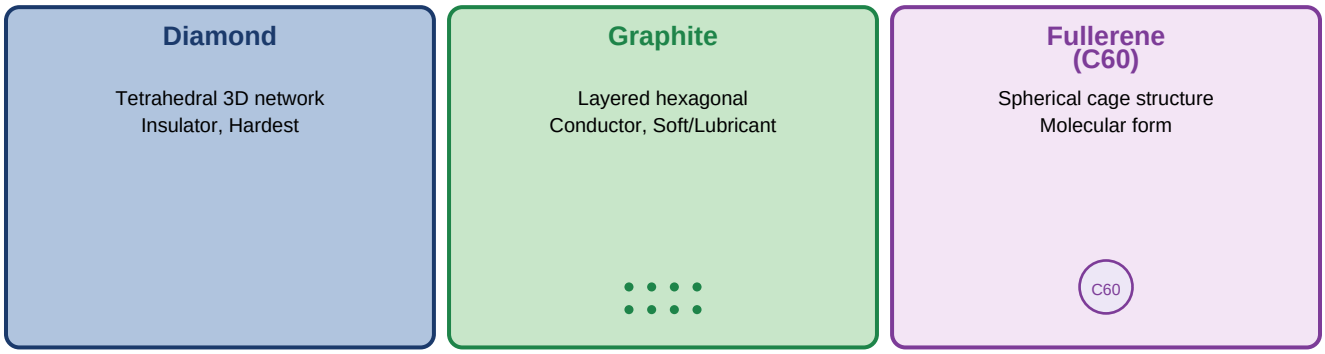
CHAPTER 4

# Carbon and its Compounds

Class 10 Science – NCERT Exemplar | Complete Study Guide


## KEY TERMS / GLOSSARY

| | |
|---|---|
| **Catenation** | Ability of carbon to form long chains by bonding with other carbon atoms. |
| **Tetravalency** | Carbon has 4 valence electrons — forms exactly 4 covalent bonds. |
| **Saturated hydrocarbon** | Contains only C–C single bonds. General formula CnH(2n+2). e.g. alkanes. |
| **Unsaturated hydrocarbon** | Contains C=C double or C≡C triple bonds. e.g. alkenes, alkynes. |
| **Functional group** | Atom/group giving organic compound its characteristic properties. e.g. –OH, –COOH, –CHO. |
| **Homologous series** | Series of compounds with same functional group, differing by –CH2– (14 mass units). |
| **Isomers** | Compounds with same molecular formula but different structural formulae. |
| **Esterification** | Reaction of carboxylic acid + alcohol → ester + water (H2SO4 catalyst). |
| **Saponification** | Hydrolysis of ester with strong base (NaOH) → carboxylate salt + alcohol. |
| **Hydrogenation** | Addition of H2 to unsaturated compound (alkene/alkyne) using Ni/Pd catalyst. |
| **Substitution reaction** | H atom in saturated hydrocarbon replaced by another atom (e.g. Cl) in sunlight. |
| **Micelle** | Spherical cluster of soap molecules: ionic heads outside (water), carbon tails inside (oil). |
| **Allotrope** | Different structural forms of the same element. Carbon allotropes: diamond, graphite, fullerene. |
| **Heteroatom** | Atom other than C and H in an organic compound. e.g. O, N, Cl, S. |

## FUNCTIONAL GROUPS REFERENCE TABLE

| Functional Group | Name | Suffix | Example |
|---|---|---|---|
| –OH | Hydroxyl (Alcohol) | -ol | Ethanol CH3CH2OH |
| –CHO | Aldehyde | -al | Ethanal CH3CHO |
| C=O (middle) | Ketone | -one | Propanone CH3COCH3 |
| –COOH | Carboxylic acid | -oic acid | Ethanoic acid CH3COOH |
| –COO– (ester link) | Ester | -oate | Methyl ethanoate CH3COOCH3 |
| –Cl, –Br | Haloalkane | chloro-/bromo- | Chloromethane CH3Cl |

## SECTION A: MULTIPLE CHOICE QUESTIONS (Q1–Q29)

✓ ***Green*** = *Correct* | ✗ ***Red*** = *Incorrect*

### Q1.

**Carbon exists in the atmosphere in the form of:**

✗ **(a)** Carbon monoxide only

✓ **(b)** Carbon monoxide in traces and carbon dioxide

✗ **(c)** Carbon dioxide only

✗ **(d)** Coal

**✓ CORRECT ANSWER: (b)**

Carbon in atmosphere = $CO_2$ (main form, 0.04%) + CO in traces (from incomplete combustion).

Coal is a solid form — not present in atmosphere as such.

$CO_2$ is absorbed by plants during photosynthesis and released during respiration/combustion.

### Q2.

**Correct statements for carbon compounds?**
**(i) Good conductors (ii) Poor conductors (iii) Strong intermolecular forces (iv) Weak intermolecular forces**

✗ **(a)** (i) and (iii)

✗ **(b)** (ii) and (iii)

✗ **(c)** (i) and (iv)

✓ **(d)** (ii) and (iv)

**✓ CORRECT ANSWER: (d) (ii) and (iv)**

Carbon compounds are COVALENT — no free electrons → POOR conductors of electricity.

Covalent molecules have WEAK intermolecular forces (van der Waals) → low melting/boiling points.

Exception: Graphite has free electrons → conducts electricity.

Ionic compounds have strong forces; covalent compounds have weak forces.

## Q3.

**Ammonia (NH3) has:**

✓ **(a)** Only single bonds

✗ **(b)** Only double bonds

✗ **(c)** Only triple bonds

✗ **(d)** Two double bonds and one single bond

**✓ CORRECT ANSWER: (a) Only single bonds**

$NH_3$: N has 3 single bonds with 3 H atoms. N–H bonds are all SINGLE covalent bonds.

N has 1 lone pair of electrons (not bonded).

Structure: H–N–H with H below, bond angle ≈ 107°.

## Q4.

**Buckminsterfullerene is an allotropic form of:**

✗ **(a)** Phosphorus

✗ **(b)** Sulphur

✓ **(c)** Carbon

✗ **(d)** Tin

**✓ CORRECT ANSWER: (c) Carbon**

Buckminsterfullerene ($C_{60}$) is an allotrope of carbon — spherical cage of 60 carbon atoms.

Carbon allotropes: Diamond (3D tetrahedral network), Graphite (layered hexagons), Fullerene (C60 sphere).

Named after architect Buckminster Fuller whose geodesic dome it resembles.

## Q5.

**Which are correct structural isomers of butane (C4H10)?**
**(i) n-butane (straight chain) (ii) isobutane (branched) (iii) methylpropane (iv) cyclobutane (ring)**

✗ **(a)** (i) and (iii)

✗ **(b)** (ii) and (iv)

✓ **(c)** (i) and (ii)

✗ **(d)** (iii) and (iv)

**✓ CORRECT ANSWER: (c) (i) and (ii)**

Butane $C_4H_{10}$ has TWO structural isomers:

(i) n-Butane: $CH_3–CH_2–CH_2–CH_3$ (straight chain, 4 carbons in a row)

(ii) Isobutane (2-methylpropane): $CH_3–CH(CH_3)–CH_3$ (branched)

(iii) and (iv) are the same as (i) and (ii) respectively — not additional isomers.

## Q6.

**CH3–CH2–OH → (Alkaline KMnO4 + Heat) → CH3–COOH. KMnO4 acts as:**

✗ **(a)** Reducing agent

✓ **(b)** Oxidising agent

✗ **(c)** Catalyst

✗ **(d)** Dehydrating agent

**✓ CORRECT ANSWER: (b) Oxidising agent**

Ethanol ($CH_3CH_2OH$) → Ethanoic acid ($CH_3COOH$): this is OXIDATION.

$KMnO_4$ is a powerful oxidising agent — it provides oxygen to oxidise the alcohol.

$KMnO_4$ itself gets reduced (purple → colourless).

The alcohol gains oxygen → ethanoic acid is formed.

## Q7.

**Oils + H2 (Pd or Ni catalyst) → fats. This is an example of:**

✓ **(a)** Addition reaction

✗ **(b)** Substitution reaction

✗ **(c)** Displacement reaction

✗ **(d)** Oxidation reaction

**✓ CORRECT ANSWER: (a) Addition reaction**

Oils have C=C double bonds (unsaturated). $H_2$ is ADDED across the double bond → saturated fats.

C=C + $H_2$ → C–C (Ni/Pd catalyst needed)

This is called HYDROGENATION — used industrially to make vanaspati from vegetable oils.

Addition reaction: small molecule adds to double/triple bond → saturated product.

## Q8.

**In which compound is –OH the functional group?**

✗ **(a)** Butanone — C=O ketone group (–CO–)

✓ **(b)** Butanol — hydroxyl/alcohol group

✗ **(c)** Butanoic acid — –COOH carboxylic acid

✗ **(d)** Butanal — –CHO aldehyde group

**✓ CORRECT ANSWER: (b) Butanol**

Butanol ($C_4H_9OH$) belongs to the alcohol family — functional group = –OH (hydroxyl).

Butanone: –CO– (ketone). Butanoic acid: –COOH. Butanal: –CHO.

## Q9.

**The soap molecule has a:**

✓ **(a)** Hydrophilic head and hydrophobic tail

✗ **(b)** Hydrophobic head and hydrophilic tail

✗ **(c)** Hydrophobic head and hydrophobic tail

✗ **(d)** Hydrophilic head and hydrophilic tail

**✓ CORRECT ANSWER: (a)**

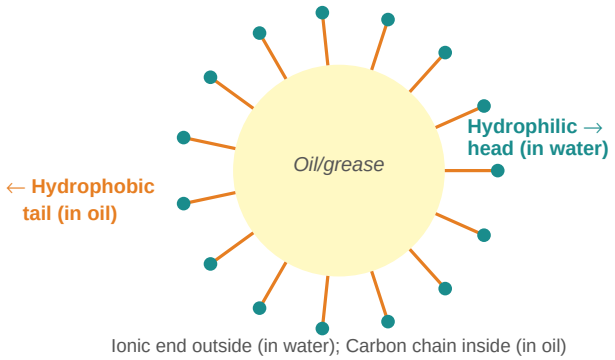
Soap molecule = long hydrocarbon chain (tail) + ionic/carboxylate group (head).

**Head:** $-COO^-Na^+$ (ionic) = HYDROPHILIC (water-loving) → dissolves in water.

**Tail:** long $-CH_2-$ chain = HYDROPHOBIC (water-fearing) → dissolves in oil/grease.

In micelle: tails point inward (into oil), heads point outward (into water).

**Soap Micelle Structure**




Ionic end outside (in water); Carbon chain inside (in oil)

## Q10.

**Correct electron dot structure of nitrogen (N2)?**

✗ **(a)** :N: :N: (single bond — N needs triple bond)

✗ **(b)** :N::N: (double bond — N needs triple bond)

✓ **(c)** :N:::N: (triple bond — correct)

✗ **(d)** N:::N: (no lone pair shown on first N)

**✓ CORRECT ANSWER: (c) :N:::N: (triple bond)**

N has 5 valence electrons. To complete octet: shares 3 electrons → triple bond.

$N_2$: N≡N — one triple bond (3 shared pairs) + 1 lone pair on each N.

Electron dot: :N■■■N: (each N has 1 lone pair + shares 3 bond pairs).

## Q11.

**Structural formula of ethyne (C2H2):**

✓ **(a)** H–C≡C–H (triple bond between carbons)

✗ **(b)** H3–C≡C–H (H3 is wrong, ethyne has 1H on each C)

✗ **(c)** H2C=CH2 (this is ethene, double bond)

✗ **(d)** H3C–CH3 (this is ethane, single bond)

**✓ CORRECT ANSWER: (a) H–C≡C–H**

Ethyne (acetylene) = $C_2H_2$ — first member of alkyne series.

Has a TRIPLE bond between two carbons: H–C≡C–H

Each C bonded to 1 H and has 3 bonds to other C → total 4 bonds per C.

Used in welding (oxyacetylene flame) and in synthesis.

## Q12.

**Identify unsaturated compounds:**
**(i) Propane (ii) Propene (iii) Propyne (iv) Chloropropane**

✗ **(a)** (i) and (ii)

✗ **(b)** (ii) and (iv)

✗ **(c)** (iii) and (iv)

✓ **(d)** (ii) and (iii)

**✓ CORRECT ANSWER: (d) (ii) and (iii)**

UNSATURATED = contains C=C double bond OR C≡C triple bond.

(i) Propane ($C_3H_8$) — all single bonds → SATURATED.

(ii) Propene ($C_3H_6$) — C=C double bond → UNSATURATED ✓

(iii) Propyne ($C_3H_4$) — C≡C triple bond → UNSATURATED ✓

(iv) Chloropropane — all single bonds, Cl substituted → SATURATED.

## Q13.

**Chlorine reacts with saturated hydrocarbons at room temperature in the:**

✗ **(a)** Absence of sunlight — no reaction without light

✓ **(b)** Presence of sunlight

✗ **(c)** Presence of water

✗ **(d)** Presence of HCl

**✓ CORRECT ANSWER: (b) Presence of sunlight**

Saturated hydrocarbons + $Cl_2$ → SUBSTITUTION reaction (requires sunlight/UV light).

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (in presence of sunlight)

Sunlight provides energy to break the Cl–Cl bond (photolytic cleavage).

Without sunlight, $Cl_2$ does NOT react with saturated hydrocarbons.

## Q14.

**In soap micelles:**

✓ **(a)** Ionic end on surface (outside); carbon chain in interior

✗ **(b)** Ionic end inside; carbon chain outside

✗ **(c)** Both ionic end and carbon chain inside

✗ **(d)** Both ionic end and carbon chain outside

**✓ CORRECT ANSWER: (a)**

Soap micelle: spherical cluster formed in water.

IONIC (hydrophilic) end = outside, pointing toward water.

CARBON CHAIN (hydrophobic) tail = inside, pointing toward oil/grease.

This structure allows soap to surround oil droplets — oil trapped inside, water outside.

## Q15.

**Pentane ($C_5H_{12}$) has how many covalent bonds?**

✗ **(a)** 5 bonds

✗ **(b)** 12 bonds

✓ **(c)** 16 covalent bonds

✗ **(d)** 17 covalent bonds

**✓ CORRECT ANSWER: (c) 16 covalent bonds**

Pentane: $C_5H_{12}$

C–C bonds: 4 (connecting 5 carbons in chain)

C–H bonds: 12 (each H makes 1 bond)

Total = 4 + 12 = **16 covalent bonds**

Formula: For CnH(2n+2) alkanes: bonds = (n-1) + (2n+2) = 3n+1. For n=5: 16 ✓

## Q16.

**Structural formula of benzene ($C_6H_6$)?**

**✓ CORRECT ANSWER: (c) — Benzene structure with alternating double bonds**

Benzene = $C_6H_6$ — hexagonal ring of 6 carbons with alternating single and double bonds.

Each C bonded to 1 H and 2 other C atoms in the ring.

Correct structure: hexagon with alternating C=C and C–C bonds (3 double, 3 single).

Actually, all bonds are equivalent (resonance/delocalized) — shown as circle inside hexagon.

## Q17.

**Ethanol reacts with sodium → two products are:**

✗ **(a)** Sodium ethanoate and hydrogen

✗ **(b)** Sodium ethanoate and oxygen

✓ **(c)** Sodium ethoxide and hydrogen

✗ **(d)** Sodium ethoxide and oxygen

**✓ CORRECT ANSWER: (c) Sodium ethoxide and hydrogen**

$2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2\uparrow$

Product 1: Sodium ethoxide ($C_2H_5ONa$) — NOT sodium ethanoate.

Product 2: Hydrogen gas ($H_2$) — not oxygen.

Na replaces the H of the –OH group. Reaction is gentler than Na + water.

## Q18.

**Correct structural formula of butanoic acid ($C_3H_7COOH$)?**

✓ **CORRECT ANSWER: (d) — 4-carbon chain with –COOH at end**

Butanoic acid = $CH_3–CH_2–CH_2–COOH$

4 carbon atoms total (including carboxyl carbon), with –COOH at one end.

Key: Carbon chain is all single bonds (C–C), terminal –C(=O)–OH group.

(a) Wrong — has C=C double bond inside chain (unsaturated).

(b) Wrong — 5 carbons (pentanoic acid).

(c) Wrong — no carboxyl group (it's an alcohol).

## Q19.

**Vinegar is a solution of:**

✗ **(a)** 50-60% acetic acid in alcohol

✗ **(b)** 5-8% acetic acid in alcohol

✓ **(c)** 5–8% acetic acid in water

✗ **(d)** 50-60% acetic acid in water

✓ **CORRECT ANSWER: (c) 5–8% acetic acid in water**

Vinegar = dilute solution of acetic acid (ethanoic acid) in WATER.

Concentration: 5–8% (w/v) acetic acid.

Used as condiment and preservative in food.

Pure acetic acid = 'glacial acetic acid' (100% — freezes at 16.7°C).

## Q20.

**Mineral acids stronger than carboxylic acids because:**
**(i) mineral acids completely ionised (ii) carboxylic acids completely ionised**
**(iii) mineral acids partially ionised (iv) carboxylic acids partially ionised**

✓ **(a)** (i) and (iv)

✗ **(b)** (ii) and (iii)

✗ **(c)** (i) and (ii)

✗ **(d)** (iii) and (iv)

✓ **CORRECT ANSWER: (a) (i) and (iv)**

Mineral acids (HCl, $H_2SO_4$, $HNO_3$) = COMPLETELY ionise → high $H^+$ concentration → STRONG.

Carboxylic acids ($CH_3COOH$) = PARTIALLY ionise → low $H^+$ → WEAK acid.

More $H^+$ ions = stronger acid = lower pH.

## Q21.

**Carbon forms 4 covalent bonds with 4 H atoms. After bonding, C attains electronic configuration of:**

✗ **(a)** Helium (2 electrons — Period 1)

✓ **(b)** Neon (10 electrons — Period 2)

✗ **(c)** Argon (18 electrons — Period 3)

✗ **(d)** Krypton (36 electrons — Period 4)

**✓ CORRECT ANSWER: (b) Neon**

Carbon: atomic number 6, configuration 2, 4 (4 valence electrons).

After sharing 4 bonds with 4 H atoms: 4 + 4 = 8 electrons in outer shell.

C with 4 shared pairs: 2 inner + 8 outer = 10 total = configuration of NEON.

Octet rule satisfied: 8 electrons in outer shell.

## Q22.

**Correct electron dot structure of water molecule?**

**✓ CORRECT ANSWER: (c) H:Ö:H — with 2 lone pairs on O**

Water: O has 6 valence electrons. Forms 2 bonds with 2 H atoms.

After bonding: O has 2 bond pairs (with H) + 2 lone pairs.

Correct dot structure: H–O–H with 2 dots (lone pairs) above/below O.

Key: oxygen must show 2 lone pairs AND 2 bonds to H atoms.

## Q23.

**Which is NOT a straight chain hydrocarbon?**

✗ **(a)** H3C–CH2–CH2–CH2–CH2 with CH3 branch — has branch!

✗ **(b)** H3C–CH2–CH2–CH2–CH2–CH3 — hexane, straight chain

✗ **(c)** Has CH3 branch — branched!

✓ **(d)** (CH3)2>CH–CH2–CH2–CH3 — 2 methyl groups on first C

**✓ CORRECT ANSWER: (d) [the one with branching at first carbon]**

Straight chain = all carbons in one continuous chain (no branches).

Option (a) and (c) also have branches — but (d) is the most clearly branched (2-methylpentane or similar).

Key test: if any carbon has MORE than 2 carbon neighbours (except ends), it is branched.

## Q24.

**Which are unsaturated hydrocarbons?**

**(i) H3C–CH2–CH2–CH3 (ii) H3C–C≡C–CH3 (iii) H3C–CH(CH3)–CH3 (iv) H3C–C(CH3)=CH2**

✗ **(a)** (i) and (iii)

✗ **(b)** (ii) and (iii)

✓ **(c)** (ii) and (iv)

✗ **(d)** (iii) and (iv)

**✓ CORRECT ANSWER: (c) (ii) and (iv)**

(i) $H_3C–CH_2–CH_2–CH_3$ = Butane — all single bonds → SATURATED

(ii) $H_3C–C≡C–CH_3$ = But-2-yne — TRIPLE bond → UNSATURATED ✓

(iii) $H_3C–CH(CH_3)–CH_3$ = Isobutane — all single bonds → SATURATED

(iv) $H_3C–C(CH_3)=CH_2$ = Isobutene — DOUBLE bond → UNSATURATED ✓

## Q25.

**Which does NOT belong to the same homologous series?**

✗ **(a)** CH4 — alkane, CnH(2n+2)

✗ **(b)** C2H6 — alkane

✗ **(c)** C3H8 — alkane

✓ **(d)** C4H8 — this is an ALKENE, not alkane!

**✓ CORRECT ANSWER: (d) C4H8**

$CH_4$, $C_2H_6$, $C_3H_8$ all follow CnH(2n+2) — the ALKANE series.

$C_4H_8$ follows CnH(2n) — the ALKENE series (has a double bond).

$C_4H_8$ would be butene, NOT butane ($C_4H_{10}$).

Homologous series: same general formula, same functional group, differ by $CH_2$.

## Q26.

**Name of compound CH3–CH2–CHO:**

✓ **(a)** Propanal

✗ **(b)** Propanone

✗ **(c)** Ethanol

✗ **(d)** Ethanal

**✓ CORRECT ANSWER: (a) Propanal**

$CH_3–CH_2–CHO$: 3 carbons + aldehyde functional group (–CHO) at end.

3 carbons → prop- prefix. Aldehyde → -al suffix. So: PROPANAL.

Ethanal would be $CH_3–CHO$ (2 carbons). Propanone ($CH_3COCH_3$) is a ketone.

## Q27.

**Heteroatoms in CH3–CH2–O–CH2–CH2Cl?**
**(i) Oxygen (ii) Carbon (iii) Hydrogen (iv) Chlorine**

✗ **(a)** (i) and (ii) — carbon is NOT a heteroatom in organic compounds

✗ **(b)** (ii) and (iii)

✗ **(c)** (iii) and (iv)

✓ **(d)** (i) and (iv)

**✓ CORRECT ANSWER: (d) (i) and (iv) — Oxygen and Chlorine**

Heteroatom = any atom OTHER than C and H in an organic compound.

In $CH_3–CH_2–O–CH_2–CH_2Cl$:

O (oxygen) = heteroatom — part of ether linkage (–O–).

Cl (chlorine) = heteroatom — haloalkane.

C and H are the main atoms in organic compounds — NOT heteroatoms.

## Q28.

**Which represents saponification reaction?**

✗ **(a)** CH3COONa + NaOH → CH4 + Na2CO3 — this is decarboxylation

✗ **(b)** CH3COOH + C2H5OH → CH3COOC2H5 + H2O — esterification

✗ **(c)** 2CH3COOH + 2Na → 2CH3COONa + H2 — acid+metal reaction

✓ **(d)** CH3COOC2H5 + NaOH → CH3COONa + C2H5OH

**✓ CORRECT ANSWER: (d)**

Saponification = hydrolysis of an ESTER using a strong BASE (NaOH).

$CH_3COOC_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$

Products: sodium salt of carboxylic acid + alcohol.

This is how soap is made (saponification of fats/oils with NaOH).

## Q29.

**First member of alkyne homologous series is:**

✓ **(a)** Ethyne (C2H2)

✗ **(b)** Ethene — alkene series, not alkyne

✗ **(c)** Propyne — 2nd member of alkyne

✗ **(d)** Methane — alkane series

**✓ CORRECT ANSWER: (a) Ethyne (C2H2)**

Alkyne series: C≡C triple bond, general formula CnH(2n-2).

First member: Ethyne ($C_2H_2$) — H–C≡C–H.

Methyne (C1) would be H–C≡ which is not stable → alkynes start from C2.

Alkene starts from ethene (C2); Alkyne starts from ethyne (C2).

## SECTION B: SHORT ANSWER QUESTIONS (Q30–Q46)

### Q30.

**Draw electron dot structure of ethyne and its structural formula:**

**✓ Answer 30 — Ethyne ($C_2H_2$)**

Molecular formula: $C_2H_2$

**Structural formula:** H–C≡C–H (each C bonded to 1H and triple-bonded to other C)

**Electron dot structure:**

H : C ■■■ C : H

(Each carbon shares 3 electron pairs in triple bond + 1 pair with H)

Carbon in ethyne is sp-hybridised. Bond angle = 180° (linear molecule).

### Q31.

**Name the following compounds:**

| Structure | Name | Reasoning |
|---|---|---|
| (a) H–C5H10–C(=O)–OH [5C + COOH] | Pentanoic acid | 5 carbons (pent) + carboxylic acid (-oic acid) |
| (b) H–C3H6–C≡C–H [3C chain + alkyne] | Butyne | 4 carbons total + triple bond (-yne) |
| (c) H–C7H14–C=O [7C + aldehyde] | Heptanal | 7 carbons + aldehyde (-al) |
| (d) H–C5H11–OH [5C + alcohol] | Pentanol | 5 carbons + hydroxyl group (-ol) |

### Q32.

**Identify and name functional groups:**

| Compound | Functional Group | Name |
|---|---|---|
| (a) 3C chain with –OH at end | –OH | Hydroxyl group (Alcohol) |
| (b) 3C chain with –COOH at end | –COOH | Carboxyl group (Carboxylic acid) |
| (c) 5C chain with C=O in middle | C=O (middle chain) | Ketone group |
| (d) 4C chain with C=C double bond | C=C | Alkene (unsaturation) |

### Q33.

**Carboxylic acid C2H4O2 + alcohol → ester X. Alcohol oxidised by alkaline KMnO4 gives same carboxylic acid. Identify acid, alcohol, ester X:**

**✓ Answer 33**

**Carboxylic acid (C2H4O2):** Molecular formula $C_2H_4O_2$ = **Acetic acid (Ethanoic acid) $CH_3COOH$**

Structure: $CH_3$–COOH

**Alcohol:** When oxidised by alkaline $KMnO_4$, gives same acid (acetic acid) → alcohol must be **Methanol ($CH_3OH$)**

$CH_3OH \rightarrow [KMnO_4] \rightarrow$ HCOOH (formic acid) — wait, that gives formic not acetic.

Actually: Ethanol ($CH_3CH_2OH$) → $[KMnO_4] \rightarrow CH_3COOH$ (acetic acid) ✓

**Alcohol = Methanol gives formic acid. Ethanol gives acetic acid.**

**Alcohol = Methanol ($CH_3OH$)**

**Compound X (ester) = Methyl ethanoate ($CH_3COOCH_3$)**

Reaction: $CH_3COOH + CH_3OH \rightarrow (H_2SO_4) \rightarrow CH_3COOCH_3 + H_2O$

## Q34.

**Why are detergents better cleansing agents than soaps?**

**✓ Answer 34**

Soaps are sodium/potassium salts of fatty acids ($–COO^-Na^+$).

Detergents are synthetic compounds (sulphonate/sulphate salts).

**Why detergents are better:**

1. Detergents work in HARD WATER — do NOT form scum (insoluble Ca/Mg salts).
2. Soaps react with $Ca^{2+}/Mg^{2+}$ in hard water → insoluble scum → waste soap.
3. Detergents work in ACIDIC media; soaps form free fatty acids in acid (don't lather).
4. Detergents have stronger, more stable lather.

**Disadvantage of detergents:** Non-biodegradable → causes water pollution.

## Q35.

**Name functional groups in:**

| Compound | Functional Group |
|---|---|
| (a) CH3COCH2CH2CH2CH3 | Ketone group (–CO– or C=O in chain) |
| (b) CH3CH2CH2COOH | Carboxylic acid group (–COOH) |
| (c) CH3CH2CH2CH2CHO | Aldehyde group (–CHO at terminal C) |
| (d) CH3CH2OH | Hydroxyl group (–OH); Alcohol |

## Q36.

**How is ethene prepared from ethanol? Give reaction:**

**✓ Answer 36 — Dehydration of Ethanol**

Process: DEHYDRATION (removal of water) using excess conc. $H_2SO_4$ at 443K (170°C).

**Reaction:**

$CH_3CH_2OH \rightarrow (\text{conc. } H_2SO_4, 443K) \rightarrow CH_2{=}CH_2 + H_2O$

$H_2SO_4$ acts as DEHYDRATING AGENT — removes water (H and OH).

This converts saturated ethanol to unsaturated ethene.

Ethene ($CH_2{=}CH_2$) is a gas used in fruit ripening and plastic manufacturing.

## Q37.

**Intake of small quantity of methanol can be lethal. Comment:**

### ✓ Answer 37

Methanol ($CH_3OH$) is HIGHLY TOXIC — even small amounts can cause death or blindness.

**What happens in the body:**

Methanol is oxidised by liver enzyme to **methanal (formaldehyde, HCHO)**.

Methanal rapidly reacts with cellular proteins → **coagulates protoplasm**.

It specifically attacks the OPTIC NERVE → permanent BLINDNESS.

As little as 10 mL can cause blindness; 30 mL can be fatal.

This is why industrial alcohol (denatured alcohol) is made toxic by adding methanol.

## Q38.

**Gas evolved when ethanol reacts with sodium. Name gas and write equation:**

### ✓ Answer 38

**Gas evolved = Hydrogen ($H_2$)**

**Balanced equation:**

$2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2\uparrow$

Na replaces the hydrogen of the –OH group in ethanol.

Products: Sodium ethoxide ($C_2H_5ONa$) + Hydrogen gas.

**Test for $H_2$:** Burns with 'pop' sound when burning splinter brought near.

Note: Reaction with Na is much gentler than Na + water.

## Q39.

**Ethanol + excess conc. H2SO4 at 443K → ethene. Role of H2SO4? Equation?**

### ✓ Answer 39

**Role of $H_2SO_4$: DEHYDRATING AGENT**

$H_2SO_4$ removes a water molecule (H from –OH and OH group) from ethanol.

It also acts as a catalyst for the elimination reaction.

**Balanced equation:**

$CH_3CH_2OH \rightarrow$ (excess conc. $H_2SO_4$, 443K) $\rightarrow CH_2{=}CH_2 + H_2O$

Excess $H_2SO_4$ ensures dehydration (not esterification).

At lower temperature (413K) with less acid → diethyl ether forms instead.

## Q40.

**Carbon (Group 14) forms compounds with:**
**(a) Chlorine (Group 17) (b) Oxygen (Group 16)**

### ✓ Answer 40

**(a) Carbon + Chlorine:** $CCl_4$ (Carbon tetrachloride / tetrachloromethane)

C shares 4 electrons with 4 Cl atoms. Tetrahedral shape, covalent compound.

Other examples: $CHCl_3$ (chloroform), $CH_3Cl$ (chloromethane)

**(b) Carbon + Oxygen:** $CO_2$ (Carbon dioxide) or CO (Carbon monoxide)

$CO_2$: O=C=O (two double bonds). Linear molecule.

CO: C≡O (triple bond). Toxic gas.

## Q41.

**Chlorine atomic number=17. (a) Write electron configuration. (b) Draw electron dot structure of Cl2.**

### ✓ Answer 41

**(a) Electronic configuration of Cl (at. no. 17):**

K=2, L=8, M=7 (or 2,8,7)

7 valence electrons in outermost shell.

**(b) Electron dot structure of Cl2:**

:Cl:–:Cl: (each Cl has 3 lone pairs + shares 1 bond pair)

Cl has 7 valence electrons. Shares 1 with another Cl → single covalent bond.

After bonding: each Cl has 8 electrons (3 lone pairs + 1 bond pair) = octet satisfied.

## Q42.

**Compare ability of catenation between carbon and silicon:**

### ✓ Answer 42

**Catenation = ability to bond with own atoms to form chains/rings.**

**Carbon has MUCH STRONGER catenation than Silicon:**

1. C–C bond energy = 348 kJ/mol (STRONG). Si–Si bond energy = 222 kJ/mol (WEAKER).

2. Carbon is SMALLER in size → C–C bonds are shorter and stronger.

3. Silicon is larger → Si–Si bonds are longer and weaker → easily broken.

4. Carbon forms stable chains of thousands of atoms (e.g. polymers, DNA).

5. Silicon forms limited chains — usually only Si–O–Si (silicates) are stable.

Result: Carbon is the basis of all organic compounds and life chemistry.

## Q43.

**Test to distinguish ethane from ethene:**

### ✓ Answer 43

Ethane = saturated (C–C only). Ethene = unsaturated (C=C double bond).

**Test 1: Bromine water test (preferred):**

Pass gas through bromine water (orange/brown).

Ethane: NO decolourisation (saturated, no addition reaction).

Ethene: Bromine water is DECOLOURISED ($CH_2$=$CH_2$ + $Br_2$ → $CH_2BrCH_2Br$).

**Test 2: Alkaline KMnO4 test:**

Ethane: purple $KMnO_4$ stays purple.

Ethene: $KMnO_4$ gets decolourised (oxidised).

Ethene is UNSATURATED — undergoes addition reactions. Ethane does NOT.

## Q44.

**Match reactions with names:**

| Reaction | Type |
|---|---|
| (a) CH3OH + CH3COOH → CH3COOCH3 + H2O | (iv) Esterification |
| (b) CH2=CH2 + H2 (Ni) → CH3–CH3 | (i) Addition reaction |
| (c) CH4 + Cl2 (sunlight) → CH3Cl + HCl | (ii) Substitution reaction |
| (d) CH3COOH + NaOH → CH3COONa + H2O | (iii) Neutralisation reaction |

## Q45.

**Write structural formulae of all isomers of hexane (C6H14):**

### ✓ Answer 45 — 5 isomers of hexane

**(1) n-Hexane:** $CH_3–CH_2–CH_2–CH_2–CH_2–CH_3$ (straight chain)

**(2) 2-Methylpentane:** $CH_3–CH(CH_3)–CH_2–CH_2–CH_3$

**(3) 3-Methylpentane:** $CH_3–CH_2–CH(CH_3)–CH_2–CH_3$

**(4) 2,2-Dimethylbutane:** $CH_3–C(CH_3)_2–CH_2–CH_3$

**(5) 2,3-Dimethylbutane:** $CH_3–CH(CH_3)–CH(CH_3)–CH_3$

All have molecular formula $C_6H_{14}$ but different structural arrangements.

## Q46.

**Role of reagents on arrows in reactions (a) Ni, (b) conc. H2SO4, (c) Alk. KMnO4:**

| Reaction | Reagent | Role |
|---|---|---|
| (a) C=C + H2 → C–C | Ni (Nickel) | Catalyst — lowers activation energy for hydrogenation. Ni is not consumed. |
| (b) CH3COOH + C2H5OH → ester | Conc. H2SO4 | Catalyst for esterification AND dehydrating agent (removes water to shift equilibrium). |
| (c) CH3CH2OH → CH3COOH | Alk. KMnO4 + Heat | Oxidising agent — oxidises ethanol to ethanoic acid. KMnO4 gets reduced. |

## SECTION C: LONG ANSWER QUESTIONS (Q47–Q57)

### Q47.

**Ethanoic acid + NaHCO3 → salt X + gas. Name X, gas. Describe activity + diagram to prove gas. Write equation:**

**✓ Answer 47**

**Salt X = Sodium ethanoate (CH3COONa)**

**Gas = Carbon dioxide (CO2)**

**Reaction:**

$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2\uparrow$

**Activity to prove gas is CO2:**

Setup: Flask with ethanoic acid + $NaHCO_3$. Gas collected via delivery tube into test tube B with lime water.

Observation: Lime water turns MILKY → proves $CO_2$.

Lime water reaction: $Ca(OH)_2 + CO_2 \rightarrow CaCO_3\downarrow$ (white ppt) + $H_2O$

Note: Unlike carbonic acid ($H_2CO_3$), ethanoic acid does NOT decompose $NaHCO_3$ normally —

but acetic acid IS acidic enough to react with $NaHCO_3$ because it is a carboxylic acid.

### Q48.

**(a) What are hydrocarbons? (b) Structural differences: saturated vs unsaturated. (c) What is functional group? 4 examples:**

**✓ Answer 48(a) — Hydrocarbons**

Hydrocarbons = organic compounds containing ONLY carbon and hydrogen.

Examples: Methane ($CH_4$), Ethane ($C_2H_6$), Ethene ($C_2H_4$), Ethyne ($C_2H_2$), Benzene ($C_6H_6$).

| Saturated Hydrocarbons | Unsaturated Hydrocarbons |
|---|---|
| Only C–C single bonds | Contains C=C double or C≡C triple bonds |
| General formula CnH(2n+2) | Alkenes CnH(2n); Alkynes CnH(2n-2) |
| e.g. Methane CH4, Ethane C2H6 | e.g. Ethene CH2=CH2; Ethyne HC≡CH |
| Undergo substitution reactions | Undergo addition reactions |
| Give clean/blue flame | Give yellow/sooty flame (C-rich) |

**✓ Answer 48(c) — Functional Groups**

Functional group = atom or group of atoms that gives characteristic chemical properties to organic compound.

Examples of functional groups:

1. –OH (hydroxyl) — alcohols: ethanol $CH_3CH_2OH$

2. –CHO (aldehyde) — aldehydes: ethanal $CH_3CHO$

3. –COOH (carboxyl) — carboxylic acids: ethanoic acid $CH_3COOH$

4. C=O in chain (ketone) — ketones: propanone $CH_3COCH_3$

## Q49.

**Reaction commonly used to convert vegetable oils to fats. Explain in detail:**

### ✓ Answer 49 — Hydrogenation Reaction

**Reaction name: Hydrogenation (Addition reaction)**

Vegetable oils: UNSATURATED (contain C=C double bonds in long fatty acid chains).

Fats: SATURATED (all C–C single bonds).

**Process:**

Oil + $H_2 \rightarrow$ Fat (using Ni or Pd catalyst, under pressure, ~200°C)

–CH=CH– + $H_2 \rightarrow$ –$CH_2$–$CH_2$– (each C=C converted to C–C by adding $H_2$)

**Industrial importance:**

Used to manufacture vanaspati ghee (hydrogenated vegetable oil).

Fats are solid at room temperature; oils are liquid — hydrogenation converts liquid→solid.

**Note:** Trans fats (unhealthy) can form during partial hydrogenation.

## Q50.

**(a) Formula and electron dot structure of CCl4. (b) What is saponification?**

### ✓ Answer 50(a) — Carbon Tetrachloride (CCl4)

**Formula: $CCl_4$** (Carbon tetrachloride / Tetrachloromethane)

C has 4 valence electrons; each Cl has 7 valence electrons.

C shares 1 electron with each of 4 Cl atoms → 4 covalent bonds.

**Electron dot structure:**

:Cl:

:Cl:–C–:Cl: (C in centre, 4 Cl atoms around it, each with 3 lone pairs)

:Cl:

Tetrahedral shape, all bond angles = 109.5°.

### ✓ Answer 50(b) — Saponification

**Saponification** = hydrolysis of an ester using a strong alkali (NaOH) to produce soap.

**General reaction:**

Fat/Oil (ester) + NaOH → Sodium salt of fatty acid (soap) + Glycerol

**Example:**

$CH_3COOC_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$

(Ethyl ethanoate + NaOH → Sodium ethanoate + Ethanol)

In soap making: vegetable oil/animal fat (glycerides) + NaOH → soap + glycerol

## Q51.

**Preparation of ester with activity and reaction (well labelled diagram):**

### ✓ Answer 51 — Esterification Activity

**Reagents needed:** Ethanoic acid ($CH_3COOH$) + Ethanol ($C_2H_5OH$) + conc. $H_2SO_4$ (catalyst)

**Procedure:**

1. Take 1 mL ethanol + 1 mL ethanoic acid + few drops conc. $H_2SO_4$ in test tube.
2. Heat in water bath at 60°C for 15 minutes (DO NOT heat directly — ethanol is flammable!).
3. Pour into beaker with 20–50 mL cold water.
4. Smell the product — fruity/sweet smell.

**Reaction:**

$CH_3COOH + C_2H_5OH \blacksquare (H_2SO_4) \blacksquare CH_3COOC_2H_5 + H_2O$

Ethyl ethanoate (fruity smelling ester) is formed.

**Note:** Reaction is reversible. Conc. $H_2SO_4$ acts as catalyst + dehydrating agent.

## Q52.

**C ($C_2H_4O_2$) + Na → R + gas (pop sound). C + alcohol A (acid) → S ($C_3H_6O_2$). NaOH + C → R + water. S + NaOH → R + A. Identify C, R, A, S:**

### ✓ Answer 52

**C = $CH_3COOH$ (Ethanoic acid / Acetic acid)**

$C_2H_4O_2 = CH_3COOH$. Reacts with Na → sodium salt + $H_2$ (pop sound).

**R = $CH_3COONa$ (Sodium ethanoate)**

$2CH_3COOH + 2Na \rightarrow 2CH_3COONa + H_2$

$NaOH + CH_3COOH \rightarrow CH_3COONa + H_2O$ (also gives R)

**A = $CH_3OH$ (Methanol)**

C + A → S ($C_3H_6O_2$). $CH_3COOH + CH_3OH \rightarrow CH_3COOCH_3$ ($C_3H_6O_2$) ✓

**S = $CH_3COOCH_3$ (Methyl ethanoate)**

$CH_3COOH + CH_3OH \rightarrow (H+) \rightarrow CH_3COOCH_3 + H_2O$

S + NaOH → $CH_3COONa$ (R) + $CH_3OH$ (A) [saponification]

## Q53.

**Fig 4.1: Ethanoic acid + Na2CO3 → gas into lime water (tube B):**

### ✓ Answer 53

**(a) Change in tube B (lime water):**

Lime water turns MILKY (white precipitate of $CaCO_3$ forms).

**(b) Reactions:**

Tube A: $2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2\uparrow$

Tube B: $Ca(OH)_2 + CO_2 \rightarrow CaCO_3\downarrow + H_2O$

**(c) If ethanol used instead of ethanoic acid:**

NO, the same change would NOT occur.

Ethanol ($C_2H_5OH$) does NOT react with $Na_2CO_3$ — it is not acidic enough to release $CO_2$.

Only acids (like ethanoic acid) react with carbonates/bicarbonates to give $CO_2$.

**(d) Preparation of lime water in lab:**

Dissolve calcium oxide (CaO) in water → $CaO + H_2O \rightarrow Ca(OH)_2$.

Filter or decant the clear supernatant liquid = lime water.

## Q54.

**Conversions: (a) ethanol → ethene; (b) propanol → propanoic acid:**

### ✓ Answer 54

**(a) Ethanol → Ethene:**

Process: DEHYDRATION (elimination of water)

$CH_3CH_2OH \rightarrow$ (excess conc. $H_2SO_4$, 443K) $\rightarrow CH_2=CH_2 + H_2O$

**(b) Propanol → Propanoic acid:**

Process: OXIDATION

$CH_3CH_2CH_2OH \rightarrow$ (Alk. $KMnO_4$/Heat) $\rightarrow CH_3CH_2COOH$

(Propan-1-ol → Propanoic acid by oxidation)

In (b): $KMnO_4$ is the oxidising agent, converting $–CH_2OH$ (primary alcohol) to –COOH.

## Q55.

**Possible isomers of C3H6O with electron dot structures:**

**✓ Answer 55 — Isomers of C3H6O**

$C_3H_6O$ — possible functional group isomers:

**Isomer 1 — Propanal (Aldehyde):**

$CH_3–CH_2–CHO$ (propan-1-al)

Structure: $H_3C–CH_2–C(=O)H$

**Isomer 2 — Propanone (Ketone):**

$CH_3–CO–CH_3$ (propan-2-one / acetone)

Structure: $H_3C–C(=O)–CH_3$

Both have molecular formula $C_3H_6O$ but different functional groups.

Propanal: –CHO at end. Propanone: C=O in middle.

Note: There are also alkene alcohols (allyl alcohol) with C=C and –OH, also C3H6O.

## Q56.

**Explain reactions: (a) Hydrogenation (b) Oxidation (c) Substitution (d) Saponification (e) Combustion:**

| Reaction Type | Definition | Example |
|---|---|---|
| (a) Hydrogenation | Addition of H2 to unsaturated compound using Ni/Pd catalyst | CH2=CH2 + H2 (Ni) → CH3–CH3 |
| (b) Oxidation | Addition of oxygen OR removal of hydrogen using oxidising agent | CH3CH2OH + [O] (KMnO4) → CH3COOH |
| (c) Substitution | Replacement of H atom by another atom (Cl) in presence of sunlight in saturated HC | CH4 + Cl2 (sunlight) → CH3Cl + HCl |
| (d) Saponification | Hydrolysis of ester with NaOH → sodium salt of acid + alcohol | CH3COOC2H5 + NaOH → CH3COONa + C2H5OH |
| (e) Combustion | Carbon compound burns in excess O2 → CO2 + H2O + Heat and light | CH4 + 2O2 → CO2 + 2H2O + Heat |

## Q57.

**Compound A + conc. H2SO4 → B. B + H2 (Ni) → C. 1 mol C combustion → 2 mol CO2 + 3 mol H2O. Identify A, B, C:**

**✓ Answer 57**

**Step 1: Find C from combustion products.**

C combustion: $C + O_2 \rightarrow 2CO_2 + 3H_2O$

$2CO_2$ → 2 carbons. $3H_2O$ → 6 hydrogens. So C = $C_2H_6$ (Ethane).

$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$ → per mole: $C_2H_6 + 7/2\ O_2 \rightarrow 2CO_2 + 3H_2O$ ✓

**C = $C_2H_6$ (Ethane)**

**Step 2: Find B. B + H2 (Ni) → C (ethane). B is one level unsaturated → B = Ethene (C2H4)**

$CH_2=CH_2 + H_2$ (Ni) $\rightarrow CH_3–CH_3$ ✓

**B = $C_2H_4$ (Ethene)**

**Step 3: Find A. A + conc. H2SO4 → B (ethene) = dehydration of alcohol.**

Ethanol ($C_2H_5OH$) + conc. $H_2SO_4$ (443K) $\rightarrow CH_2=CH_2 + H_2O$ ✓

**A = $C_2H_5OH$ (Ethanol)**

## MCQ ANSWER KEY SUMMARY GRID

| Q | Ans | Q | Ans | Q | Ans | Q | Ans |
|---|---|---|---|---|---|---|---|
| 1 | **(b)** | 2 | **(d)** | 3 | **(a)** | 4 | **(c)** |
| 5 | **(c)** | 6 | **(b)** | 7 | **(a)** | 8 | **(b)** |
| 9 | **(a)** | 10 | **(c)** | 11 | **(a)** | 12 | **(d)** |
| 13 | **(b)** | 14 | **(a)** | 15 | **(c)** | 16 | **(c)** |
| 17 | **(c)** | 18 | **(d)** | 19 | **(c)** | 20 | **(a)** |
| 21 | **(b)** | 22 | **(c)** | 23 | **(d)** | 24 | **(c)** |
| 25 | **(d)** | 26 | **(a)** | 27 | **(d)** | 28 | **(d)** |
| 29 | **(a)** | | | | | | |

## EXAM TIPS AND COMMON MISTAKES

**■ EXAM TIP** *Saturated = single bonds (alkanes, CnH2n+2). Unsaturated = double/triple bonds. Unsaturated compounds decolourise bromine water.*

**■ COMMON MISTAKE** *Confusing 'unsaturated' with 'acidic'. Unsaturated = multiple bonds, NOT acidic.*

**■ EXAM TIP** *Functional group determines chemical properties. Learn: –OH=alcohol, –CHO=aldehyde, C=O(middle)=ketone, –COOH=acid.*

**■ COMMON MISTAKE** *Confusing ketone and aldehyde — KETONE has C=O in middle; ALDEHYDE has –CHO at terminal C.*

**■ EXAM TIP** *Soap micelle: IONIC HEAD outside (in water), CARBON TAIL inside (in oil/grease). This is how soap cleans.*

**■ COMMON MISTAKE** *Saying soap works in hard water — soaps do NOT work well in hard water (form scum). Detergents do.*

**■ EXAM TIP** *Esterification: Acid + Alcohol → Ester + Water (conc. H2SO4 catalyst). Saponification = REVERSE of esterification using NaOH.*

**■ COMMON MISTAKE** *Confusing esterification with saponification — esterification makes ester; saponification breaks it.*

**■ EXAM TIP** *Hydrogenation adds H2 to C=C (Ni catalyst). Dehydration removes H2O from alcohol (H2SO4, 443K). Oxidation adds O to alcohol → acid (KMnO4).*

**■ COMMON MISTAKE** *Saying H2SO4 in esterification is an oxidising agent — it is a CATALYST/DEHYDRATING AGENT, NOT oxidising.*

## QUICK REVISION TABLE

| Concept | Key Point | Example |
|---|---|---|
| Catenation | C forms long chains — basis of organic chemistry | Millions of organic compounds |
| Tetravalency | C makes exactly 4 bonds | CH4: C + 4H |
| Alkanes | CnH(2n+2), all single bonds, saturated | CH4, C2H6, C3H8 |
| Alkenes | CnH(2n), one C=C double bond | C2H4, C3H6 |
| Alkynes | CnH(2n-2), one C≡C triple bond | C2H2, C3H4 |
| Homologous series | Same FG, differ by –CH2–, same general formula | Methane→Ethane→Propane |
| Isomers | Same formula, different structure | n-butane & isobutane (C4H10) |
| Esterification | Acid + Alcohol → Ester + H2O (H2SO4 cat.) | CH3COOH + C2H5OH → CH3COOC2H5 |
| Saponification | Ester + NaOH → salt + alcohol (soap making) | Ester + NaOH → soap + glycerol |
| Hydrogenation | C=C + H2 (Ni) → C–C (oil → fat) | Oil→vanaspati ghee |
| Dehydration | Alcohol + conc. H2SO4, 443K → alkene + H2O | Ethanol → Ethene |
| Vinegar | 5–8% acetic acid in water | NOT in alcohol |
| Soap micelle | Ionic head outside (water); tail inside (oil) | Used in cleaning |
| Carbon allotropes | Diamond (hard, insulator), Graphite (conductor), Fullerene (C60) | All pure carbon |
| Methanol danger | Oxidised to formaldehyde in liver → blindness/death | 10mL can blind |
| Ethanol + Na | 2C2H5OH + 2Na → 2C2H5ONa + H2 | Sodium ethoxide + H2 |