InkChemistry

ANSWER BOOK

Addition polymers

Alkenes and alcohols · Unit C18

AQA 3.3.4.3 · OCR A 4.1.3

19 questions · 56 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 AD-Q2

B1 PTFE is made from tetrafluoroethene, $CF_2=CF_2$. **B1** PVC is made from chloroethene, $CH_2=CHCl$. [2]

A2 AD-Q4

B1 the repeating unit is $-[CH_2-CH(CN)]-$, two main-chain carbons. **B1** the monomer is $CH_2=CHCN$, propenenitrile. [2]

A3 AD-Q11

B1 its C–F and C–C bonds are very strong, so PTFE does not react with food and is stable at cooking temperatures. **B1** the fluorine atoms form a tight, unreactive sheath around the chain, so food has almost nothing to bond to and does not stick. [2]

A4 AD-Q17

B1 two carbons in the main chain joined by a single bond, with an ethyl side group on the second: $-[CH_2-CH(CH_2CH_3)]-$. **B1** a bond extended out through each bracket and n after the closing bracket; reject a C=C in the chain. [2]

A5 AD-Q19

B1 photodegradation needs ultraviolet light to break bonds in the chain. **B1** buried under soil or other rubbish, the bag receives no light, so its chains are not broken. [2]

A6 AD-Q21

B1 tip the mixture into water: the poly(propene) floats and the PVC sinks. **B1** poly(propene) has a density of about 0.90 g cm^{-3}, less than water, while PVC's is about 1.4 g cm^{-3}, more than water. [2]

SECTION B · Standard, 3 to 5 marks

B1 AD-Q3

B1 the repeating unit is $-[CH_2-CH(CH_3)]-$, two carbons in the main chain with CH_3 as a side group. **B1** a bond extends out through each bracket, and n is written after the closing bracket. **M1** the repeating unit has the same Mr as the monomer, so number of units = $2.52 \times 10^5 \div 42.0$. **A1** 6.00×10^3 repeating units, to three significant figures. [4]

B2 AD-Q7

B1 the C–Cl bonds in PVC are polar, so there are permanent dipole–dipole forces between the chains as well as van der Waals forces. **B1** the stronger forces hold the chains more firmly in place, so they slide past each other less easily; reject 'bonds between chains'. **B1** unplasticised PVC is used for window frames or drainpipes, because it is rigid and does not rot. **B1** plasticised PVC is used for cable insulation or flooring, because it is flexible and an electrical insulator. [4]

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B3 AD-Q1

B1 the π bond of each chloroethene molecule opens and its electrons form σ bonds to the neighbouring monomers. **B1** the monomers join with no other product, so the reaction is an addition. **B1** every atom of every monomer ends up in the polymer, so the mass of desired product equals the total mass of reactants. [3]

B4 AD-Q5

B1 the chains are saturated, containing only C–C and C–H single bonds. **B1** these bonds are strong and almost non-polar, so they are not attacked by electrophiles or nucleophiles. **B1** there is no functional group that enzymes in microorganisms can act on, so the polymer is not broken down in the environment. [3]

B5 AD-Q6

B1 the plasticiser molecules fit between the polymer chains and push them further apart. **B1** this weakens the intermolecular forces between the chains. **B1** so the chains can slide over each other more easily and the material bends. [3]

B6 AD-Q9

M1 amount of repeating units = 250 ÷ 62.5 = 4.00 mol. **M1** each repeating unit contains one chlorine atom, so 4.00 mol of HCl forms. **A1** mass of HCl = 4.00 × 36.5 = 146 g, to three significant figures. [3]

B7 AD-Q10

B1 burning PVC releases hydrogen chloride, from the chlorine in the polymer. **B1** hydrogen chloride is toxic and acidic, contributing to acid rain, so it must not be released. **B1** the scrubber contains a base such as calcium oxide or calcium carbonate, which neutralises the hydrogen chloride. [3]

B8 AD-Q13

B1 ethene contains a C=C double bond, a σ and a π bond, while poly(ethene) has only C–C and C–H single bonds. **B1** ethene is unsaturated and reacts with electrophiles such as bromine, while poly(ethene) is saturated and unreactive, like an alkane. **B1** ethene decolourises bromine water, but poly(ethene) does not. [3]

B9 AD-Q14

B1 the waste is collected and sorted so that only poly(propene) is present. **B1** it is washed and then shredded into small pieces. **B1** the pieces are melted and moulded or extruded into new products. [3]

B10 AD-Q16

B1 high-density poly(ethene) has unbranched chains that pack closely, so the van der Waals forces between them are stronger. **B1** it is therefore stiffer and softens at a higher temperature, so a bottle keeps its shape. **B1** low-density poly(ethene) has branched chains that pack loosely, so it is flexible and can be made into thin film. [3]

B11 AD-Q18

B1 the C=O groups absorb ultraviolet light, which poly(ethene) itself barely absorbs. **B1** the energy absorbed breaks a C–C bond next to the C=O group. **B1** the chains break into shorter pieces, so the plastic becomes brittle and fragments. [3]

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B12 AD-Q20 [3]

M1 amount of ethene = 1000 ÷ 28.0 = 35.7 mol. **M1** energy released = 35.7 mol × 82 kJ mol^{-1}. **A1** 2.9 × 10^{3} kJ released, to two significant figures, the precision of the enthalpy change given; allow 2930 kJ.

SECTION C · Long, 6 marks or more

C1 AD-Q12 [6]

Indicative content

B1 both polymers have saturated chains of strong, non-polar bonds, so they are unreactive and non-biodegradable, and in landfill they last for centuries with their carbon wasted. **B1** sorted, cleaned poly(ethene) can be remelted and moulded into new objects, saving crude oil and energy, but the sorting costs money and a little PVC spoils a batch. **B1** feedstock recycling heats the waste to break the chains into small molecules, such as alkenes, that become raw materials for new polymers and other chemicals. **B1** feedstock recycling accepts mixed and dirty plastic that cannot be remelted, though the cracking plant needs energy and capital to run. **B1** burning for energy uses the energy stored in the polymer to generate electricity and cuts the volume of waste, but releases carbon dioxide, and carbon monoxide if combustion is incomplete. **B1** burning PVC also gives hydrogen chloride, which is toxic and acidic and is removed from the waste gases by a base such as calcium oxide before they are released.

Levels

Level 3 (5–6 marks) remelting, feedstock recycling and burning for energy are each weighed against landfill, feedstock recycling is explained as breaking the chains into small molecules that become new raw materials, and the HCl from PVC is removed with a base; the judgement matches each method to the kind of waste it suits, such as clean poly(ethene) to remelting and mixed waste to feedstock recycling.

Level 2 (3–4 marks) most of the methods are weighed on both sides and PVC is singled out for its hydrogen chloride; typically feedstock recycling is treated as remelting under another name, or the HCl is noted with no means of removing it, and the conclusion picks one method for all waste.

Level 1 (1–2 marks) a few separate statements about disposal, often that the plastic rots slowly in landfill or that PVC burns as cleanly as poly(ethene); no method is set against another.

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