Addition polymerisation

4.7.3.1 · Organic chemistry · revision notes

How alkenes join together to make addition polymers such as poly(ethene) and poly(propene), how to draw the repeating unit from a monomer, and how to work back from a polymer to its monomer. GCSE Chemistry only. Expect drawing questions worth 1 to 3 marks and short explanations.

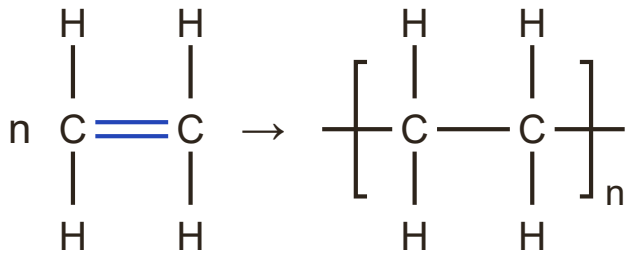
Key facts

- Monomer = small molecule; polymer = very large molecule made from many monomers
- Addition polymer monomers contain a C=C
- Addition polymerisation: C=C opens to C–C; no other product
- Repeating unit has the same atoms as the monomer
- n CH_2=CH_2 → –(CH_2–CH_2)$_n$–
- Ethene → poly(ethene); propene → poly(propene)
- Repeating unit: 2 chain carbons, single bond, side groups, bonds through brackets, n
- M_r of polymer = n × M_r of monomer

Notes

Monomers and polymers

- **Polymers** are very large molecules made when many small molecules, called **monomers**, join together.
- In **addition polymerisation**, the monomers are alkenes (or other molecules with a **C=C** double bond).
- The C=C in each monomer opens up to a single bond, and the monomers join into a long chain.

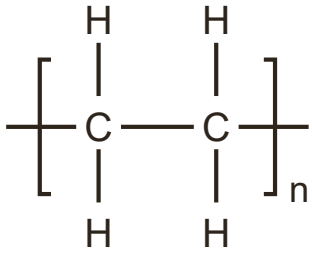


n ethene → poly(ethene): each C=C opens up and links to the next monomer.

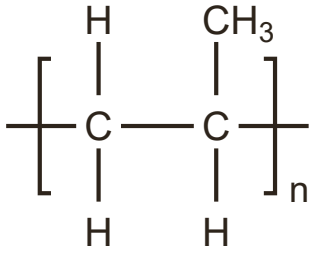
- **No other product** forms, so the **repeating unit** has exactly the same atoms as the monomer.
- Examples: ethene makes poly(ethene); propene makes poly(propene).

Drawing the repeating unit

- 1. Draw the two carbon atoms of the C=C, now joined by a single bond.
- 2. Keep every other atom or group on those carbons exactly as in the monomer.
- 3. Draw a bond out from each of the two carbons, through a bracket on each side, and write **n** at the bottom right of the closing bracket.
- Equation: n CH_2=CH_2 → –(CH_2–CH_2)$_n$–
- Repeating unit of poly(ethene):



- In poly(propene), the CH_3 group is a branch. Only the two carbons of the C=C are in the main chain:



Working backwards

- To find the monomer, take the two chain carbons of the repeating unit, join them with a double bond, and remove the brackets, the n and the bonds that stick out.
- In a section of chain, the pattern repeats every two carbon atoms: that two-carbon section is the repeating unit.
- n is large (often thousands), and the relative formula mass of the polymer = n × the relative formula mass of the monomer.

How to answer each type of question

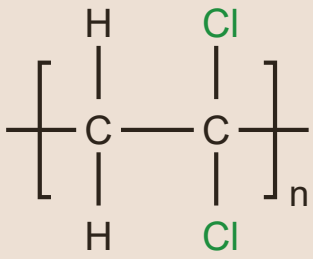
Draw the repeating unit of an addition polymer

2 to 3 marks | **Grade 5**

1. Find the C=C in the monomer: its two carbon atoms form the chain.
2. Draw them joined by a single bond, keeping all the other atoms and groups.
3. Add a bond out through a bracket on each side, and write n.

Example. A monomer has the formula $CH_2=CCl_2$.
Draw the repeating unit of the polymer made from this monomer.

Model answer.



Two carbon atoms joined by a single bond (1). Two H atoms on one carbon and two Cl atoms on the other (1). Bonds extending through brackets on both sides, with n (1).

Draw or name the monomer from a polymer

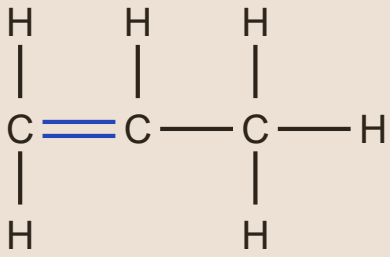
1 to 3 marks | Grade 5

1. Find the repeating unit: two carbon atoms in the main chain.
2. Put a double bond between them.
3. Remove the brackets, the n and the bonds that stick out.

Example. Part of a polymer chain is shown.
$–CH_2–CH(CH_3)–CH_2–CH(CH_3)–CH_2–CH(CH_3)–$
(a) Draw the displayed formula of the monomer.
(b) Name the polymer.

Model answer.

(a)



A C=C between two carbon atoms (1). A CH_3 group on one of them and three other H atoms, all bonds drawn (1).
(b) Poly(propene) (1)

Explain why the repeating unit has the same atoms as the monomer

1 to 2 marks | Grade 7

1. Say that the monomers join by opening the C=C.
2. Say that no other product is formed, so no atoms are lost.

Example. The repeating unit of poly(propene) has the formula C_3H_6, the same as propene. Explain why.

Model answer. In addition polymerisation the monomers join by opening their C=C double bonds (1). No other product is formed, so no atoms are lost from the monomer (1).

Calculate the number of monomer units

2 marks | Grade 6

1. Work out the relative formula mass of the monomer.
2. Divide the relative formula mass of the polymer by it.

Example. A molecule of poly(ethene) has a relative formula mass of 84 000.
Calculate the number of ethene molecules, C_2H_4, that joined to make it.

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

Model answer.

M_r of C_2H_4 = (2 × 12) + (4 × 1) = 28 (1)

84 000 ÷ 28 = 3000 (1)

Don’t lose marks

- Leaving the C=C in the repeating unit. It must be a single bond.
- Forgetting the bonds through the brackets, or the n.
- Putting the CH_3 of propene into the main chain, making a three-carbon backbone.
- Saying water or another small molecule forms in addition polymerisation. Nothing else forms.
- Drawing the extending bonds from a side group instead of from the two chain carbons.

More tips

Memory tricks

- Open the door and hold hands: the C=C opens, and each carbon reaches out to link with the next monomer.
- Repeating unit = the monomer with its double bond made single and two 'arms' through the brackets.
- Side groups such as CH_3 or Cl hang off the chain; they never go into the main chain.
- Naming: 'poly' + the monomer's name in brackets.

Exam technique

- Draw the brackets tall enough that the extending bonds clearly pass through them.
- Check that your repeating unit has the same number of each type of atom as the monomer.
- Use the words 'monomer', 'polymer', 'repeating unit' and 'double bond' in explanations.

What each grade needs

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

Grade 3 — **Define monomer and polymer**
Monomers are small molecules that join together in large numbers to make a very large molecule, a polymer.

Grade 4 — **Name the polymer made from an alkene**

Write 'poly' and put the monomer's name in brackets: propene gives poly(propene).

Grade 5

Recognise monomers that form addition polymers

The monomer must contain a C=C double bond.

Grade 5

Draw the repeating unit from a monomer

Change the C=C to C–C, keep the other atoms, and draw bonds out through brackets with n.

Grade 5

Draw the monomer from a repeating unit

Put a C=C between the two chain carbons and remove the brackets, n and the extending bonds.

Grade 6

Calculate the number of monomers in a polymer

Divide the relative formula mass of the polymer by that of the monomer.

Grade 7

Explain why the repeating unit matches the monomer

No other product forms in addition polymerisation, so the repeating unit has the same atoms as the monomer.

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