Carbon and it’s compound

Introduction

- Carbon is a unique element that forms the basis of life on Earth.
- It can form **millions of compounds**, more than all other elements combined.
- We can test the presence of carbon in a material on the basis of the fact that carbon and its compounds burn in air to give carbon dioxide gas which turns lime water milky.
- This property is due to:
    1. **Catenation** (self-linking ability)
    2. **Always forms covalent bonds.**
    3. **Tetravalency** (forms four covalent bonds)
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- Occurrence of Carbon

  Carbon occurs in nature in 'free state' (as element) as well as in the 'combined state' (in the form of compounds with other elements).

    1. In free state, carbon occurs in nature mainly in two forms: diamond and graphite.
    2. In the combined state, carbon occurs in nature in the form of compounds such as: gas in air (ii) Carbonates (like limestone, marble and chalk) (iii) Fossil fuels like coal, petroleum and natural gas (iv) Organic compounds like carbohydrates, fats and proteins, and (v) Wood, cotton and wool, etc.

Allotropes of Carbon

The various physical forms in which an element can exist are called allotropes of the element. The carbon element exists in three solid forms called allotropes. The three allotropes of carbon are:

1 Diamond,

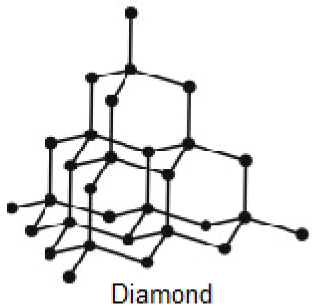
2 Graphite, and

3. Buckminsterfullerene..

Diamond and graphite are the two common allotropes of carbon which are known to us for centuries. Buckminsterfullerene is the new allotrope of carbon which has been discovered recently.

DIAMOND:-

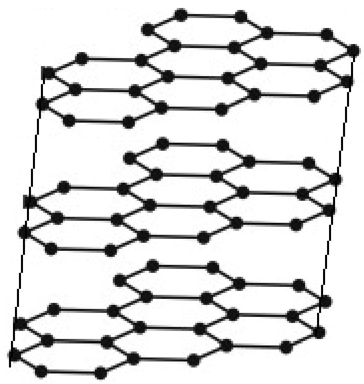
- ✓ Diamond is a colourless transparent substance having extraordinary brilliance. Diamond is quite heavy. Diamond is extremely hard.
- ✓ It is the hardest natural substance known.
- ✓ Diamond does not conduct electricity.
- ✓ Diamond burns on strong heating to form carbon dioxide. If we burn diamond in oxygen, then only carbon dioxide gas is formed and nothing is left behind. This shows that diamond is made up of carbon only.
- ✓ The carbon dioxide formed by burning diamond can turn lime water milky. Since diamond is made up of carbon atoms only, its symbol is taken to be C.



Diamond

GRAPHITE:-

- ✓ Graphite is a greyish-black opaque substance.
- ✓ Graphite is lighter than diamond.
- ✓ Graphite is soft and slippery to touch.
- ✓ Graphite conducts electricity.
- ✓ Graphite burns on strong heating to form carbon dioxide. If we burn graphite in oxygen, then only carbon dioxide gas is formed and nothing is left behind. This shows that graphite is made up of carbon only. The carbon dioxide formed by burning graphite can turn lime water milky. Since graphite is made up of carbon atoms only, its symbol is taken to be C.



Graphite

ORGANIC COMPOUNDS :-

The compounds of carbon are known as organic compounds. Apart from carbon, most of the organic compounds contain hydrogen and many organic compounds contain oxygen or other elements.

Examples:-

Methane (CH_4), Ethane (C□H□), Ethene (C_2H_4), Ethyne (C□H□), Trichloromethane ($CHCl_3$), Ethanol (C_2H_5OH), Ethanal (CH_3CHO), Ethanoic acid (CH_3COOH), and Urea [$CO(NH_2)_2$].

Carbon compounds (or organic compounds) are covalent compounds having low melting points and boiling points.

Types of Organic Compounds

Some of the common types of organic compounds are :

1. Hydrocarbons
2. Haloalkanes (Halogenated hydrocarbons)

3. Alcohols 4. Aldehydes

5. Ketones 6. Carboxylic acids (Organic acids)

A compound made up of hydrogen and carbon only is called hydrocarbon (Hydrogen + Carbon = Hydrocarbon).
Example:-
Methane (CH_4), ethane (C□H□), ethene (C_2H_4), and ethyne (C_2H_2The most important natural source of hydrocarbons is petroleum (or crude oil) which is obtained from underground oil deposits by drilling oil wells. The natural gas which occurs above petroleum deposits also contains hydrocarbons.

Types of Hydrocarbons:-

a. Saturated hydrocarbons (Alkanes) :- A hydrocarbon in which the carbon atoms are connected by only single bonds is called a saturated hydrocarbon.
   The general formula of saturated hydrocarbons or alkanes is C_nH_{2n+2} where n is the number of carbon atoms in one molecule of the alkane
b. Unsaturated hydrocarbons (Alkenes and Alkynes) :- A hydrocarbon in which the two carbon atoms are connected by a 'double bond' or a 'triple bond' is called an unsaturated hydrocarbon.
   i) Alkenes:- An unsaturated hydrocarbon in which the two carbon atoms are connected by a double bond is called an alkene. The general formula of an alkene is C_nH_{2n} where n is the number of carbon atoms in its one molecule.
   ii) Alkynes :- An unsaturated hydrocarbon in which the two carbon atoms are connected by a triple bond is called an alkyne. The general formula of alkynes is C,H_{2n-2} where 11 is the number of carbon atoms in one molecule of the alkyne.

Alkyl Groups:- The group formed by the removal of one hydrogen atom from an alkane molecule is called an alkyl group.

NAMING OF HYDROCARBONS

One carbon atom= 'Meth'

Two carbon ='Eth'

Three carbon atoms ='Prop'

Four carbon ='But'

Five carbon atoms ='Pent'

Six carbon atoms ='Hex'

Seven carbon atoms ='Hept'

Eight carbon ='Oct'

Nine carbon atoms ='Non'

Ten carbon atoms ='Dec' (read as Dek)

2. A saturated hydrocarbon containing single bonds is indicated by writing the word **'ane'** after the stem.

3. An unsaturated hydrocarbon containing a double bond is indicated by writing the word '**ene**' after the stem.

4. An unsaturated hydrocarbon containing a triple bond is indicated by writing the word '**yne**' after the stem.

KINDLY DRAW THE STRUCTURE OF THE HYDROCARBONS MENTIONED ABOVE AS PER DONE IN THE CLASS.

IUPAC Nomenclature for Branched-Chain Saturated Hydrocarbons

1. The longest chain of carbon atoms in the structure of the compound (to be named) is found first. The compound is then named as a derivative of the alkane hydrocarbon which corresponds to the longest chain of carbon atoms (This is called parent hydrocarbon).
2. The alkyl groups present as side chains (branches) are considered as substituents and named separately as methyl (CH3) or ethyl (C□H□) groups.
3. The carbon atoms of the longest carbon chain are numbered in such a way that the alkyl groups (substituents) get the lowest possible number (smallest possible number).
4. The position of alkyl group is indicated by writing the number of carbon atom to which it is attached.
5. The IUPAC name of the compound is obtained by writing the 'position and name of alkyl group' just before the name of 'parent hydrocarbon'.

Isomers are compounds that have the same molecular formula but different structural arrangements of atoms. Example: Both C□H□O can represent:
a. Ethanol (CH□–CH□–OH)
b. Dimethyl ether (CH□–O–CH□)

Homologous Series Table

Series	General Formula	n	Molecular Formula	Name
Alkanes	C_nH_{2n+2}	1	CH_4	Methane
		2	C_2H_6	Ethane
		3	C_3H_8	Propane
		4	C_4H_{10}	Butane
		5	C_5H_{12}	Pentane
		6	C_6H_{14}	Hexane
Alkenes	C_nH_{2n}	2	C_2H_4	Ethene
		3	C_3H_6	Propene
		4	C_4H_8	Butene
		5	C_5H_{10}	Pentene
		6	C_6H_{12}	Hexene
Alkynes	C_nH_{2n-2}	2	C_2H_2	Ethyne
		3	C_3H_4	Propyne
		4	C_4H_6	Butyne
		5	C_5H_8	Pentyne
		6	C_6H_{10}	Hexyne

FUNCTIONAL GROUPS:-

Functional Group	Symbol / Formula	Family / Class of Compounds	Example	Formula of Example
Alcohol	–OH	Alcohols	Ethanol	C□H□OH
Aldehyde	–CHO	Aldehydes	Ethanal	CH□CHO
Ketone	–CO–	Ketones	Propanone	CH□COCH□
Carboxylic Acid	–COOH	Carboxylic Acids	Ethanoic acid	CH□COOH
Halo group	–Cl, –Br, –I	Haloalkanes	Chloromethane	CH□Cl
Alkene	C=C	Alkenes	Ethene	C□H□
Alkyne	C≡C	Alkynes	Ethyne	C□H□

KINDLY DRAW THE STRUCTURE OF THE HYDROCARBONS MENTIONED ABOVE AS PER DONE IN THE CLASS.

CHEMICAL PROPERTIES OF CARBON COMPOUNDS

1. **Combustion (Burning)**

Carbon compounds burn in the presence of oxygen to produce:

- Carbon dioxide (CO□)
- Water (H□O)
- Heat and light

Example:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + \text{heat}$$

Most carbon compounds undergo complete combustion and release a lot of energy.

Notes:

- Saturated hydrocarbons burn with a blue, clean flame.
- Unsaturated hydrocarbons burn with a yellow, sooty flame (due to incomplete combustion).

2. **Addition Reaction**

This reaction occurs only in **unsaturated hydrocarbons** (alkenes and alkynes).
A molecule **adds across the double or triple bond**, converting it into a single bond.

Example:

Ethene + Hydrogen → Ethane

$$CH_2 = CH_2 + H_2 \rightarrow CH_3 - CH_3$$

This reaction requires a **catalyst** (like Ni, Pt, or Pd).
Used in the **hydrogenation of oils** (making ghee from vegetable oil).

3. **Substitution Reaction**

This occurs in **saturated hydrocarbons** (alkanes).
One hydrogen atom is **replaced (substituted)** by another atom or group.

Example:

Methane + Chlorine → Chloromethane

$$CH_4 + Cl_2 \underset{\text{sunlight}}{\rightarrow} CH_3Cl + HCl$$

Requires **sunlight** or **UV light**.
This reaction continues further to form multiple substituted products.

ETHANOL (C□H□OH)

A. Physical Properties

- **State:** Liquid
- **Color:** Colorless
- **Odor:** Characteristic alcoholic smell
- **Solubility:** Miscible with water in all proportions
- **Boiling point:** 78°C (moderate)
- **Density:** Less than water (~0.789 g/cm³)

B. Chemical Properties

1. **Combustion:** Burns with a blue flame.

C2H5OH + 3O2 → 2CO2 + 3H_2O
2. **Oxidation:**

- Mild oxidizing agents convert ethanol → ethanoic acid.

$$C_2H_5OH \overset{[O]}{\rightarrow} CH_3COOH$$

3. **Esterification:**

- Reacts with carboxylic acids in presence of conc. H_2SO_4 to form esters.

CH3CH2OH + CH3COOH → CH3COOC2H5 + H2O

4. **Dehydration:**

- With conc. H_2SO_4, ethanol loses water → ethene.

$$C_2H_5OH \overset{H_2SO_4}{\rightarrow} C_2H_4 + H_2O$$

C. Basic Tests

- **Iodoform test:** Positive for ethanol (pale yellow precipitate of CHI_3 forms).

D. Uses

- As a **solvent** in labs and industries
- As **alcoholic beverages**
- As **fuel** and **fuel additive** (bioethanol)
- As **antiseptic**

E. Harmful Effects

- Excess consumption → **alcoholism**, liver damage
- Toxic if ingested in large quantities
- Can cause **dizziness**, **addiction**, and **accidents**

SOME IMPORTANT CARBON COMPOUNDS:-

ETHANOIC ACID (CH_3COOH)

A. Physical Properties

- **State:** Liquid
- **Color:** Colorless
- **Odor:** Pungent, vinegar-like smell
- **Solubility:** Miscible with water
- **Boiling point:** 118°C
- **Density:** ~1.05 g/cm³

B. Chemical Properties

1. **Acidic nature:** Reacts with bases to form salts (acetates).

CH3COOH + NaOH $\underset{H2SO4}{-->}$ CH3COONa + H_2O
]

2. **Reaction with carbonates:** Produces CO_2.

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

3. **Esterification:** Forms esters with alcohols in the presence of H_2SO_4.
4. **Reduction:** Can be reduced to ethanol with reducing agents.

C. Basic Tests

- **Sodium carbonate test:** Effervescence (CO_2) indicates carboxylic acid.
- **Litmus test:** Turns blue litmus red.

D. Uses

- **Food industry:** Vinegar, pickles, sauces
- **Laboratory:** Reagent for ester formation and chemical synthesis
- **Industrial:** Manufacture of cellulose acetate, plastics, solvents

E. Harmful Effects

- Corrosive to skin and eyes in concentrated form
- Can cause **burns**, irritation, and respiratory problems if inhaled
- Not suitable for drinking in concentrated form

SOAP AND DETERGENT ACTION

Soap and detergents are cleaning agents. They help remove **dirt and grease** from clothes, utensils, and the body.

Structure of Soap and Detergent

- **Soap:** Sodium or potassium salt of **fatty acids**.
  Example: Sodium stearate → $C_{17}H_{35}COONa$
- **Detergent:** Sulfonates or sulfates of long-chain hydrocarbons.
  Example: Sodium lauryl sulfate → $CH_3(CH_2)_{11}SO_3Na$

Key Feature:

Both have a **dual nature molecule**:

Part	Nature	Function
Long hydrocarbon tail	Non-polar	Dissolves in grease/oil
Ionic head (–COO⁻, $-SO_3^-$)	Polar	Dissolves in water

This makes them **amphipathic** (both water- and oil-loving).

Soap molecule

Action of Soap and Detergent

Step 1: Formation of Micelles

- Soap molecules surround grease or oil in water.
- The **non-polar tail** goes into the grease, and the **polar head** faces outward toward water.

Micelle structure:

Water

|

[O– grease –O]

- The grease gets **trapped inside micelles**, forming an emulsion.

Step 2: Removal of Dirt

- Water washes away micelles containing grease/dirt.
- Result: Dirt and oil are removed.

Comparison between Soap and Detergent

Feature	**Soap**	**Detergent**
Composition	Sodium/potassium salts of fatty acids	Sodium/potassium salts of sulfonic or sulfate acids
Water hardness	Forms scum with hard water (Ca^{2+}, Mg^{2+})	Works in hard water (no scum)
Biodegradability	Easily biodegradable	Some are not easily biodegradable
Cleaning power	Good in soft water	Good in all water types
Example	Sodium stearate	Sodium lauryl sulfate

Advantages of Detergents over Soap

- Works in **hard water**
- More **effective in removing grease**
- Available in various forms: powder, liquid, bars