

Reactions of Organic Compounds

What are the main types of organic reaction, and how do you predict the products?

●●○ Intermediate

Organic Chemistry

Last reviewed 5 October 2026

Before you start: it helps to understand [Functional Groups](#) and [Hydrocarbons and Naming Alkanes](#).

What is it?

Organic reactions look complicated, but almost all of them fall into a few **types**. Once you know the functional group in a molecule, you can predict which type of reaction it undergoes and what the product will be.

Type	What happens	Typical example
Addition	two molecules join to make one; a C=C becomes C-C	alkene + Br ₂
Substitution	one atom or group swaps for another	alkane + Cl ₂
Elimination	a small molecule (often H ₂ O) is removed, forming C=C	alcohol → alkene
Oxidation	gain of O or loss of H	alcohol → aldehyde → acid
Condensation	two molecules join and release a small molecule (H ₂ O)	acid + alcohol → ester

💡 KEY IDEA

The **functional group** decides the reaction. Alkenes **add** across the C=C; alkanes and haloalkanes **substitute**; alcohols can be **oxidized**, **eliminated** (dehydrated) or **condensed** with acids. Learn one example of each and you can apply it to the whole family.

Why does it matter?

- **Making things.** Medicines, plastics, dyes and fuels are made by chains of these reactions, converting one functional group into another.
- **Everyday chemistry.** Margarine is made by adding hydrogen to vegetable oils; wine turns to vinegar by oxidation; the breathalyser test once relied on dichromate turning green.
- **Analysis.** Simple colour tests (bromine water, acidified dichromate) tell you which functional groups a compound contains.

How does it work?

1. Addition reactions of alkenes

The C=C double bond opens, and one atom or group adds to each carbon:

- **Hydrogen** (with a nickel catalyst, about 150 °C): $\text{CH}_2=\text{CH}_2 + \text{H}_2 \longrightarrow \text{CH}_3\text{CH}_3$
- **Bromine**: $\text{CH}_2=\text{CH}_2 + \text{Br}_2 \longrightarrow \text{CH}_2\text{BrCH}_2\text{Br}$ (1,2-dibromoethane)
- **Hydrogen bromide**: $\text{CH}_2=\text{CH}_2 + \text{HBr} \longrightarrow \text{CH}_3\text{CH}_2\text{Br}$
- **Water** (steam, acid catalyst): $\text{CH}_2=\text{CH}_2 + \text{H}_2\text{O} \longrightarrow \text{CH}_3\text{CH}_2\text{OH}$, the industrial route to ethanol.

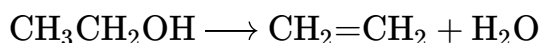
Test for C=C: shake with orange-brown **bromine water**. An alkene **decolourises** it (the bromine adds across the double bond); an alkane does not.

2. Substitution reactions

- **Alkanes + halogens** in ultraviolet light: $\text{CH}_4 + \text{Cl}_2 \longrightarrow \text{CH}_3\text{Cl} + \text{HCl}$. A hydrogen is swapped for a chlorine. Further substitution gives a mixture (CH_2Cl_2 , CHCl_3 , CCl_4).
- **Haloalkanes + hydroxide ions** (warm, aqueous):
 $\text{CH}_3\text{CH}_2\text{Br} + \text{OH}^- \longrightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{Br}^-$. The halogen is replaced by -OH, giving an alcohol.

3. Elimination: dehydrating alcohols

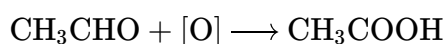
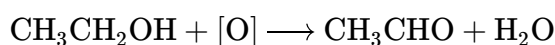
Heating an alcohol with concentrated sulfuric acid (or passing its vapour over hot aluminium oxide) removes water and forms an alkene:



4. Oxidation of alcohols

Warming with **acidified potassium dichromate** oxidizes alcohols; the orange dichromate turns **green** as it is reduced to Cr^{3+} . Writing [O] for the oxidizing agent:

- **Primary** alcohol (-OH on an end carbon) → **aldehyde** (if distilled off at once) → **carboxylic acid** (if heated under reflux):



- **Secondary** alcohol → **ketone**: $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3 + [\text{O}] \longrightarrow \text{CH}_3\text{COCH}_3 + \text{H}_2\text{O}$
- **Tertiary** alcohol (-OH on a carbon with no hydrogen): **not** oxidized, so the dichromate stays orange.

5. Condensation

A carboxylic acid and an alcohol, with an acid catalyst, condense to an ester and water (see Functional Groups). Repeating condensation many times builds **polymers** such as polyesters and nylon.

∞ THINK OF IT LIKE THIS

Think of the reaction types as moves in a game of building blocks. **Addition** snaps a new piece onto an open slot (the C=C). **Substitution** swaps one piece for another. **Elimination** pulls two pieces off and leaves a new open slot. **Condensation** clicks two models together and drops a small spare piece (water).

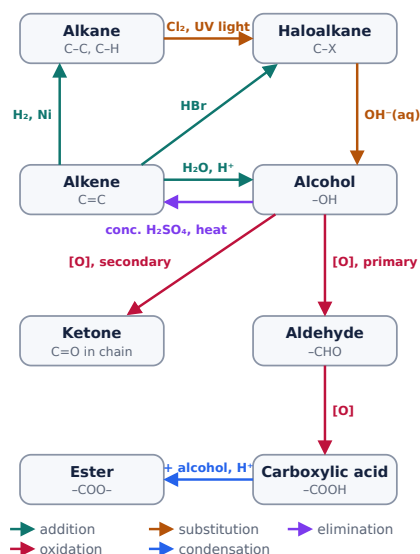
🔍 MORE PRECISELY

When an unsymmetrical reagent such as HBr adds to an unsymmetrical alkene such as propene, two products are possible. The major product follows **Markovnikov's rule**: the hydrogen adds to the carbon that already has more hydrogens, giving mostly 2-bromopropane. Substitution of haloalkanes is a **nucleophilic substitution**: the electron-rich OH^- attacks the carbon bonded to the electronegative halogen. Oxidation of alcohols is a redox reaction: carbon's oxidation number rises while chromium's falls from +6 to +3.

Visualise it

Map of organic reactions

Arrows show reagents; colours show the reaction type.



Functional groups are linked by a handful of reaction types; colours show the type.

Worked example

WORKED EXAMPLE: Predicting products

Question: Give the product, its name and the type of reaction: (a) propene + bromine (b) ethanol heated with concentrated sulfuric acid (c) propan-2-ol warmed with acidified potassium dichromate.

Step 1 (a) Bromine adds across the C=C:
 $\text{CH}_2=\text{CHCH}_3 + \text{Br}_2 \longrightarrow \text{CH}_2\text{BrCHBrCH}_3$, **1,2-dibromopropane**; **addition**.

Step 2 (b) Water is removed: $\text{CH}_3\text{CH}_2\text{OH} \longrightarrow \text{CH}_2=\text{CH}_2 + \text{H}_2\text{O}$, **ethene**; **elimination** (dehydration).

Step 3 (c) A secondary alcohol is oxidized to a ketone: **propanone**, CH_3COCH_3 ; **oxidation** (orange to green).

WORKED EXAMPLE: Telling an alkane from an alkene

Question: Two colourless liquids are hexane and hex-1-ene. How can you tell them apart?

Step 1 Add a few drops of orange-brown **bromine water** to each and shake.

Step 2 **Hex-1-ene** decolourises it: $\text{C}_6\text{H}_{12} + \text{Br}_2 \longrightarrow \text{C}_6\text{H}_{12}\text{Br}_2$ (addition across the C=C, giving 1,2-dibromohexane).

Step 3 **Hexane** has no C=C, so the orange colour stays (substitution needs UV light).

WORKED EXAMPLE: Mass of bromine that reacts

Question: What mass of bromine reacts completely with 5.00 g of hex-1-ene? ($\text{C}_6\text{H}_{12} = 84.16 \text{ g/mol}$; $\text{Br}_2 = 159.80 \text{ g/mol}$)

Step 1 Equation: $\text{C}_6\text{H}_{12} + \text{Br}_2 \longrightarrow \text{C}_6\text{H}_{12}\text{Br}_2$ (1 : 1)

Step 2 $n(\text{C}_6\text{H}_{12}) = \frac{5.00 \text{ g}}{84.16 \text{ g/mol}} = 0.05941 \text{ mol}$

Step 3 $n(\text{Br}_2) = 0.05941 \text{ mol C}_6\text{H}_{12} \times \frac{1 \text{ mol Br}_2}{1 \text{ mol C}_6\text{H}_{12}} = 0.05941 \text{ mol}$

Step 4 $m(\text{Br}_2) = 0.05941 \text{ mol} \times 159.80 \text{ g/mol} = \mathbf{9.49 \text{ g}}$

Common mistake

COMMON MISTAKE: Expecting alkanes to react with bromine water

Alkanes have no C=C, so they cannot undergo addition. They react with halogens only by substitution, and only in ultraviolet light. A colour change with bromine water in the dark means a C=C is present.

COMMON MISTAKE: Oxidizing a tertiary alcohol

A tertiary alcohol has no hydrogen on the carbon bearing the -OH, so acidified dichromate cannot oxidize it: the solution stays orange. Only primary alcohols give aldehydes and acids; secondary alcohols give ketones.

COMMON MISTAKE: Confusing addition and substitution products

Addition puts **both** parts of the reagent into **one** product ($\text{CH}_2\text{BrCH}_2\text{Br}$). Substitution gives **two** products, because the atom that is replaced leaves ($\text{CH}_3\text{Cl} + \text{HCl}$).

NOTATION NOTE

- [O] means “oxygen from an oxidizing agent”; [H] is sometimes used for a reducing agent.
- Conditions are written over the arrow in many books, for example UV light, Ni catalyst or reflux.
- Primary, secondary and tertiary (1° , 2° , 3°) describe how many carbons are bonded to the carbon carrying the -OH: one, two or three.

Remember this

REMEMBER THIS

- Addition (alkenes): $+ \text{H}_2$ (Ni), $+ \text{Br}_2$, $+ \text{HBr}$, $+ \text{H}_2\text{O}$ (H^+). Bromine water decolourised = C=C present.
- Substitution: alkane $+ \text{Cl}_2$ (UV); haloalkane $+ \text{OH}^- \rightarrow$ alcohol.
- Elimination: alcohol $+ \text{conc. H}_2\text{SO}_4$, heat $\rightarrow$ alkene $+ \text{water}$.
- Oxidation (acidified dichromate, orange $\rightarrow$ green): 1° alcohol $\rightarrow$ aldehyde $\rightarrow$ acid; $2^\circ \rightarrow$ ketone; $3^\circ \rightarrow$ no reaction.
- Condensation: acid $+ \text{alcohol} \rightleftharpoons$ ester $+ \text{water}$; repeated, it makes polymers.

References

1. Brown, T. L.; LeMay, H. E., Jr.; Bursten, B. E.; Murphy, C. J.; Woodward, P. M.; Stoltzfus, M. W. Chemistry: The Central Science, 15th ed.; Pearson, 2022.

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