Structure and formulae of alkenes

4.7.2.1 · Organic chemistry · revision notes

What alkenes are, why they are unsaturated, their general formula, and how to name, recognise and draw the first four. This subtopic is in GCSE Chemistry only, not Combined Science. Expect formula, naming and displayed formula questions, usually worth 1 or 2 marks each.

Key facts

- Alkene = hydrocarbon with a C=C double bond
- Unsaturated: contains C=C; two fewer H atoms than the alkane with the same number of C atoms
- Alkane: -ane, C_nH_{2n+2}, saturated. Alkene: -ene, C_nH_{2n}, unsaturated
- Grade 7+ only Alkene M_r = 14n
- General formula C_nH_{2n}
- Ethene C_2H_4, propene C_3H_6, butene C_4H_8, pentene C_5H_{10}
- Functional group of the alkenes: C=C

Notes

What alkenes are

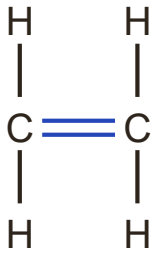
- **Alkenes** are hydrocarbons that contain a carbon–carbon **double bond**, C=C.
- They form a homologous series with the general formula $\mathbf{C_nH_{2n}}$.
- Alkenes are **unsaturated**: they have two fewer hydrogen atoms than the alkane with the same number of carbon atoms. Ethene is C_2H_4; ethane is C_2H_6.
- Alkanes have single bonds only, so they are **saturated**.
- There is no alkene with one carbon atom: a C=C needs at least two carbon atoms.

The first four alkenes

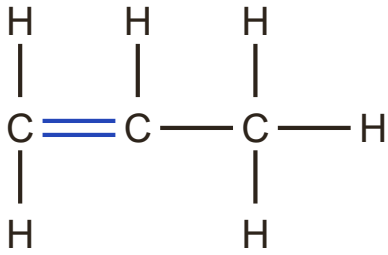
- **Ethene** C_2H_4, **propene** C_3H_6, **butene** C_4H_8 and **pentene** C_5H_{10}. These are the only alkene names you need.
- The names use the same stems as the alkanes (eth = 2, prop = 3, but = 4, pent = 5 carbon atoms) with the ending **-ene**.
- A formula such as $CH_2{=}CHCH_3$ (propene) shows where the double bond is.

Displayed formulae

- Ethene:



- Propene:



- Every carbon atom still makes four bonds: the double bond counts as two.
- In butene and pentene, the C=C can be between different carbon atoms in the chain. Each position gives a correct structure; the one usually drawn has the double bond at the end of the chain, e.g. $CH_2{=}CHCH_2CH_3$.
- Relative formula mass of an alkene: M_r = 12n + 2n = 14n. Grade 7+ only

How to answer each type of question

Name or give the formula of an alkene 1 mark each **Grade 4**

1. Use the stem for the number of carbon atoms (eth 2, prop 3, but 4, pent 5) with the ending '-ene'.
2. The number of hydrogen atoms is twice the number of carbon atoms.
3. Check that the name and formula match: an '-ene' has 2n hydrogens.

Example. (a) Give the molecular formula of butene.
(b) Name the alkene with the formula C_5H_{10}.
(c) Which of these compounds is an alkene: C_3H_8, C_3H_6 or C_3H_7OH?

Model answer.

(a) C_4H_8 (1)

(b) Pentene (1)

(c) C_3H_6, because it is a hydrocarbon that fits C_nH_{2n} (1)

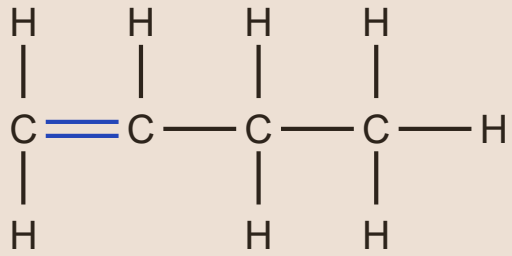
Draw the displayed formula of an alkene

1 to 2 marks | Grade 5

1. Draw the carbon chain with one double bond between two of the carbon atoms.
2. Add hydrogen atoms so that every carbon atom has exactly four bonds (the double bond counts as two).
3. Count the hydrogens: there should be 2n.

Example. Draw a displayed formula for butene, C_4H_8.

Model answer.



Four carbon atoms in a chain with one C=C double bond (1). Eight hydrogen atoms, with every bond drawn and four bonds on each carbon atom (1). (The double bond may instead be between the middle two carbon atoms.)

Describe the differences between an alkane and an alkene

2 marks | Grade 5

1. Give the bonding difference: the alkene has a C=C double bond; the alkane has single bonds only.
2. Give the formula difference: the alkene has two fewer hydrogen atoms.
3. Use 'saturated' and 'unsaturated' correctly if you use them.

Example. Butane and butene both have four carbon atoms in each molecule.
Describe **two** differences between a molecule of butane and a molecule of butene.

Model answer. Butene has a C=C double bond, but butane has only single bonds (1). Butene has two fewer hydrogen atoms: C_4H_8 compared with C_4H_{10} (1).

Calculate: identify an alkene from its relative formula mass

2 to 3 marks | Grade 7

1. M_r = 12n + 2n = 14n.
2. Divide the M_r by 14 to find n.
3. Write the formula C_nH_{2n} and name the alkene.

Example. An alkene has a relative formula mass (M_r) of 42.

Relative atomic masses (A_r): H = 1, C = 12

Give the molecular formula and the name of the alkene.

Model answer.

14n = 42	(1)
n = 3, so the formula is C_3H_6	(1)
Propene	(1)

Don't lose marks

- Drawing a carbon atom with five bonds, usually next to the double bond. Count to four on every carbon.
- Calling an alkene saturated. Saturated means single bonds only.
- Mixing up propane (C_3H_8) and propene (C_3H_6). Check the ending and the hydrogen count.
- Trying to name 'methene'. There is no alkene with one carbon atom.
- Writing CH_3 at the end of the chain when a displayed formula is asked for. Draw all three C–H bonds.

More tips

Memory tricks

- '-ane' = single bonds only (saturated); '-ene' = there is a double bond (unsaturated).
- Alkene hydrogens: just double the carbons (C_4 gives H_8). Alkane hydrogens: double and add two.
- Carbon stems: meth 1, eth 2, prop 3, but 4, pent 5 (pent as in pentagon, 5 sides).
- Bond check on every carbon: four bonds, where the = counts as two.
- Unsaturated means there is 'room' for more hydrogen atoms: the double bond could open up to take them.

Exam technique

- For 'describe two differences', give one difference in bonding and one in the formula, and compare using 'but' or 'whereas'.
- Draw the double bond as two clear parallel lines, so it cannot be mistaken for a single bond.
- If a question shows a displayed formula, count the C and H atoms carefully before deciding whether it is an alkane or an alkene.

What each grade needs

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

Grade 3

State what an alkene is

A hydrocarbon with a carbon–carbon double bond, C=C.

Grade 4

Name the first four alkenes

Ethene C_2H_4, propene C_3H_6, butene C_4H_8 and pentene C_5H_{10}.

Grade 5

Use the general formula of the alkenes

C_nH_{2n}: the number of hydrogen atoms is double the number of carbon atoms.

Grade 5

Explain what unsaturated means

Alkenes have two fewer hydrogen atoms than the alkane with the same number of carbon atoms, because they contain a C=C.

Grade 5

Draw displayed formulae of the first four alkenes

Show every bond, with one C=C and exactly four bonds on each carbon atom.

Grade 5

Tell alkanes and alkenes apart from formulae

Alkanes fit C_nH_{2n+2} and have single bonds only; alkenes fit C_nH_{2n} and have a C=C.

Grade 7

Work out an alkene's formula from its Mr

M_r = 14n, so an M_r of 56 gives n = 4: C_4H_8, butene.

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