

CHAPTER 4

Carbon

&

Its compounds

Acknowledgment

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- Some images and video clips have been modified according to the syllabus.

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Contents

Covalent bond

Hydrogenation

Catenation

Saponification

Isomerism

MCQ

Hydrocarbons

Homologous series

Functional groups

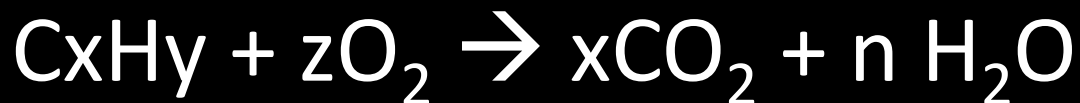
Chemical properties

(Activity 4.1) Make a list of ten things you have used or consumed since the morning. If there are items which are made up of more than one material, put them into both the relevant columns.

Things made of metal	Things made of glass/clay	Others
Fan, Refrigerator, Spoon, TV, Pen, Telephone, Key, Coins, Tiffin box, Bus	Cup, Tumbler, TV, Bulb, Saucer, Watch, Picture frame, Flower vase, Statue, Bottle	Clothes, Tooth brush, Tooth paste, Shoes, Purse, Pencil, Bread, Milk, Books, Chair

What would be the product if a compound containing carbon is burnt?

When a carbon compound is burnt in presence of sufficient amount of oxygen, carbon dioxide and water is produced.



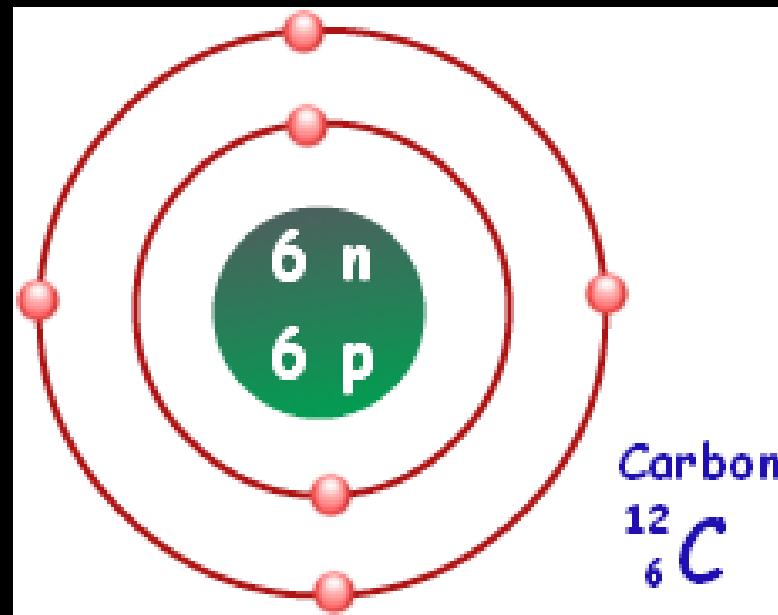
Percentage of carbon present in the earth's crust

The earth's crust has only 0.02% carbon in the form of minerals (like carbonates, hydrogen carbonates, coal and petroleum) and the atmosphere has 0.03% of carbon dioxide.

Reservoir	Carbon (gigatons)	Percent of total carbon on Earth
Oceans	38×10^3	0.05
Rocks and sediments	75×10^6	>99.5
Terrestrial biosphere	2×10^3	0.003
Aquatic biosphere	1-2	0.000002
Fossil fuels	4.2×10^3	0.006
Methane hydrates	10^4	0.014

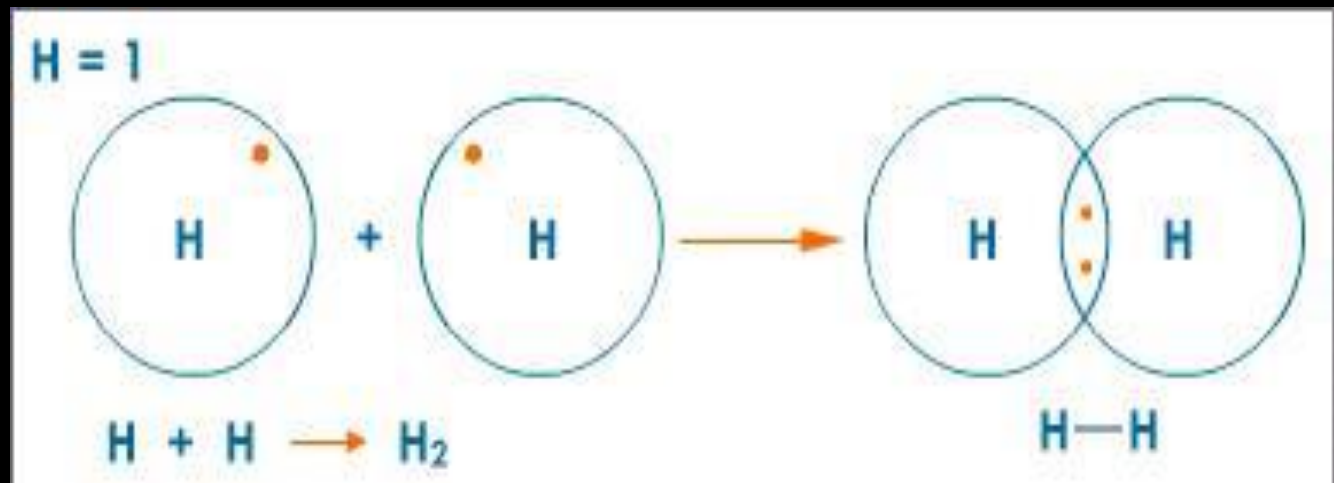
Properties of carbon compounds

The atomic number of carbon is 6. Its electronic configuration is (2,2,2) $1s^2, 2s^2 2p^2$.



Formation of hydrogen molecule.

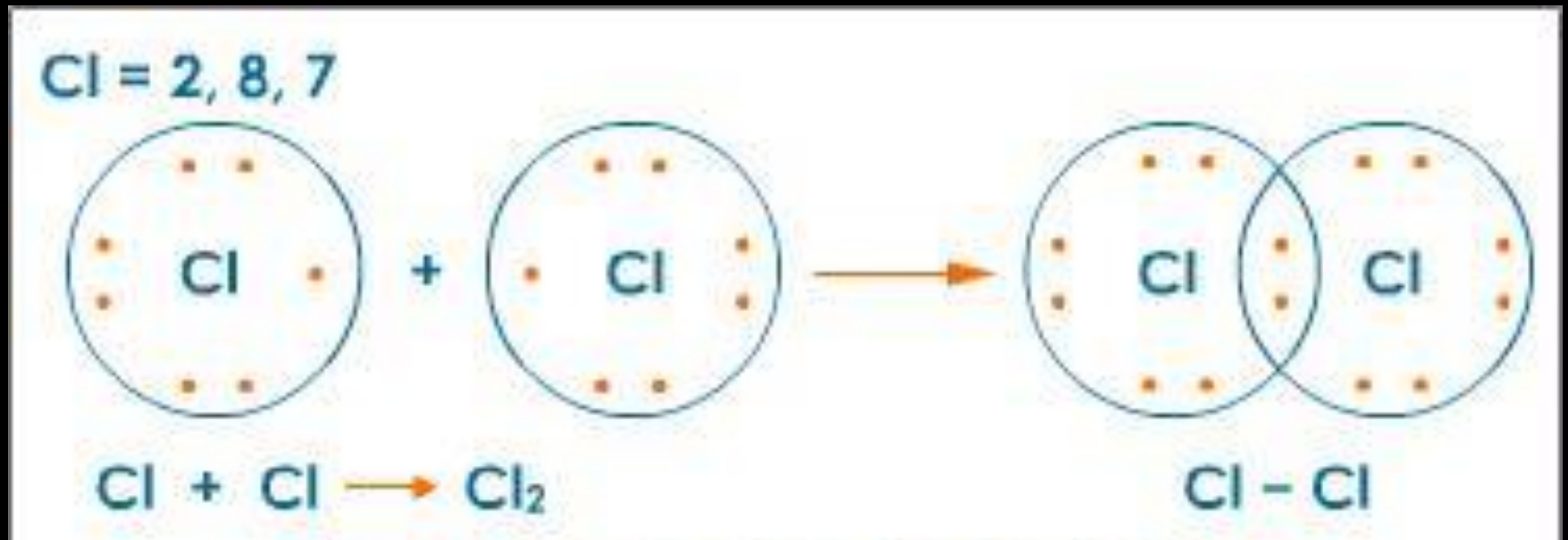
The atomic number of hydrogen is 1. It has one electron in its K shell and requires one more electron to fill the K shell. Two hydrogen atoms share their electrons to form a molecule of hydrogen.



Formation of chlorine molecule.

A chlorine atom has an electron arrangement of 2,8,7. It has seven valence electrons. Each chlorine atom needs one more electron to achieve a stable octet electron arrangement. Two chlorine atoms will combine with each other. Each of these two chlorine atoms contributes one electron to each other for sharing. The two chlorine atoms share one pair of electrons that bind them together.

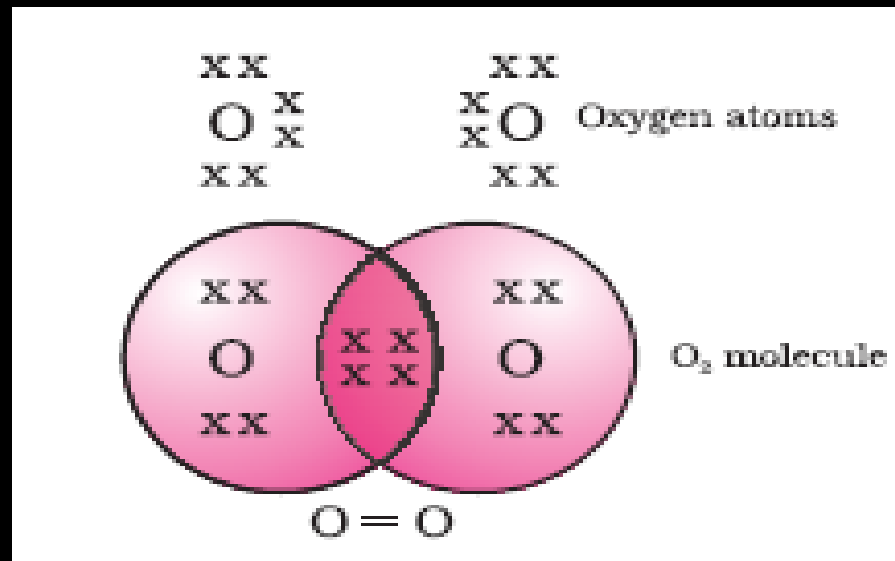
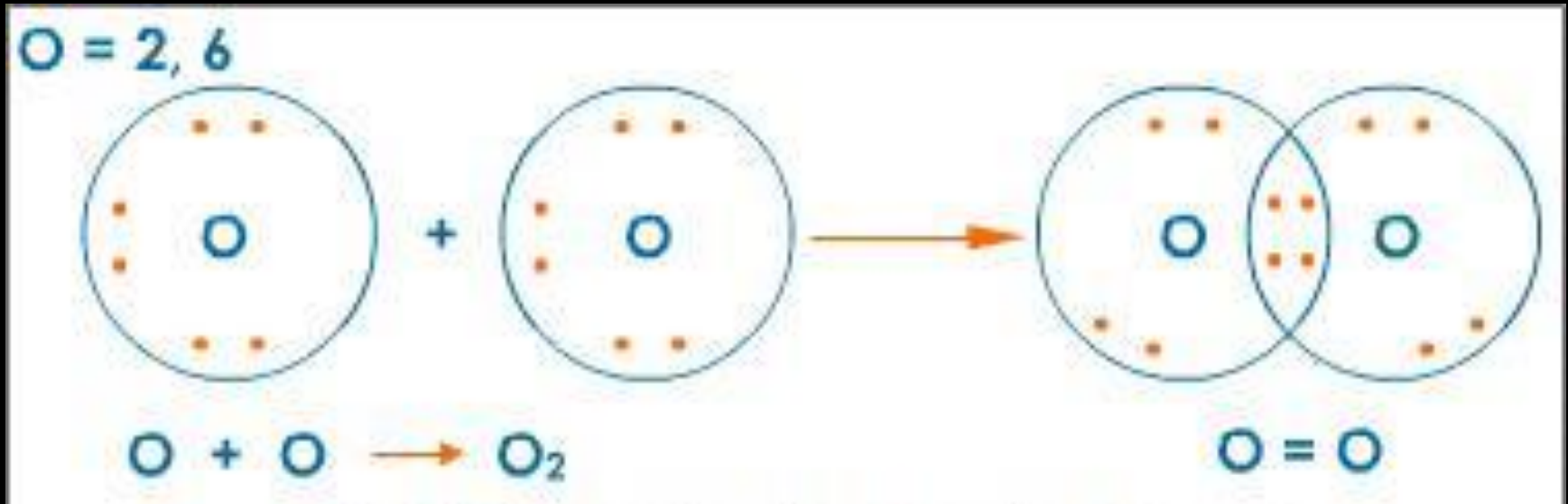
Formation of chlorine molecule.



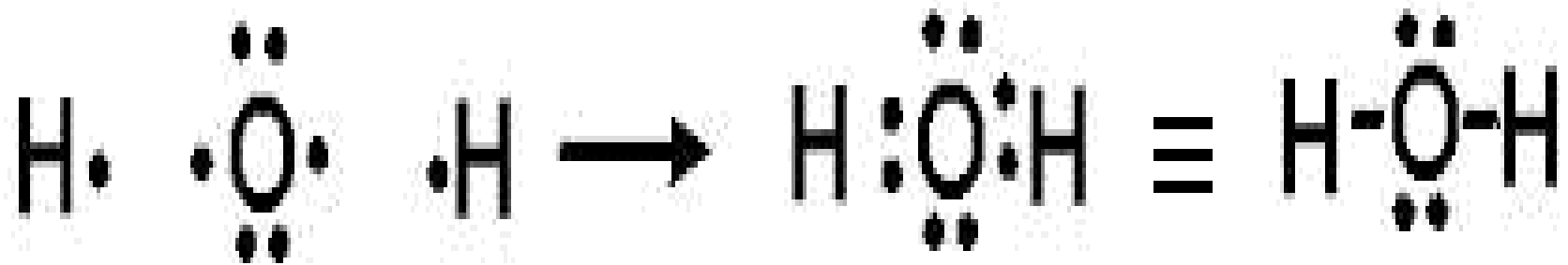
Formation of oxygen molecule.

The atomic number of oxygen is 16. Its electronic configuration is (2, 8, 6). A double bond is formed between two oxygen atoms. The outermost shell has 6 electrons. It requires two electrons to complete its octet. Each oxygen atom shares two electrons with another oxygen atom. The two electrons contributed by each oxygen atom give rise to two shared pairs of electrons.

Formation of oxygen molecule.



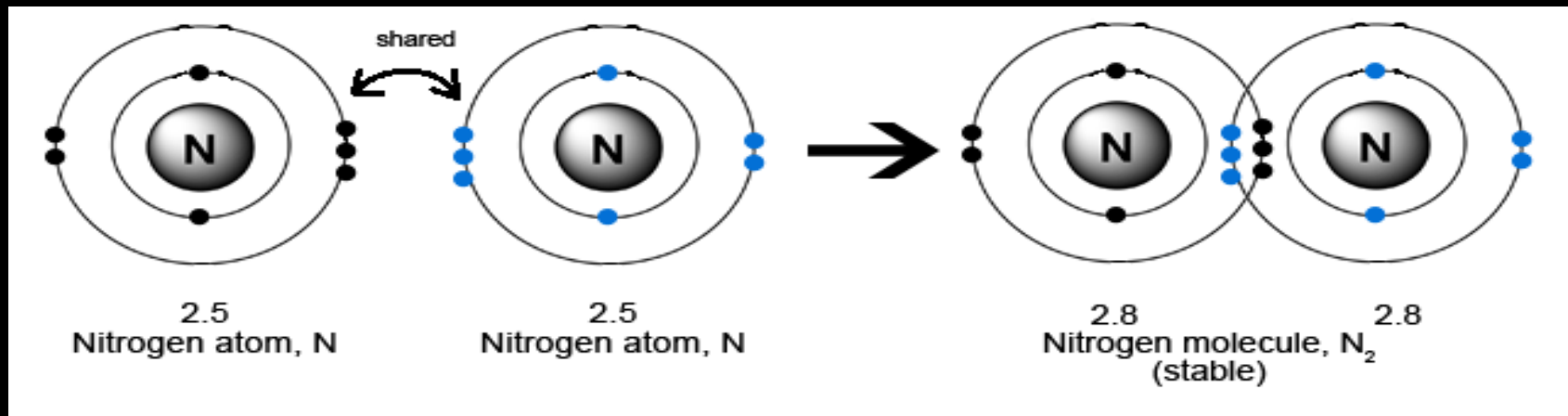
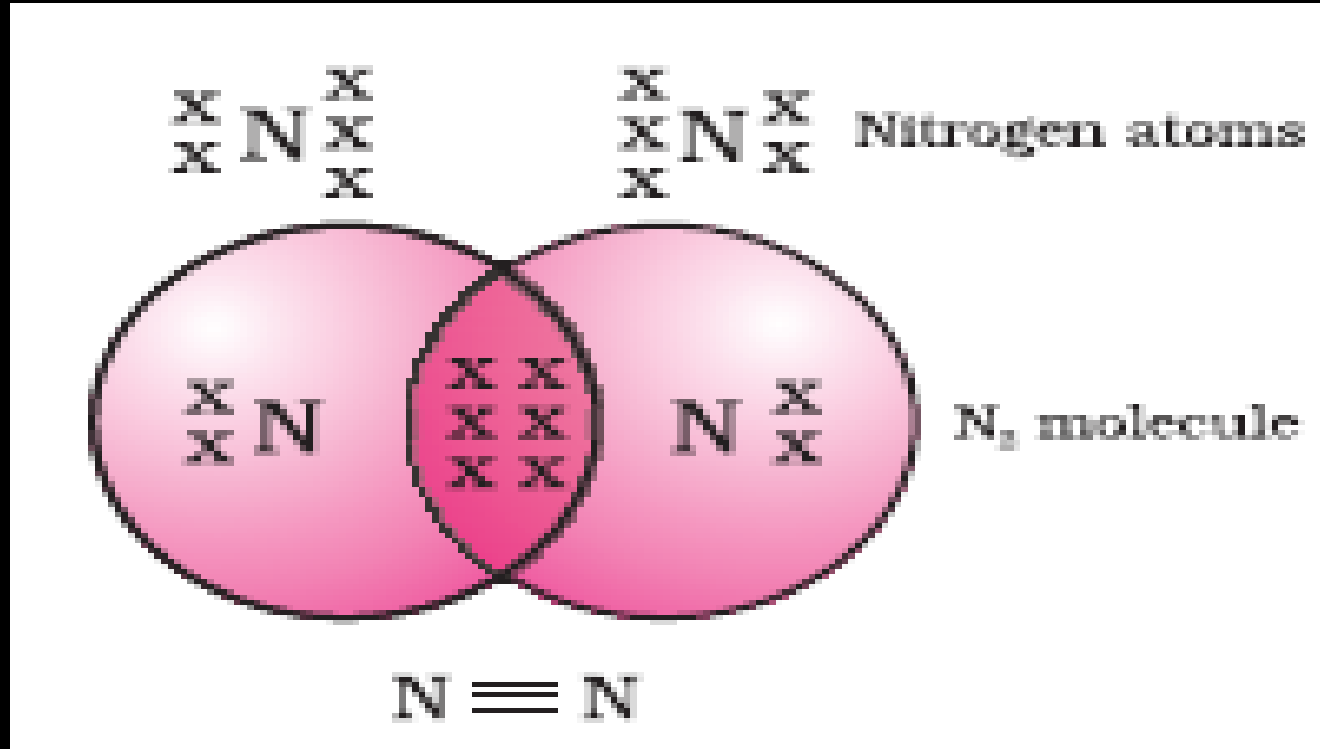
Formation of water molecule.



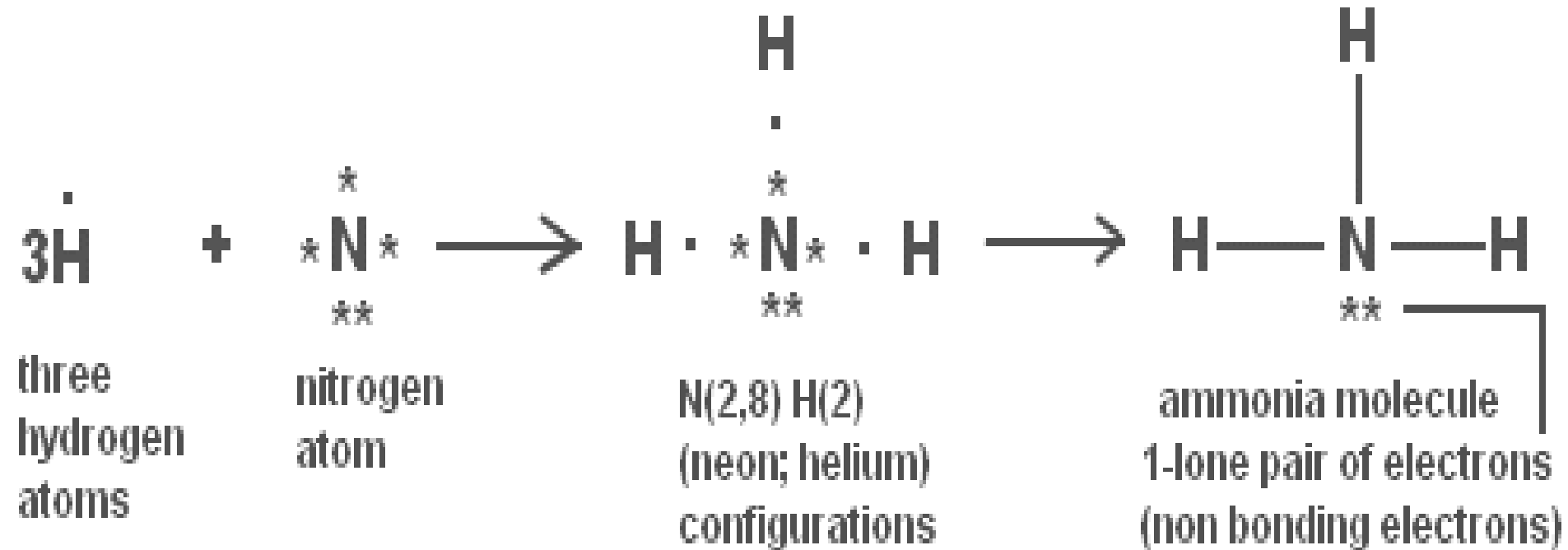
Formation of Nitrogen molecule.

Atomic number of nitrogen is 7. Its electronic configuration is (2,5). In order to attain an octet, each nitrogen atom in a molecule of nitrogen contributes three electrons giving rise to three shared pairs of electrons. This is said to constitute a triple bond between the two atoms.

Formation of Nitrogen molecule.



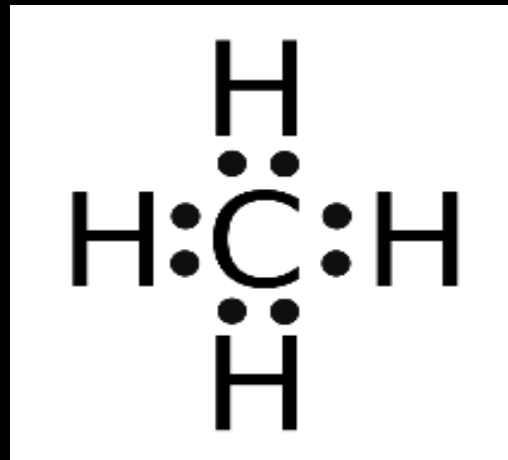
Electron dot structure of ammonia.



Formation of Methane molecule.

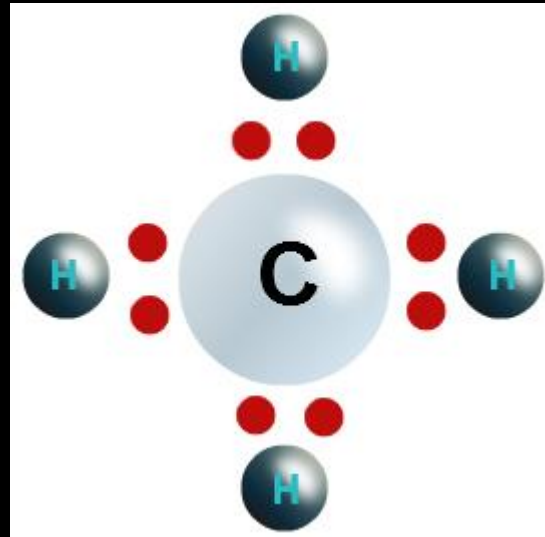
Carbon atom has atomic number 6. Its electronic configuration is 2,4. It has four electrons in its valence shell and needs 4 more electrons to get the stable noble gas configuration. Hydrogen atom has one electron and needs one more electron to get stable electronic configuration of nearest noble gas, helium. Therefore, one atom of carbon shares its four electrons with four atoms of hydrogen to form four covalent bonds.

Formation of Methane molecule.



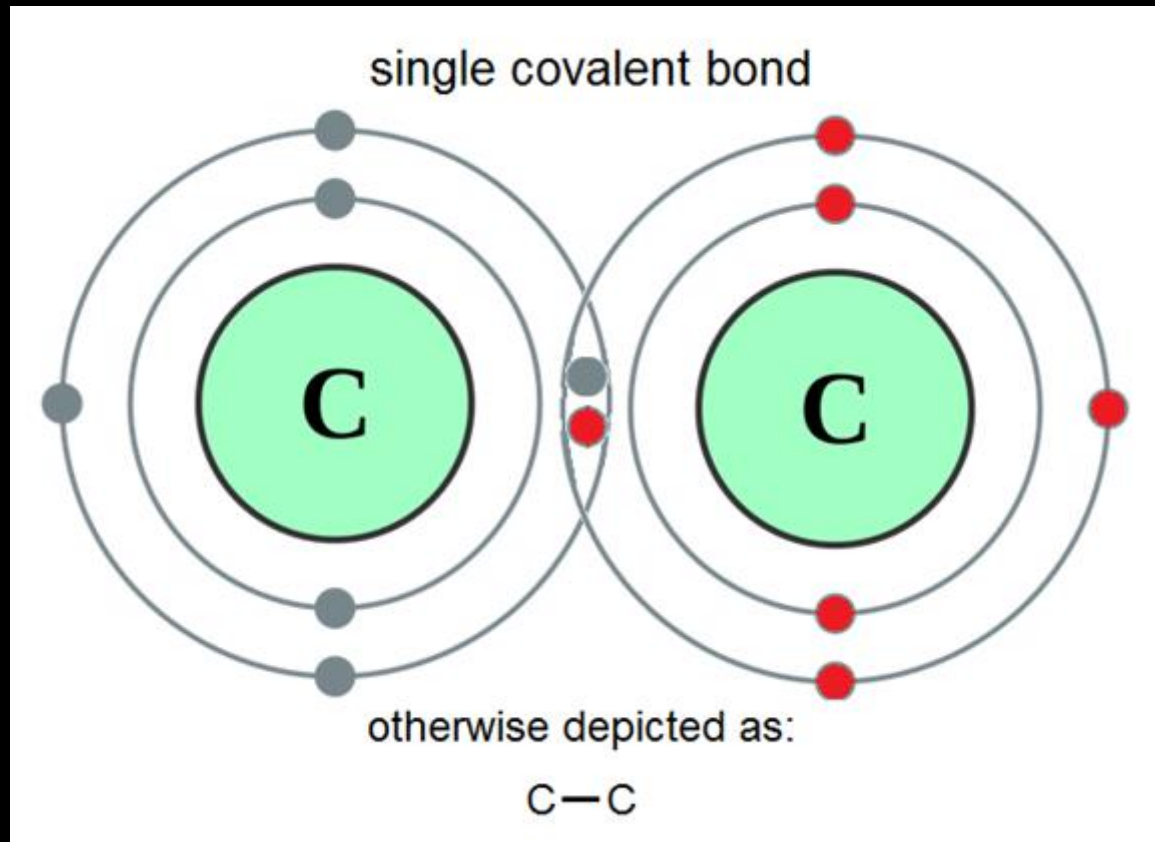
Why is carbon tetravalent?

Carbon is tetravalent because it has four valence electrons. In order to achieve noble gas configuration, carbon shares these electrons with four atoms of hydrogen.



Covalent bond

Bonds which are formed by the sharing of an electron pair between two atoms is known as covalent bonds.

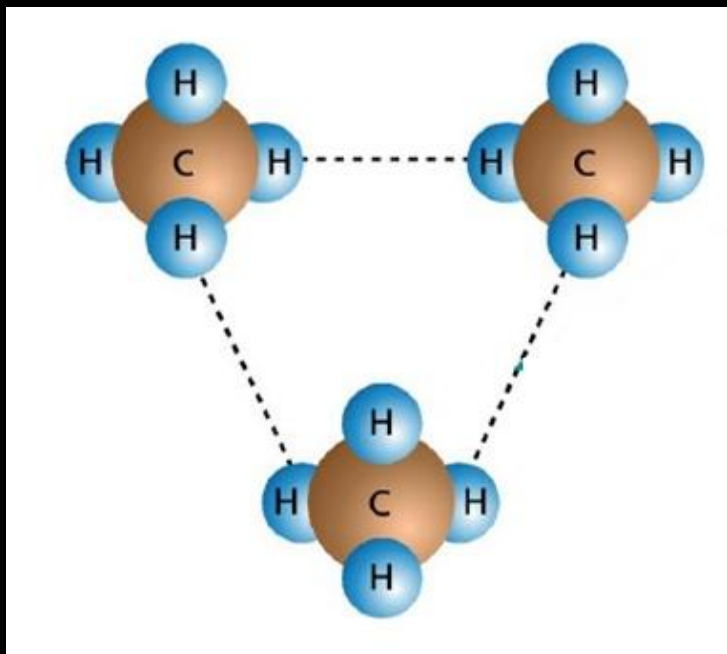


Characteristics of Covalent bond

- a) Covalent bonded molecules have strong bonds within the molecule.
- b) They have small intermolecular forces.
- c) They have low melting and boiling points.
- d) They do not form charged particles.
- e) They are generally poor conductors of electricity.

Covalent compounds have low melting and boiling points.

Covalent compounds have small inter-molecular force hence they have low melting and boiling points.



Compound	Melting point (K)	Boiling point (K)
Acetic acid (CH ₃ COOH)	290	391
Chloroform (CHCl ₃)	209	334
Ethanol (CH ₃ CH ₂ OH)	156	351
Methane (CH ₄)	90	111

Covalent compounds do not form charged particles.

The electrons are shared between atoms so no charge particles are formed.

Why does carbon exist in large number of compounds?

The nature of the covalent bond enables carbon to form a large number of compounds.

Properties of carbon which lead to the huge number of carbon compounds

The two characteristics seen in carbon which helps to form large number of compounds is

- a) tetravalency
- b) catenation.

Catenation

The unique ability of carbon to form bonds with other atoms of carbon, giving rise to large molecules is called **catenation**.

Ex: Carbon and silicon.

How is the catenation of silicon different from that of carbon?

Silicon forms compounds with hydrogen which have chains of upto seven or eight atoms, but these compounds are very reactive. The catenation of carbon is very strong and stable.

Why are carbon-carbon bonds very strong and stable?

Carbon is small in size. This enables the nucleus to hold on to the shared pairs of electrons strongly.

Vital Force theory

It was thought that carbon compounds or organic compounds could only be formed within a living system.

It was postulated that a 'vital force' was necessary for their synthesis.

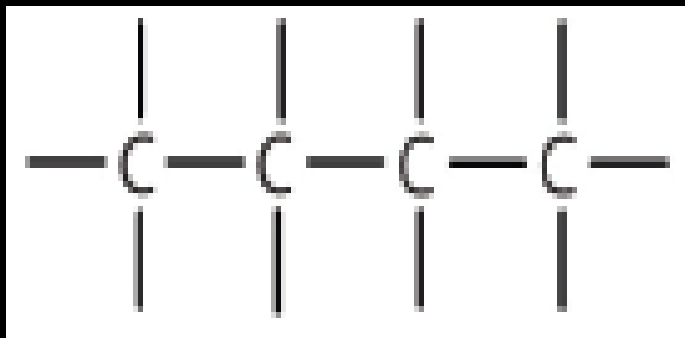
Failure of Vital Force theory

Friedrich Wöhler disproved the vital force theory in 1828 by preparing urea (an organic compound) from ammonium cyanate in the laboratory.

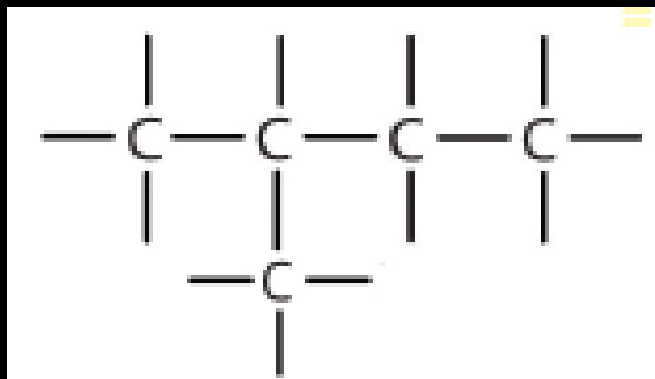
Isomers

Compounds with identical molecular formula but different structures are called **structural isomers**.

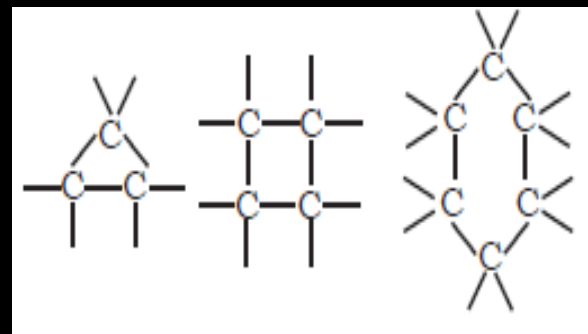
Types of carbon chains



Straight chain



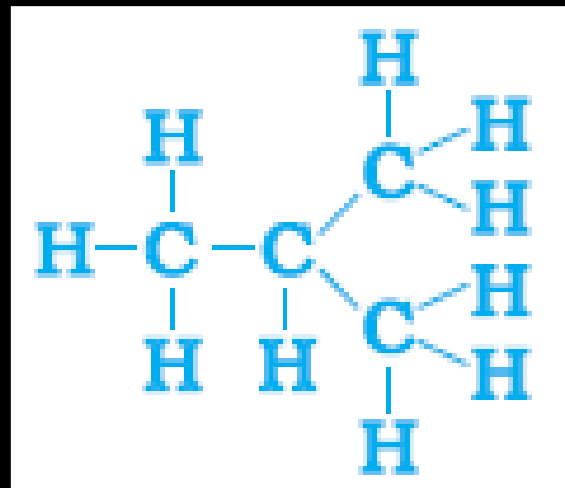
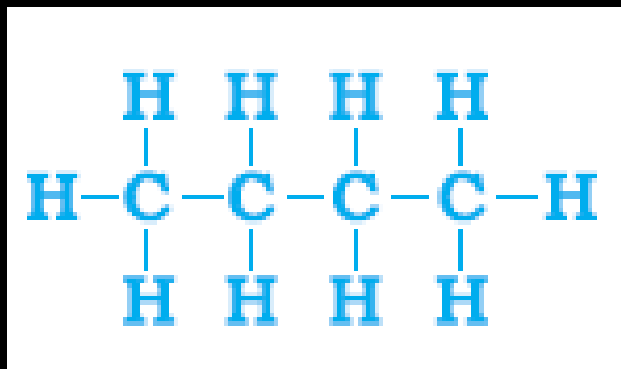
Branched chain



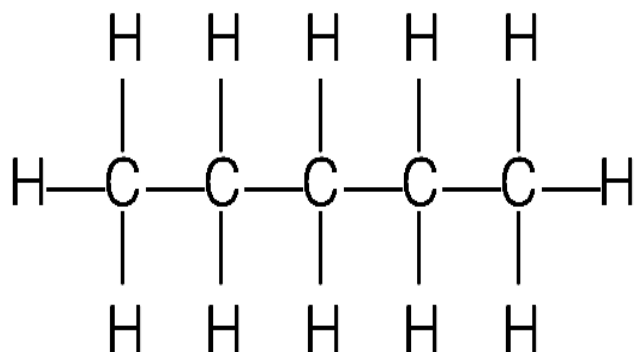
Closed chain

Structural isomers of Butane

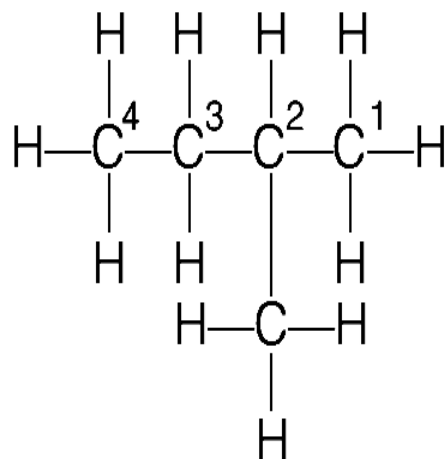
Butane C_4H_{10}



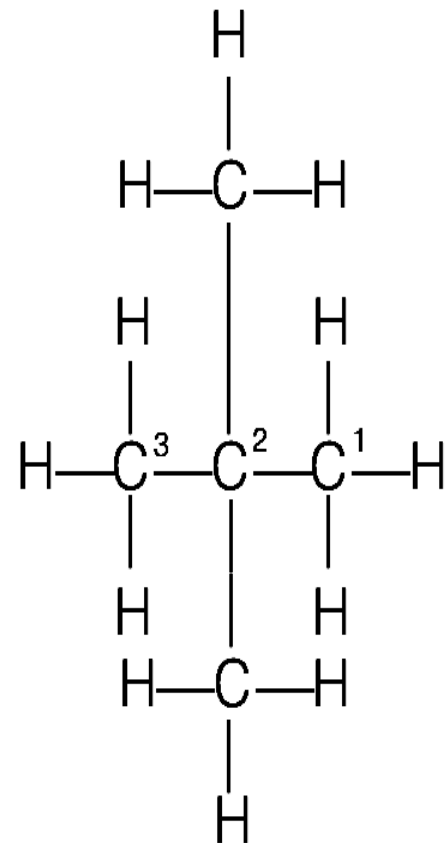
Structural isomers of pentane



(*n*-pentane)

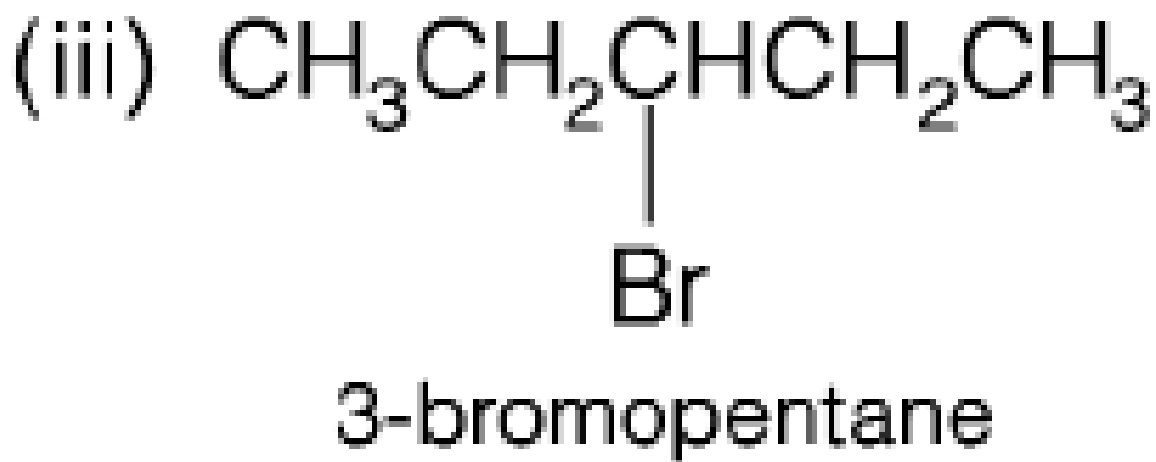
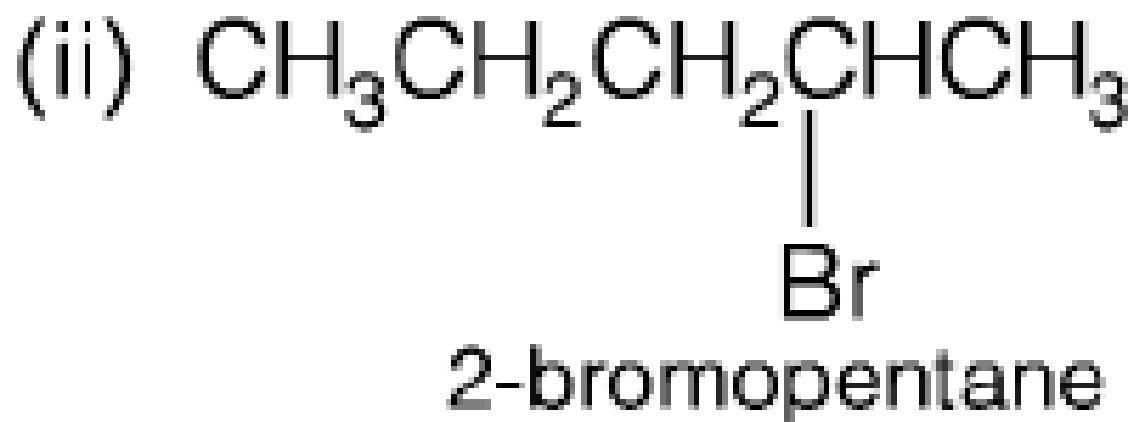


(2-methylbutane)



(2, 2-dimethyl propane)

Isomers of Bromopentane

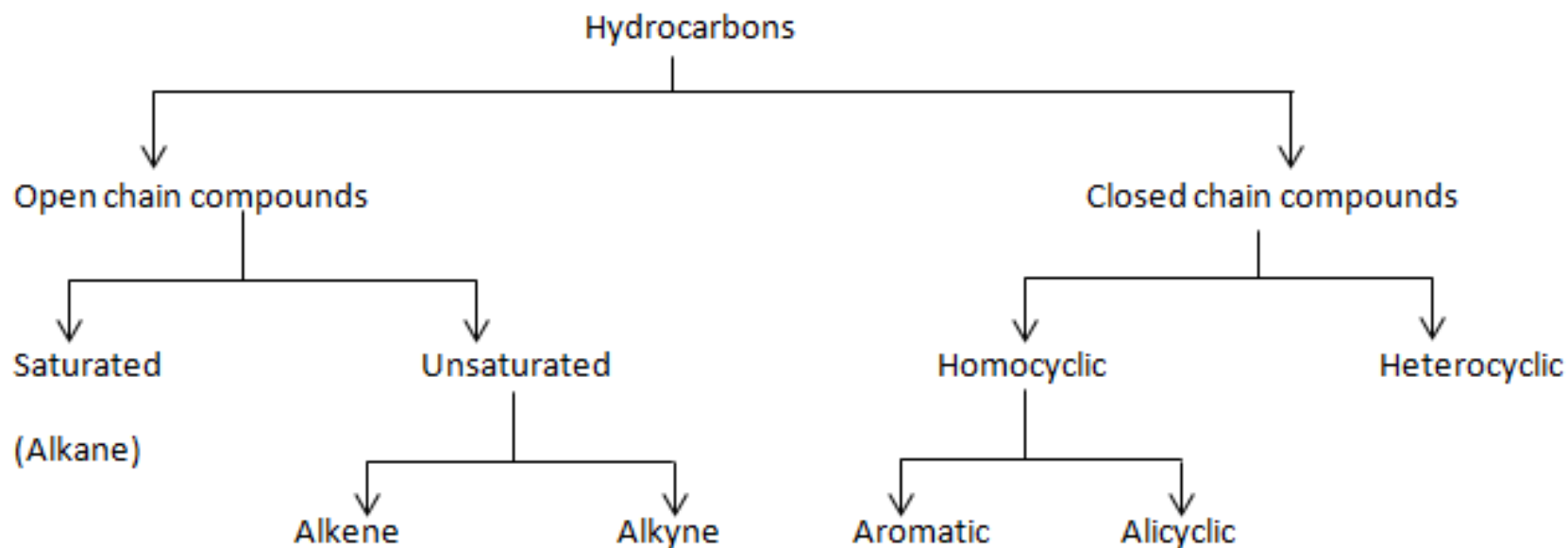


Hydrocarbons
Halocarbons

Hydrocarbons

Carbon compounds which contain carbon and hydrogen only are called **hydrocarbons**.

Classification of Hydrocarbons



Saturated carbon compounds

Compounds of carbon, which are linked by only single bonds between the carbon atoms are called **saturated compounds**.

Unsaured carbon compounds

Compounds of carbon having double or triple bonds between their carbon atoms are called **unsaturated compounds**.

Difference between Saturated and Unsaturated carbon compounds

Saturated compounds	Unsaturated compounds
They are linked by only single bond between carbon atoms.	They are linked by double or triple bonds between their carbon atoms.
They are less reactive.	They are more reactive.

Alkanes

Alkanes are saturated hydrocarbons in which the carbon atoms are connected by only single bond.

Ex: Methane, Ethane, Propane

Characteristics of Alkanes

- In alkanes the carbon atoms are bonded with maximum number of hydrogen atoms.
- They have **single bond** between carbon atoms.
- Their general formula is C_nH_{2n+2}
- The primary suffix of these hydrocarbons is '**ane**'.

Alkanes

Value of n	C_nH_{2n+2}	Formula
1	$C_1H_{2(1)+2}$	CH_4
2	$C_2H_{2(2)+2}$	C_2H_6
3	$C_3H_{2(3)+2}$	C_3H_8
4	$C_4H_{2(4)+2}$	C_4H_{10}

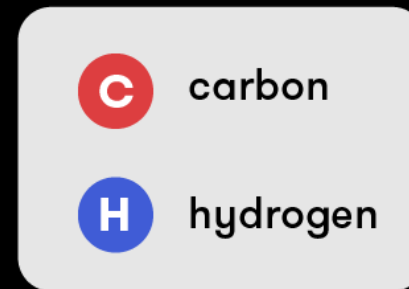
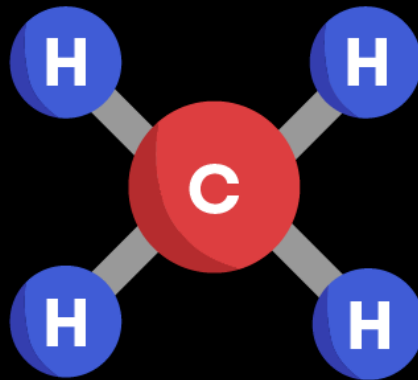
Prefix of alkanes

meth	=	1
eth	=	2
prop	=	3
but	=	4
pent	=	5
hex	=	6
hept	=	7
oct	=	8
non	=	9
dec	=	10
undec	=	11
dodec	=	12

IUPAC stands for International Union of Pure and Applied Chemistry

Methane or 'Marsh gas'

Methane is the first member of alkanes or saturated hydrocarbons.



Homologous series

A homologous series is a family of organic compounds with the same general formula, similar chemical properties and successive members differing by $-\text{CH}_2$.

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

Homologous series

Next homologue of Methane

Methane is CH_4

Next homologue is $\text{CH}_4 + \text{CH}_2 =$
 C_2H_6 (Ethane)

Homologous series

Next homologue of Pentane

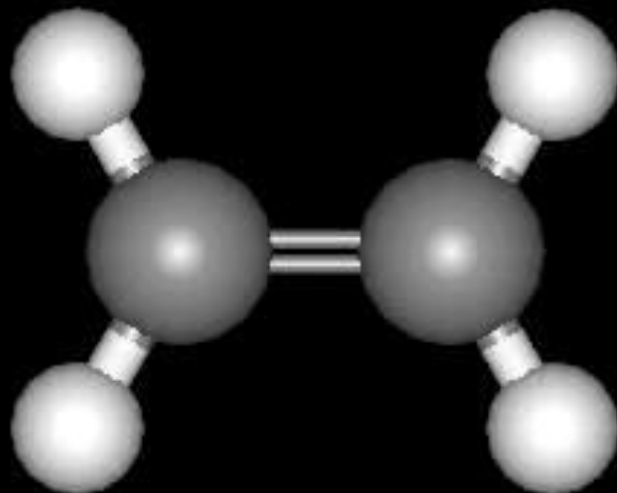
Pentane is C_5H_{12} , next
homologue is $C_5H_{12} + CH_2 =$
 C_6H_{14} (Hexane)

Why does the physical properties of compounds in homologous series increase?

The melting and boiling points increase with increasing molecular mass. Hence there is a gradation in physical properties.

Alkenes

Alkenes are unsaturated hydrocarbons in which the two carbon atoms are connected by double bond.



Alkenes

The name of these hydrocarbons end with 'ene'.
Their general formula is C_nH_{2n} .
They are referred to as olefins.
Ex: Ethene, Propene, Butene
etc

Relation between the number of carbon atoms and hydrogen atoms in alkenes.

Alkenes have a general formula is C_nH_{2n} . The ratio of the carbon atoms to the hydrogen atoms is 1:2.

Alkynes

Alkynes are unsaturated hydrocarbons that contain one **triple** bond between carbon atoms.

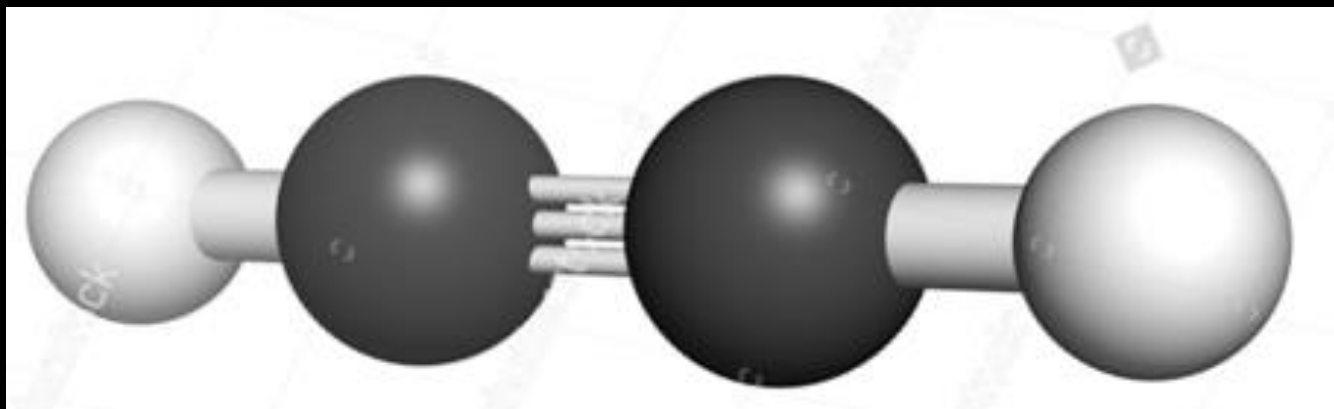
The name of these hydrocarbons end with '**yne**'.

Alkynes

Their general formula is



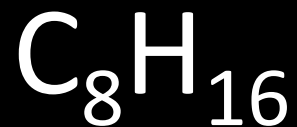
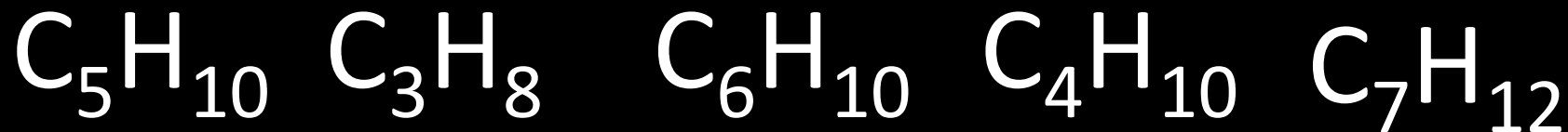
Ex: Ethyne, Propyne etc.



Difference between

Alkanes	Alkenes	Alkynes
They are saturated	They are unsaturated	They are unsaturated
They have single bond between carbon atoms	They have double bond between one of the carbon atoms	They have triple bond between one of the carbon atoms.
Their general formula is C_nH_{2n+2}	Their general formula is C_nH_{2n}	Their general formula is C_nH_{2n-2}
Their names end with 'ane'	Their names end with 'ene'	Their names end with 'yne'

Classify into alkanes, alkenes & alkynes

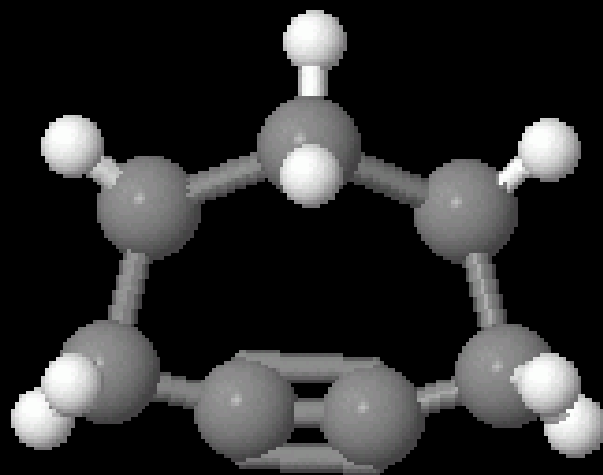


Alkanes	Alkenes	Alkynes

Click for solution

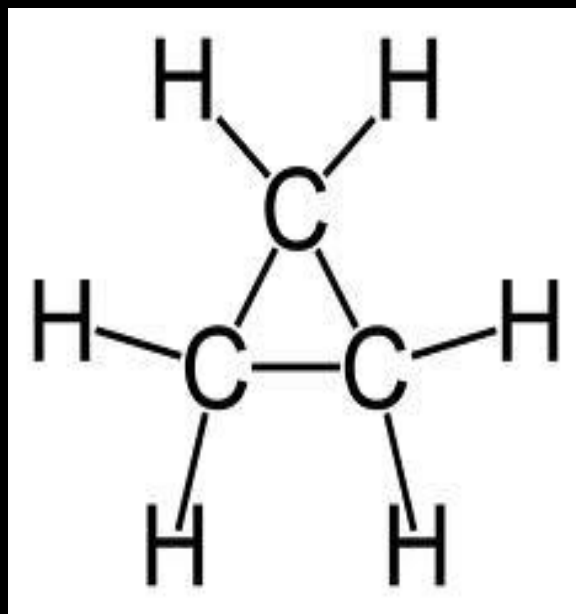
Cycloalkanes

Cycloalkanes are closed chain saturated hydrocarbons having one ring and the general formula C_nH_{2n} .



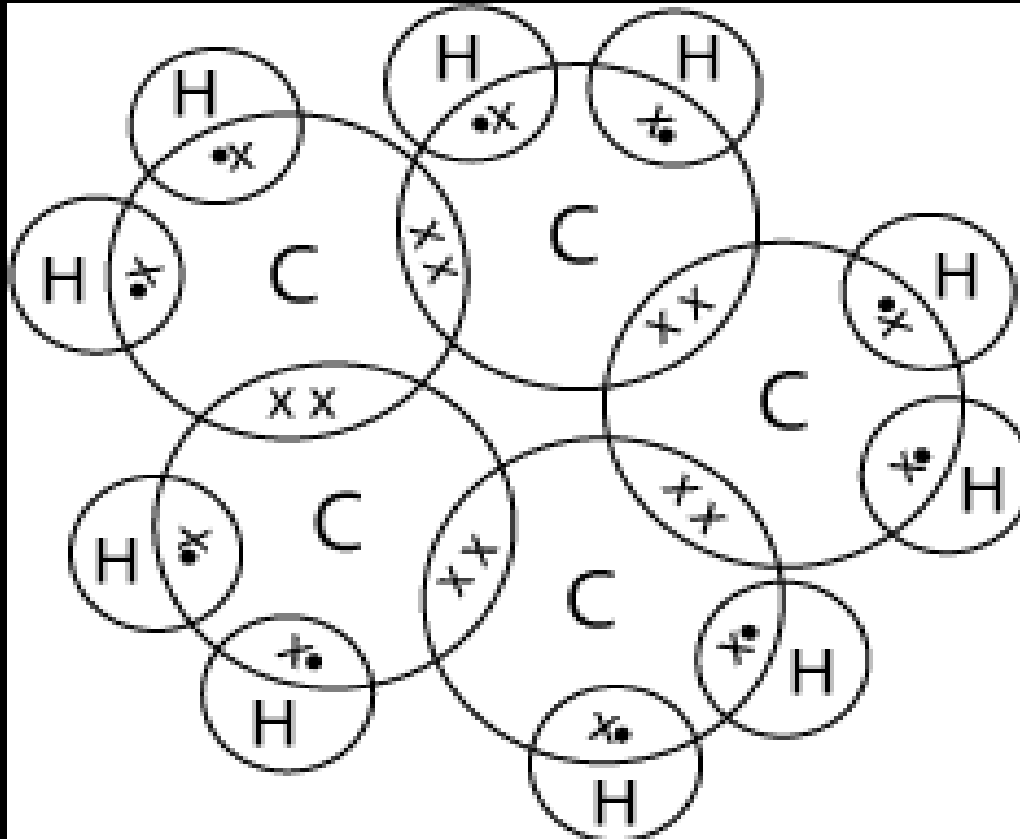
First member of Cycloalkanes

The first member of the Cycloalkanes is Cyclopropane (C_3H_6). Its structure is



Cyclopentane

Cyclopentane (C_5H_{10}). Its structure is



Difference between

Alkenes

1. They are unsaturated

2. They have double bond between carbon atoms

3. Their name end with 'ene'.

4. They are acyclic.

Cycloalkanes

1. They are saturated

2. They have single bond between carbon atoms.

3. Their names end with 'ane'

4. They are cyclic

(Activity 4.2) Calculate the difference in the formulae and molecular masses for (a) CH_3OH and $\text{C}_2\text{H}_5\text{OH}$ (b) $\text{C}_2\text{H}_5\text{OH}$ and $\text{C}_3\text{H}_7\text{OH}$, and (c) $\text{C}_3\text{H}_7\text{OH}$ and $\text{C}_4\text{H}_9\text{OH}$.

In all the given pairs of compounds, the molecular formula of the first compound differs from the second by a $-\text{CH}_2$ unit.

Mass of $\text{CH}_2 = 12 + 2 \times 1 = 14\text{u}$.

So the difference in molecular mass of the compounds in each pair is 14u .

(Activity 4.2) Is there any similarity in these three?

Yes, all the given pairs of compounds differ by a $-\text{CH}_2$ group.

(Activity 4.2) Arrange these alcohols in the order of increasing carbon atoms to get a family.

The order of alcohols is CH_3OH ,
 $\text{C}_3\text{H}_5\text{OH}$, $\text{C}_3\text{H}_7\text{OH}$, $\text{C}_4\text{H}_9\text{OH}$

(Activity 4.2) Can we call this family a homologous series?

Yes they form homologous series.

FUNCTIONAL

GROUPS

Heteroatoms

In hydrocarbons, the element replacing hydrogen is referred to as heteroatoms.

Functional group

Hydrocarbons in which one or more hydrogen atoms have been replaced by atom or group of atoms of other elements are called **functional groups**.

Alcohols

Compounds containing -OH as the functional group are called **alcohols**.

Their general formula is



Why KOH and NaOH are not alcohols?

NaOH and KOH are strong bases which are ionic compounds that contain OH ions. Alcohols are covalent compounds, even though they have one or more hydroxyl (-OH) functional groups, they do not behave like bases. The -OH group attached to a carbon atom is a covalent bond.

First five alcohols

Name of Alcohol	Molecular Formula
1. Methanol	CH_3OH
2. Ethanol	$\text{C}_2\text{H}_5\text{OH}$
3. Propanol	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ or $\text{C}_3\text{H}_7\text{OH}$
4. Butanol	$\text{C}_4\text{H}_9\text{OH}$
5. Pentanol	$\text{C}_5\text{H}_{11}\text{OH}$

Aldehydes

Compounds containing -CHO as the functional group are called **aldehydes**.

Their general formula is **R - CHO** .

First five aldehydes

Name of Aldehyde	Molecular Formula
1. Methanal	HCHO
2. Ethanal	CH ₃ CHO
3. Propanal	CH ₃ CH ₂ CHO
4. Butanal	CH ₃ CH ₂ CH ₂ CHO
5. Pentanal	CH ₃ CH ₂ CH ₂ CH ₂ CHO

Ketones

Compounds containing -one as functional group are called **ketones**.

Their general formula is **R - ONE** .

Example: Propanone.

Carboxylic acids

Compounds containing –COOH as the functional group are called **Carboxylic acids**.

Their general formula is



First five Carboxylic acids

Name of carboxylic acid	Molecular Formula
1. Methanoic acid	HCOOH
2. Ethanoic acid	CH ₃ COOH
3. Propanoic acid	C ₂ H ₅ COOH
4. Butanoic acid	C ₃ H ₇ COOH
5. Pentanoic acid	C ₄ H ₉ COOH

Name the functional groups

- a) CH_3CHO
- b) $\text{CH}_3\text{CH}_2\text{COOH}$
- c) $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- d) Methanal
- e) Methanol
- f) Methanoic acid

(Activity 4.2) Generate the homologous series for compounds containing up to four carbons for the other functional groups.

Aldehyde group H-CHO , $\text{CH}_3\text{-CHO}$, $\text{C}_2\text{H}_5\text{-CHO}$, $\text{C}_3\text{H}_7\text{-CHO}$

Carboxylic acid group H-COOH , $\text{CH}_3\text{-COOH}$, $\text{C}_2\text{H}_5\text{-COOH}$, $\text{C}_3\text{H}_7\text{COOH}$

Chemical properties of carbon compounds

Combustion

Carbon reacts with oxygen

Carbon, in all its allotropic forms, burn in oxygen to give carbon dioxide along with release of heat and light.

Ex: (i) $C + O_2 \rightarrow CO_2 + \text{heat and light}$

(ii) $CH_4 + O_2 \rightarrow CO_2 + H_2O + \text{heat and light}$

(iii) $CH_3CH_2OH + O_2 \rightarrow CO_2 + H_2O + \text{heat and light}$

(Activity 4.2) Take some carbon compounds (naphthalene, camphor, alcohol) one by one on a spatula and burn them. Observe the nature of the flame and note whether smoke is produced. Place a metal plate above the flame. Is there a deposition on the plate in case of any of the compounds?

Carbon compound	Nature of flame	Deposits on metal plate
Camphor	Smoky flame	Carbon deposits
Alcohol	Non-smoky flame	No carbon deposit
Acetone	Non-smoky flame	No carbon deposit
Naphthalene	Smoky flame	Carbon deposits

(Activity 4.3) Light a Bunsen burner and adjust the air hole at the base to get different types of flames/presence of smoke.

When do you get a yellow, sooty flame?

We get a yellow sooty flame if some of the holes in the bottom of burner are blocked and the burner does not get sufficient oxygen.

When do you get a blue flame?

We get a blue flame if all the holes are open and sufficiently oxygen rich air is available.

(Activity 4.3) Light a Bunsen burner and adjust the air hole at the base to get different types of flames/presence of smoke.

Video

Why does burning of coal or charcoal not produce any flame?

A flame is only produced when gaseous substances burn. When wood or charcoal is ignited, the volatile substances present vapourise and burn with a flame in the beginning.



(Activity 4.5) Take about 3 mL of ethanol in a test tube and warm it gently in a water bath. Add a 5% solution of alkaline potassium permanganate drop by drop to this solution.

Does the colour of potassium permanganate persist when it is added initially?

Initially colour of potassium permanganate disappears because coloured permanganate ions of potassium permanganate are consumed to oxidise ethanol.

(Activity 4.5) Take about 3 mL of ethanol in a test tube and warm it gently in a water bath. Add a 5% solution of alkaline potassium permanganate drop by drop to this solution.

Why does the colour of potassium permanganate not disappear when excess is added?

When excess of potassium permanganate is added, colour does not disappear because there is no alcohol left and hence there is no reaction.

(Activity 4.5) Take about 3 mL of ethanol in a test tube and warm it gently in a water bath. Add a 5% solution of alkaline potassium permanganate drop by drop to this solution.

Video

Converting unsaturated hydrocarbons to saturated hydrocarbons

Unsaturated hydrocarbons add hydrogen in the presence of catalysts such as palladium or nickel to give saturated hydrocarbons.

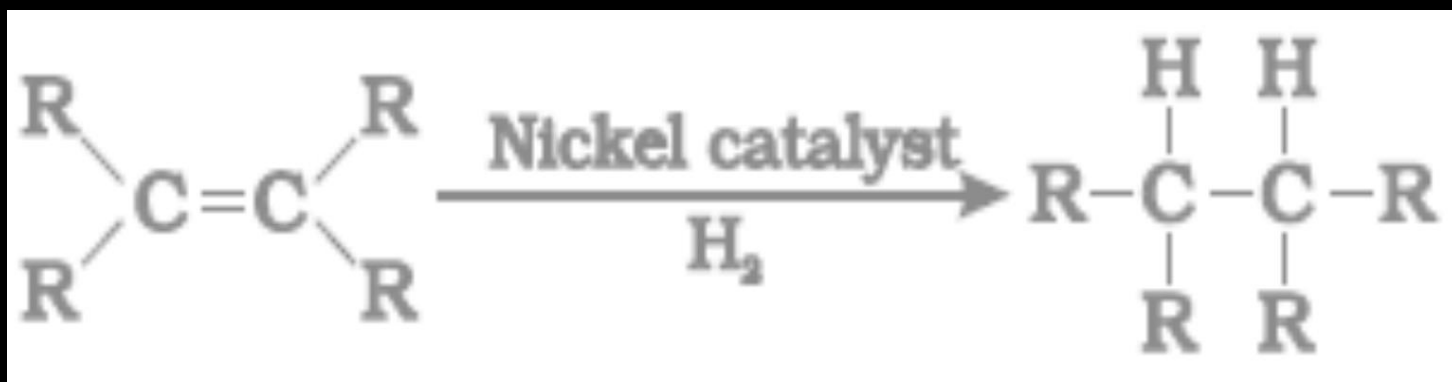
Addition reaction

A reaction in which a reactant molecule is added to another reactant molecule is called **addition reaction**.

For example: Hydrogen is added across the double bond of ethene in the presence of catalysts such as nickel, palladium or platinum to give saturated hydrocarbons.

Hydrogenation

Addition of hydrogen to alkenes to form alkanes is known as hydrogenation.



Conversion of alkenes into alkanes by hydrogenation

Difference between

Fats	Oils
Fats are mostly saturated	Oils are mostly unsaturated
They are solids at room temperature	They are liquids at room temperature
They are chemically inactive	They are chemically reactive
They are digested slowly	They are digested fast
They have longer shelf life	They have short shelf life
It is easy to transport	It is difficult to transport

Substitution reaction

The reaction in which one or more hydrogen atoms of a hydrocarbon are replaced by some other atoms is called **substitution reaction**.

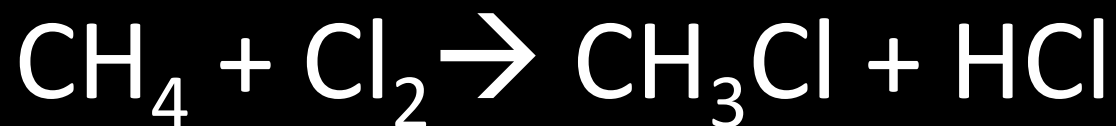
Give a test that can be used to differentiate chemically between butter and cooking oil.

Butter contains saturated compounds while cooking oil contains unsaturated compounds. Since unsaturated compounds are oxidised by alkaline KMnO_4 with disappearance of its pink colour.

When cooking oil is treated with a few drops of alkaline KMnO_4 , pink colour of KMnO_4 disappears. With butter however, the pink colour KMnO_4 does not disappear

Reaction of methane with chlorine

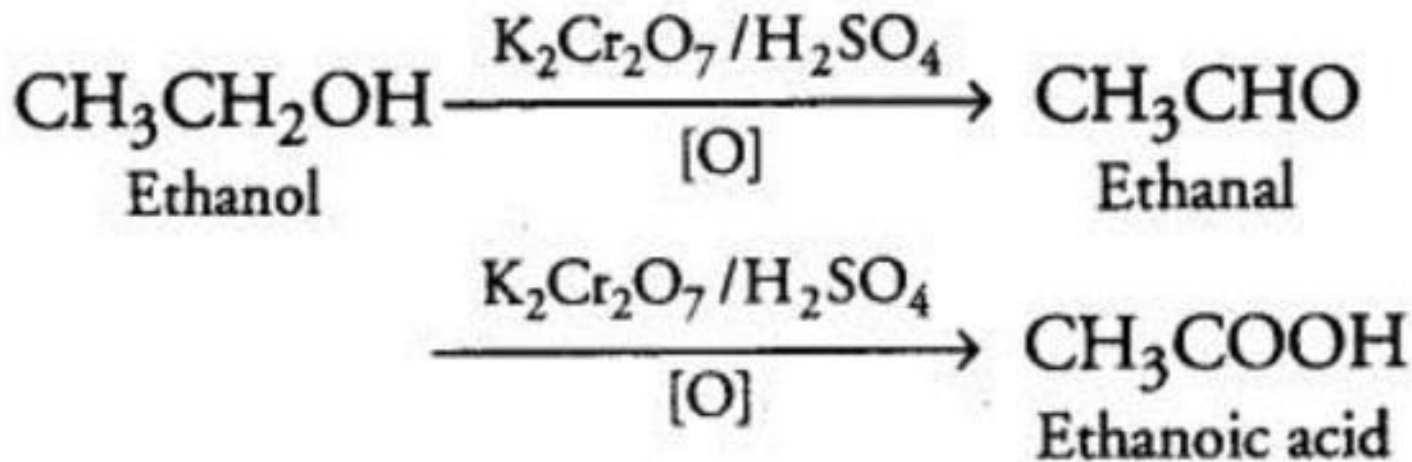
Methane reacts with chlorine in presence of sunlight.



(in the presence of sunlight)

Conversion of ethanol to ethanoic acid

The conversion of ethanol to ethanoic acid involves the addition of oxygen to ethanol, it is an oxidation reaction.



A mixture of oxygen and ethyne is burnt for welding. Can you tell why a mixture of ethyne and air is not used?

When ethyne is burnt in air, it gives a sooty flame. This is due to incomplete combustion caused by limited supply of air. If ethyne is burnt with oxygen, it gives a clean flame with temperature 3000°C because of complete combustion.

This oxy-acetylene flame is used for welding. It is not possible to attain such a high temperature without mixing oxygen. Hence a mixture of ethyne and air is not used.

Oxy-acetylene welding



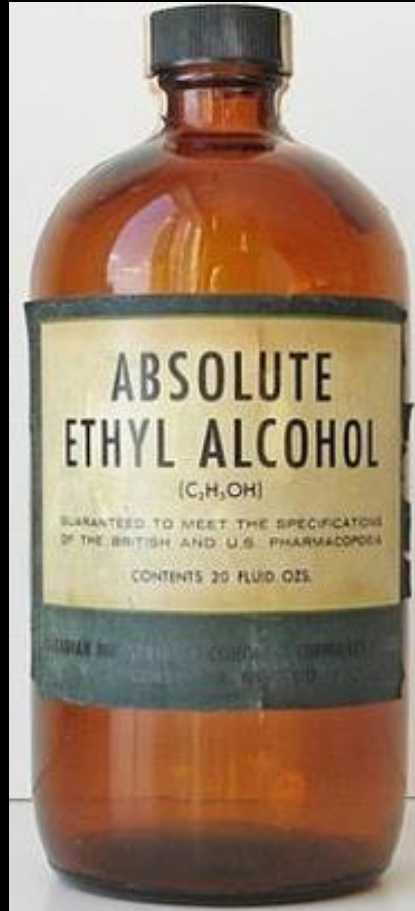
Uses of ethanol

- a) Ethanol is a good solvent.
- b) It is an active ingredient in all alcoholic drinks.
- c) It is used in medicines such as tincture iodine, cough syrups and many tonics.



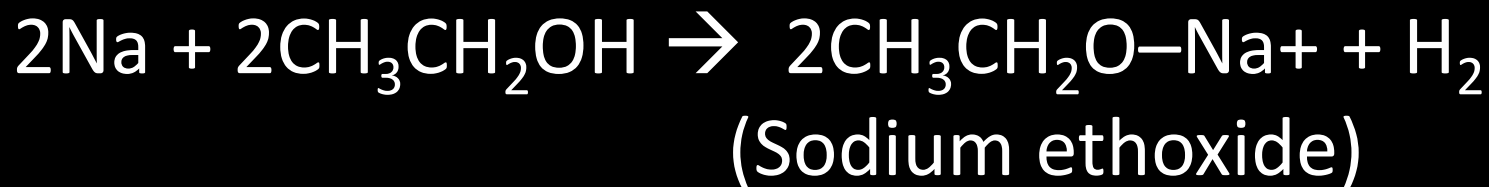
Absolute alcohol

100% pure ethanol is called absolute alcohol.



How does sodium react with ethanoic acid?

Ethanol reacts with sodium to form sodium ethoxide and hydrogen.



(Activity 4.6) Drop a small piece of sodium, about the size of a couple of grains of rice, into ethanol (absolute alcohol).

What do you observe?

Vigorous reaction occurs and hydrogen gas is bubbled out.

How will you test the gas evolved?

The gas evolved burns with a pop sound when exposed to burning match stick.

(Activity 4.6) Drop a small piece of sodium, about the size of a couple of grains of rice, into ethanol (absolute alcohol).

Video

(Activity 4.6) Drop a small piece of sodium, about the size of a couple of grains of rice, into ethanol (absolute alcohol).

How does ethanol react with sulphuric acid? OR
Explain the industrial preparation of ethene.

Heating ethanol at 443 K with excess concentrated sulphuric acid results in the dehydration of ethanol to give ethene.



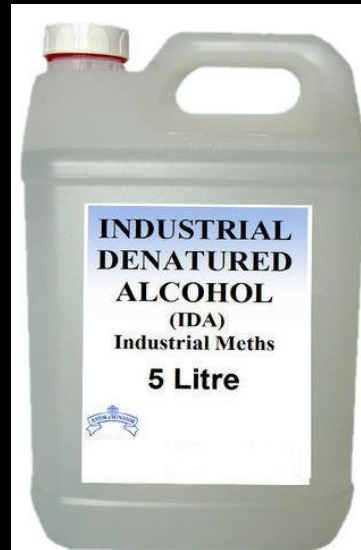
What is the role of sulphuric acid in the manufacture of ethene?

Sulphuric acid removes water from ethanol during the manufacture of ethene.

Denatured alcohol

Alcohol which is made unfit for drinking is known as denatured alcohol.

To prevent the misuse of ethanol produced for industrial use, it is made unfit for drinking by adding poisonous substances like methanol to it.



Why is the consumption of methanol dangerous?

Intake of methanol in very small quantities can cause death. Methanol is oxidised to methanal in the liver. Methanal reacts rapidly with the components of cells. It causes the protoplasm to get coagulated, in much the same way an egg is coagulated by cooking. Methanol also affects the optic nerve, causing blindness.

Vinegar

5 – 8% solution of acetic acid in water is called vinegar.



Vinegar

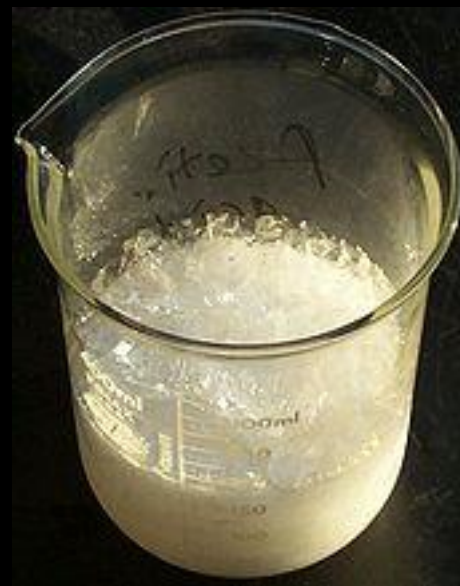
5 – 8% solution of acetic acid in water is called vinegar.

Vinegar is used widely as a preservative in pickles.



Why is ethanoic acid referred to as glacial acetic acid?

The melting point of pure ethanoic acid is 290K and hence it freezes during winter in cold climate. Hence ethanoic acid is referred to as glacial acetic acid.



How is carboxylic acid different from mineral acids?

Mineral acids like HCl get completely ionised whereas carboxylic acids are weak acids which do not completely ionise.

(Activity 4.7) Compare the pH of dilute acetic acid and dilute hydrochloric acid using both litmus paper and universal indicator.

Are both acids indicated by the litmus test?

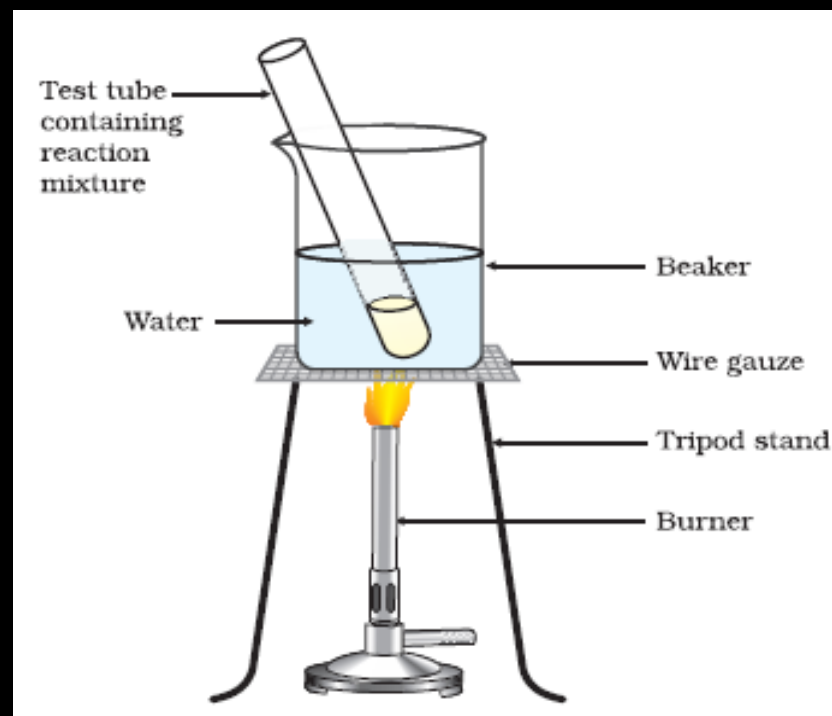
Both acids, acetic acid and dilute hydrochloric acid turn litmus paper red.

Does the universal indicator show them as equally strong acids?

Universal indicator shows different colours with acetic acid and hydrochloric acid showing clearly that hydrochloric acid is stronger acid than acetic acid.

(Activity 4.8) Take 1 mL ethanol (absolute alcohol) and 1 mL glacial acetic acid along with a few drops of concentrated sulphuric acid in a test tube. Warm in a water-bath for at least five minutes as shown in figure. Pour into a beaker containing 20-50 mL of water and smell the resulting mixture.

The resulting mixture gives a sweet smell due to the formation of ester called ethyl acetate.



Formation of Esters

Esters are most commonly formed by reaction of an acid and an alcohol. Ethanoic acid reacts with absolute ethanol in the presence of an acid catalyst to give an ester.



Properties of Esters

- Esters are sweet-smelling substances.
- Esters react in the presence of an acid or a base to form alcohol and carboxylic acid.

Saponification

The reaction of an ester to react with a base to give back the alcohol and carboxylic acid is called **saponification**.

SAPONIFICATION



acid
(oil)

+



base
(lye)

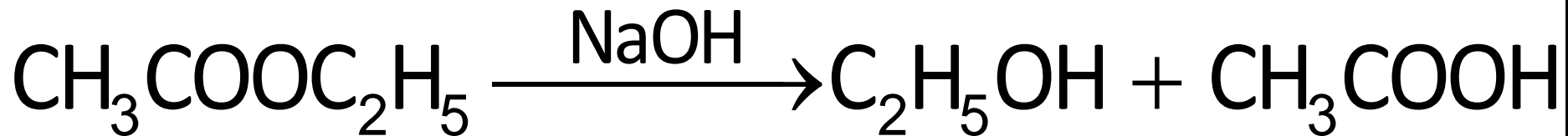
=



salt
(soap)

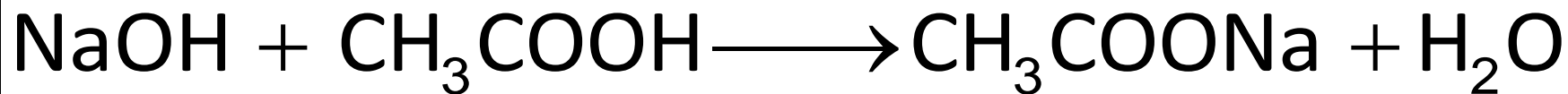
How does ethyl ethanoate react with sodium hydroxide?

Ethyl ethanoate ($\text{CH}_3\text{COOC}_2\text{H}_5$) when heated with sodium hydroxide gets hydrolysed to form ethyl alcohol and acetic acid.



How does ethanoic acid react with sodium hydroxide?

Ethanoic acid reacts with a base such as sodium hydroxide to give a salt (sodium ethanoate or commonly called sodium acetate) and water.



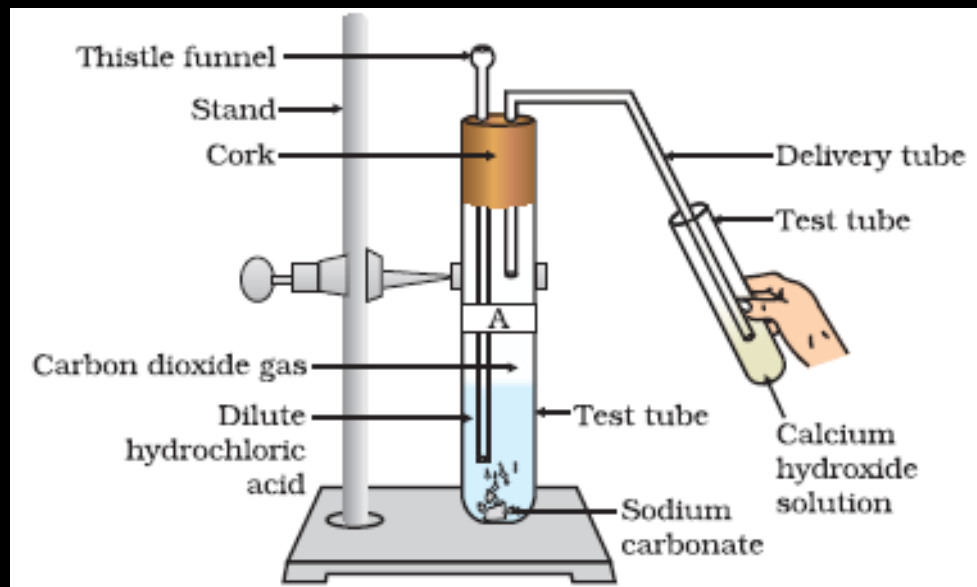
How does ethanoic acid react with carbonates and hydrogen carbonates?

Ethanoic acid reacts with carbonates and hydrogen carbonates to give a salt (sodium acetate), carbon dioxide and water.



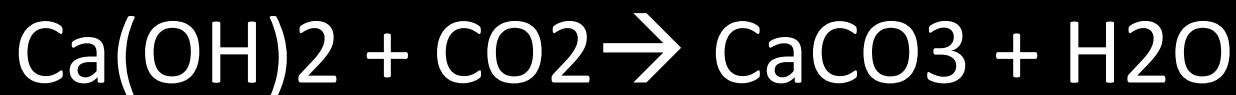
Take a spatula full of sodium carbonate in a test tube and add 2 mL of dilute ethanoic acid. What do you observe?

A gas (Carbon dioxide) evolves with effervescence.



Pass the gas produced through freshly prepared lime-water. What do you observe?

The gas evolved turns lime water milky.

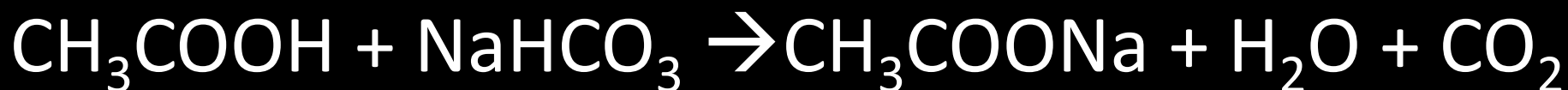


Can the gas produced by the reaction between ethanoic acid and sodium carbonate be identified by this test?

The evolution of carbon dioxide is identified by this test.

Repeat this activity with sodium hydrogen carbonate instead of sodium carbonate.

Similar observations as above will be seen if we use sodium hydrogen carbonate instead of sodium carbonate.



How would you distinguish experimentally between an alcohol and a carboxylic acid?

Sodium bicarbonate test (NaHCO_3 test)

Alcohol + $\text{NaHCO}_3 \rightarrow$ No effervescence

Acid + $\text{NaHCO}_3 \rightarrow$ Brisk effervescence

The sample which produces brisk effervescence when treated with NaHCO_3 due to release of CO_2 is a carboxylic acid.

(Activity 4.10) Take about 10 mL of water each in two test tubes. Add a drop of oil (cooking oil) to both the test tubes and label them as A and B. To test tube B, add a few drops of soap solution. Now shake both the test tubes vigorously for the same period of time.

Can you see the oil and water layers separately in both the test tubes immediately after you stop shaking them?

The oil and water do not separate immediately after shaking in both the test tubes and a turbidity is observed.

(Activity 4.10) Take about 10 mL of water each in two test tubes. Add a drop of oil (cooking oil) to both the test tubes and label them as A and B. To test tube B, add a few drops of soap solution. Now shake both the test tubes vigorously for the same period of time.

Leave the test tubes undisturbed for some time and observe. Does the oil layer separate out?

In which test tube does this happen first?

On keeping, oil and water separate in test tube A whereas in test tube B containing soap solution, oil and water form permanent emulsion.

Soap

Soap is a sodium (or potassium) salt of higher fatty acid like palmitic, oleic or stearic acid.

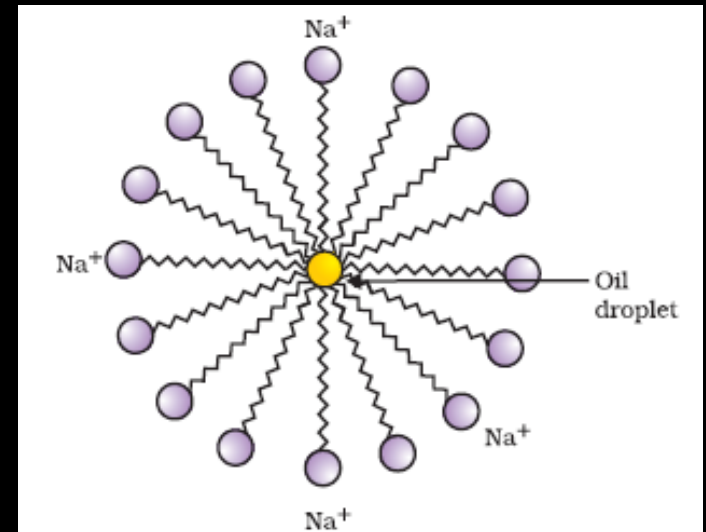
Ex: Sodium palmitate ($C_{15}H_{31}COONa$),
Sodium oleate ($C_{16}H_{33}COONa$),
Sodium stearate ($C_{17}H_{35}COONa$)

Action of Soap

The molecules of soap are sodium or potassium salts of long-chain carboxylic acids. The ionic-end of soap dissolves in water while the carbon chain dissolves in oil. The soap molecules, thus form structures called micelles where one end of the molecules is towards the oil droplet while the ionic-end faces outside. This forms an emulsion in water. The soap micelle thus helps in dissolving the dirt in water and we can wash our clothes clean.

Micelles

Micelles are clusters of molecules in which water-repelling end tails are in the interior of the cluster and the ionic ends are on the surface of the clusters.



Why soap in the form of micelles able to clean?

Soap in the form of a micelle is able to clean, since the oily dirt will be collected in the centre of the micelle. The micelles stay in solution as a colloid and will not come together to precipitate because of ion-ion repulsion. The dirt suspended in the micelles is also easily rinsed away. The soap micelles are large enough to scatter light. Hence a soap solution appears cloud.

Why soap in the form of micelles able to clean?

(a)
Soap or detergent dissolves in water



(b)
Surfactant ions orientate themselves in grease and water



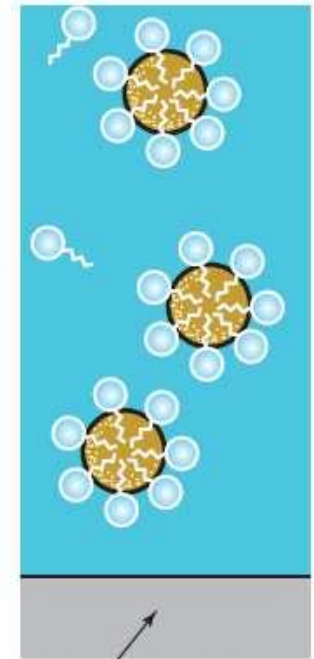
(c)
Agitation begins to separate grease from surface



(d)
Process continues



(e)
Cleaning complete



(Activity 4.11) Take about 10 mL of distilled water (or rain water) and 10 mL of hard water (from a tube well or hand-pump) in separate test tubes. Add a couple of drops of soap solution to both. Shake the test tubes vigorously for an equal period of time and observe the amount of foam formed.

In which test tube do you get more foam?

The test tube containing distilled water shows more foam. This is because the whole of soap is available to form foam.

(Activity 4.11) Take about 10 mL of distilled water (or rain water) and 10 mL of hard water (from a tube well or hand-pump) in separate test tubes. Add a couple of drops of soap solution to both. Shake the test tubes vigorously for an equal period of time and observe the amount of foam formed.

In which test tube do you observe a white curdy precipitate?

The test tube containing hand-pump water may show a white curdy precipitate, if it is hard. This is because calcium and magnesium ions form precipitate with soap, thus wasting some of the soap.



(Activity 4.12) Take two test tubes with about 10 mL of hard water in each. Add five drops of soap solution to one and five drops of detergent solution to the other. Shake both test tubes for the same period.

Do both test tubes have the same amount of foam?

The test tube containing detergent solution has more amount of foam.

In which test tube is a curdy solid formed?

The test tube containing soap solution shows a curdy solid being formed.

Hard water

Water which does not give lather easily with soap solution is called hard water.

Salts that cause hardness of water

Calcium and magnesium salts.



Why is soap wasted when used with hard water?

When soap is used with hard water, soap reacts with the calcium and magnesium salts, which cause the hardness of water. Hence a larger amount of soap is used.

How are detergents able to clean better?

Detergents are generally ammonium or sulphonate salts of long chain carboxylic acids. The charged ends of these compounds do not form insoluble precipitates with the calcium and magnesium ions in hard water. So they clean better even in hard water.

Would you be able to check if water is hard by using a detergent?

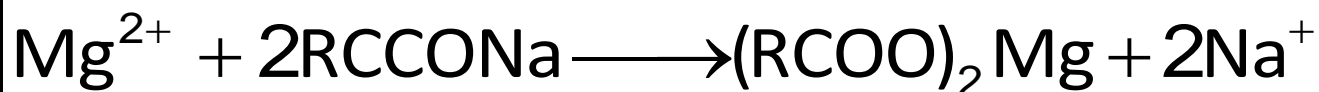
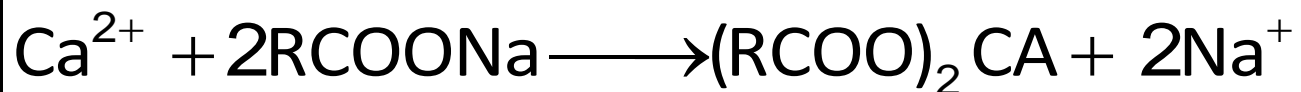
Unlike soap, they do not react with calcium and magnesium ions present in hard water to form scum. They give a good amount of lather irrespective of whether the water is hard or soft. This means that detergents can be used in both soft and hard water. Therefore, it cannot be used to check whether the water is hard or not.

People use a variety of methods to wash clothes. Usually after adding the soap, they 'beat' the clothes on a stone, or beat it with a paddle, scrub with a brush or the mixture is agitated in a washing machine. Why is agitation necessary to get clean clothes?

A soap molecule has two parts namely hydrophobic and hydrophilic. With the help of these, it attaches to the grease or dirt particle and forms a cluster called micelle. These micelles remain suspended as a colloid. To remove these micelles (entrapping the dirt), it is necessary to agitate clothes.

Explain the formation of scum when hard water is treated with soap.

Soap does not work properly when the water is hard. A soap is a sodium or potassium salt of long chain fatty acids. Hard water contains salts of calcium and magnesium. When soap is added to hard water, calcium and magnesium ions present in water displace sodium or potassium ions from the soap molecules forming an insoluble substance called scum. A lot of soap is wasted in the process. Reaction taking place are shown below.



Exercise (MCQ)

1. Ethane, with the molecular formula C_2H_6 has

- (a) 6 covalent bonds.
- (b) 7 covalent bonds.
- (c) 8 covalent bonds.
- (d) 9 covalent bonds.

2. Butanone is a four-carbon compound with the functional group:

- (a) carboxylic acid.
- (b) aldehyde.
- (c) ketone.
- (d) alcohol.

3. While cooking, if the bottom of the vessel is getting blackened on the outside, it means that

- (a) the food is not cooked completely.
- (b) the fuel is not burning completely.
- (c) the fuel is wet.
- (d) the fuel is burning completely.

END