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Carbon and its Compounds Class 10 Notes | CBSE Chapter 4 Science

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Carbon and its Compounds Class 10 Notes | CBSE Chapter 4 Science

Carbon and its Compounds is Chapter 4 of CBSE Class 10 Science. Carbon is a unique element — it can form bonds with other carbon atoms to create chains, branches, and rings, giving rise to an enormous number of compounds. This chapter covers the bonding in carbon, homologous series, nomenclature (IUPAC naming), chemical properties of carbon compounds, and important compounds like ethanol and ethanoic acid.

This is a high-weightage chapter for board exams — expect 5–8 marks. IUPAC nomenclature, properties of ethanol and ethanoic acid, and soap/detergent chemistry are the most frequently tested topics.

Key Concepts

1. Why is Carbon Special?

Carbon has atomic number 6 and electronic configuration 2, 4. It has 4 valence electrons — it needs to gain or lose 4 electrons to achieve a noble gas configuration. Since gaining or losing 4 electrons requires too much energy, carbon **shares electrons** to form **covalent bonds**.

Two special properties of carbon:

- **Catenation:** The ability of carbon atoms to bond with other carbon atoms to form long chains, branched chains, and rings. This is because the C–C bond is very strong (due to small atomic size).
- **Tetravalency:** Carbon has 4 valence electrons, so it can form 4 covalent bonds. This allows it to bond with many different elements (H, O, N, S, Cl, etc.) and with itself.

These two properties together explain why there are more carbon compounds (over 10 million) than compounds of all other elements combined.

2. Covalent Bonding

In a **covalent bond**, two atoms share one or more pairs of electrons to achieve a stable (noble gas) configuration.

Types of Covalent Bonds

Type	Electron Pairs Shared	Example	Representation
Single bond	1 pair (2 electrons)	H ₂ (H–H), CH ₄	—
Double bond	2 pairs (4 electrons)	O ₂ (O=O), C ₂ H ₄	=
Triple bond	3 pairs (6 electrons)	N ₂ (N≡N), C ₂ H ₂	≡

Properties of Covalent Compounds

- Low melting and boiling points (weak intermolecular forces)
- Generally poor conductors of electricity (no free ions or electrons)
- Usually insoluble in water, soluble in organic solvents

3. Hydrocarbons

Compounds made of only carbon and hydrogen are called **hydrocarbons**.

Types of Hydrocarbons

Type	Bonds	General Formula	Examples	Key Feature
Saturated (Alkanes)	Only single bonds (C–C)	C _n H _{2n+2}	CH ₄ (methane), C ₂ H ₆ (ethane), C ₃ H ₈ (propane)	Less reactive, burn cleanly
Unsaturated (Alkenes)	At least one double bond (C=C)	C _n H _{2n}	C ₂ H ₄ (ethene), C ₃ H ₆ (propene)	More reactive, undergo addition reactions
Unsaturated (Alkynes)	At least one triple bond (C≡C)	C _n H _{2n-2}	C ₂ H ₂ (ethyne/acetylene), C ₃ H ₄ (propyne)	Most reactive among hydrocarbons

4. Homologous Series

A **homologous series** is a family of organic compounds that have the same general formula and similar chemical properties, with each successive member differing by –CH₂– (14 atomic mass units).

Characteristics:

- Same general formula (e.g., C_nH_{2n+2} for alkanes)
- Same functional group
- Similar chemical properties

- Gradual change in physical properties (melting point, boiling point increase with molecular size)
- Successive members differ by CH_2 (14 u)

Example — Alkane series: CH_4 (methane) $\rightarrow$ C_2H_6 (ethane) $\rightarrow$ C_3H_8 (propane) $\rightarrow$ C_4H_{10} (butane) $\rightarrow$ C_5H_{12} (pentane)

5. IUPAC Nomenclature (Naming Organic Compounds)

The name of an organic compound has three parts: **Prefix + Root word + Suffix**

Root Words (based on number of carbon atoms)

Carbon Atoms	Root Word	Carbon Atoms	Root Word
1	Meth-	6	Hex-
2	Eth-	7	Hept-
3	Prop-	8	Oct-
4	But-	9	Non-
5	Pent-	10	Dec-

Suffix (based on bond type)

Type	Suffix	Example (2 carbons)
Alkane (single bond)	-ane	Ethane (C_2H_6)
Alkene (double bond)	-ene	Ethene (C_2H_4)
Alkyne (triple bond)	-yne	Ethyne (C_2H_2)

Functional Groups and Their Suffixes/Prefixes

Functional Group	Formula	Suffix/Prefix	Example
Alcohol (Hydroxyl)	$-\text{OH}$	-ol	Methanol (CH_3OH), Ethanol ($\text{C}_2\text{H}_5\text{OH}$)
Aldehyde	$-\text{CHO}$	-al	Methanal (HCHO), Ethanal (CH_3CHO)
Ketone	$>\text{C}=\text{O}$	-one	Propanone (CH_3COCH_3) — acetone
Carboxylic acid	$-\text{COOH}$	-oic acid	Methanoic acid (HCOOH), Ethanoic acid (CH_3COOH)
Halide (Chloro, Bromo)	$-\text{Cl}$, $-\text{Br}$	Chloro-, Bromo-	Chloromethane (CH_3Cl)

6. Chemical Properties of Carbon Compounds

a) Combustion (Burning)

Carbon compounds burn in oxygen to produce CO_2 , H_2O , and energy (heat and light).

- $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} + \text{Energy}$
- $\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} + \text{Energy}$

Saturated hydrocarbons (alkanes) burn with a **clean blue flame** (sufficient oxygen).

Unsaturated hydrocarbons (alkenes, alkynes) burn with a **yellow, sooty flame** (incomplete combustion — carbon particles glow yellow).

b) Oxidation

Controlled oxidation using oxidising agents can convert one functional group to another:

- Ethanol $\rightarrow$ Ethanoic acid (using alkaline KMnO_4 or acidified $\text{K}_2\text{Cr}_2\text{O}_7$)
- $\text{C}_2\text{H}_5\text{OH} + [\text{O}] \rightarrow \text{CH}_3\text{COOH} + \text{H}_2\text{O}$

Alkaline KMnO_4 is used as an oxidising agent. The purple colour of KMnO_4 decolourises as it is used up.

c) Addition Reaction

Unsaturated hydrocarbons add hydrogen (H_2) across the double/triple bond in the presence of a catalyst (Ni or Pd) to form saturated compounds.

- $\text{C}_2\text{H}_4 + \text{H}_2 \rightarrow \text{C}_2\text{H}_6$ (ethene $\rightarrow$ ethane) — with Ni catalyst

Hydrogenation of vegetable oils: Vegetable oils (unsaturated) + $\text{H}_2 \rightarrow$ Vanaspati ghee (saturated fat). This is why vanaspati ghee is harmful — it increases cholesterol.

d) Substitution Reaction

Saturated hydrocarbons (alkanes) undergo substitution — one atom is replaced by another.

- $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$ (in presence of sunlight)
- Methane $\rightarrow$ Chloromethane (one H replaced by Cl)

7. Important Carbon Compounds

A. Ethanol ($\text{C}_2\text{H}_5\text{OH}$) — Common Alcohol

Properties:

- Colourless liquid with a pleasant smell
- Boiling point: 78°C
- Miscible (fully soluble) in water
- Used in alcoholic drinks, medicines, as a solvent, and as a fuel

Reactions of Ethanol:

- **With sodium:** $2\text{C}_2\text{H}_5\text{OH} + 2\text{Na} \rightarrow 2\text{C}_2\text{H}_5\text{ONa} + \text{H}_2\uparrow$ (sodium ethoxide + hydrogen)
- **Dehydration (with conc. H_2SO_4 at 170°C):** $\text{C}_2\text{H}_5\text{OH} \rightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{O}$ (ethanol $\rightarrow$ ethene). Conc. H_2SO_4 acts as a dehydrating agent.
- **Oxidation (with alkaline KMnO_4):** Ethanol $\rightarrow$ Ethanoic acid (acetic acid)

Effects of alcohol consumption:

- Ethanol is the alcohol in beverages — consumed in diluted form
- Slows nervous system, affects coordination, judgement, and liver
- Methanol (CH_3OH) is extremely poisonous — even 10 mL can cause blindness, 30 mL can cause death. It is sometimes found in illicit liquor.

B. Ethanoic Acid (CH_3COOH) — Acetic Acid

Properties:

- Colourless liquid with a pungent (vinegar-like) smell
- Boiling point: 118°C
- 5–8% solution in water = vinegar
- Pure ethanoic acid freezes at 16.6°C — below room temperature in winter. The frozen form looks like ice, so it is called **glacial acetic acid**

Reactions of Ethanoic Acid:

- **With base (NaOH):** $\text{CH}_3\text{COOH} + \text{NaOH} \rightarrow \text{CH}_3\text{COONa} + \text{H}_2\text{O}$ (sodium acetate + water — neutralisation)
- **With carbonate/bicarbonate:** $2\text{CH}_3\text{COOH} + \text{Na}_2\text{CO}_3 \rightarrow 2\text{CH}_3\text{COONa} + \text{H}_2\text{O} + \text{CO}_2\uparrow$ — this reaction produces brisk effervescence (CO_2 gas)
- $\text{CH}_3\text{COOH} + \text{NaHCO}_3 \rightarrow \text{CH}_3\text{COONa} + \text{H}_2\text{O} + \text{CO}_2\uparrow$
- **Esterification:** $\text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} \rightarrow \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O}$ (in presence of conc. H_2SO_4 as catalyst). The product (ethyl ethanoate/ethyl acetate) is an **ester** — it has a sweet, fruity smell.

8. Soaps and Detergents

Esters and Saponification

Esters react with NaOH (a base) in a reaction called **saponification** to form soap + alcohol:

Ester + NaOH → Soap (sodium salt of fatty acid) + Alcohol

Actual soap-making: Animal fat/vegetable oil + NaOH → Soap + Glycerol

Structure of Soap

A soap molecule has two parts:

- **Hydrophilic end (head):** Ionic part ($-\text{COO}^-\text{Na}^+$) — dissolves in water
- **Hydrophobic end (tail):** Long hydrocarbon chain — dissolves in oil/grease

How Does Soap Clean?

1. The hydrophobic (oil-loving) tails of soap molecules attach to the oil/grease on a dirty surface
2. The hydrophilic (water-loving) heads remain in the water
3. This forms a spherical cluster called a **micelle** — the oil is trapped inside, surrounded by soap molecules
4. When rinsed with water, the micelles (with trapped dirt and oil) are washed away

Why Soap Doesn't Work in Hard Water

Hard water contains dissolved calcium and magnesium salts. Soap reacts with $\text{Ca}^{2+}/\text{Mg}^{2+}$ ions to form an insoluble white precipitate (scum) — this wastes soap and doesn't clean well.



Detergents

Detergents (synthetic cleansing agents) work like soap but are effective in both hard and soft water. They don't form scum with hard water because their calcium/magnesium salts are soluble.

Feature	Soap	Detergent
Made from	Vegetable oil/animal fat + NaOH	Petroleum products
In hard water	Forms scum, poor cleaning	Works well, no scum
Biodegradable?	Yes	Some are not (environmental concern)

Important Definitions

Term	Definition
Covalent bond	Chemical bond formed by sharing of electron pairs between two atoms
Catenation	Ability of carbon to form bonds with other carbon atoms, creating chains, branches, and rings
Tetravalency	Carbon has 4 valence electrons and can form 4 covalent bonds
Hydrocarbon	Compound containing only carbon and hydrogen
Saturated hydrocarbon	Hydrocarbon with only single bonds between carbon atoms (alkanes)
Unsaturated hydrocarbon	Hydrocarbon with at least one double or triple bond (alkenes, alkynes)
Homologous series	Family of compounds with same general formula, differing by $-\text{CH}_2-$ per member
Functional group	Atom or group of atoms that determines the chemical properties of a compound
Isomers	Compounds with the same molecular formula but different structural arrangements
Esterification	Reaction between a carboxylic acid and an alcohol to form an ester + water
Saponification	Hydrolysis of ester (or fat) with NaOH to form soap + glycerol
Micelle	Spherical cluster of soap molecules in water that traps oil/grease inside
Hard water	Water containing dissolved calcium and magnesium salts

Solved Examples (NCERT-Based)

Example 1

Why does carbon form compounds mainly by covalent bonding?

Answer: Carbon has 4 valence electrons (electronic configuration 2, 4). To achieve a noble gas configuration, it would need to gain 4 electrons (too much energy for the nucleus to hold 10 electrons) or lose 4 electrons (too much energy needed to remove 4 electrons). Therefore, carbon shares electrons with other atoms to form covalent bonds — this is the most energy-efficient way to achieve stability.

Example 2

Why does ethene (C_2H_4) burn with a yellow, sooty flame while ethane (C_2H_6) burns with a clean blue flame?

Answer: Ethene is an unsaturated hydrocarbon (contains a C=C double bond) with a higher percentage of carbon relative to hydrogen. During combustion, there isn't enough oxygen to completely burn all the carbon — unburnt carbon particles glow yellow and deposit as soot. Ethane is saturated (only single bonds) with a lower carbon-to-hydrogen ratio, so it burns completely in air, producing a clean blue flame.

Example 3

How would you distinguish between ethanol and ethanoic acid without tasting them?

Answer: Add a pinch of sodium hydrogen carbonate (NaHCO_3) to each. Ethanoic acid (a carboxylic acid) will react with NaHCO_3 and produce brisk effervescence due to CO_2 gas: $\text{CH}_3\text{COOH} + \text{NaHCO}_3 \rightarrow \text{CH}_3\text{COONa} + \text{H}_2\text{O} + \text{CO}_2\uparrow$. Ethanol will NOT react with NaHCO_3 — no bubbles will appear. This is a simple and reliable chemical test.

Example 4

Why is the conversion of vegetable oil to vanaspati ghee considered unhealthy?

Answer: Vegetable oils are unsaturated fats (contain C=C double bonds) — they are generally healthier. During hydrogenation (addition of H_2 using Ni catalyst), the double bonds are converted to single bonds, turning the oil into a saturated fat (vanaspati ghee). Saturated fats increase LDL cholesterol, which can lead to heart disease and blocked arteries. Additionally, the process may create trans fats, which are particularly harmful.

Important Questions for Board Exams

1-Mark Questions

1. What is the general formula of alkenes?
2. Name the functional group present in ethanol.
3. What is the IUPAC name of CH_3COOH ?
4. Why does diamond have a high melting point even though it is a covalent compound?
5. What is glacial acetic acid?

2-Mark Questions

1. What is a homologous series? Give two characteristics.
2. Write the chemical equation for the reaction of ethanol with sodium.
3. Differentiate between saturated and unsaturated hydrocarbons with examples.
4. What is hydrogenation? What is its industrial application?
5. Why does soap form scum in hard water?

3-Mark Questions

1. Explain why carbon forms compounds mainly by covalent bonding. What are catenation and tetravalency?
2. Write the names and structural formulas of the first three members of the alkane homologous series.
3. What is esterification? Write the reaction with equation. How is this reaction reversed?
4. Describe the cleansing action of soap with a diagram of micelle formation.
5. List three chemical properties of ethanoic acid with equations.

5-Mark Questions

1. What are the chemical properties of carbon compounds? Explain combustion, oxidation, addition, and substitution reactions with examples.
 2. Compare soaps and detergents. Explain how soap cleans dirty clothes with a diagram.
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Quick Revision Points

- Carbon: atomic number 6, valence electrons 4, forms covalent bonds by sharing
 - Catenation = carbon chains/rings; Tetravalency = 4 bonds possible
 - Alkanes (C_nH_{2n+2}): single bonds, saturated; Alkenes (C_nH_{2n}): double bond; Alkynes (C_nH_{2n-2}): triple bond
 - Root words: meth(1), eth(2), prop(3), but(4), pent(5)
 - Functional groups: $-OH$ (alcohol, -ol), $-CHO$ (aldehyde, -al), $-COOH$ (acid, -oic acid), $>C=O$ (ketone, -one)
 - Homologous series: same general formula, differ by CH_2 , similar chemical properties
 - Saturated $\rightarrow$ clean blue flame; Unsaturated $\rightarrow$ yellow sooty flame
 - Ethanol + Na $\rightarrow$ Sodium ethoxide + H_2 ; Ethanol + conc. H_2SO_4 ($170^\circ C$) $\rightarrow$ Ethene + H_2O
 - Ethanoic acid + $NaHCO_3 \rightarrow$ brisk effervescence (CO_2) — key test for carboxylic acids
 - Esterification: Acid + Alcohol $\rightarrow$ Ester + Water (sweet fruity smell)
 - Saponification: Ester/Fat + NaOH $\rightarrow$ Soap + Glycerol
 - Soap molecule: hydrophobic tail (in oil) + hydrophilic head (in water) $\rightarrow$ forms micelle
 - Soap fails in hard water (scum forms); Detergents work in both hard and soft water
 - Hydrogenation: Vegetable oil + H_2 (Ni catalyst) $\rightarrow$ Vanaspati ghee (unhealthy saturated fat)
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Previous Chapter: Chapter 3 — Metals and Non-metals

Next Chapter: Chapter 5 — Life Processes



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