

Fire, fuels and burning safely

Grade 8 science (Year 9 · Class 8) · Lesson

Quick answer: Combustion is a fast reaction of a fuel with oxygen that releases heat and light. Fire needs fuel, oxygen and heat, and removing any one puts it out. Complete combustion of carbon fuels makes carbon dioxide and water, while limited oxygen makes poisonous carbon monoxide.

Level: Grade 8 science (Year 9 · Class 8) · **Curriculum:** MS-PS1-2

What is combustion?

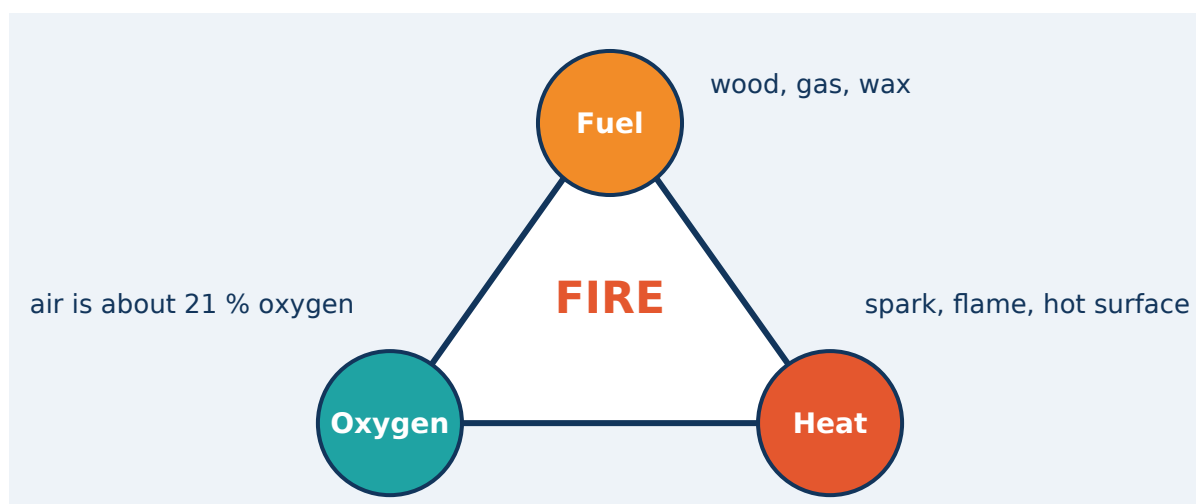
A cooking flame, a candle and a car engine all depend on the same chemistry. Combustion is a reaction in which a substance reacts quickly with oxygen and gives out energy as heat and light. It is an **exothermic** reaction, meaning energy goes out into the surroundings.

Definition

Combustion is the reaction of a fuel with oxygen that releases heat and usually light. A **fuel** is a substance that burns to release useful energy, such as wood, charcoal, methane or ethanol.

What does a fire need?

Fire needs three things at once: fuel, oxygen and enough heat to start the reaction. This is the **fire triangle**. If any one side is removed, the fire stops.



The fire triangle. Take away any one side and the fire goes out.

Method	Which side it removes	Example
Water spray	Heat	Camp fire in a park
Fire blanket or lid	Oxygen	Burning pan in a kitchen

Method	Which side it removes	Example
Closing a gas valve	Fuel	Leaking cooker pipe
CO ₂ extinguisher	Oxygen (and some cooling)	Electrical fire in an office

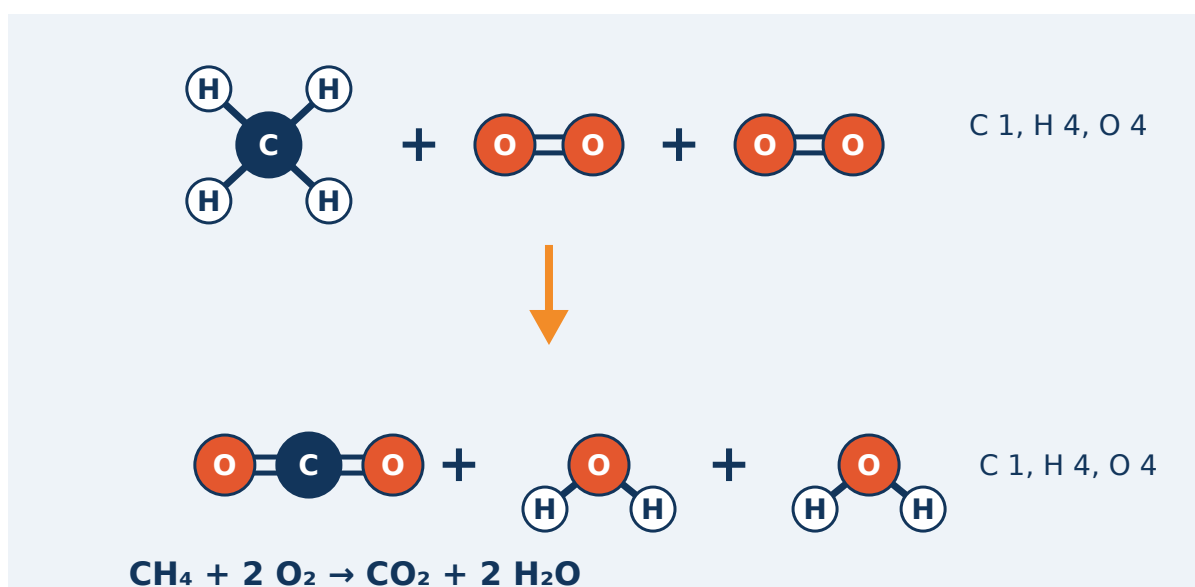
What are the products of burning carbon and methane?

When there is plenty of oxygen the burning is **complete combustion**. A fuel containing carbon and hydrogen then makes carbon dioxide and water vapour. The atoms are only rearranged, so the equation must balance.

Equations

Carbon: $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$

Methane: $\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$



Methane burning completely: the atoms are regrouped into carbon dioxide and water.

Worked example 1

Tunde in Ibadan burns 16 g of methane with 64 g of oxygen and collects 44 g of carbon dioxide. What mass of water forms?

Mass in = 16 + 64 = 80 g. Mass out = 44 + water, so water = 80 – 44 = **36 g**.

Worked example 2

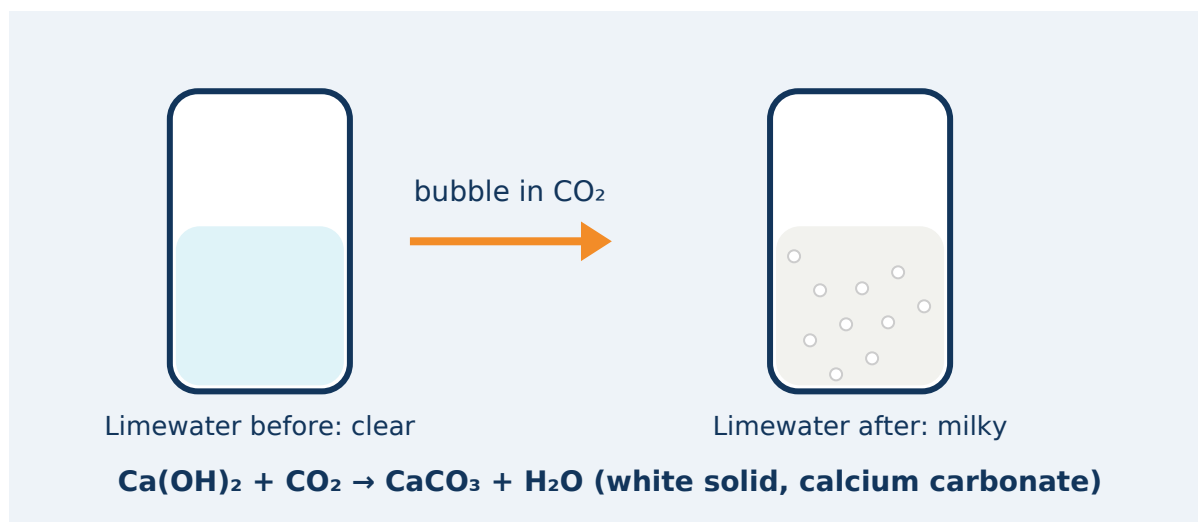
Isabel in Mexico City uses a spirit burner with ethanol: $\text{C}_2\text{H}_5\text{OH} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$. Balance it.

Carbon: 2 CO_2 . Hydrogen: 6 H, so 3 H_2O . Oxygen on the right: 4 + 3 = 7; the ethanol supplies 1, so 6 more atoms, which is 3 O_2 .

$\text{C}_2\text{H}_5\text{OH} + 3 \text{O}_2 \rightarrow 2 \text{CO}_2 + 3 \text{H}_2\text{O}$. Check: C 2/2, H 6/6, O 7/7.

How do you test for carbon dioxide?

Bubble the gas through **limewater**, which is a clear solution of calcium hydroxide. Carbon dioxide reacts with it to form tiny white crystals of calcium carbonate that make the liquid look milky.



The limewater test for carbon dioxide: the clear solution turns milky because insoluble calcium carbonate forms.

Common mistake

Keep bubbling and the milky substance can vanish again, because extra CO_2 turns the carbonate into a soluble substance. A burning splint is not a CO_2 test: many gases put out a flame. Only limewater going milky confirms CO_2 .

Why is carbon monoxide dangerous?

If the supply of oxygen is limited, **incomplete combustion** happens. It makes carbon monoxide (CO) and soot (carbon) instead of only CO_2 , and it releases less energy. For example, $2\text{CH}_4 + 3\text{O}_2 \rightarrow 2\text{CO} + 4\text{H}_2\text{O}$. Carbon monoxide has no colour, no smell and no taste, but it stops the blood carrying oxygen and can be fatal.

Feature	Complete combustion	Incomplete combustion
Oxygen supply	Plenty	Limited
Carbon products	CO_2	CO and soot
Flame	Blue, clean	Yellow, sooty
Energy released	More	Less

Lina's tip

Link each flame colour to a risk: blue means plenty of air, yellow means too little air. A yellow flame on a gas cooker or heater is a signal to get it checked.

Key points to remember

- Fire triangle: fuel, oxygen and heat; remove one to stop a fire.
- Complete combustion of methane: $\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$.
- Limewater turns milky when carbon dioxide is bubbled through it.
- Incomplete combustion makes carbon monoxide (CO) and soot.
- Carbon monoxide is colourless, odourless and toxic.

Fire, fuels and burning safely: frequently asked questions

What are the three parts of the fire triangle?

They are fuel, oxygen and heat. A fire needs all three together, so removing any one of them puts the fire out.

What are the products of complete combustion of methane?

Carbon dioxide and water, shown by $\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}$. The atoms are only rearranged, so each side of the equation has one carbon, four hydrogen and four oxygen atoms.

How does limewater test for carbon dioxide?

Carbon dioxide reacts with clear limewater to make white calcium carbonate, so the liquid turns milky. If the water stays clear, the gas is not carbon dioxide.

Why is carbon monoxide so dangerous?

It is made when fuels burn without enough oxygen and has no smell or colour. It stops blood carrying oxygen around the body, so people may not notice the danger until they feel unwell.

What is the difference between complete and incomplete combustion?

Complete combustion has plenty of oxygen and makes CO_2 and water with a blue flame. Incomplete combustion has too little oxygen and makes carbon monoxide and soot with a yellow, sooty flame.