Reactions of alkenes

4.7.2.2 · Organic chemistry · revision notes

How alkenes react because of their C=C functional group: combustion, and addition reactions with hydrogen, water (steam) and the halogens. You need the conditions and must be able to draw the products. GCSE Chemistry only. Expect 'name the product', 'draw the product' and 'give the conditions' questions, and explaining the bromine water test.

Key facts

- Functional group of the alkenes: C=C
- Alkene + hydrogen → alkane (nickel catalyst, heat)
- Alkene + halogen → compound with two halogen atoms, e.g. dibromoethane (room temperature)
- Bromine water: orange → colourless, because bromine adds across the C=C
- $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$
- Addition: atoms add across the C=C, which becomes C–C; one product only
- Alkene + steam → alcohol (high temperature, high pressure, catalyst)
- $C_2H_4 + H_2O \rightarrow C_2H_5OH$
- Alkenes burn with smoky flames (incomplete combustion)

Notes

The C=C functional group

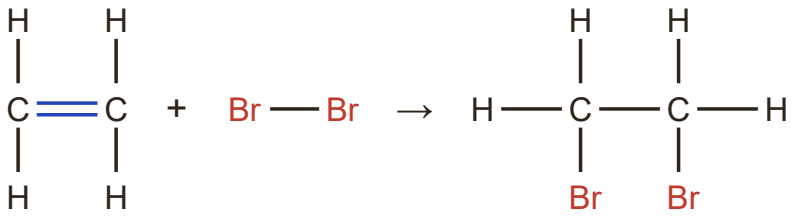
- A **functional group** is the group of atoms that decides how a compound reacts. For the alkenes it is **C=C**.
- All alkenes have this group, so they all react in the same way. Learn the reactions of ethene and apply them to any alkene.

Combustion

- Alkenes burn in oxygen like other hydrocarbons. Complete combustion gives carbon dioxide and water: $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$.
- In air they tend to burn with **smoky flames**, because of **incomplete combustion**.

Addition reactions

- Alkenes react with hydrogen, water and the halogens by **addition**: atoms add across the C=C, and the double bond becomes a **single** C–C bond.
- Only one product forms, so all the atoms of the reactants end up in it (the atom economy is 100%).
- **Hydrogen**: needs a **nickel catalyst** and heating. The product is an **alkane**: ethene + hydrogen → ethane.
- **Water**: the alkene reacts with **steam** at a high temperature (about 300 °C) and high pressure, with a catalyst (phosphoric acid). The product is an **alcohol**: ethene + steam → ethanol.
- **Halogens** (chlorine, bromine, iodine): react at room temperature with no catalyst. The product has two halogen atoms: ethene + bromine → dibromoethane.

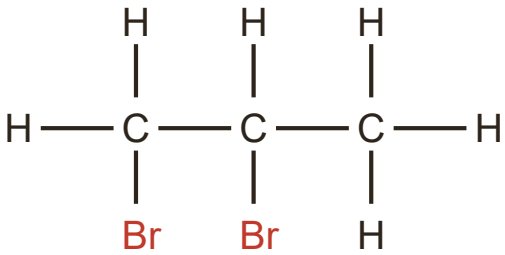


Addition: the C=C opens up and one Br atom adds to each carbon.
Ethene + bromine → dibromoethane.

- This is why alkenes decolourise bromine water: the orange bromine adds across the C=C, forming a colourless product.

Drawing the products

- Keep the carbon chain the same, and change the C=C to C–C.
- Put one added atom or group on each of the two carbon atoms that were joined by the double bond: H and H, H and OH, or two halogen atoms.
- Propene + bromine → dibromopropane:



- Propene + steam → propanol: one carbon gets an H and the neighbouring carbon gets an OH.

How to answer each type of question

Name the product and give the conditions

1 to 3 marks | Grade 5

1. Identify what is added: hydrogen, steam or a halogen.
2. Name the product from the alkene's stem: alkane, alcohol, or a di-halogen compound (e.g. dichloropropane).
3. Give the conditions: nickel catalyst for hydrogen; high temperature, high pressure and a catalyst for steam; none needed for halogens.

Example. (a) Propene reacts with hydrogen. Name the product and the catalyst used.
(b) Propene reacts with steam. Name the product.

Model answer.

(a) Propane (1); nickel (1)
(b) Propanol (1)

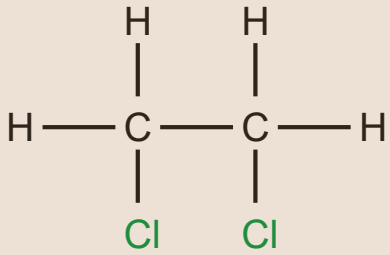
Draw the product of an addition reaction

2 to 3 marks | Grade 5

1. Draw the same carbon chain, with the double bond now a single bond.
2. Add one new atom or group to each carbon atom of the old C=C.
3. Check that every carbon has four bonds and that every atom from the reactants is there.

Example. Ethene reacts with chlorine.
Draw the displayed formula of the product and name it.

Model answer.



Two carbon atoms joined by a single bond (1). One Cl atom on each carbon atom and four H atoms, with every bond drawn (1). Dichloroethane (1)

Explain the bromine water results

2 to 4 marks **Grade 5**

1. Give what you would see: orange to colourless for an alkene; stays orange for an alkane.
2. Explain the alkene: it has a C=C double bond, and bromine adds across it.
3. Explain the alkane: it has no C=C (single bonds only), so no addition reaction happens.

Example. A student shakes pentene with bromine water, then shakes pentane with bromine water. Describe and explain what the student would see in each case.

Model answer.

Pentene: the bromine water turns from orange to colourless (1), because the bromine adds across the C=C double bond (1).

Pentane: the bromine water stays orange (1), because pentane has only single bonds, so no addition reaction takes place (1).

Combustion of alkenes

2 to 4 marks **Grade 5**

1. For a smoky flame, say 'incomplete combustion' and name the soot (carbon) that forms.
2. For an equation, balance C, then H, then O, as for alkanes.
3. Double every number if you end up with half an O_2.

Example. (a) Propene burns in air with a smoky flame. Explain why.
(b) Write a balanced equation for the complete combustion of propene, C_3H_6.

Model answer.

(a) Incomplete combustion takes place (1), producing particles of carbon (soot) (1).

(b) Correct formulae: $C_3H_6 + O_2 \rightarrow CO_2 + H_2O$ (1). Balanced: $2C_3H_6 + 9O_2 \rightarrow 6CO_2 + 6H_2O$ (1). ($C_3H_6 + 4½O_2 \rightarrow 3CO_2 + 3H_2O$ is also correct.)

Don’t lose marks

- Putting both new atoms on the same carbon atom. One goes on each carbon of the old double bond.
- Leaving the double bond in the product. After addition it is a single bond.
- Missing out the nickel catalyst for the reaction with hydrogen.
- Writing 'water' without saying steam, or leaving out the catalyst, high temperature and high pressure.
- Adding a second product, such as HBr or H_2O, to an addition reaction. There is only one product.
- Saying that alkanes decolourise bromine water.

More tips

Memory tricks

- 'Add across the double bond': one new atom goes to each end of the C=C.
- Hydrogen makes an alkANE; water makes an alcohOL; a halogen makes a di-halogen compound.
- Catalysts: nickel for hydrogen, phosphoric acid for steam, nothing for halogens.
- Addition makes one product, so its formula is just the two formulae added together: $C_3H_6 + Br_2 \rightarrow C_3H_6Br_2$.

Exam technique

- When asked for 'conditions', give the catalyst, and the temperature and pressure where they matter.
- Name products using the alkene's stem: propene gives propane, propanol or dibromopropane.
- In displayed formulae, draw every bond, including the O–H bond in an alcohol.
- Use the phrase 'adds across the double bond', and say that the double bond becomes a single bond.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Name the functional group of the alkenes**
C=C, the carbon–carbon double bond.

Grade 4 — **Explain why alkenes burn with smoky flames**
In air they tend to undergo incomplete combustion, which produces soot (carbon).

Grade 5 — **Name the products of addition reactions**
Hydrogen gives an alkane, steam gives an alcohol, and a halogen gives a compound with two halogen atoms.

Grade 5 — **Give the conditions for adding hydrogen and steam**
Hydrogen: a nickel catalyst. Steam: high temperature, high pressure and a catalyst (phosphoric acid).

Grade 5 — **Explain what happens in an addition reaction**
Atoms add across the C=C, which becomes a single bond; only one product forms.

Grade 5 — **Draw displayed formulae of addition products**
Keep the carbon chain, make the C=C single, and put one new atom or group on each carbon of the old double bond.

Grade 5 — **Explain the bromine water test**
Bromine adds across the C=C to form a colourless product; alkanes have no C=C, so the bromine water stays orange.

Free notes, Full packs, practice papers and mock exams at chhetriacademy.com. Written for this site; not taken from past papers. Stuck? 1-to-1 tutoring with a free 30-minute trial lesson.