

Alkanes and Alkenes

Matthew Williams • Chemistry • May 15, 2026

Alkanes and Alkenes

Alkanes and alkenes are both hydrocarbons — compounds of carbon and hydrogen only — but they differ in one fundamental way: alkanes have only single bonds between carbon atoms, while alkenes contain at least one carbon-carbon double bond. This structural difference drives almost every difference in their reactivity.

Alkanes

Alkanes are **saturated** hydrocarbons — every carbon atom forms only single bonds, so no more atoms can be added without breaking existing bonds.

General formula: C_nH_{2n+2}

Name	Molecular formula	Condensed formula
Methane	CH ₄	CH ₄
Ethane	C ₂ H ₆	CH ₃ CH ₃
Propane	C ₃ H ₈	CH ₃ CH ₂ CH ₃
Butane	C ₄ H ₁₀	CH ₃ CH ₂ CH ₂ CH ₃
Pentane	C ₅ H ₁₂	CH ₃ (CH ₂) ₃ CH ₃
Hexane	C ₆ H ₁₄	CH ₃ (CH ₂) ₄ CH ₃

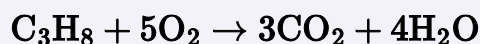
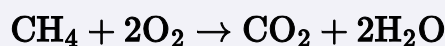
Physical properties change gradually along the series: boiling point, density, and viscosity all increase as chain length grows, because longer molecules have stronger intermolecular forces.

Properties of Alkanes

- Relatively **unreactive** — no functional group and strong C-H and C-C bonds
- **Non-polar** — do not dissolve in water but dissolve in organic solvents
- **Flammable** — the most commercially important reaction is combustion

Combustion of Alkanes

Complete combustion (excess oxygen): produces carbon dioxide and water. The flame is blue.



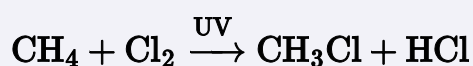
Incomplete combustion (limited oxygen): produces carbon monoxide (CO) and/or carbon (soot) instead of CO₂. The flame is yellow and sooty.



Carbon monoxide is colourless, odourless, and extremely toxic. It binds irreversibly to haemoglobin, preventing oxygen transport in blood. It is a leading cause of accidental poisoning in enclosed spaces with poorly ventilated gas appliances.

Substitution Reactions of Alkanes

In the presence of ultraviolet (UV) light, alkanes undergo **substitution reactions** with halogens. One hydrogen atom is replaced by a halogen atom:



Chloromethane is produced, plus hydrogen chloride. The reaction can continue to give CH₂Cl₂, CHCl₃ and CCl₄, if excess chlorine is present. UV light initiates the reaction; it does not occur in the dark.

This is called a substitution reaction because a Cl atom is substituted for an H atom — the number of bonds to carbon does not change.

Alkenes

Alkenes are **unsaturated** hydrocarbons — the C=C double bond means the molecule can add atoms across the double bond without breaking the carbon skeleton.

General formula: **C_nH_{2n}**

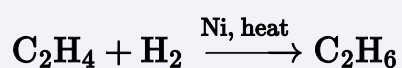
Name	Molecular formula	Condensed formula
Ethene	C_2H_4	$\text{CH}_2=\text{CH}_2$
Propene	C_3H_6	$\text{CH}_3\text{CH}=\text{CH}_2$
But-1-ene	C_4H_8	$\text{CH}_2=\text{CHCH}_2\text{CH}_3$
But-2-ene	C_4H_8	$\text{CH}_3\text{CH}=\text{CHCH}_3$

Addition Reactions of Alkenes

The $\text{C}=\text{C}$ double bond opens to allow two new atoms or groups to add — one to each carbon. These are called **addition reactions**.

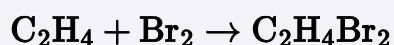
Hydrogenation (addition of hydrogen)

Alkenes react with hydrogen gas in the presence of a nickel catalyst to form alkanes. This converts liquid unsaturated oils into solid saturated fats (used in margarine manufacture):



Halogenation (addition of a halogen)

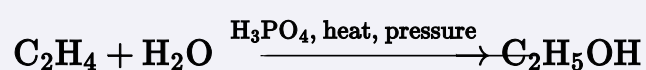
Alkenes decolourise bromine water by addition across the double bond:



The orange/brown bromine solution turns **colourless** — this is the standard test for unsaturation.

Hydration (addition of water)

Alkenes react with steam in the presence of a phosphoric acid catalyst to form alcohols. This is the industrial method for making ethanol:



Addition Polymerisation

Under high pressure and with a catalyst, many alkene monomers link together to form long-chain polymers. The double bond opens and each monomer adds to the chain — covered in detail on the polymers page.

Distinguishing Alkanes from Alkenes

Because alkanes are saturated and alkenes are unsaturated, they can be distinguished using two chemical tests:

Test	Alkane result	Alkene result
Add bromine water	No decolourisation — orange remains	Decolourises — turns colourless
Add acidified potassium manganate(VII)	No change — purple remains	Decolourises — turns colourless

Exam Tip

The syllabus states that burning is not an acceptable test to distinguish alkanes from alkenes. Both burn, and although alkenes tend to produce smokier flames, this is not a reliable or acceptable answer. Use the bromine water or acidified KMnO_4 test.

Remember

Saturated means only C–C single bonds — no more atoms can add without breaking.

Unsaturated means at least one C=C double bond — atoms can add across it. The prefix "un-" signals that the molecule is not full of hydrogen atoms.

Properties, Uses, and Structure

The relationship between structure and reactivity runs through everything in this topic:

Feature	Alkanes	Alkenes
Bonding	Only C–C and C–H single bonds	Contains C=C double bond
Saturation	Saturated	Unsaturated
Typical reaction	Substitution (with halogens, UV light)	Addition (with H, Br, HO)
Reactivity	Relatively low	Higher than alkanes

Main use	Fuels and solvents	Making polymers; feedstocks
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Biogas

When organic matter such as animal manure or plant waste decomposes anaerobically (without oxygen), bacteria produce a mixture of gases dominated by methane. This **biogas** can be collected and burned as a fuel. It is a renewable energy source and helps manage agricultural waste.

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