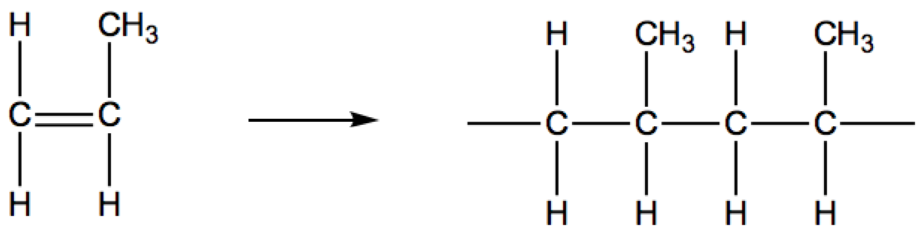
Addition Polymers

Addition polymers are made from lots of [alkenes](#) joined together. The double bonds are broken and a very long hydrocarbon chain is the end result.

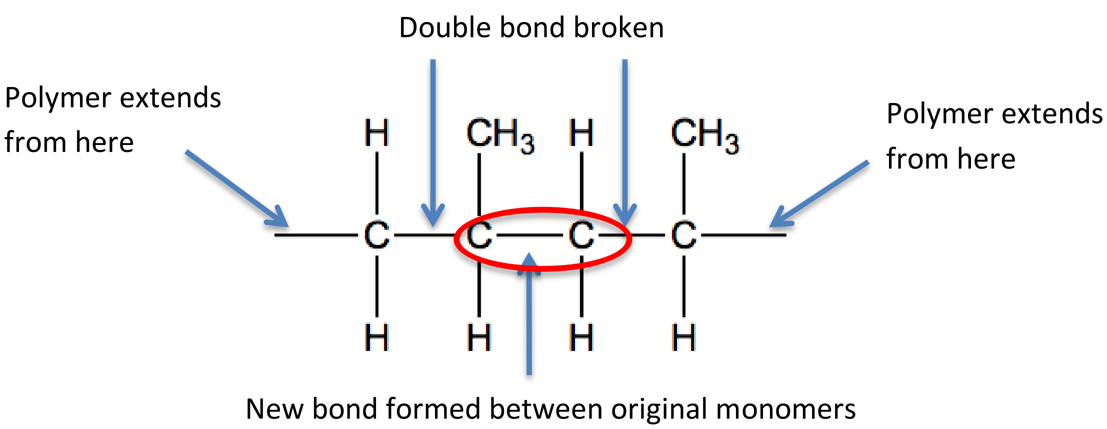
The **C=C bond** is the vital part. This is where the polymer "grows" from.

Below is a possible polymerisation reaction of propene. I have only drawn two alkene units added together to keep it simple. I have deliberately drawn the alkene with **vertical lines** (see later).



monomer polymer

- ✓ the alkene is the starting molecule and in polymer chemistry it is called a monomer. 'Mono' means one and 'poly' means many.
- ✓ naming is very easy. If you start with **ethene**, the polymer is **polyethene**. Just stick the word poly at the front of the original alkene name.



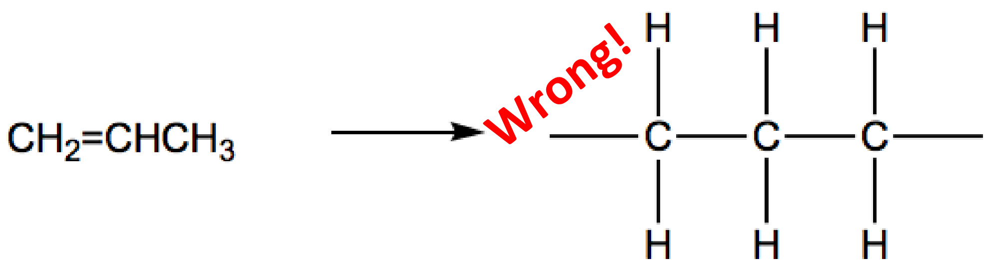
All you are doing is breaking the double bond and drawing lines coming out the end of the two carbons at each end of the polymer.

- ✓ it is massively beneficial to draw the alkene with **vertical bonds** as shown above. Students often try to draw the alkene in a straight line and they get into all sorts of problems.

You must remember that the C=C bond is the important part. In **any** addition polymer structure the lines coming out the end of the polymer show this is where the chain is extending from.

The wrong way to do it

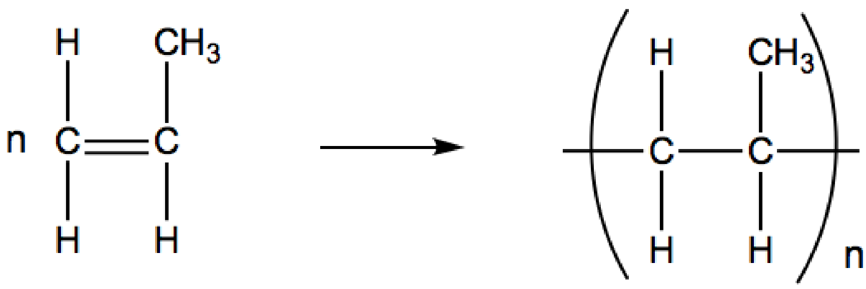
If you don't draw it with vertical lines and draw propene as normal, something like this could happen below. Students often draw the lines coming out from the end carbons instead of the C=C:



✓ a good tip is to always count **two carbons** at a time with polymers. It is impossible to have 3 like I have drawn above on the right hand side as the polymer grows from the C=C which is only **two carbons**. The other carbon in this case must be drawn as a side group. So there should be a **pattern every two carbons**.

The Polymer

If they ask you to draw the polymer you really need to put in the **little 'n'**. This just says that there are lots of monomers joined together and we don't know how many.



If you draw the monomer correctly as shown on the left, all you need to do to get the polymer is **remove the double bond** and draw **two lines coming out the ends** of each carbon. Then put curved brackets round the ends. It's very easy.

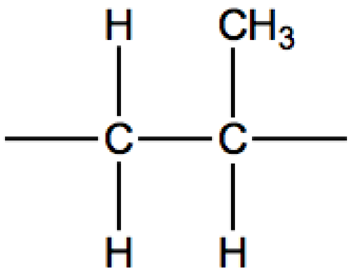
✓ The lines coming out the end must pass through the brackets.

✓ The above representation would be how you write an equation if they asked for that as well. The 'n' must be on both sides to balance the equation.

The Repeat Unit

It's surprisingly rare that they ask for the polymer structure. Instead, they usually ask for the repeat unit. This is not much different. Just remove the brackets, you **don't need little 'n'** and you have the repeating unit.

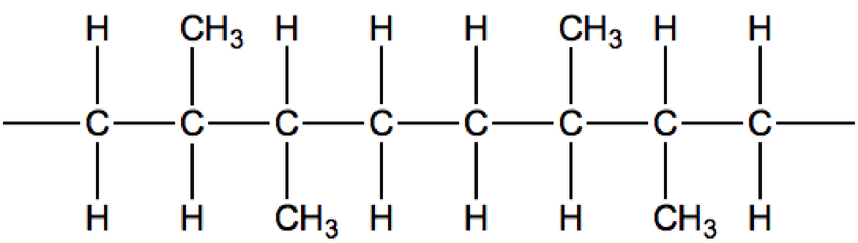
✓ remember to count two carbons at a time horizontally and put everything else as side groups



Example

I don't think I've ever seen anyone get this question correct at the first attempt. It is just to demonstrate all the points I made above.

Here is a section of a polymer. The question: what is the **monomer?**

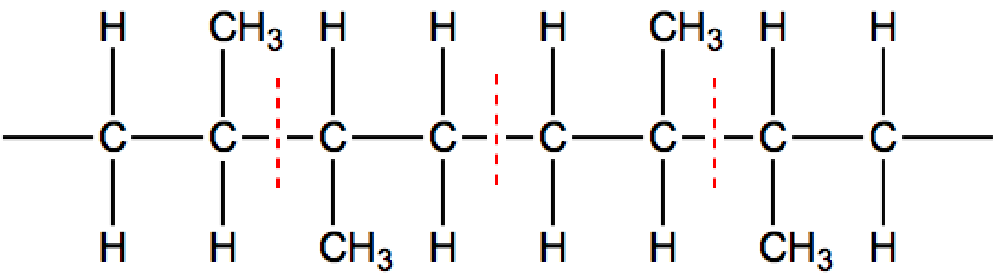


The answer is one of:

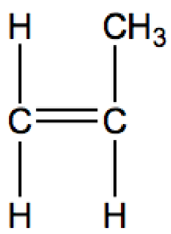
- **E-but-2-ene**
- **Z-but-2-ene**
- **Methylpropene**
- **propene**

Look for the **repeating pattern** every two carbons.

A lot of students think the pattern repeats after **4 carbons** and they choose either E-but-2-ene or Z-but-2-ene as the answer. There is a pattern every 4 carbons but that's not how you do polymer questions! Remember It has to be every **two carbons** as it's all about the C=C breaking open. So look again:



Every two carbons is where the new bond was formed, therefore beak the polymer where I have drawn the red dashed lines. This gives **propene** as the answer:

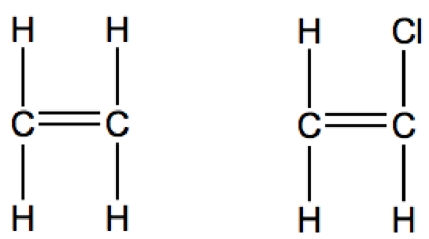


It is a difficult(ish) question but you have to stick to the rules! They have drawn the CH_3 pointing up and down and on the left and right carbons. Just do as I did above, break the polymer after every two carbons and draw what is left. Stick a double bond in and that's it.

✓ It is also possible to add **two different alkenes** together to form a polymer. Therefore there would be **two monomers**. But you still follow the same rules i.e. count two carbons and then break the bond.

Polymer Properties

Polymer properties are determined by what groups are attached to the C=C of the monomer. For example, polyethene versus polychloroethene are very different. The two monomers are shown below:



You have to think of long polymer chains interacting with each other. Polyethene only has van der waal forces **between the chains**. Polychloroethene (PVC), due to the Cl group, can form stronger **permanent dipole-dipole interactions** between polymer chains.

Therefore polychloroethene is much stronger and more rigid than polyethene. Think of polychloroethene as a strong rigid plastic versus polyethene as a carrier bag from a supermarket.

Due to this strength, PVC is used in pipes and windows. **Plasticisers** can be added to push the polymer chains further apart, which weakens the intermolecular forces making the polymer softer and flexible.

For example, PVC with plasticisers is used in clothing.

Non-biodegradable

All these addition polymers are forming **strong C-C bonds** and as a result they are hard to break down or decompose. They are said to be non-biodegradable i.e. do not breakdown naturally.

They need to be burned as fuels, recycled, put in landfill sites or used as feedstock for the chemical industry.

Scientists are currently looking to make biodegradable and photodegradable polymers.