

# 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 <sub>4</sub>	CH <sub>4</sub>
Ethane	C <sub>2</sub> H <sub>6</sub>	CH <sub>3</sub> CH <sub>3</sub>
Propane	C <sub>3</sub> H <sub>8</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub>
Butane	C <sub>4</sub> H <sub>10</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>
Pentane	C <sub>5</sub> H <sub>12</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>
Hexane	C <sub>6</sub> H <sub>14</sub>	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>4</sub> CH <sub>3</sub>

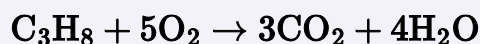
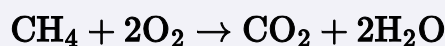
Physical properties change gradually along the series: boiling point, density, and viscosity all increase as chain length grows, because longer molecules have stronger intermolecular forces.

### 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.



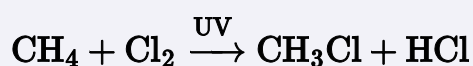
**Incomplete combustion** (limited oxygen): produces carbon monoxide (CO) and/or carbon (soot) instead of CO<sub>2</sub>. The flame is yellow and sooty.



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 CH<sub>2</sub>Cl<sub>2</sub>, CHCl<sub>3</sub> and CCl<sub>4</sub>, 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<sub>n</sub>H<sub>2n</sub>**

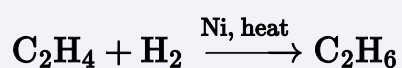
Name	Molecular formula	Condensed formula
Ethene	$\text{C}_2\text{H}_4$	$\text{CH}_2=\text{CH}_2$
Propene	$\text{C}_3\text{H}_6$	$\text{CH}_3\text{CH}=\text{CH}_2$
But-1-ene	$\text{C}_4\text{H}_8$	$\text{CH}_2=\text{CHCH}_2\text{CH}_3$
But-2-ene	$\text{C}_4\text{H}_8$	$\text{CH}_3\text{CH}=\text{CHCH}_3$

## 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**.

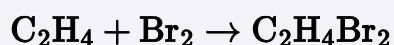
### Hydrogenation (addition of hydrogen)

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)

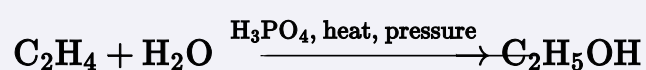
Alkenes decolourise bromine water by addition across the double bond:



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  $\text{KMnO}_4$  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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