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Plastics are examples of materials known as polymers.

- Polymers are long chain molecules formed by joining together a large number of small molecules called monomers.
- Addition polymerisation is the name given to a chemical reaction in which unsaturated monomers are joined, forming a polymer.

Name	Definition
monomer	Small molecules which join together to form polymers
polymer	The long chain molecule made by the joining up of monomers
polymerisation	The process where monomers join together to form polymers



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The name of the addition polymer is related to the name of the monomer:

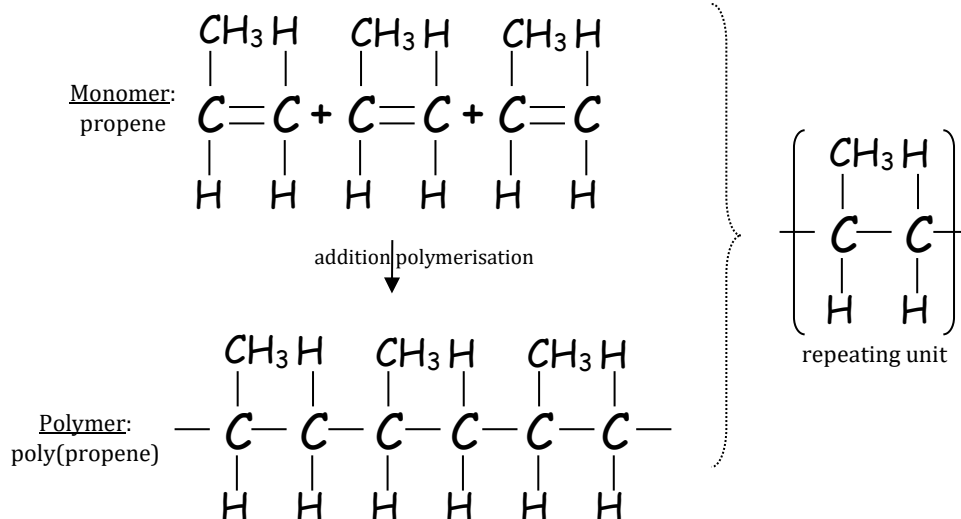
Monomer	ethene	styrene	propene	chloroethene
Polymer	poly(ethene)	poly(styrene)	poly(propene)	poly(chloroethene)



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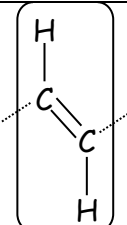
The structure of a polymer can be drawn given either the structure of the monomer or the repeating unit

- A repeating unit is the shortest section of polymer chain which, if repeated, would yield the complete polymer chain (except for the end-groups)
- From the structure of a polymer, the monomer or repeating unit can be drawn.



Nat5 Traffic Lights		Past Paper Question Bank Unit 3.2 Plastics										JABchem				
Outcome	Original Specimen Paper	New Specimen Paper	Nat5 2014	Nat5 2015	Nat5 2016	Nat5 2017	Nat5 2018	Nat5 2019	Nat5 2020	Nat5 2021						
24																
25			L4b			L13b(ii)	L2a(i)									
26																
27																
28																
29	mc20	mc21	L4a	mc17	L2a L2b	L13b(i)	L2a(i) L2b	mc20								
30																

MC Qu	Answer	% Correct	Reasoning
2015 MC 17	A	79	<p>propene</p> $ \begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ \text{C} = & \text{C} + & \text{C} = & \text{C} + & \text{C} = & \text{C} \\ & & & & & \\ \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} \end{array} $ <p style="text-align: center;">↓</p> <p>poly(propene)</p> $ \begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\ & & & & & \\ \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} \end{array} $
2019 MC 20	C	-	<p>polymer</p> $ \begin{array}{cccccc} \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} \\ & & & & & \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\ & & & & & \\ \text{H} & \text{CH}_3 & \text{H} & \text{H} & \text{H} & \text{CH}_3 \end{array} $ <p style="text-align: center;">↓</p> <p>Two different monomers</p> $ \begin{array}{cccccc} \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} \\ & & & & & \\ \text{C} = & \text{C} + & \text{C} = & \text{C} + & \text{C} = & \text{C} \\ & & & & & \\ \text{H} & \text{CH}_3 & \text{H} & \text{H} & \text{H} & \text{CH}_3 \end{array} $ <p>but-2-ene propene but-2-ene</p>

Nat5	Answer	Reasoning						
2014 4a	Diagram Showing:	$ \begin{array}{cccccc} \text{H} & \text{NC}_{12}\text{H}_8 & \text{H} & \text{NC}_{12}\text{H}_8 & \text{H} & \text{NC}_{12}\text{H}_8 \\ & & & & & \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} $						
2014 4b	Addition	<table border="1"> <thead> <tr> <th>Polymerisation</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>Addition</td> <td>C=C double bonds in monomers join together to form a long chain of C-C single bonds.</td> </tr> <tr> <td>Condensation</td> <td>Water molecules are removed as monomers join together to make larger polymer.</td> </tr> </tbody> </table>	Polymerisation	Description	Addition	C=C double bonds in monomers join together to form a long chain of C-C single bonds.	Condensation	Water molecules are removed as monomers join together to make larger polymer.
Polymerisation	Description							
Addition	C=C double bonds in monomers join together to form a long chain of C-C single bonds.							
Condensation	Water molecules are removed as monomers join together to make larger polymer.							
2016 2a	Diagram showing:	$ \begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\ & \text{C}_6\text{H}_5 & \text{H} & \text{C}_6\text{H}_5 & \text{H} & \text{C}_6\text{H}_5 \end{array} $						
2016 2b	$ \begin{array}{c} \text{H} \quad \text{CN} \\ \quad \\ \text{C} = \text{C} \\ \quad \\ \text{H} \quad \text{COOCH}_3 \end{array} $	$ \begin{array}{ccccccc} \text{H} & \text{H} & \text{H} & \text{CN} & \longrightarrow & \text{H} & \text{H} & \text{H} & \text{CN} \\ & & & & & & & & \\ -\text{C} & -\text{C} & -\text{C} & -\text{C}- & & \text{C} = \text{C} & + & \text{C} = \text{C} \\ & \text{C}_6\text{H}_5 & \text{H} & \text{COOCH}_3 & & & & & \\ \text{H} & & & & & \text{H} & \text{C}_6\text{H}_5 & \text{H} & \text{COOCH}_3 \end{array} $						
2017 13b(i)		The repeating units can be joined together and when the brackets are removed the original polymer is drawn.						
2017 13b(ii)	Addition	Addition polymerisation usually involves a C=C double bond opening up to leave a C-C single bond as the monomers join together to form the polymer. The C≡C triple bond in ethyne opens up to leave a C=C double bond as the monomers join together to form the polymer poly(ethyne)						
2018 2a(i)	addition	Addition reactions involve the opening up of the 2 nd bond in a C=C double bond and single bonds being formed on either side. Addition Polymerisation is when the C=C double bond in the monomer opens up and joins with other monomers to form a long polymer chain.						
2018 2a(ii)	$ \begin{array}{cccccc} \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \\ & & & & & \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\ & & & & & \\ \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \end{array} $	<p>tetrafluoroethene</p> $ \begin{array}{cccccc} \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \\ & & & & & \\ \text{C} = \text{C} & + & \text{C} = \text{C} & + & \text{C} = \text{C} \\ & & & & & \\ \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \end{array} $ <p style="text-align: center;">↓ Addition polymerisation</p> <p>poly(tetrafluoroethene)</p> $ \begin{array}{cccccc} \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \\ & & & & & \\ -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\ & & & & & \\ \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \end{array} $						
2018 2b	$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{C} = \text{C} \\ \quad \\ \text{H} \quad \text{H} \end{array} $	<p>A addition monomer always has the shape:</p> $ \begin{array}{c} \quad \\ \text{C} = \text{C} \\ \quad \end{array} $ <p>The monomer given in the question has four fluorine atoms in its corners. The other monomer has four hydrogen atoms in its corners.</p>						

Nat5

Traffic Lights

Past Paper Question Bank

JABchem

Unit 3.2 Plastics

Outcome	Int2 2000	Int2 2001	Int2 2002	Int2 2003	Int2 2004	Int2 2005	Int2 2006	Int2 2007	Int2 2008	Int2 2009	Int2 2010	Int2 2011	Int2 2012	Int2 2013	Int2 2014	Int2 2015
24 25 26								L7a						L10b(ii)		
27								L7c								
28 29 30	L7b	L3a	L7c	mc14	mc15	L6c	mc19	mc14 L7b	L6b	mc18	mc15	L10a(i)		L10b(i)	L5b	mc21

Int2	Answer	% Correct	Reasoning
2003 MC 14	A	44	There are two monomers used to create this polymer. The 1 st 2 carbons (from either end) are from an ethane monomer. The 3 rd and 4 th carbons have a -CH ₃ side group making the monomer for this group propene
2004 MC 15	B	85	<input checked="" type="checkbox"/> A -CH ₃ and -COOCH ₃ groups must be on the same carbon <input checked="" type="checkbox"/> B monomer has -CH ₃ and -COOCH ₃ on the same carbon & has a C=C double bond <input checked="" type="checkbox"/> C -CH ₃ and -COOCH ₃ groups must be on the same carbon <input checked="" type="checkbox"/> D molecule lacks C=C double bond to be the monomer which joins together
2006 MC 19	A	85	$ \begin{array}{cccccc} \text{H} & \text{CN} & \text{H} & \text{CN} & \text{H} & \text{CN} \\ & & & & & \\ -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 \end{array} $ <p style="text-align: right;">polymer</p> $ \begin{array}{cccccc} \text{H} & \text{CN} & \text{H} & \text{CN} & \text{H} & \text{CN} \\ & & & & & \\ \text{C}=\text{C} & + & \text{C}=\text{C} & + & \text{C}=\text{C} & \\ & & & & & \\ \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 \end{array} $ <p style="text-align: right;">monomer</p>
2007 MC 14	B	100	<input checked="" type="checkbox"/> A Cannot be a repeating unit as the molecule contains a C=C double bond <input checked="" type="checkbox"/> B Although this is the answer - the question had a mistake ∴ mark awarded to all <input checked="" type="checkbox"/> C Cannot be a repeating unit as the molecule contains a C=C double bond <input checked="" type="checkbox"/> D Side group has 2 carbons but in polymer side groups only have 1 carbon
2009 MC 18	A	37	<input checked="" type="checkbox"/> A 2 carbon monomer (ethene) and 3 carbon monomer (propene) <input checked="" type="checkbox"/> B Largest monomer in plastic has 3 carbons (-CH ₃ group off main chain) <input checked="" type="checkbox"/> C Largest monomer in plastic has 3 carbons (-CH ₃ group off main chain) <input checked="" type="checkbox"/> D Largest monomer in plastic has 3 carbons (-CH ₃ group off main chain)
2010 MC 15	B	87	$ \begin{array}{cccccc} \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 \\ & & & & & \\ -\text{H}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 \end{array} $ <p style="text-align: right;">polymer</p> $ \begin{array}{cccccc} \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 \\ & & & & & \\ \text{C}=\text{C} & + & \text{C}=\text{C} & + & \text{C}=\text{C} & \\ & & & & & \\ \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 \end{array} $ <p style="text-align: right;">monomer</p>
2015 MC 21	A	76	$ \begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ \text{C}=\text{C} & + & \text{C}=\text{C} & + & \text{C}=\text{C} & \rightarrow \\ & & & & & \\ \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} \end{array} $ <p style="text-align: center;">propene</p> $ \begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} \end{array} $ <p style="text-align: center;">poly(propene)</p>

Int2	Answer	Reasoning
2000 7b	Diagram showing:	$ \begin{array}{ccccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \\ & & & & & & \\ \text{C} = & \text{C} + & \text{C} = & \text{C} + & \text{C} = & \text{C} & \longrightarrow \\ & & & & & & \\ \text{H} & \text{CH}_2 & \text{H} & \text{CH}_2 & \text{H} & \text{CH}_2 & \\ & & & & & & \\ & \text{CHO} & & \text{CHO} & & \text{CHO} & \end{array} $
2001 3a	$ \begin{array}{c} \text{OCOCH}_3 \\ \quad \\ \text{C} = \text{C} \\ \quad \\ \text{H} \quad \text{H} \end{array} $	$ \begin{array}{ccccccc} \text{CH}_3 & \text{CH}_3 & \text{CH}_3 & & \text{CH}_3 & \text{CH}_3 & \text{CH}_3 \\ & & & & & & \\ \text{C} = \text{O} & \text{C} = \text{O} & \text{C} = \text{O} & & \text{C} = \text{O} & \text{C} = \text{O} & \text{C} = \text{O} \\ & & & & & & \\ \text{O} & \text{H} & \text{O} & \text{H} & \text{O} & \text{H} & \\ & & & & & & \\ \text{C} = & \text{C} + & \text{C} = & \text{C} + & \text{C} = & \text{C} & \longrightarrow \\ & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \\ & & & & & & \\ & \text{H} & & \text{H} & & \text{H} & \end{array} $
2002 7c	$ \begin{array}{c} \text{F} \quad \text{F} \\ \quad \\ \text{C} = \text{C} \\ \quad \\ \text{F} \quad \text{F} \end{array} $	Take a 2 carbon portion of the polymer and redraw with C=C double bond in the middle of the 2 carbons.
2005 6c	Diagram showing:	$ \begin{array}{ccccccc} & \text{CH}_3 & \text{H} & & \text{CH}_3 & \text{H} & & \text{CH}_3 & \text{H} \\ & & & & & & & & \\ \text{propene} & \text{C} = & \text{C} + & \text{C} = & \text{C} + & \text{C} = & \text{C} \\ & & & & & & & & \\ & \text{H} & \text{H} & & \text{H} & \text{H} & & \text{H} & \text{H} \\ & & & & \downarrow & & & & \\ & \text{CH}_3 & \text{H} & & \text{CH}_3 & \text{H} & & \text{CH}_3 & \text{H} \\ & & & & & & & & \\ \text{poly(propene)} & \text{C} - & \text{C} - & \text{C} - & \text{C} - & \text{C} - & \text{C} \\ & & & & & & & & \\ & \text{H} & \text{H} & & \text{H} & \text{H} & & \text{H} & \text{H} \end{array} $
2007 7a	C=C double bond	Styrene forms poly(styrene) by addition polymerisation. Addition reactions require a C=C double bond for a reaction to occur.
2007 7b	Structure showing:	$ \begin{array}{ccccccc} \text{H} & \text{C}_6\text{H}_5 & \text{H} & \text{C}_6\text{H}_5 & \text{H} & \text{C}_6\text{H}_5 & \\ & & & & & & \\ \text{C} = & \text{C} + & \text{C} = & \text{C} + & \text{C} = & \text{C} & \\ & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \\ & & & \downarrow & & & \\ \text{H} & \text{C}_6\text{H}_5 & \text{H} & \text{C}_6\text{H}_5 & \text{H} & \text{C}_6\text{H}_5 & \\ & & & & & & \\ \text{C} - & \text{C} - & \text{C} - & \text{C} - & \text{C} - & \text{C} - & \\ & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \end{array} $ <p>Styrene or phenylethene</p> <p>poly(styrene) or poly(phenylethene)</p>

2007 7c	Poly(phenylethene)	Styrene is also known as phenylethene ∴ poly(styrene) is also known as poly(phenylethene)
2008 6b	$\begin{array}{c} \text{H} \quad \text{OH} \\ \quad \\ -\text{C}-\text{C}- \\ \quad \\ \text{H} \quad \text{H} \end{array}$	$\begin{array}{cccccc} \text{H} & \text{OH} & \text{H} & \text{OH} & \text{H} & \text{OH} \\ & & & & & \\ -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} \quad \text{poly(ethanol)}$ <p style="text-align: center;">↓</p> $\begin{array}{cccccc} \text{H} & \text{OH} & \text{H} & \text{OH} & \text{H} & \text{OH} \\ & & & & & \\ \text{C}=\text{C} & + & \text{C}=\text{C} & + & \text{C}=\text{C} & \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} \quad \text{ethanol}$
2011 10a(i)	$\begin{array}{c} \text{H} \quad \text{COOH} \\ \quad \\ \text{C}=\text{C} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	$\begin{array}{cccccc} & \text{COOH} & & \text{COOH} & & \text{COOH} \\ & & \text{H} & & \text{H} & \\ \text{H} & -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} \quad \text{polymer}$ <p style="text-align: center;">↓</p> $\begin{array}{cccccc} & \text{COOH} & & \text{COOH} & & \text{COOH} \\ & & \text{H} & & \text{H} & \\ \text{H} & -\text{C}=\text{C} & + & \text{C}=\text{C} & + & \text{C}=\text{C} \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} \quad \text{monomer}$
2013 10b(i)	Diagram showing product:	$\begin{array}{cccccc} \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \\ & & & & & \\ \text{C}=\text{C} & + & \text{C}=\text{C} & + & \text{C}=\text{C} & \\ & & & & & \\ \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \end{array} \quad \text{tetrafluoroethene}$ <p style="text-align: center;">↓</p> $\begin{array}{cccccc} \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \\ & & & & & \\ -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{F} & \text{F} & \text{F} & \text{F} & \text{F} & \text{F} \end{array} \quad \text{poly(tetrafluoroethene)}$
2013 10b(ii)	Addition	Addition polymerisation has monomers with C=C double bonds which open up and join up with each other to form a long chain of C-C single bonds in a polymer.
2014 5b	Diagram Showing:	$\begin{array}{cccccc} \text{H} & \text{CN} & \text{H} & \text{CN} & \text{H} & \text{CN} \\ & & & & & \\ -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 \end{array}$

Outcome	2000 Credit	2001 Credit	2002 Credit	2003 Credit	2004 Credit	2005 Credit	2006 Credit	2007 Credit	2008 Credit	2009 Credit	2010 Credit	2011 Credit	2012 Credit	2013 Credit		
24 25 26											10b(ii)					
27																
28 29 30	12a		10b(i)	14b	10a	11a	8a				18a	10b(i)	13a	20a		

SG Credit	Answer	Reasoning			
2000C 12a	$\begin{array}{c} \text{H} \quad \text{COOCH}_3 \\ \quad \\ \text{C} = \text{C} \\ \quad \\ \text{H} \quad \text{CN} \end{array}$	$\begin{array}{c} \text{COOCH}_3 \quad \text{COOCH}_3 \quad \text{COOCH}_3 \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{C} = \text{C} + \text{C} = \text{C} + \text{C} = \text{C} \\ \quad \quad \quad \\ \text{H} \quad \text{CN} \quad \text{H} \quad \text{CN} \quad \text{H} \quad \text{CN} \end{array} \rightarrow \begin{array}{c} \text{COOCH}_3 \quad \text{COOCH}_3 \quad \text{COOCH}_3 \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \\ \text{H} \quad \text{CN} \quad \text{H} \quad \text{CN} \quad \text{H} \quad \text{CN} \end{array}$			
2002C 10b(i)	$\left[\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{C} - \text{C} \\ \quad \\ \text{Cl} \quad \text{H} \end{array} \right]$	<table border="1" style="width: 100%; text-align: center;"> <tr> <td style="width: 33%;"> $\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ \text{C} = \text{C} + \text{C} = \text{C} + \text{C} = \text{C} \\ \quad \quad \quad \quad \quad \\ \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \end{array}$ <p>monomer</p> </td> <td style="width: 33%;"> $\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \quad \quad \\ \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \end{array}$ <p>polymer</p> </td> <td style="width: 33%;"> $\left[\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{C} - \text{C} \\ \quad \\ \text{Cl} \quad \text{H} \end{array} \right]$ <p>Repeating Unit</p> </td> </tr> </table>	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ \text{C} = \text{C} + \text{C} = \text{C} + \text{C} = \text{C} \\ \quad \quad \quad \quad \quad \\ \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \end{array}$ <p>monomer</p>	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \quad \quad \\ \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \end{array}$ <p>polymer</p>	$\left[\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{C} - \text{C} \\ \quad \\ \text{Cl} \quad \text{H} \end{array} \right]$ <p>Repeating Unit</p>
$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ \text{C} = \text{C} + \text{C} = \text{C} + \text{C} = \text{C} \\ \quad \quad \quad \quad \quad \\ \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \end{array}$ <p>monomer</p>	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \quad \quad \\ \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \quad \text{Cl} \quad \text{H} \end{array}$ <p>polymer</p>	$\left[\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{C} - \text{C} \\ \quad \\ \text{Cl} \quad \text{H} \end{array} \right]$ <p>Repeating Unit</p>			
2003C 14b	$\begin{array}{c} \text{CH}_3\text{H} \quad \text{CH}_3\text{H} \quad \text{CH}_3\text{H} \\ \quad \quad \quad \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$	<p>Draw propene into a 'H' shape, draw three and polymerise them into polymer</p> $\begin{array}{c} \text{CH}_3\text{H} \quad \text{CH}_3\text{H} \quad \text{CH}_3\text{H} \\ \quad \quad \quad \quad \quad \\ \text{C} = \text{C} + \text{C} = \text{C} + \text{C} = \text{C} \\ \quad \quad \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array} \rightarrow \begin{array}{c} \text{CH}_3\text{H} \quad \text{CH}_3\text{H} \quad \text{CH}_3\text{H} \\ \quad \quad \quad \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array}$			
2004C 10a	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{C} = \text{C} \\ \quad \\ \text{CN} \quad \text{H} \end{array}$	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ \text{C} = \text{C} + \text{C} = \text{C} + \text{C} = \text{C} \\ \quad \quad \quad \quad \quad \\ \text{CN} \quad \text{H} \quad \text{CN} \quad \text{H} \quad \text{CN} \quad \text{H} \end{array} \rightarrow \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \quad \quad \\ \text{CN} \quad \text{H} \quad \text{CN} \quad \text{H} \quad \text{CN} \quad \text{H} \end{array}$ <p style="text-align: center;">acrylonitrile poly(acrylonitrile)</p>			
2005C 11a	Diagram showing:	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \quad \quad \\ \text{H} \quad \text{C}_6\text{H}_5 \quad \text{H} \quad \text{C}_6\text{H}_5 \quad \text{H} \quad \text{C}_6\text{H}_5 \end{array}$			
2006C 8a	$\begin{array}{c} \text{F} \quad \text{F} \\ \quad \\ \text{C} = \text{C} \\ \quad \\ \text{F} \quad \text{F} \end{array}$	<table border="1" style="width: 100%; text-align: center;"> <tr> <td style="width: 33%;"> $\begin{array}{c} \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \\ \quad \quad \quad \quad \quad \\ \text{C} = \text{C} + \text{C} = \text{C} + \text{C} = \text{C} \\ \quad \quad \quad \quad \quad \\ \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \end{array}$ <p>monomer</p> </td> <td style="width: 33%;"> $\begin{array}{c} \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \\ \quad \quad \quad \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \quad \quad \\ \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \end{array}$ <p>polymer</p> </td> <td style="width: 33%;"> $\left[\begin{array}{c} \text{F} \quad \text{F} \\ \quad \\ \text{C} - \text{C} \\ \quad \\ \text{F} \quad \text{F} \end{array} \right]$ <p>Repeating Unit</p> </td> </tr> </table>	$\begin{array}{c} \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \\ \quad \quad \quad \quad \quad \\ \text{C} = \text{C} + \text{C} = \text{C} + \text{C} = \text{C} \\ \quad \quad \quad \quad \quad \\ \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \end{array}$ <p>monomer</p>	$\begin{array}{c} \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \\ \quad \quad \quad \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \quad \quad \\ \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \end{array}$ <p>polymer</p>	$\left[\begin{array}{c} \text{F} \quad \text{F} \\ \quad \\ \text{C} - \text{C} \\ \quad \\ \text{F} \quad \text{F} \end{array} \right]$ <p>Repeating Unit</p>
$\begin{array}{c} \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \\ \quad \quad \quad \quad \quad \\ \text{C} = \text{C} + \text{C} = \text{C} + \text{C} = \text{C} \\ \quad \quad \quad \quad \quad \\ \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \end{array}$ <p>monomer</p>	$\begin{array}{c} \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \\ \quad \quad \quad \quad \quad \\ -\text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C}- \\ \quad \quad \quad \quad \quad \\ \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \quad \text{F} \end{array}$ <p>polymer</p>	$\left[\begin{array}{c} \text{F} \quad \text{F} \\ \quad \\ \text{C} - \text{C} \\ \quad \\ \text{F} \quad \text{F} \end{array} \right]$ <p>Repeating Unit</p>			

2009C 18a	$\begin{array}{c} \text{H} \quad \text{CN} \\ \quad \\ -\text{C}-\text{C}- \\ \quad \\ \text{H} \quad \text{COOCH}_3 \end{array}$	A repeating unit is a 2 carbon segment of the main chain
2010C 10b(i)	Man-made or not found in nature	Synthetic materials are not found naturally on Earth and are made by the chemical industry.
201C 10b(ii)	Diagram showing:	$\begin{array}{cccccc} \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 \\ & & & & & \\ -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 \end{array}$
2011C 13a	$\begin{array}{c} \text{Cl} \quad \text{H} \\ \quad \\ \text{C}=\text{C} \\ \quad \\ \text{Cl} \quad \text{H} \end{array}$	<p>poly(vinylidichloride) —</p> $\begin{array}{cccccc} \text{Cl} & \text{H} & \text{Cl} & \text{H} & \text{Cl} & \text{H} \\ & & & & & \\ -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{Cl} & \text{H} & \text{Cl} & \text{H} & \text{Cl} & \text{H} \end{array}$ <p style="text-align: center;">↓</p> <p>vinylidichloride</p> $\begin{array}{cccccc} \text{Cl} & \text{H} & \text{Cl} & \text{H} & \text{Cl} & \text{H} \\ & & & & & \\ \text{C}=\text{C} & + & \text{C}=\text{C} & + & \text{C}=\text{C} \\ & & & & & \\ \text{Cl} & \text{H} & \text{Cl} & \text{H} & \text{Cl} & \text{H} \end{array}$
2012C 20a	Diagram showing the polymer shown:	$\begin{array}{cccc} \text{H} & \text{COOCH}_3 & \text{H} & \text{COOCH}_3 \\ & & & \\ \text{C}=\text{C} & + & \text{C}=\text{C} & + & \text{C}=\text{C} & \text{monomer} \\ & & & & & \\ \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 \end{array}$ <p style="text-align: center;">↓</p> $\begin{array}{cccccc} & \text{COOCH}_3 & & \text{COOCH}_3 & & \text{COOCH}_3 \\ & & \text{H} & & \text{H} & \\ -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 \end{array} \quad \text{polymer}$

Outcome	2000 General	2001 General	2002 General	2003 General	2004 General	2005 General	2006 General	2007 General	2008 General	2009 General	2010 General	2011 General	2012 General	2013 General		
24 25 26	20b(i)									11e			14b			
27	20b(ii)					14b(i)		10c	17a	11d	17b(iii)		14a			
28 29 30		10a				11b							15a(ii)			

SG General	Answer	Reasoning										
2000G 20b(i)	addition polymerisation	Addition polymers like poly(tetrafluoroethene) is made when C=C double bonds open out to form a long chain of C-C single bonds										
2000G 20b(ii)	tetrafluoroethene	<table border="1"> <thead> <tr> <th>Monomer</th> <th>ethene</th> <th>propene</th> <th>chloroethene</th> <th>tetrafluoroethene</th> </tr> </thead> <tbody> <tr> <th>Polymer</th> <td>poly(ethene)</td> <td>poly(propene)</td> <td>poly(chloroethene)</td> <td>poly(tetrafluoroethene)</td> </tr> </tbody> </table>	Monomer	ethene	propene	chloroethene	tetrafluoroethene	Polymer	poly(ethene)	poly(propene)	poly(chloroethene)	poly(tetrafluoroethene)
Monomer	ethene	propene	chloroethene	tetrafluoroethene								
Polymer	poly(ethene)	poly(propene)	poly(chloroethene)	poly(tetrafluoroethene)								
2001G 10a	diagram showing the product:	$ \begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ \text{C}=\text{C} & + & \text{C}=\text{C} & + & \text{C}=\text{C} & \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ <p style="text-align: right;">ethene</p> <p style="text-align: center;">↓</p> $ \begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ <p style="text-align: right;">poly(ethene)</p>										
2004G 11b	diagram showing the following product:	$ \begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ \text{C}=\text{C} & + & \text{C}=\text{C} & + & \text{C}=\text{C} & \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ <p style="text-align: right;">ethene</p> <p style="text-align: center;">↓</p> $ \begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ -\text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- & \text{C}- \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ <p style="text-align: right;">poly(ethene)</p>										
2005G 14b(i)	poly(butene)	Addition Polymerisation: butene \longrightarrow poly(butene) monomer polymer										

2007G 10c	ethene	<table border="1"> <tbody> <tr> <td>Polymer</td> <td>poly(ethene)</td> <td>poly(propene)</td> <td>poly(chloroethene)</td> <td>poly(styrene)</td> </tr> <tr> <td>Monomer</td> <td>ethene</td> <td>propene</td> <td>chloroethene</td> <td>styrene</td> </tr> </tbody> </table>	Polymer	poly(ethene)	poly(propene)	poly(chloroethene)	poly(styrene)	Monomer	ethene	propene	chloroethene	styrene
Polymer	poly(ethene)	poly(propene)	poly(chloroethene)	poly(styrene)								
Monomer	ethene	propene	chloroethene	styrene								
2008G 17a	chloroethene	<table border="1"> <tbody> <tr> <td>Monomer</td> <td>ethene</td> <td>propene</td> <td>chloroethene</td> <td>styrene</td> </tr> <tr> <td>Polymer</td> <td>poly(ethene)</td> <td>poly(propene)</td> <td>poly(chloroethene)</td> <td>poly(styrene)</td> </tr> </tbody> </table>	Monomer	ethene	propene	chloroethene	styrene	Polymer	poly(ethene)	poly(propene)	poly(chloroethene)	poly(styrene)
Monomer	ethene	propene	chloroethene	styrene								
Polymer	poly(ethene)	poly(propene)	poly(chloroethene)	poly(styrene)								
2009G 11d	styrene	<table border="1"> <tbody> <tr> <td>Polymer</td> <td>poly(ethene)</td> <td>poly(propene)</td> <td>poly(chloroethene)</td> <td>poly(styrene)</td> </tr> <tr> <td>Monomer</td> <td>ethene</td> <td>propene</td> <td>chloroethene</td> <td>styrene</td> </tr> </tbody> </table>	Polymer	poly(ethene)	poly(propene)	poly(chloroethene)	poly(styrene)	Monomer	ethene	propene	chloroethene	styrene
Polymer	poly(ethene)	poly(propene)	poly(chloroethene)	poly(styrene)								
Monomer	ethene	propene	chloroethene	styrene								
2009G 11e	Polymerisation or Addition Polymerisation	Polymerisation: process where monomers join together to make a bigger molecule (polymer)										
2010G 17b(iii)	poly(propene)	C_3H_6 is the formula of both propene and cyclopropane. To be turned into a plastic, the monomer must have a $C=C$ double bond $\therefore C_3H_6$ is propene. If monomer is propene then the name of the polymer is poly(propene).										
2011G 15a(ii)	Diagram showing the following product:	<p style="text-align: center;">ethene</p> $ \begin{array}{cccccc} H & H & H & H & H & H \\ & & & & & \\ C & = & C & + & C & = & C & + & C & = & C \\ & & & & & & & & & & \\ H & & H & & H & & H & & H & & H \end{array} $ <p style="text-align: center;">↓</p> <p style="text-align: center;">poly(ethene)</p> $ \begin{array}{cccccc} H & H & H & H & H & H \\ & & & & & \\ - & C & - & C & - & C & - & C & - & C & - & C & - \\ & & & & & \\ H & H & H & H & H & H \end{array} $										
2012G 14a	Styrene	<table border="1"> <tbody> <tr> <td>Monomer</td> <td>ethene</td> <td>propene</td> <td>styrene</td> <td>chloroethene</td> </tr> <tr> <td>Polymer</td> <td>poly(ethene)</td> <td>poly(propene)</td> <td>poly(styrene)</td> <td>poly(chloroethene)</td> </tr> </tbody> </table>	Monomer	ethene	propene	styrene	chloroethene	Polymer	poly(ethene)	poly(propene)	poly(styrene)	poly(chloroethene)
Monomer	ethene	propene	styrene	chloroethene								
Polymer	poly(ethene)	poly(propene)	poly(styrene)	poly(chloroethene)								
2012G 14b	addition polymerisation	<u>Addition</u> : $C=C$ double bonds open up join together to form long chain of $C-C$ <u>Polymerisation</u> : monomers join together to form polymer										