

Class 12 Chemistry – Aldehydes, Ketones & Carboxylic Acids | Study Guide

1. Theory in Simple Words with Visuals

1.1 What are Aldehydes, Ketones, and Carboxylic Acids?

Compound	General Formula	Structure	Example	Analogy
Aldehydes	R-CHO	Carbonyl (C=O) at end of chain	CH ₃ CHO (Ethanal)	"C=O = front door of carbon street"
Ketones	R-CO-R	Carbonyl (C=O) inside chain	CH ₃ COCH ₃ (Propanone)	"C=O = middle bridge connecting carbons"
Carboxylic Acids	R-COOH	Carbonyl + -OH	CH ₃ COOH (Acetic acid)	"C=O + OH = sour lemon flag"

1.2 Physical Properties

Property	Aldehydes	Ketones	Carboxylic Acids
Boiling Point	Moderate	Moderate	High (H-bonding)
Solubility	Soluble in water (small molecules)	Soluble in water (small molecules)	Highly soluble (H-bonding)
Odor	Pungent / fruity	Sweet / fragrant	Sour smell

1.3 Important Functional Group Reactions

Aldehydes & Ketones:

- Nucleophilic addition reactions (C=O is reactive)
- **Tollens' test:** Aldehydes → Silver mirror
- **Fehling's test:** Aldehydes → Red precipitate
- Ketones usually **do not give Tollens'/Fehling's test**

Carboxylic Acids:

- Acidic nature: R-COOH + NaOH → R-COONa + H₂O

- **Esterification:** $\text{R}-\text{COOH} + \text{R}'-\text{OH} \rightarrow \text{R}-\text{COOR}' + \text{H}_2\text{O}$ (acid catalyst)
 - **Reduction:** $\text{R}-\text{COOH} \rightarrow \text{R}-\text{CH}_2\text{OH}$
-

1.4 Classification

Type	Example	Notes
Aldehyde	Formaldehyde, Acetaldehyde	C=O at end
Ketone	Acetone, Butanone	C=O inside chain
Carboxylic Acid	Formic acid, Acetic acid	Contains -COOH

2. Key Concepts & Formulas

Concept	Formula / Key Points	Mnemonics / Tips
Oxidation	Aldehyde \rightarrow Carboxylic acid	"Aldehyde can be oxidized, Ketone cannot"
Reduction	Aldehyde \rightarrow Alcohol, Ketone \rightarrow Alcohol, Carboxylic acid \rightarrow Alcohol	"C=O + H \rightarrow CH-OH"
Nucleophilic Addition	$\text{R}-\text{CHO} + \text{Nu}^- \rightarrow \text{R}-\text{CH}\text{Nu}-\text{OH}$	Focus on carbonyl carbon being δ^+
Acid-base	$\text{R}-\text{COOH} + \text{Base} \rightarrow \text{Salt} + \text{H}_2\text{O}$	H^+ donor = acidic
Esterification	$\text{R}-\text{COOH} + \text{R}'-\text{OH} \rightarrow \text{Ester} + \text{H}_2\text{O}$	Acid catalyzed

Mnemonic for Oxidation Tests:

"Aldehydes react, Ketones rest" \rightarrow Tollens' / Fehling's test.

3. Solved Numerical / Reaction Problems

Example 1: Identify Reaction Product

Problem: $\text{CH}_3\text{CHO} + [\text{O}] \rightarrow ?$

Solution:

- Aldehyde oxidation: $\text{CH}_3\text{CHO} \rightarrow \text{CH}_3\text{COOH}$ (Acetic acid)

Tip: Remember: Only aldehydes oxidize easily.

Example 2: Ester Formation

Problem: $\text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} \rightarrow ?$

Solution:

- Esterification: $\text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} \rightarrow \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O}$

Mnemonic: "Acid + Alcohol → Ester + Water"

Example 3: Tollens' Test

Problem: Identify aldehyde by Tollens' reagent

Solution:

- $\text{R}-\text{CHO} + \text{Ag}(\text{NH}_3)_2^+ \rightarrow \text{R}-\text{COOH} + 2\text{Ag}$ (silver mirror)

Tip: Ketones do NOT give this test.

4. Previous Years' Board Questions

- High-weightage topics:
 - Oxidation/reduction of aldehydes & ketones
 - Esterification reactions
 - Identification tests for aldehydes, ketones, acids
 - Nucleophilic addition reactions

Trends: Mechanism-based reactions, reaction products, comparison of aldehyde vs ketone reactivity.

5. Quick Revision Notes / Important Points

- Functional groups:
 - Aldehyde = $-\text{CHO}$
 - Ketone = $-\text{CO}-$
 - Carboxylic acid = $-\text{COOH}$
- Key reactions:
 - Nucleophilic addition ($\text{C}=\text{O}$)
 - Oxidation (aldehyde \rightarrow acid)
 - Reduction ($\text{C}=\text{O} \rightarrow -\text{CH}-\text{OH}$)
 - Esterification (acid + alcohol \rightarrow ester)
 - Acid-base ($\text{COOH} + \text{base} \rightarrow \text{salt} + \text{water}$)

Color-coded visual table:

Compound	Key Reaction	Test / Observation
Aldehyde	Oxidation	Silver mirror (Tollens')

Compound	Key Reaction	Test / Observation
Ketone	Nucleophilic addition	No Tollens', forms alcohol on reduction
Carboxylic acid	Esterification / Neutralization	Acidic reactions, salts

6. Predicted / Likely Questions

1. Oxidation products of aldehydes
 2. Reactions of ketones with Grignard reagents
 3. Preparation of carboxylic acids from alcohols / aldehydes
 4. Esterification reactions and mechanism
 5. Identification of functional groups via chemical tests
 6. Comparison: Aldehyde vs Ketone reactivity
-

7. Exam Tips & Tricks

- Mark C=O carbon δ^+ for addition reactions
 - Remember Tollens' test only for aldehydes
 - Esterification is acid-catalyzed, reversible
 - Color coding: Carbonyl = red, alcohol = blue, acid = green
 - Draw flowcharts for: oxidation, reduction, esterification
-

8. Visual & Kid-Friendly Learning Style

- Picture C=O as a carbon “door” → easy for nucleophiles to attack
- Acid = sour flag → reacts with base to make salt
- Ester = sweet perfume → product of acid + alcohol
- Use flowcharts for reactions:
 - Aldehyde → Oxidation → Acid
 - Alcohol → Oxidation → Aldehyde → Acid
 - Acid + Alcohol → Ester + Water