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Organic Chemistry Some Basic Principles and Techniques Class 11 Notes | CBSE Chemistry Chapter 11

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Organic Chemistry Some Basic Principles and Techniques Class 11 Notes | CBSE Chemistry Chapter 11

Organic Chemistry: Some Basic Principles and Techniques is Chapter 11 of CBSE Class 11 Chemistry — and it is the single most important gateway chapter you will study this year. Almost every reaction, name, and mechanism you meet later in Hydrocarbons, Haloalkanes, Alcohols, Aldehydes, and Biomolecules is built on the ideas introduced here. Get this chapter right and the entire ocean of organic chemistry suddenly starts making sense.

By the end of these notes you will be able to draw structures three different ways, classify and name any organic compound by IUPAC rules, identify every type of isomerism, predict how electrons move in a reaction using inductive, resonance, electromeric and hyperconjugation effects, tell a nucleophile from an electrophile, and describe the standard methods of purification and analysis. This is a high-weightage chapter carrying roughly 8–10 marks in boards and a guaranteed 2–3 questions in NEET and JEE.

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Key Concepts

1. Tetravalence of Carbon and Hybridisation

Carbon has the electronic configuration $1s^2 2s^2 2p^2$, giving it **four valence electrons**. To complete its octet it forms **four covalent bonds** — this property is called **tetravalence**, and it is why carbon builds endless chains, rings, and branches.

Carbon achieves tetravalence through **hybridisation** — mixing of atomic orbitals to form equivalent hybrid orbitals.

- **sp^3 hybridisation:** 4 σ -bonds, tetrahedral, bond angle 109.5° (e.g. CH_4 , all single bonds).
- **sp^2 hybridisation:** 3 σ -bonds + 1 π -bond, planar, bond angle 120° (e.g. C_2H_4 , a C=C double bond).
- **sp hybridisation:** 2 σ -bonds + 2 π -bonds, linear, bond angle 180° (e.g. C_2H_2 , a C $\equiv$ C triple bond).

Key idea: A σ -bond forms by head-on overlap and allows rotation; a π -bond forms by sideways overlap and restricts rotation, giving rise to geometrical isomerism.

2. Structural Representation of Organic Compounds

The same molecule can be drawn in three standard ways. Knowing all three is a common 1-mark trap in exams.

- **Complete (Lewis) structural formula:** every bond shown — e.g. ethane drawn with all 7 bonds.
- **Condensed formula:** bonds omitted to save space — CH_3CH_3 for ethane, $(\text{CH}_3)_2\text{CHCH}_3$ for isobutane.
- **Bond-line (zig-zag) formula:** carbons at the ends and bends of lines, hydrogens on carbon not shown — used widely for rings and long chains.

[DIAGRAM: Butane shown three ways — full Lewis structure, condensed $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$, and a zig-zag bond-line of three connected line segments.]

3. Classification of Organic Compounds

Organic compounds are first split into **acyclic (open-chain)** and **cyclic (closed-chain)** families.

- **Acyclic / aliphatic:** straight or branched chains (e.g. propane, isobutane).
- **Alicyclic:** carbon rings that are not aromatic (e.g. cyclohexane).
- **Aromatic:** contain benzene-like rings obeying Hückel's rule of $(4n+2)$ π -electrons (e.g. benzene, naphthalene).
- **Heterocyclic:** rings containing an atom other than carbon — N, O or S (e.g. pyridine, furan).

Functional Group and Homologous Series

A **functional group** is the atom or group of atoms that decides the chemical properties of a compound (e.g. $-\text{OH}$ in alcohols, $-\text{COOH}$ in acids). A **homologous series** is a family of compounds with the same functional group and general formula, where each member differs from the next by a $-\text{CH}_2-$ unit and 14 u of mass (e.g. the alkanes $\text{C}_n\text{H}_{2n+2}$).

4. IUPAC Nomenclature

The IUPAC name is built as **Prefix + Word Root + Primary Suffix + Secondary Suffix**. The word root tells the number of carbons in the longest chain (meth-, eth-, prop-, but-, pent-...); the primary suffix shows saturation ($-\text{ane}$, $-\text{ene}$, $-\text{yne}$); the secondary suffix names the functional group.

Rules for Naming

- Select the **longest continuous carbon chain** as the parent.
- **Number the chain** from the end that gives the lowest locants to the functional group, then to substituents (lowest-set rule).
- Name substituents alphabetically; use di, tri, tetra for repeats (these prefixes are ignored while alphabetising).

- The functional group gets the **lowest possible number**, taking priority over substituents.

Example: $\text{CH}_3\text{--CH}(\text{CH}_3)\text{--CH}_2\text{--OH}$ is named **2-methylpropan-1-ol**.

Priority Order of Functional Groups (highest first)

$\text{--COOH} > \text{--SO}_3\text{H} > \text{--COOR (ester)} > \text{--COCl} > \text{--CONH}_2 > \text{--CN} > \text{--CHO} > >\text{C=O} > \text{--OH} > \text{--NH}_2$.

5. Isomerism

Isomers are compounds with the same molecular formula but different structures or arrangements. Isomerism is split into two main branches.

Structural (Constitutional) Isomerism

- **Chain isomerism:** different carbon skeletons (n-butane vs isobutane).
- **Position isomerism:** functional group at different positions (propan-1-ol vs propan-2-ol).
- **Functional isomerism:** different functional groups (ethanol vs dimethyl ether, both $\text{C}_2\text{H}_6\text{O}$).
- **Metamerism:** different alkyl groups on either side of a functional group (diethyl ether vs methyl propyl ether).
- **Tautomerism:** dynamic interconversion of keto and enol forms.

Stereoisomerism

Same connectivity but different spatial arrangement — **geometrical (cis–trans)** isomerism due to restricted rotation about a $\text{C}=\text{C}$ bond, and **optical isomerism** due to a chiral (asymmetric) carbon.

6. Fission of Covalent Bonds

A covalent bond can break in two ways, and which one occurs decides the whole mechanism.

- **Homolytic fission:** the bond breaks evenly, each atom keeping one electron, producing neutral **free radicals** (shown with single-barbed half-arrows). Favoured by heat or light in non-polar solvents.
- **Heterolytic fission:** the bond breaks unevenly, the more electronegative atom taking both electrons, producing a **carbocation** (C^+) and an anion, or a **carbanion** (C^-). Favoured in polar solvents.

Stability order: carbocations $3^\circ > 2^\circ > 1^\circ > \text{CH}_3^+$; carbanions reverse this; free radicals $3^\circ > 2^\circ > 1^\circ$.

7. Nucleophiles and Electrophiles

Reagents attacking a substrate are of two kinds — and recognising them is a high-yield exam skill.

- **Nucleophile (Nu^-):** “nucleus-loving”, electron-rich, donates an electron pair. Examples: OH^- , CN^- , NH_3 , H_2O .

- **Electrophile (E^+):** "electron-loving", electron-deficient, accepts an electron pair. Examples: H^+ , NO_2^+ , carbocations, $AlCl_3$.

Electron movement is shown with curved arrows: a **full curved arrow** shows the shift of an electron *pair*, while a **half-headed (fish-hook) arrow** shows the shift of a single electron.

8. Electronic Displacement Effects

These four effects explain why molecules react where and how they do. They are the heart of every organic mechanism question.

(a) Inductive Effect (I)

A **permanent** shift of σ -bond electrons along a chain due to an electronegativity difference. It is transmitted through bonds and weakens after three carbons.

- **-I groups** (electron-withdrawing): $-NO_2$, $-CN$, $-COOH$, halogens.
- **+I groups** (electron-donating): alkyl groups ($-CH_3$, $-C_2H_5$).

(b) Resonance / Mesomeric Effect (M)

Delocalisation of π or lone-pair electrons across a conjugated system, shown by canonical (resonance) structures connected by a double-headed arrow $\leftrightarrow$. The real molecule is a **resonance hybrid**, more stable than any single structure (lower energy = resonance energy).

- **+M / +R groups** push electron density into the system: $-OH$, $-NH_2$, $-OR$, halogens.
- **-M / -R groups** withdraw electron density: $-NO_2$, $-CHO$, $-COOH$, $-CN$.

(c) Electromeric Effect (E)

A **temporary, complete** transfer of a π -electron pair that occurs *only in the presence of an attacking reagent* and reverses once the reagent is removed.

(d) Hyperconjugation

Delocalisation of $\sigma(C-H)$ electrons of an alkyl group into an adjacent empty p-orbital or π -bond — sometimes called "no-bond resonance". More α -hydrogens means more hyperconjugation, which is why carbocation and alkene stability rise with more alkyl groups.

9. Types of Organic Reactions

Organic reactions fall into four broad classes — knowing one example of each is worth easy marks.

Type	What Happens	Example
Substitution	One atom/group replaced by another	$\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$
Addition	Reagent adds across a multiple bond	$\text{CH}_2=\text{CH}_2 + \text{H}_2 \rightarrow \text{CH}_3\text{CH}_3$
Elimination	Atoms/groups removed to form a multiple bond	$\text{CH}_3\text{CH}_2\text{Br} \rightarrow \text{CH}_2=\text{CH}_2 + \text{HBr}$
Rearrangement	Atoms reorganise within the molecule	$1^\circ \text{ carbocation} \rightarrow \text{more stable } 3^\circ \text{ carbocation}$

Reactions are further classed by the attacking reagent as **nucleophilic**, **electrophilic**, or **free-radical**.

10. Methods of Purification of Organic Compounds

An organic compound must be pure before its structure can be studied. The method chosen depends on the nature and impurities of the compound.

Method	Principle	Used For
Crystallisation	Difference in solubility in a hot vs cold solvent	Solids (e.g. sugar, alum)
Sublimation	Solid $\rightarrow$ vapour directly on heating	Camphor, naphthalene, NH_4Cl
Simple distillation	Difference in boiling points (large gap)	Liquid + non-volatile impurity
Fractional distillation	Close boiling points separated via a fractionating column	Petroleum, acetone–water
Steam distillation	Steam carries a water-immiscible, steam-volatile compound	Aniline, essential oils
Differential extraction	Partition between two immiscible solvents	Compound in water extracted by ether
Chromatography	Differential adsorption / partition on a stationary phase	Mixtures of pigments, drugs

Chromatography has two main types: **adsorption** (column, TLC — based on differing adsorption on silica/alumina) and **partition** (paper — based on differing solubility between two phases). Purity is finally confirmed by a **sharp, fixed melting or boiling point**.

11. Qualitative Analysis

Qualitative analysis detects *which* elements are present besides C, H and O.

- **Carbon and hydrogen:** heating the compound with dry CuO turns C into CO₂ (turns lime water milky) and H into H₂O (turns anhydrous CuSO₄ blue).
- **Nitrogen, sulphur, halogens:** detected by **Lassaigne's test** — the compound is fused with sodium to convert covalent N, S, X into ionic NaCN, Na₂S, NaX, which are then identified by colour tests (Prussian blue for N, black PbS for S, AgX precipitate for halogen).

12. Quantitative Analysis

Quantitative analysis finds *how much* of each element is present, giving the percentage composition and hence the empirical formula.

- **Carbon and hydrogen (Liebig's method):** mass of CO₂ gives % C; mass of H₂O gives % H. $\%C = (12/44) \times (\text{mass CO}_2/\text{mass compound}) \times 100$.
- **Nitrogen:** Dumas method (measures N₂ gas volume) or Kjeldahl's method (converts N to (NH₄)₂SO₄, then NH₃ is titrated).
- **Halogens (Carius method):** compound is heated with fuming HNO₃ and AgNO₃; the AgX precipitate is weighed.
- **Sulphur (Carius):** oxidised to H₂SO₄ and precipitated as BaSO₄.

From the percentages we get the **empirical formula** (simplest whole-number ratio of atoms), and using the molar mass, the **molecular formula** (n × empirical formula).

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	8–10 marks	IUPAC naming, isomerism, inductive & resonance effects, purification methods
JEE Main / Advanced	2–3 questions	Carbocation stability, hyperconjugation, resonance, IUPAC of complex structures
NEET	2–3 questions	Electronic effects, nucleophile/electrophile identification, Lassaigne's test

[TABLE: Question-type split — VSA (1 mark): definitions, electrophile vs nucleophile, type of fission; SA (2–3 marks): IUPAC names, isomer counting, inductive/resonance comparison; LA (5 marks): purification methods, quantitative-analysis calculations, full electronic-effect explanation.]

Important Definitions

Term	Definition
Tetravalence	Carbon's ability to form four covalent bonds by sharing its four valence electrons
Functional group	Atom or group that determines the chemical behaviour of a compound (e.g. $-\text{OH}$, $-\text{COOH}$)
Homologous series	Family of compounds with the same functional group differing by $-\text{CH}_2-$ (14 u)
Isomers	Compounds with the same molecular formula but different structures/arrangements
Homolytic fission	Even bond breaking giving free radicals, each atom keeping one electron
Heterolytic fission	Uneven bond breaking giving a carbocation and an anion (or carbanion)
Nucleophile	Electron-rich species that donates an electron pair (e.g. OH^- , CN^-)
Electrophile	Electron-deficient species that accepts an electron pair (e.g. H^+ , NO_2^+)
Inductive effect	Permanent shift of σ -electrons along a chain due to electronegativity difference
Resonance	Delocalisation of π /lone-pair electrons giving a more stable resonance hybrid
Hyperconjugation	Delocalisation of $\sigma(\text{C}-\text{H})$ electrons into an adjacent p-orbital or π -bond
Empirical formula	Simplest whole-number ratio of atoms in a compound

Solved Examples

Example 1

Write the IUPAC name of $(\text{CH}_3)_2\text{CH}-\text{CH}_2-\text{CH}_2-\text{OH}$.

Answer: Longest chain = 4 carbons with $-\text{OH}$ on C1; a methyl branch sits on C3. Name = **3-methylbutan-1-ol**.

Example 2

Identify the type of isomerism between ethanol ($\text{C}_2\text{H}_5\text{OH}$) and dimethyl ether (CH_3OCH_3).

Answer: Both have the molecular formula $\text{C}_2\text{H}_6\text{O}$ but different functional groups ($-\text{OH}$ vs $-\text{O}-$), so they are **functional isomers**.

Example 3

Arrange the carbocations CH_3^+ , CH_3CH_2^+ , $(\text{CH}_3)_2\text{CH}^+$ and $(\text{CH}_3)_3\text{C}^+$ in increasing order of stability.

Answer: Stability increases with +I effect and hyperconjugation, so: $\text{CH}_3^+ < \text{CH}_3\text{CH}_2^+ < (\text{CH}_3)_2\text{CH}^+ < (\text{CH}_3)_3\text{C}^+$ (methyl $< 1^\circ < 2^\circ < 3^\circ$).

Example 4

A compound contains 40% carbon and 6.7% hydrogen, the rest being oxygen. Find its empirical formula.

Answer: O = 100 – 40 – 6.7 = 53.3%. Moles: C = 40/12 = 3.33, H = 6.7/1 = 6.7, O = 53.3/16 = 3.33. Ratio ($\div 3.33$) = 1 : 2 : 1. Empirical formula = CH_2O .

Example 5

In Lassaigne's test, the appearance of a Prussian blue colour indicates the presence of which element?

Answer: Nitrogen. Sodium fusion gives NaCN, which forms ferric ferrocyanide (Prussian blue) with $\text{Fe}^{2+}/\text{Fe}^{3+}$ ions.

Example 6

Classify each as nucleophile or electrophile: OH^- , NO_2^+ , NH_3 , BF_3 .

Answer: OH^- — nucleophile; NO_2^+ — electrophile; NH_3 — nucleophile (lone pair on N); BF_3 — electrophile (electron-deficient boron).

Important Questions for Board Exams

1-Mark Questions (VSA)

1. Define the inductive effect.
2. What is the difference between a nucleophile and an electrophile? Give one example of each.
3. Name the type of bond fission that produces free radicals.
4. Write the IUPAC name of $(\text{CH}_3)_3\text{CH}$.
5. What is a homologous series?

2–3-Mark Questions (SA)

1. Distinguish between homolytic and heterolytic fission with one example each.
2. Explain hyperconjugation and how it stabilises a carbocation.
3. Write all the structural isomers of C_4H_{10} and name them.
4. Describe Lassaigne's test for the detection of nitrogen in an organic compound.
5. Differentiate between inductive and resonance effects.

5-Mark Questions (LA)

1. Explain the principle and procedure of (a) crystallisation and (b) steam distillation, with one example of a compound purified by each.
 2. Describe the four electronic displacement effects (inductive, resonance, electromeric, hyperconjugation) with suitable examples.
 3. An organic compound on analysis gave C = 54.5%, H = 9.1% and O = 36.4%. Its molar mass is 88 g/mol. Determine its empirical and molecular formula.
-

Quick Revision Points

- Carbon is tetravalent; sp^3 (109.5°), sp^2 (120°), sp (180°) hybridisation
 - Three ways to draw structures: complete, condensed, bond-line
 - Classification: acyclic, alicyclic, aromatic, heterocyclic; homologous series differ by $-CH_2-$ (14 u)
 - IUPAC name = prefix + word root + primary suffix + secondary suffix; functional group gets the lowest locant
 - Structural isomerism: chain, position, functional, metamerism, tautomerism; stereoisomerism: geometrical & optical
 - Homolytic fission $\rightarrow$ free radicals; heterolytic fission $\rightarrow$ carbocation + anion
 - Nucleophile = electron-rich donor; electrophile = electron-poor acceptor
 - Inductive (permanent, through σ -bonds), resonance (delocalised π /lone pairs), electromeric (temporary, on reagent), hyperconjugation (σ C-H delocalisation)
 - Reaction types: substitution, addition, elimination, rearrangement
 - Purification: crystallisation, sublimation, distillation (simple/fractional/steam), extraction, chromatography
 - Lassaigne's test detects N, S, halogens; Liebig's, Dumas, Kjeldahl, Carius for quantitative analysis
 - Empirical formula = simplest ratio; molecular formula = $n \times$ empirical formula
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Next Chapter: Chapter 13 — Hydrocarbons



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