text{C} - \text{C} - \text{H} \\ | \quad | \\ \text{H} \quad \text{H} \end{array}$	.....	.....
5	.....	.....	.....

Table 6.4

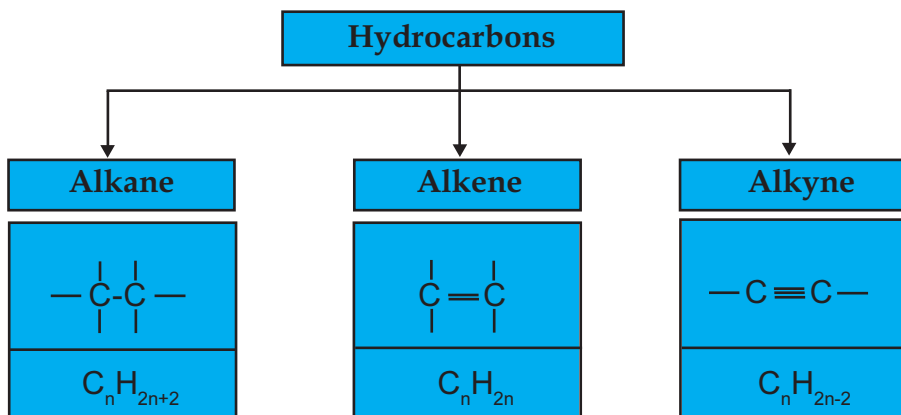


- Analyse Table 6.4 and find out how many hydrogen atoms would be present in an alkyne with 'n' carbon atoms.
- If so, can a general formula of alkynes be deduced?

Try to write the general formula of alkynes?

Check whether the alkynes given in the above table are members of a homologous series.

Look at the classification of the hydrocarbons that we have discussed so far.



Nomenclature of hydrocarbons

Organic compounds are found in large numbers and have complex structures. Hence naming of organic compounds is a difficult task.

IUPAC has put forward some rules for the naming of hydrocarbons. What are the main points to be considered while naming hydrocarbons?

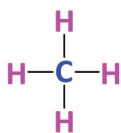
- Number of carbon atoms
- Nature of the chemical bond between the carbon atoms.

Word roots are selected based on the number of carbon atoms.

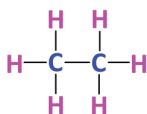
C_1 = Meth	C_6 = Hex
C_2 = Eth	C_7 = Hept
C_3 = Prop	C_8 = Oct
C_4 = But	C_9 = Non
C_5 = Pent	C_{10} = Dec

Nomenclature of Unbranched Alkanes

Examine the given structural formula, molecular formula and IUPAC names of some alkanes.



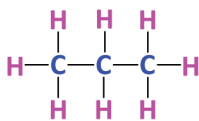
CH_4 Methane



C_2H_6 Ethane



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'.



Propane

Have you seen any special features in these names?

How are the names derived from the word roots?

Alkanes are named by adding the suffix 'ane' along with the word root that denotes the number of carbon atoms.

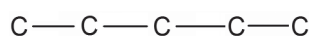
Meth + ane → Methane

Eth + ane → Ethane

Word root + ane → Alkane

Write the IUPAC names of all the alkanes in Table 6.2.

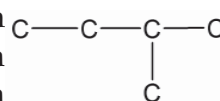
Nomenclature of Branched Hydrocarbons



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

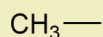


What is the change in the carbon chain here? Isn't it clear that a carbon atom has formed a branch?



Alkyl Radical

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

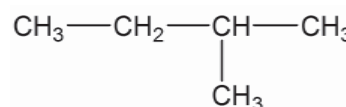


Similarly, $\text{CH}_3 - \text{CH}_2 -$ is named an ethyl radical and

$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 -$ is named a propyl radical.

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

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

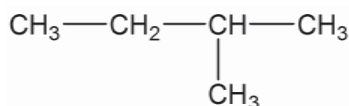


According to the IUPAC rules of nomenclature, the longest chain (with the maximum number of carbon atoms) should be considered as the main chain and the remaining carbon atoms are treated as branches. The position of the branches can be found out by numbering carbon atoms in the main chain.

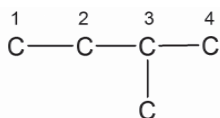
Numbering of the carbon atoms in the chain should be done in such a way that the carbon atom carrying the branch gets the lowest number.



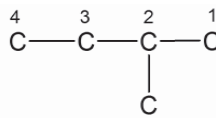
Let's see how an IUPAC name is given to the compound shown here.



See the two ways in which the carbon chain is numbered.



(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-Methyl butane

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

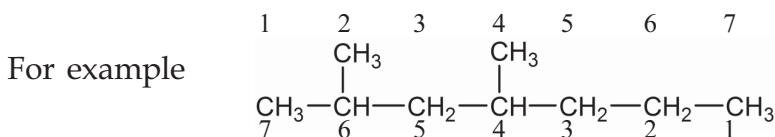
Compound	Number of carbon atoms in the longest chain	Name of branch	Position of branch	IUPAC name
$\begin{array}{ccccccc} \text{CH}_3 & - & \text{CH}_2 & - & \text{CH}_2 & - & \text{CH} & - & \text{CH}_3 \\ & & & & & & | & & \\ & & & & & & \text{CH}_3 & & \end{array}$
$\begin{array}{ccccccc} & & & & \text{CH}_3 & & \\ & & & & | & & \\ \text{CH}_3 & - & \text{CH}_2 & - & \text{CH} & - & \text{CH}_2 & - & \text{CH}_3 \end{array}$
$\begin{array}{ccccccc} \text{CH}_3 & - & \text{CH}_2 & - & \text{CH} & - & \text{CH}_2 & - & \text{CH}_3 \\ & & & & | & & & & \\ & & & & \text{CH}_2 & & & & \\ & & & & | & & & & \\ & & & & \text{CH}_3 & & & & \end{array}$
$\begin{array}{ccccccc} \text{CH}_3 & - & \text{CH} & - & \text{CH}_2 & - & \text{CH}_3 \\ & & | & & & & \\ & & \text{CH}_2 & & & & \\ & & | & & & & \\ & & \text{CH}_3 & & & & \end{array}$

Table 6.3

Nomenclature of hydrocarbons with more than one branch

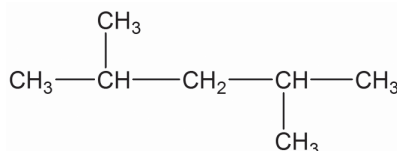
If the same branch appears more than once in a carbon chain, the number of branches are to be indicated using prefixes like di (two), tri (three) etc.

If the same type of branch is present more than once, 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.

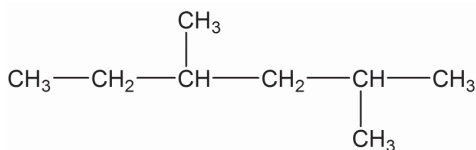


Number of carbon atoms in the main chain:	7
Number of branches	: 2
Position of the first branch while numbering from left to right	: 2
Position of the first branch while numbering from right to left	: 4
Correct way of numbering	: left to right
IUPAC name	: 2, 4-Dimethylheptane

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	:

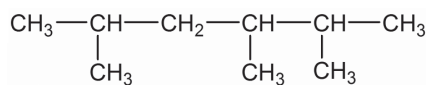


Number the carbon atoms in the main chain of the compound given above. Put a '✓' against the correct position numbers of the branches.

2,4	<input type="checkbox"/>
3,5	<input type="checkbox"/>

- 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?

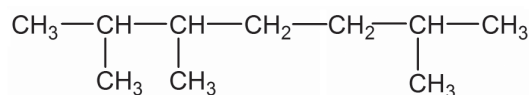
Put a '✓' mark against the correct one

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.

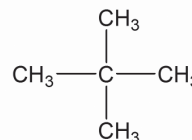
See the given compound

Number of branches present in this compound :

Name of the branches :

Position numbers of branches :

IUPAC name :



Recommendations for the nomenclature of branched hydrocarbons

- Find out the main chain and identify the branch/branches.
- Numbering should be done from the end in which the branch occurs.
- In case of hydrocarbons with more than one branch, the main chain should be numbered from the end nearest to the first branch.
- If the number of the first branch becomes equal from both sides the next branch is to be considered consecutively.

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

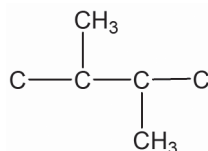
- How can structure of 2, 3-dimethylbutane be written?

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

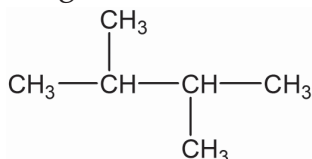
- Let us represent the main chain.
C—C—C—C
- Which are the branches?

- What are the 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 valencies of carbon with hydrogen.



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

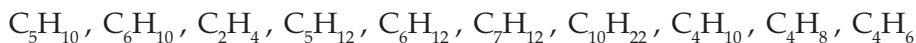
Complete the table given below (Table 6.4).

Compound	IUPAC name
$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH} - \text{CH}_2 - \text{CH}_3 \\ | \qquad \qquad | \\ \text{CH}_3 \qquad \qquad \text{CH}_3 \end{array}$	.....
.....	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)



Alkane	Alkene	Alkyne

Table 6.5

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

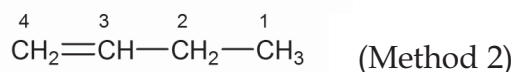
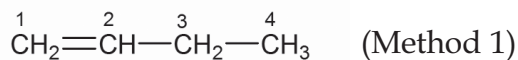
Replace the 'ane' in the IUPAC name of the alkane with 'ene'

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

One of the structural formulae of the hydrocarbon C_4H_8 is given below.



Notice the position numbers given to the carbon atoms.



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 method (1) that the lowest position numbers are given to the doubly bonded carbon atoms. What will be the IUPAC name of the compound $CH_2=CH-CH_2-CH_3$ then?

But-1-ene

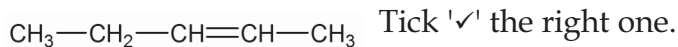
- If so, what will be the structural formula of But-2-ene.

- While naming the alkenes the position of the double bond is also considered.



Word root + Position of double bond + Suffix

- Which is the IUPAC name of the compound



Pent-3-ene

Pent-2-ene

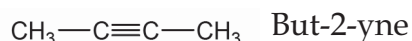
Can't you name alkynes too, in the same way?

Add suffix 'yne'

Alk + yne = Alkyne



Word root + Position of triple bond + Suffix

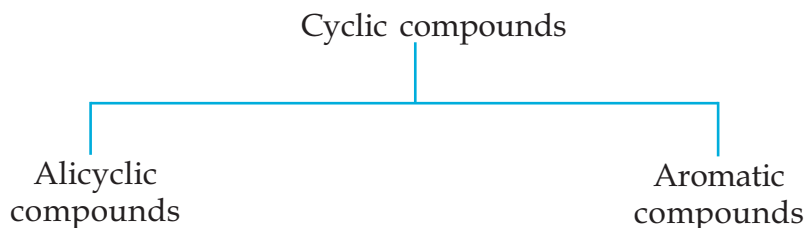


How many hydrocarbons can be written by changing the position of triple bond in this compound? Try to write their IUPAC names also.

Cyclic or Ring Compounds

- You know that carbon atoms combine together to form cyclic compounds.

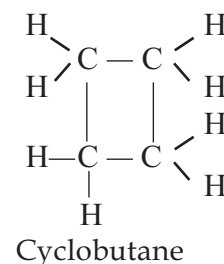
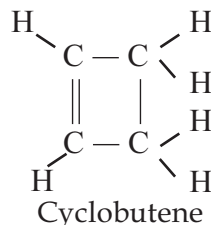
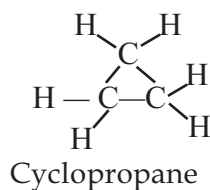
Cyclic or ring compounds are classified into two.



Alicyclic Hydrocarbons

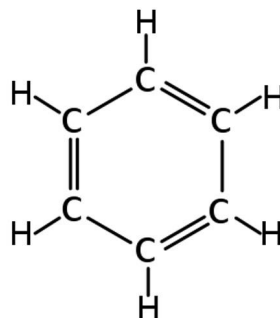
Alicyclic hydrocarbons are cyclic hydrocarbons similar to open chain hydrocarbons like alkane, alkene and alkyne.

- Structure some alicyclic hydrocarbons and their IUPAC names are given below.



Aromatic Hydrocarbons

Aromatic compounds are cyclic compounds having their own aroma. Benzene is an aromatic compound having industrial importance. Note down its structure.



Try to write down the molecular formula of Benzene.

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 atoms 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 those of methanol and methanoic acid.

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

Let us familiarise ourselves with some of the functional groups.

1. Hydroxyl Group (– OH)

See some compounds containing –OH group.



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

The compounds having – OH (hydroxyl) as the functional group are commonly called alcohols.

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

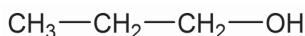


For more experience open 'Chemistry for Class X' in 'School Resources' of IT @ School Edubuntu, animation page 'Organic samyukthangal namakaranavum isomerisavum' and play 'Organic samyukthangal-namakaranam'.

Alkane - e + ol → Alkanol

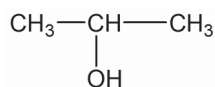
Ethane - e + ol → Ethanol

See the compound given below.



- Write its molecular formula -----

If so, what about this compound?



- Write its molecular formula -----

What is the difference between the two?

Here, the position of functional group changes.

Therefore, while writing the IUPAC names of these two compounds the position of functional group is to be added. The carbon atom having 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. Carboxylic Group $\left[\begin{array}{c} \text{O} \\ || \\ \text{C} \\ | \\ \text{OH} \end{array} \right]$ 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 $\text{CH}_3\text{—COOH}$

The IUPAC name of this compound is Ethanoic acid.

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

That is, **ethane - e + oic acid** → **Ethanoic acid**

$\text{H}-\text{COOH}$ Methanoic acid.

$\text{CH}_3-\text{CH}_2-\text{COOH}$ Propanoic acid

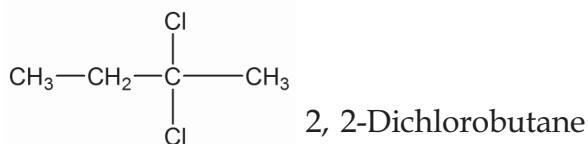
The naming is done after counting the carbon atom in the functional group as a part of the main chain.

3. 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 the halo group + - + name of halo group + name of alkane.

$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{Cl}$ 1-Chloropropane



4. Alkoxy Group (—O—R)

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

$\text{CH}_3-\text{CH}_2-\text{O}-\text{CH}_2-\text{CH}_3$ Ethoxyethane

$\text{CH}_3-\text{O}-\text{CH}_2-\text{CH}_3$ 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.

Based on the above discussion, complete Table 6.6.

Functional Group	Compounds including functional group	IUPAC name
.....	$\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—OH}$	.....
.....	$\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—COOH}$	.....
— Cl	.....	2 - Chloropentane
—O—R	.....	Ethoxypropane

Table 6.6

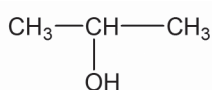
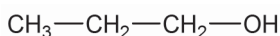


For more experience open 'Chemistry for Class X' in 'School Resources' of IT @ School Edubuntu, animation page 'Organic samyukthangal namakaranavum isomerisavum' and play 'Organic samyukthangal-namakaranam'.



Isomerism

See the two compounds given below.



- What are the similarities between these two compounds?

Molecular formula :

Functional group :

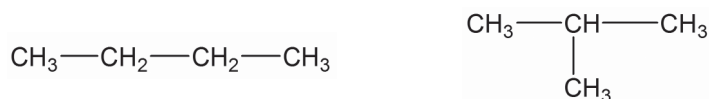
- What is the difference between them?

Isn't the position number of carbon atoms to which the —OH group is attached different? These compounds have the same molecular formula. But the position of the functional group differs. These compounds are different even though they have the same molecular formula. They are known as 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.



- 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 $\text{CH}_3\text{—CH}_2\text{—OH}$, $\text{CH}_3\text{—O—CH}_3$

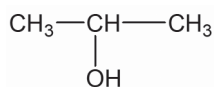
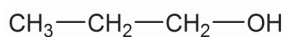
- Try to write down their molecular formula.

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

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

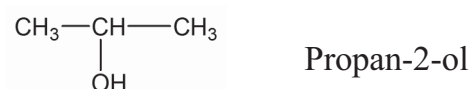
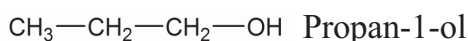
Haven't you understood that functional isomers exist as a result of having different functional groups in compounds with the same molecular formula?

Examine the two compounds which you have already seen.



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

See their IUPAC names.



These are position isomers.

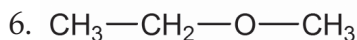
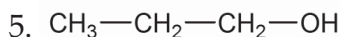
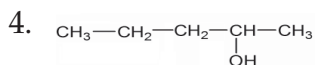
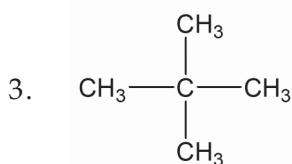
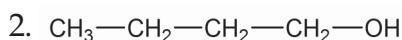
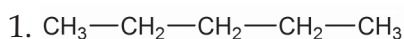




If the position of the functional group is different in two compounds having the same molecular formula and the same functional group, then they are position Isomers.

- Try to write down all position isomers of the compound $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—Cl}$.

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

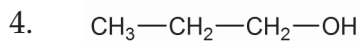
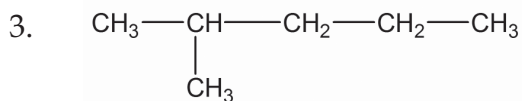
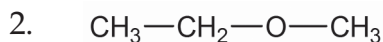
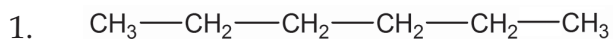


- How many position isomers are possible for the compound $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—OH}$.

Write the structure and IUPAC names of its functional isomers?

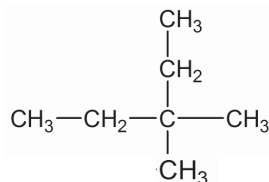
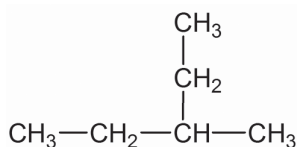
- How many chain isomers are possible for the compound $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_2\text{—CH}_3$? Write them down.

- The structural formula of various compounds are given. Tabulate them into different pairs of isomers. Write down their IUPAC names also.

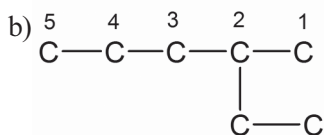
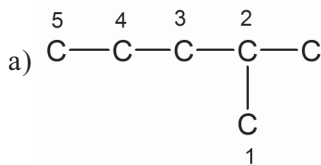


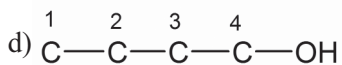
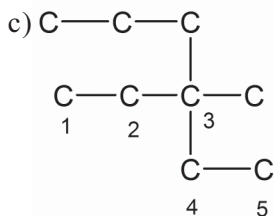
Let us Assess

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

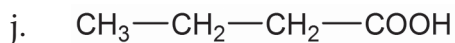
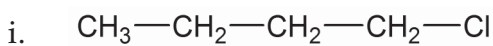
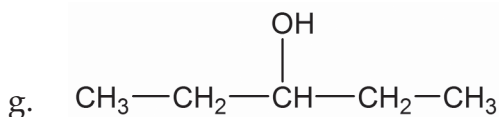
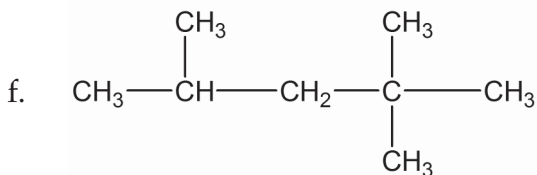
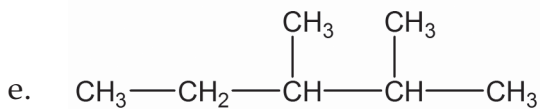
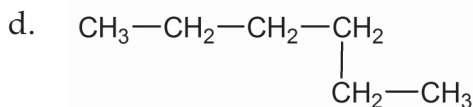
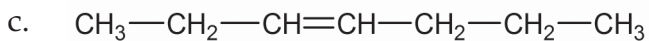
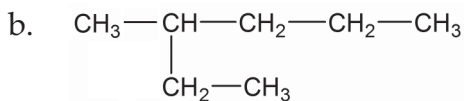
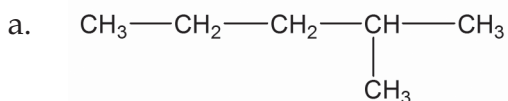


2. See how some carbon chains are numbered. Correct the wrong ones.





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

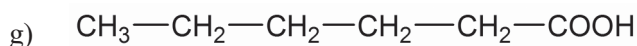
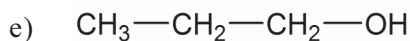


4. Write down the structural formulae of compounds given below.
- 2, 2- Dimethyl hexane
 - But-2-ene
5. Write down the structural formula of the compound C_5H_{10} . Write down the structural formula of one of its isomers which is an alicyclic compound.



Extended Activities

- Given below are certain hints about a hydrocarbon.
 - The molecular formula is C_5H_{10}
 - Has a methyl radical as branch
 - Write the structural formula of any two possible isomers of this compound.
 - Write their IUPAC names.
- Write down the IUPAC names of the compounds given below.
 - $$\begin{array}{ccccccccc} \text{CH}_3 & - & \text{CH}_2 & - & \text{CH}_2 & - & \text{CH} & - & \text{CH}_2 & - & \text{CH} & = & \text{CH}_2 \\ & & & & & & | & & & & & & \\ & & & & & & \text{CH}_3 & & & & & & \end{array}$$
 - $$\begin{array}{ccccccccccc} & & & & & & & & \text{CH}_2 & - & \text{CH}_3 \\ & & & & & & & & | & & \\ \text{CH}_3 & - & \text{CH}_2 & - & \text{CH} & - & \text{CH}_2 & - & \text{CH} & - & \text{CH}_2 & - & \text{CH}_3 \\ & & & & | & & & & & & & & \\ & & & & \text{CH}_2 & - & \text{CH}_3 & & & & & & \end{array}$$
 - $$\begin{array}{ccccccccc} \text{CH}_3 & - & \text{CH} & - & \text{CH}_2 & - & \text{CH} & - & \text{CH}_2 & - & \text{CH}_3 \\ & & | & & & & | & & & & \\ & & \text{CH}_3 & & & & \text{CH}_3 & & & & \end{array}$$
 - $$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{C} \equiv \text{CH}$$



3. Write the structural formulae of all possible isomers of the compound with molecular formula $\text{C}_4\text{H}_{10}\text{O}$. 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.
- Propan-1-ol
 - 2, 2, 3, 3 - Tetramethylbutane
 - Octane
 - Propan -2- ol
 - Methoxyethane
5. The structural formulae of two organic compounds are given.
- (i) $\text{CH}_3\text{—O—CH}_2\text{—CH}_3$ (ii) $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{—OH}$
- What are the IUPAC names of these compounds?
 - Write one similarity and one difference between these two compounds.
 - What is this phenomenon known as?
6. Write down the structural formulae of the following compounds.
- Cyclopentane
 - Cyclobutene

7

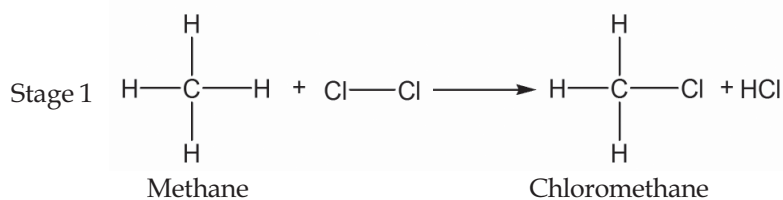
Chemical Reactions of Organic Compounds



The various substances that we use in different fields of daily life are the contributions of organic chemistry. The different types of organic compounds such as medicines, polymers, fuels, alcohols, soaps, detergents etc. are prepared by different organic reactions. Let us see some of such basic chemical reactions.

Substitution Reactions

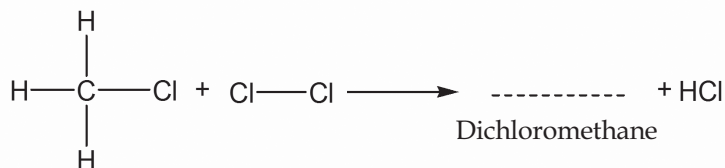
Examine the different stages of the reaction of methane (CH_4) with chlorine in the presence of sunlight.



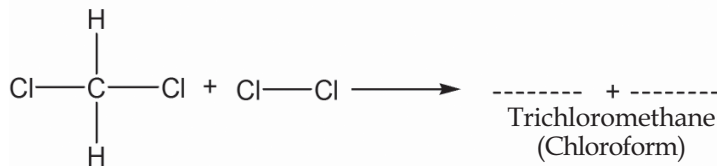
Here, one hydrogen atom of methane molecule is replaced by one chlorine atom, isn't it? If this process continues....

Complete the stages 2, 3, 4 respectively.

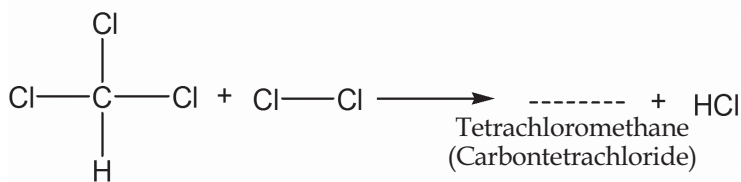
Stage 2



Stage 3



Stage 4



When methane reacts with chlorine each hydrogen atom of methane is replaced successively by chlorine atom. As a result, a mixture of CH_3Cl (Chloromethane), CH_2Cl_2 (dichloromethane), CHCl_3 (trichloromethane) and CCl_4 (Tetrachloromethane) is formed. Such reactions are called Substitution reactions.

A reaction in which an atom or a group in a compound is replaced by another atom or a group is called substitution reaction.

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

Addition Reactions

- Write down the structural formulae of ethane and ethene.

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

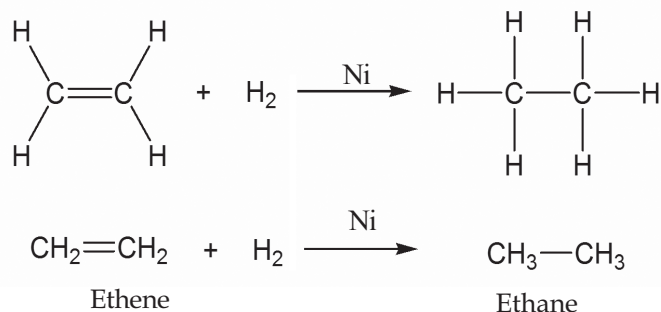


You know that ethene is an unsaturated compound due to the presence of the carbon - carbon double bond.

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

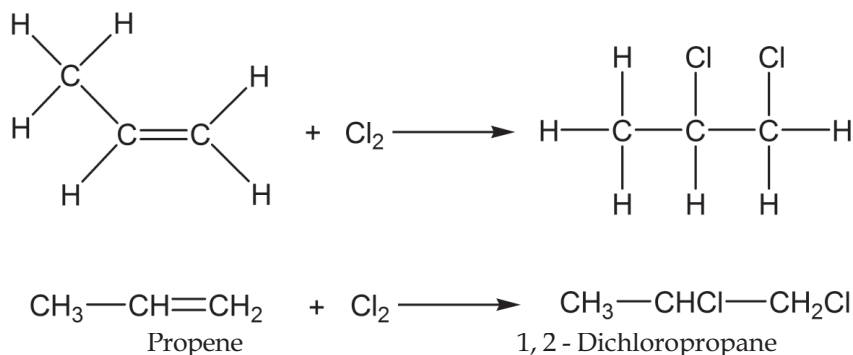
Let us examine a chemical reaction of ethene molecule.

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



- What do we get as the product?

Let us examine another similar reaction.



- Which hydrocarbon is the reactant here?

.....

- Is the product saturated or unsaturated?

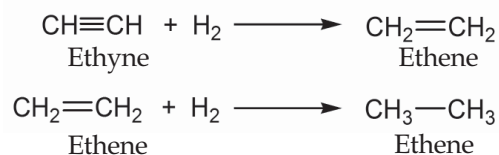
.....

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

Chemical reaction	Product	IUPAC name of the product
$\text{CH}_2=\text{CH}_2 + \text{Cl}_2$
$\text{CH}_2=\text{CH}_2 + \text{HCl}$
$\text{CH}_3-\text{CH}=\text{CH}_2 + \text{H}_2$
$\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3 + \text{HBr}$

Table 7.1.

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

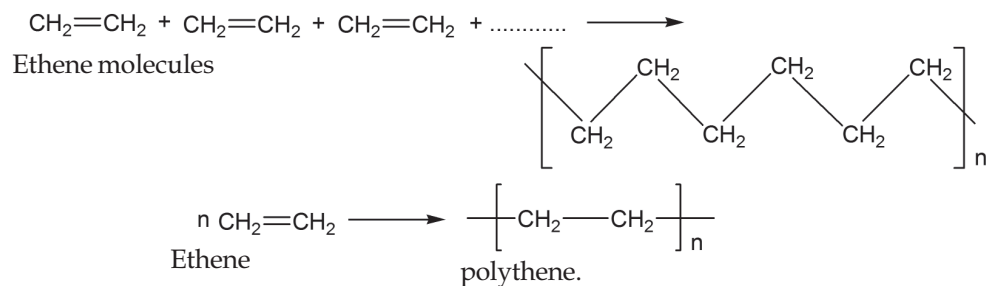


Reactions in which unsaturated organic compounds with double bond or triple bond react with other molecules to form saturated compounds are called addition reactions.

Polymerisation

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

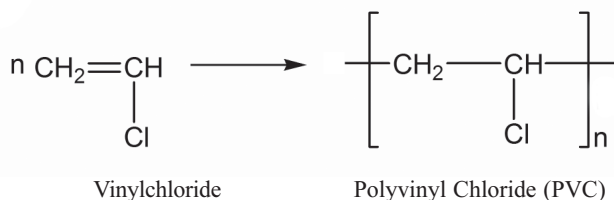
Consider the reaction in which a large number of ethene molecules combine under high pressure and temperature in the presence of a catalyst. The product formed here is polythene.



Polymerisation is the process in which a large number of simple molecules combine under suitable conditions to form complex molecules. The product 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 (Polyvinyl Chloride) is a polymer commonly used for making pipes. It is formed by the polymerisation of a large number of chloroethene (Vinyl chloride) molecules.



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

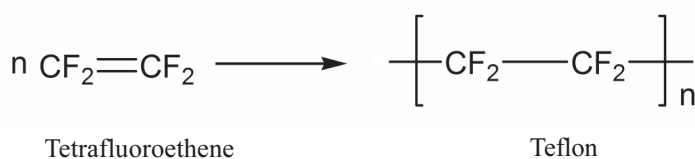


Table 7.2 given below includes some familiar polymers and their monomers. Complete the table suitably.

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 these.

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.



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

- Butane is the important component in the domestic fuel LPG. Can you write the balanced chemical equation for the combustion of butane (C_4H_{10})?
-

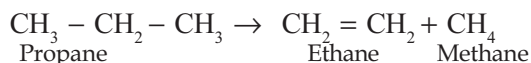
Thermal Cracking



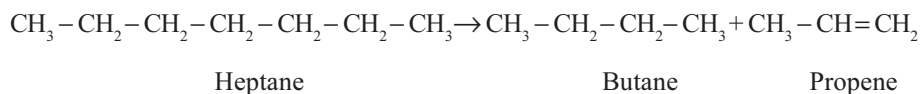
Some hydrocarbons with high molecular masses, when heated in the absence of air undergo decomposition to form hydrocarbons with lower molecular masses. This process is called **Thermal cracking**.

A number of products are made in this way. Propane is one of the simplest hydrocarbons which can undergo thermal cracking.

Examine the equation for the thermal cracking of propane.



When hydrocarbons with larger number of carbon atoms undergo thermal cracking, the carbon chain can undergo cleavage or breaking in a number of ways. The products formed as a result of thermal cracking depend on the nature of the hydrocarbons getting cracked, temperature and pressure. See another example given below.



When saturated hydrocarbons are subjected to thermal cracking the products formed contain both saturated and unsaturated hydrocarbons.

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

Complete the tables 7.3 and 7.4 containing chemical reaction of hydrocarbons.

$\text{CH}\equiv\text{CH} + \text{H}_2$	\rightarrow	.....
$\text{CH}_3\text{Cl} + \text{Cl}_2$	\rightarrow	..... + HCl
.....	\rightarrow	$\left[\text{CH}_2-\text{CH}_2 \right]_n$
$\text{CH}_4 + \text{.....}$	\rightarrow	$\text{CO}_2 + \text{H}_2\text{O}$
..... + H_2	\rightarrow	CH_3-CH_3

Table 7.3

Find out the appropriate reactions and match the columns. A, B and C suitably (Table 7.4).

Reactants (A)	Products (B)	Name of the reaction (C)
$\text{CH}_3-\text{CH}_3 + \text{Cl}_2$	$\text{CO}_2 + \text{H}_2\text{O}$	Addition reaction
$\text{C}_2\text{H}_6 + \text{O}_2$	$\text{CH}_2=\text{CH}_2$	Thermal cracking
$n\text{CH}_2=\text{CH}_2$	$\text{CH}_2=\text{CH}_2 + \text{CH}_4$	Substitution reaction
$\text{CH}_3-\text{CH}_2-\text{CH}_3$	$\text{CH}_3-\text{CH}_2\text{Cl} + \text{HCl}$	Polymerisation
$\text{CH}\equiv\text{CH} + \text{H}_2$	$\left[\text{CH}_2-\text{CH}_2 \right]_n$	Combustion

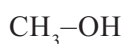
Table 7.4

Some Important Organic Compounds

Now, let us familiarise ourselves with some organic compounds.

1. Alcohols

Consider the two compounds given below.



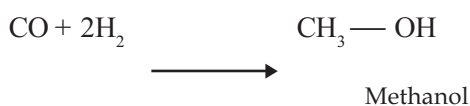
Can't you write the IUPAC names of these two compounds?

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

a. Methanol (CH₃OH)

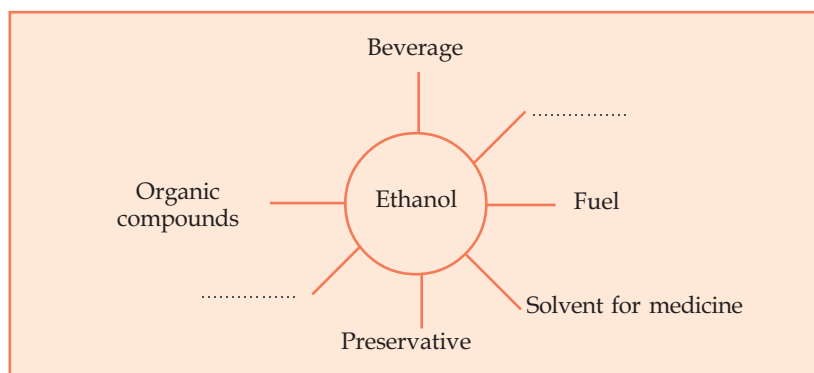
Methanol is used as a solvent in the manufacture of paints and as a reactant in the manufacture of varnish and formalin. Hence it is clear that its industrial preparation is very important.

Methanol is industrially prepared by treating carbon monoxide with hydrogen in the presence of a catalyst at high temperature and pressure. It is a poisonous substance.



b. Ethanol (CH₃CH₂OH)

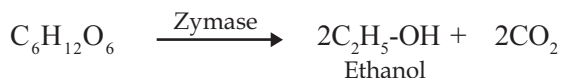
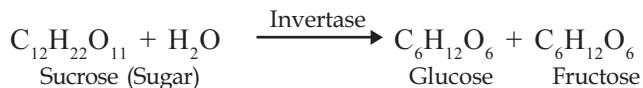
Ethanol is an alcohol which is extensively used for industrial purposes. Ethanol is used as an organic solvent and in the manufacture of various organic compounds and paints. It can be used as a fuel by itself or in combination with other compounds. Complete the following word web including more uses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



Industrial preparation of Ethanol

Molasses is the concentrated solution of sugar (mother liquor) left behind after separation of sugar crystal during the manufacture of sugar. Ethanol is manufactured by fermenting dilute molasses by

adding yeast. Within a few days it changes to ethanol in the presence of the enzymes invertase and zymase produced by yeast.



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 beverage. This product is known as 'denatured spirit'. If methanol is used as a poison for denaturing then the product is called methylated spirit. Ethanol of purity above 99% 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

Carboxylic acids are compounds containing $-\text{COOH}$ functional group.

You know the IUPAC names of compounds like CH_3-COOH , and $\text{CH}_3-\text{CH}_2-\text{COOH}$

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

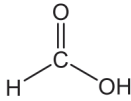
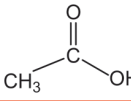
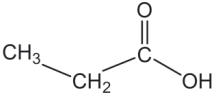
Condensed Formula	Structural Formula	IUPAC name	Common name
$\text{H}-\text{COOH}$		methanoic acid	formic acid
CH_3-COOH		Ethanoic acid	Acetic acid
$\text{CH}_3-\text{CH}_2-\text{COOH}$		Propanoic acid	Propionic acid

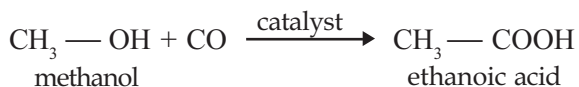
Table 7.5

Most of the fruits contain carboxylic acids. Organic acids containing more number of carbon atoms are called fatty acids.

About 5-8% ethanoic acid (acetic acid) is known as vinegar. Vinegar is obtained when ethanol is subjected to fermentation in the presence of air using the bacteria acetobacter.

Industrial preparation of Ethanoic Acid

Ethanoic acid can be manufactured by treating methanol with carbon monoxide in the presence of catalyst.



Can you list the uses of the ethanoic acid?

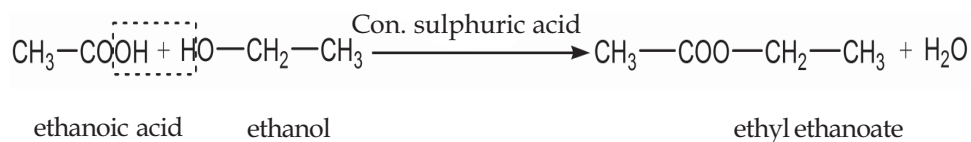
- In manufacture of rayon.
- In rubber and silk industry.
-

3. Esters

Esters are obtained by the reaction between alcohols and carboxylic acids. This reaction is called esterification. Esters have the pleasant smell of fruits and flowers.



If so, what are the possible uses of esters? 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 preparation.

1. $\text{CH}_3\text{—CH}_2\text{—COO—CH}_3$
2. $\text{CH}_3\text{—CH}_2\text{—COOH}$
3. $\text{CH}_3\text{—CH}_2\text{—CO—CH}_3$
4. $\text{CH}_3\text{—OH}$
5. $\text{CH}_3\text{—CH}_2\text{—CH}_2\text{OH}$
6. $\text{CH}_3\text{—COOH}$
7. $\text{CH}_3\text{—COO—CH}_2\text{—CH}_2\text{—CH}_3$

Soap

Oils and fats are esters formed by the combination of the alcohol, glycerol, and the fatty acids like palmitic acid, stearic acid, oleic acid etc. Soap is the salt formed when oils and fats react with alkalies. Sodium hydroxide and potassium hydroxide are commonly used alkalies. Glycerol, which is obtained as the by product in the industrial production of soap (Hot process) is used for the preparation of several products like medicines and cosmetic materials.

Let us make soap

Take 40 mL water in a beaker and dissolve 18 gm sodium hydroxide (caustic soda) in it. Allow the solution to cool. Add 100 gm coconut oil to this solution in small quantities and stir it well. The soap formed is allowed to solidify in moulds. Soaps having different colours and smells are obtained on adding different colouring materials and perfumes.

Let us look how soap removes dirt. Soap has an oil soluble non polar end and a water soluble polar end. The hydro carbon part in soap dissolves in oil and the ionic part (polar end) dissolves in water. So in the presence of soap, dirt can be easily removed. Moreover, soap decreases the surface tension of water and as a

result the clothes are soaked well. Soap molecules act as a link between water and dirt and remove the dirt.

Detergent

Like soap, detergents are cleansing agents. Similar to soaps, they also have an oil soluble non polar end and a water soluble polar end. Detergents are made from hydro carbons obtained from coal and petroleum. Most detergents are salts of sulphonic acids. Let us do an activity.

Take 10 mL distilled water in a test tube and take the same volume of hard water in another test tube. Add a few drops of soap solution to both the test tubes and shake well. Do both the test tubes contain the same quantity of foam? Which test tube contains more foam? What do you infer?

Let us do another experiment.

Take 10 mL each of hard water in two test tubes. Add a few drops of soap solution in the first test tube and add the same amount of detergent solution in the second one. Shake both the test tubes well. What do you observe?

Which test tube contains more foam?

Soap does not lather well in hard water. The hardness of water is due to dissolved calcium and magnesium salts in it. These salts react with soap to form insoluble compounds resulting in the decrease of lather. But detergents do not give insoluble components on reaction with these salts. Hence detergents are more effective than soaps in hard water. Similarly, detergents can also be used in acidic solutions.

But the excessive use of the detergents causes environmental problems. The micro organisms in water cannot decompose the components of detergents. Hence the detergents released into water leads to the destruction of aquatic life. For example, the detergents which contain phosphate increases the growth of algae and limits the quantity of oxygen. Therefore, it decreases the quantity of oxygen for the breath of the organisms in water and causes their destruction.

List out the merits and demerits of detergents, compared to soaps.



Let us assess

1. Given below are two chemical equations.



Identify the compounds 'A' and 'B'. Name these reactions.

- Name the important chemical reactions of hydrocarbons. Give one example for each.
- 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.
- Complete the equation for the following chemical reaction. Name this reaction.



5. Which of the given molecules can form polymers?

Butane, Propane, Propene, Methane, Butene



Extended Activities

- You are familiar with different chemical reactions of hydrocarbons. Identify the situations in daily life in which such reactions are used.
- 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.
- 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.

Notes

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Notes

A large rectangular area with a red border, containing 20 horizontal dashed lines for writing notes.

Notes

A large rectangular area with a red border, containing 20 horizontal dashed blue lines for writing notes.

Let's save water

Keralites mainly depend on wells as the main source of drinking water. We should conserve the wells which are the primary source of ground water in and around our locality. The contamination of such sources of water causes water-borne diseases like typhoid, cholera, jaundice etc.

Precautions to be taken to avoid contamination of ground water sources (wells)

- ▶ Do not bath or wash clothes near wells.
- ▶ Keep the well covered with nets of proper size.
- ▶ Keep the bucket and rope used to draw water clean.
- ▶ Cattle sheds, compost pits etc., should be built at least 7.5m away from wells.
- ▶ Septic tanks and toilets should be built at a safe distance away from the well.
- ▶ Prevent rain water from flowing into the well by constructing suitable walls around the well.
- ▶ Disinfect well water at adequate intervals.

How to disinfect well water?

Add 2.5 g bleaching powder to 1000 litre water (approx. to size of a small match box). Allow it to settle and pour the clear liquid into the well. This well water can be used for domestic purposes after 6 hours. The following table shows the presence of certain components and their permissible quantity in drinking water. It is also essential to assess the quality of drinking water often. There are government analytical laboratories under different departments for testing the quality of water. Make use of their service.

The admissible amount of contents in drinking water:

Constituent	Permissible quantity
Foul smell/taste	Nil
pH	6.5 - 8.5
Soluble content	500 mg/l
Hardness	300mg/l
Iron	0.3mg/l
Fluoride	0.6 - 1.2 mg/l
Chloride	250mg/l
Choliform bacteria	Nil

Kerala State Pollution Control Board

Pattom.P.O., Thiruvananthapuram - 695004

Tel: 0471 - 2318153, 2318155 Fax: 2318152

Website: www.keralapcb.org

CHILDREN'S RIGHTS

Dear Children,

*Wouldn't you like to know about your rights? Awareness about your rights will inspire and motivate you to ensure your protection and participation, thereby making social justice a reality. You may know that a commission for child rights is functioning in our state called the **Kerala State Commission for Protection of Child Rights**.*

Let's see what your rights are:

- Right to freedom of speech and expression.
- Right to life and liberty.
- Right to maximum survival and development.
- Right to be respected and accepted regardless of caste, creed and colour.
- Right to protection and care against physical, mental and sexual abuse.
- Right to participation.
- Protection from child labour and hazardous work.
- Protection against child marriage.
- Right to know one's culture and live accordingly.
- Protection against neglect.
- Right to free and compulsory education.
- Right to learn, rest and leisure.
- Right to parental and societal care, and protection.

Major Responsibilities

- Protect school and public facilities.
- Observe punctuality in learning and activities of the school.
- Accept and respect school authorities, teachers, parents and fellow students.
- Readiness to accept and respect others regardless of caste, creed or colour.

Contact Address:



Kerala State Commission for Protection of Child Rights

'Sree Ganesh', T. C. 14/2036, Vanross Junction

Kerala University P. O., Thiruvananthapuram - 34, Phone : 0471 - 2326603

Email: childrights.cpcr@kerala.gov.in, rte.cpcr@kerala.gov.in

Website : www.kescpcr.kerala.gov.in

Child Helpline - 1098, Crime Stopper - 1090, Nirbhaya - 1800 425 1400

Kerala Police Helpline - 0471 - 3243000/44000/45000

Online R. T. E Monitoring : www.nireekshana.org.in