

AQA A-LEVEL CHEMISTRY • 7405

CHEMISTRY



EXAM QUESTION PACK

3.3.12 POLYMERS

SCORE

/130

PERCENTAGE

%

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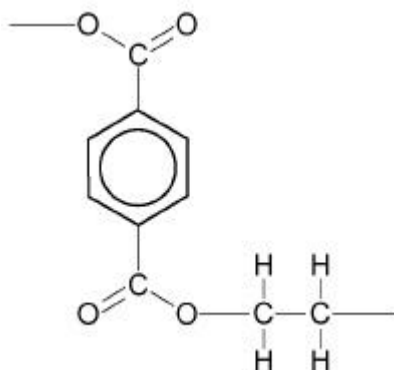
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Q1.

The structure of part of a polyester chain is shown.



Which statement correctly explains why plastics made from this polyester only soften at high temperatures?

- A** Hydrogen bonds and van der Waals' forces exist between polyester chains.
- B** Permanent dipole-dipole forces and van der Waals' forces exist between polyester chains.
- C** The carbon-carbon bonds in the chain are strong.
- D** The carbon-oxygen bonds in the chain are strong.

☐
☐
☐
☐

(Total 1 mark)

Q2.

Which polymer is least likely to be biodegraded after several years in a landfill site?

A Kevlar

☐

B Nylon

☐

C Polythene

☐

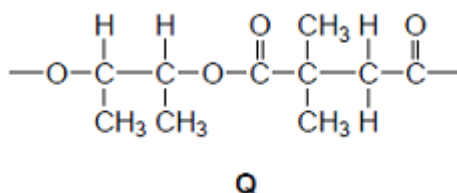
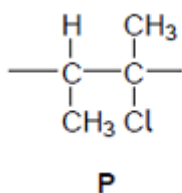
D Terylene

☐

(Total 1 mark)

Q3.

Repeating units of two polymers, **P** and **Q**, are shown in the figure below.



- (a) Draw the structure of the monomer used to form polymer **P**.
Name the type of polymerisation involved.

Monomer

Type of polymerisation

(2)

- (b) Draw the structures of **two** compounds that react together to form polymer **Q**.

Structure of compound 1

Structure of compound 2

(2)

- (c) Suggest an environmental advantage of polymer **Q** over polymer **P**.
Justify your answer.

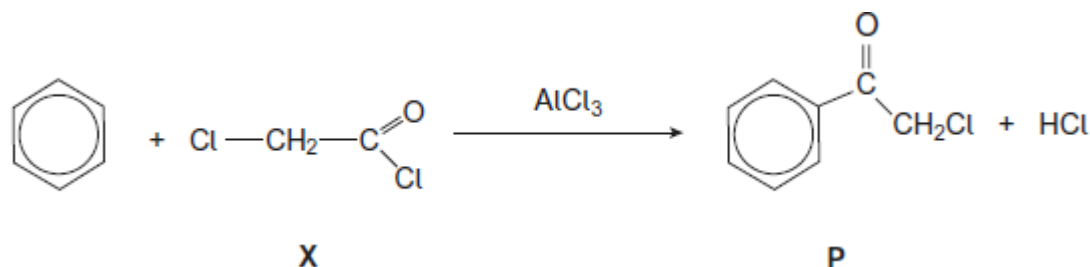
Advantage _____

Justification _____

Q4.

Compound **X** (ClCH_2COCl) is used as a reagent in organic synthesis.

- (a) One important reaction of **X** is in the preparation of compound **P** as shown.



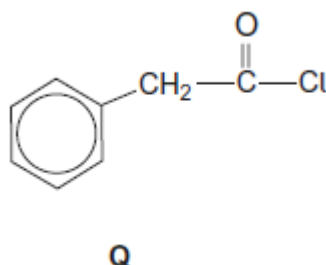
- (i) Draw the structure of the electrophile formed by the reaction of **X** with AlCl_3 .

(1)

- (ii) Outline the mechanism for the reaction of the electrophile from part (a)(i) with benzene in the preparation of **P**.

(3)

- (b) Compound **Q** is an alternative product that could be formed when **X** reacts with benzene.



Describe how you could distinguish between **P** and **Q** by a test-tube reaction. Give the reagent used and the observation with each compound.

Reagent _____

Observation with **P** _____

Observation with Q _____

(3)

- (c) **X** is also used to make the compound HOCH_2COOH . This compound is polymerised to form the polymer known as PGA. PGA is used in surgical sutures (stitches).

(i) Draw the repeating unit of PGA.

(1)

- (ii) Production of PGA occurs via a cyclic compound. Two HOCH_2COOH molecules react together to form the cyclic compound and two molecules of water.

Draw the structure of this cyclic compound.

(1)

- (d) Poly(propene) is also used in surgical sutures.

(i) Draw the repeating unit of poly(propene).

(1)

- (ii) Suggest an advantage of surgical sutures made from PGA rather than from poly(propene).
Explain your answer.

Q5.

Lactic acid, $\text{CH}_3\text{CH}(\text{OH})\text{COOH}$, is formed in the human body during metabolism and exercise. This acid is also formed by the fermentation of carbohydrates such as sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$.

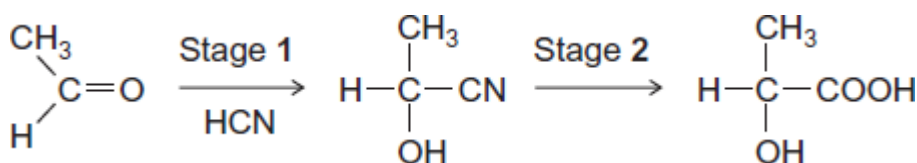
- (a) (i) Give the IUPAC name for lactic acid.

_____ (1)

- (ii) Write an equation for the formation of lactic acid from sucrose and water.

_____ (1)

- (b) A molecule of lactic acid contains an asymmetric carbon atom. The lactic acid in the body occurs as a single enantiomer. A racemic mixture (racemate) of lactic acid can be formed in the following two-stage synthesis.



- (i) Name and outline a mechanism for Stage 1.

Name of mechanism _____

Mechanism

- (ii) Give the meaning of the term *racemic mixture (racemate)*.

- (iii) Explain how you could distinguish between a racemic mixture (racemate) of lactic acid and one of the enantiomers of lactic acid.

(2)

- (c) A mixture of lactic acid and its salt sodium lactate is used as an acidity regulator in some foods. An acidity regulator makes sure that there is little variation in the pH of food.

(i) Write an equation for the reaction of lactic acid with sodium hydroxide.

(1)

- (ii) The acid dissociation constant K_a for lactic acid has the value $1.38 \times 10^{-4} \text{ mol dm}^{-3}$ at 298 K.

Calculate the pH of an equimolar solution of lactic acid and sodium lactate.

(2)

- (iii) Suggest an alternative name for the term *acidity regulator*.
Explain how a mixture of lactic acid and sodium lactate can act as a regulator when natural processes increase the acidity in some foods.

Name _____

Explanation _____

(3)

(d)



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The cup shown is made from PLA, poly(lactic acid).
PLA is the condensation polymer formed from lactic acid.

The polymer is described as 100% biodegradable and 100% compostable.

Compostable material breaks down slowly in contact with the moist air in a garden bin. This produces compost that can be used to improve soil.

The manufacturers stress that PLA cups differ from traditional plastic cups that are neither biodegradable nor compostable.

(i) Draw a section of PLA that shows **two** repeating units.

(2)

(ii) Name the type of condensation polymer in PLA.

(1)

(iii) An intermediate in the production of PLA is a cyclic compound ($C_6H_8O_4$) that is formed from two PLA molecules.

Draw the structure of this cyclic compound.

(1)

- (iv) Traditional non-biodegradable plastic cups can be made from poly(phenylethene), commonly known as *polystyrene*.

Draw the repeating unit of poly(phenylethene).

(1)

- (v) The manufacturers of PLA claim that the material will break down to compost in just 12 weeks.

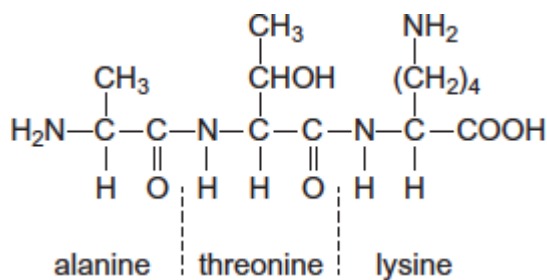
Suggest **one** reason why PLA in landfill may take longer than 12 weeks to break down.

(1)

(Total 22 marks)

Q6.

- (a) The tripeptide shown is formed from the amino acids alanine, threonine and lysine.



- (i) Draw a separate circle around **each** of the asymmetric carbon atoms in the tripeptide.
- (ii) Draw the zwitterion of alanine.

(1)

(1)

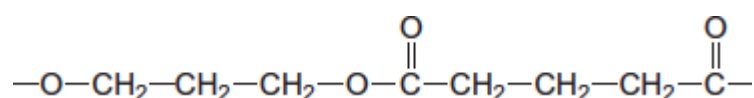
- (iii) Give the IUPAC name of threonine.

(1)

- (iv) Draw the species formed by lysine at low pH.

(1)

- (b) The repeating unit shown represents a polyester.



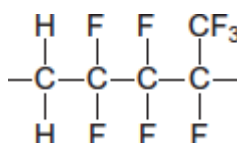
- (i) Name this type of polymer.

(1)

- (ii) Give the IUPAC name for the alcohol used to prepare this polyester.

(1)

- (c) The repeating unit shown represents a polyalkene co-polymer. This co-polymer is made from two different alkene monomers.



- (i) Name the type of polymerisation occurring in the formation of this co-polymer.

(1)

- (ii) Draw the structure of each alkene monomer.

Alkene monomer 1

Alkene monomer 2

(2)

- (d) One of the three compounds shown in parts (a), (b) and (c) cannot be broken down by hydrolysis.

Write the letter **(a)**, **(b)** or **(c)** to identify this compound and explain why hydrolysis of this compound does **not** occur.

Compound _____

Explanation _____

(2)

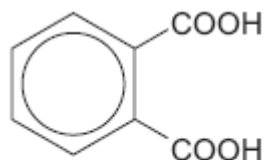
(Total 11 marks)

Q7.

Items softened with plasticisers have become an essential part of our modern society.

Compound **S**, shown below, is commonly known as phthalic acid.

Esters of phthalic acid are called phthalates and are used as plasticisers to soften polymers such as PVC, poly(chloroethene).



S

- (a) Give the IUPAC name for phthalic acid.

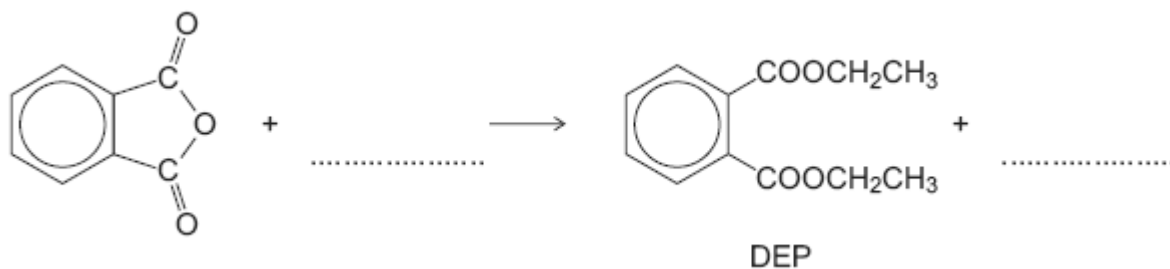
(1)

- (b) Draw the displayed formula of the repeating unit of poly(chloroethene).

(1)

- (c) The ester diethyl phthalate (DEP) is used in food packaging and in cosmetics.

- (i) Complete the following equation showing the formation of DEP from phthalic anhydride.



(2)

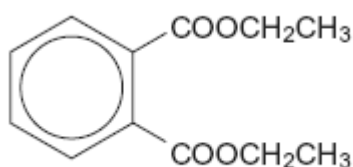
- (ii) Deduce the number of peaks in the ^{13}C n.m.r. spectrum of DEP.

(1)

- (iii) One of the peaks in the ^{13}C n.m.r. spectrum of DEP is at $\delta = 62$ ppm.

Table 3 on the Data Sheet can be used to identify a type of carbon atom responsible for this peak.

Draw a circle around **one** carbon atom of this type in the structure below.



(1)

- (d) The mass spectrum of DEP includes major peaks at $m/z = 222$ (the molecular ion) and at $m/z = 177$

Write an equation to show the fragmentation of the molecular ion to form the fragment that causes the peak at $m/z = 177$

(2)

- (e) Because of their many uses, phthalates have been tested for possible adverse effects to humans and to the environment.

An organisation that represents the manufacturers of plasticisers asserts that experimental evidence and research findings show that phthalates do not pose a risk to human health because they biodegrade in a short time scale.

According to the organization's research, phthalates do not represent a risk for humans or for the environment and they are biodegradable.

- (i) Hydrolysis of DEP in an excess of water was found to follow first order kinetics.

Write a rate equation for this hydrolysis reaction using DEP to represent the ester.

(1)

- (ii) Suggest what needs to be done so that the public could feel confident that the research discussed above is reliable.

(2)

(Total 11 marks)

Q8.

Esters have many important commercial uses such as solvents and artificial flavourings in foods.

Esters can be prepared in several ways including the reactions of alcohols with carboxylic acids, acid anhydrides, acyl chlorides and other esters.

- (a) Ethyl butanoate is used as a pineapple flavouring in sweets and cakes.

Write an equation for the preparation of ethyl butanoate from an acid and an alcohol.

Give a catalyst used for the reaction.

(4)

- (b) Butyl ethanoate is used as a solvent in the pharmaceutical industry.

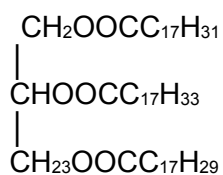
Write an equation for the preparation of butyl ethanoate from an acid anhydride and an alcohol.

(3)

- (c) Name and outline a mechanism for the reaction of CH_3COCl with CH_3OH to form an ester.

(5)

- (d) The ester shown below occurs in vegetable oils. Write an equation to show the formation of biodiesel from this ester.



(3)

- (e) Draw the repeating unit of the polyester Terylene that is made from benzene-1,4-dicarboxylic acid and ethane-1,2-diol.

Although Terylene is biodegradeable, it is preferable to recycle objects made from Terylene.

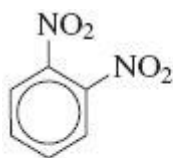
Give **one** advantage and **one** disadvantage of recycling objects made from Terylene.

(4)

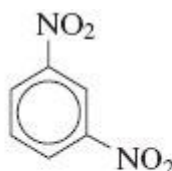
(Total 19 marks)

Q9.

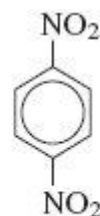
Three isomers of $C_6H_4(NO_2)_2$ are shown below.



W



X



Y

- (a) (i) Give the number of peaks in the ^{13}C n.m.r. spectrum of each isomer.

(3)

- (ii) Draw the displayed formula of the compound used as a standard in recording these spectra.

(1)

- (b) Isomer **X** is prepared from nitrobenzene by reaction with a mixture of concentrated nitric acid and concentrated sulfuric acid.

The two acids react to form an inorganic species that reacts with nitrobenzene to form **X**.

- (i) Give the formula of this inorganic species formed from the two acids and write an equation to show its formation.

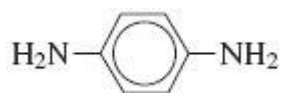
(2)

- (ii) Name and outline a mechanism for the reaction of this inorganic species with nitrobenzene to form **X**.

(4)

- (c) Isomer **Y** is used in the production of the polymer Kevlar.

Y is first reduced to the diamine shown below.



- (i) Identify a suitable reagent or mixture of reagents for the reduction of **Y** to form this diamine. Write an equation for this reaction using [H] to represent the reducing agent.

(2)

- (ii) This diamine is then reacted with benzene-1, 4-dicarboxylic acid to form Kevlar.
Draw the repeating unit of Kevlar.

(2)

- (iii) Kevlar can be used as the inner lining of bicycle tyres. The rubber used for the outer part of the tyre is made of polymerised alkenes.

State the difference in the biodegradability of Kevlar compared to that of rubber made of polymerised alkenes.

Use your knowledge of the bonding in these polymer molecules to explain this difference.

(4)

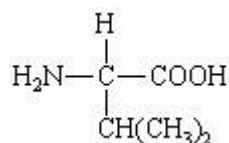
(Total 18 marks)

Q10.

Fibres are made from natural and from synthetic polymers. Both types of polymer have advantages and disadvantages.

- (a) Amino acids are the building blocks of naturally-occurring polymers called proteins.

Consider the following amino acid.



- (i) Draw the structure of the amino acid species present in a solution at pH 12.

- (ii) Use your understanding of amino acid chemistry to deduce the structure of the dipeptide formed from two molecules of this amino acid and illustrate your answer with a sketch showing the structure of the dipeptide.

- (iii) Protein chains are often arranged in the shape of a helix. Name the type of interaction that is responsible for holding the protein chain in this shape.

(3)

- (b) Alkenes are the building blocks of synthetic addition polymers.

Consider the hydrocarbon **G**, $(\text{CH}_3)_2\text{C}=\text{CHCH}_3$, which can be polymerised.

- (i) Draw the repeating unit of the polymer.

- (ii) Draw the structure of an isomer of **G** which shows *E-Z* isomerism.

- (iii) Draw the structure of an isomer of **G** which does not react with bromine water.

(3)

- (c) Draw the repeating unit of the polymer formed by the reaction between butanedioic acid and hexane-1,6-diamine.

(2)

- (d) Two plastic objects were manufactured, one from the polyalkene represented by the repeating unit in part (b)(i) and the other from the polyamide represented by the repeating unit in part (c).

After use it was suggested that both objects be disposed of as landfill.

- (i) Describe an experiment in which you could compare the biodegradability of these two objects.

(3)

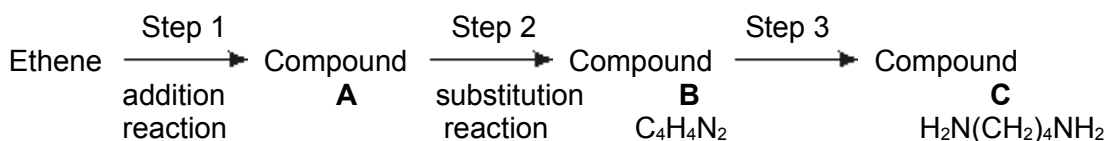
- (ii) Describe an advantage or a disadvantage of a different method of disposal of such objects compared with landfill.

(3)

(Total 14 marks)

Q11.

- (a) Compound **C**, $\text{H}_2\text{N}(\text{CH}_2)_4\text{NH}_2$, can be synthesised from ethene in three steps as shown below.



Name compound **C** and draw a structure for each of compounds **A** and **B**.

This image shows a single sheet of white paper with horizontal blue ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

(b) Draw the repeating unit of the polyamide formed when **C** reacts with hexanedioic acid. Discuss the interactions between the chains of the polyamide.

[illegible]

(c) Explain why polyamides are degraded by sodium hydroxide whereas polymers such as poly(ethene) are not.

(3)
(Total 14 marks)

Mark schemes

Q1.

B

[1]

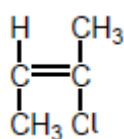
Q2.

C

[1]

Q3.

(a)

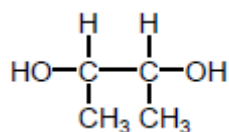


1

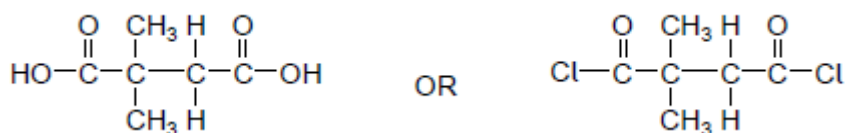
Addition

1

(b)



1



1

(c) **Q** is biodegradable

1

Polar C=O group or δ^+ C in **Q** (but not in **P**)

1

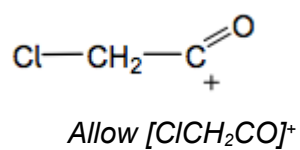
Therefore, can be attacked by nucleophiles (leading to breakdown)

1

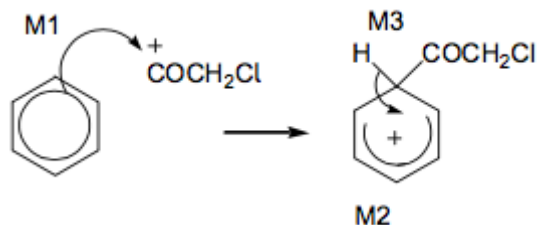
[7]

Q4.

(a) (i)



1



(ii)

M1 for arrow from inside hexagon to C or + on C on correct electrophile

M2 for structure of intermediate

- *Horseshoe centred on C1;*
- *+ in intermediate not too close to C1 (allow on or "below" a line from C2 to C6)*

M3 for Arrow from bond to H into ring

- *Allow M3 arrow independent of M2 structure*
- *+ on H in intermediate loses M2 not M3*
- *Ignore Cl- removing H⁺*

1
1
1

(b) Reagent

Water

(Aqueous) silver nitrate

NaOH followed by acidified silver nitrate

(Water +) named indicator

Named alcohol

Na₂CO₃ or NaHCO₃

Ammonia

1

P

No reaction

No reaction (or slow formation of ppt)

No reaction (or slow formation of ppt)

No colour change

NVC

NVC

No reaction

Do NOT award

No observation

1

Q

Steamy /misty/ white fumes

White precipitate (immediately formed)

White precipitate (immediately formed)

Indicator turns to correct acid colour

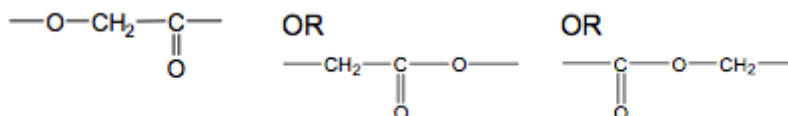
Fruity or sweet smell or misty fumes

Fizzing or effervescence (not just gas produced)

White smoke

1

(c) (i)



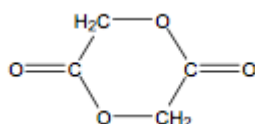
One unit only

Must have trailing bonds

Ignore n and brackets

allow $\text{---O---CH}_2\text{---CO---}$

1

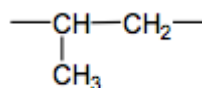


(i)

Allow CO for C=O

1

(d) (i)



One unit only

Must have trailing bonds

Ignore n and brackets

1

(ii) PGA sutures react/dissolve/break down/are biodegradable/ are hydrolysed / attacked by water or nucleophiles /no need to remove

OR Polypropene not biodegradeable/ not hydrolysed / not attacked by water/nucleophiles

1

(Ester links have) polar bonds

polypropene contains non-polar bonds

ignore intermolecular forces

1

[12]

Q5.

(a) (i) 2-hydroxypropanoic acid
OR

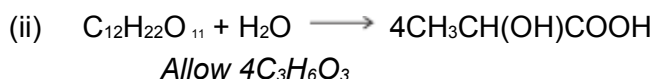
2-hydroxypropan(-1-)oic acid

Do not penalise different or missing punctuation or extra spaces.

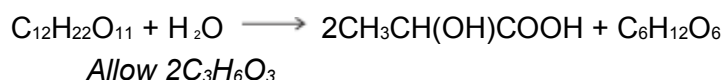
Spelling must be exact and order of letters and numbers as here.

Can ignore -1- before -oic, but penalise any other numbers here.

1



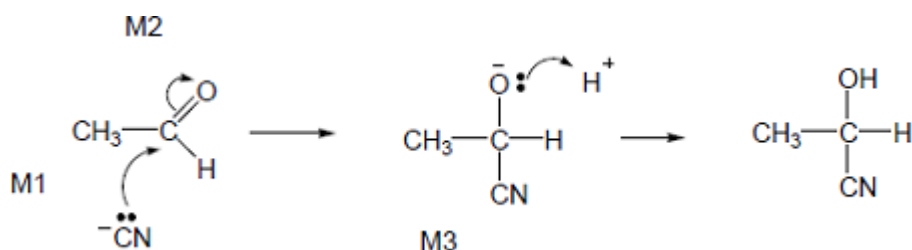
OR



1

(b) (i) Nucleophilic addition

M4 for lp, arrow and H⁺



- M1 lp and minus must be on C
- M1 and M4 include lone pair and curly arrow.
- M2 not allowed independent of M1, but allow following some attempt at attack on carbonyl C
- allow M1 for correct attack on C⁺
- + rather than δ⁺ on C=O loses M2
- M3 is for correct structure including minus sign but lone pair is part of M4
- Allow arrow in M4 to H of H-CN with arrow forming cyanide ion.

5

(ii) Equal mixture of enantiomers / (optical) isomers

1

(iii) (Plane) polarized light

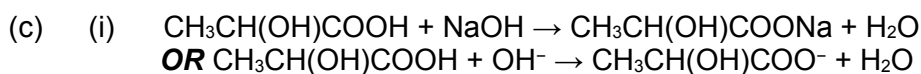
If missing no further mark.

1

(Polarised light) rotated by single enantiomer but unaffected by racemate

Both needed; not allow bend, twist etc.

1



Not ambiguous mol formulae for product - must show
COONa or CO₂Na or COO⁻ or CO₂⁻

1

(ii) $[H^+] = K_a$ **OR** $pH = pK_a$

1

$pH = 3.86$

Allow more than 2 decimal places but not fewer.

1

(iii) M1 buffer

Ignore acidic but penalise alkaline or basic.

1

Any two out of the three marks M2 , M3 & M4

M2 Large lactate concentration in buffer

OR sodium lactate completely ionised

M3 added acid reacts with / is removed by lactate ion or A⁻ or sodium lactate or salt

OR equation $H^+ + A^- \rightarrow HA$

Ignore reaction of H⁺ with OH⁻

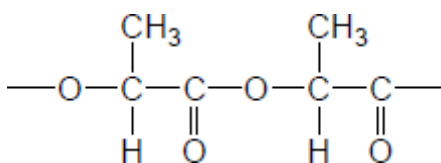
Ignore reference to equilibrium unless it is shown.

M4 ratio [HA] / [A⁻] stays almost constant

Ignore H⁺ or pH remains constant.

Max 2

(d) (i)



No marks if ester link missing

Correct ester link

allow -COO-

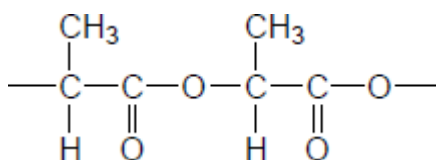
NB Correct answer scores 2

Ignore n here (compare with (d)(iv)).

Ignore brackets

1

OR



All rest correct with trailing bonds

If OH or COOH on either or both ends, lose one, ie dimer scores 1

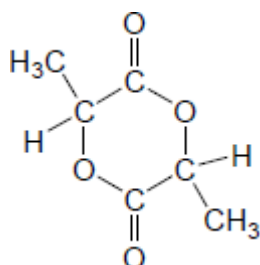
If more than two repeating units, lose 1

1

- (ii) (Poly)ester ie allow ester
Not terylene.
Ignore spaces and brackets in answer.

1

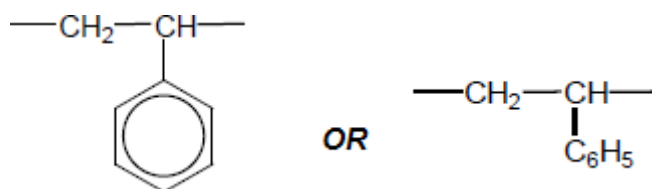
(iii)



Allow any cyclic C₆H₈O₄

1

(iv)



Penalise n here (compare with (d)(i))

Ignore brackets.

Not allow Ph for phenyl.

1

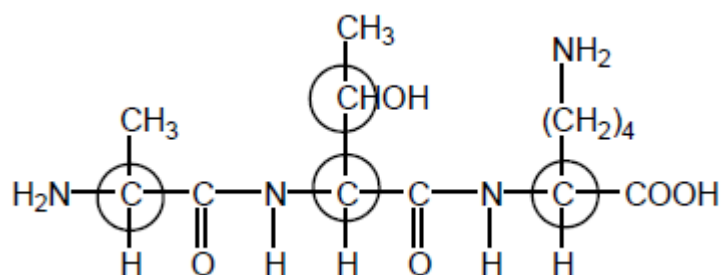
- (v) In landfill, no air or UV, to assist decay
OR not enough water or moisture (to hydrolyse polyester)
Allow landfill has / contains:
no or few bacteria / micro-organisms / enzymes compared with compost heap
OR less oxygen
OR lower temperature.

1

[22]

Q6.

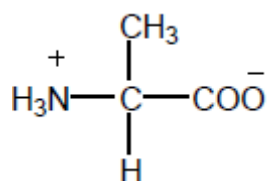
(a) (i)



These four only

1

(ii)



Allow –NH₃⁺ and ⁺NH₃–

1

(iii) 2-amino-3-hydroxybutanoic acid

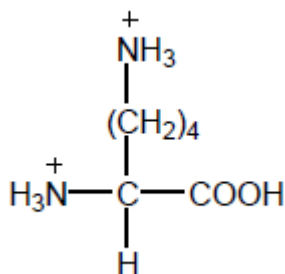
Ignore 1 in butan-1-oic acid

Do not penalise commas or missing hyphens

Penalise other numbers

1

(iv)



Allow –NH₃⁺ and ⁺NH₃–

1

(b) (i) Condensation

Allow polyester

1

(ii) propane-1,3-diol

Must have e

Allow 1,3-propanediol

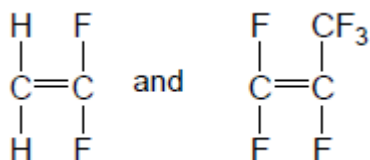
1

(c) (i) Addition

Not additional

1

(ii)

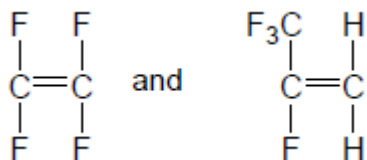


Allow monomers drawn either way round

Allow bond to F in CF₃

1

OR



1 for each structure within each pair

1

(d) c

If wrong, CE = 0

1

C-C or C-F bonds too strong

1

[11]

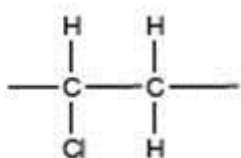
Q7.

(a) Benzene-1,2-dicarboxylic acid

Allow 1,2-benzenedicarboxylic acid

1

(b)



Must show all bonds including trailing bonds
Ignore n

1

(c) (i) 2 C₂H₅OH

NB Two ethanols

1

H₂O

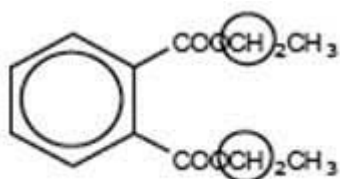
but only one water

1

(ii) 6 or six

1

(iii)

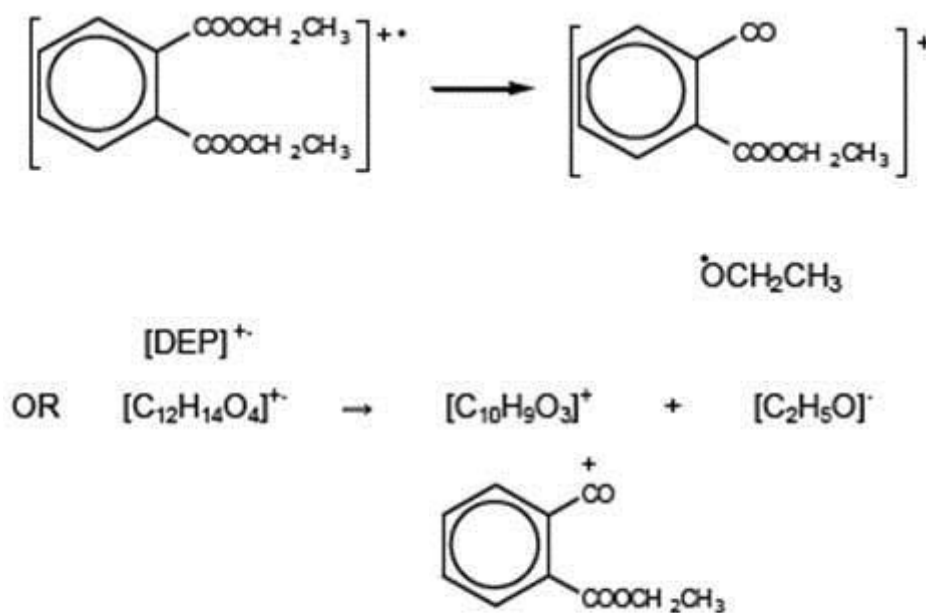


Ignore overlap with O to the left or H to the

right, but must only include this one carbon.
either or allow both (as they are identical)

1

(d)



Allow + on C or O in

1

Dot must be on O in radical

1

(e) (i) Rate = $k[\text{DEP}]$

Must have brackets but can be ()

1

(ii) Any **two** of

- experiment repeated/continued over a long period
 - repeated by independent body/other scientists/avoiding bias
 - investigate breakdown products
 - results made public
- Not just repetition*
Ignore animal testing

2 max

[11]

Q8.

(a) **M1** $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
not $\text{C}_3\text{H}_7\text{COOH}$

1

M2 $\text{CH}_3\text{CH}_2\text{OH}$ or $\text{C}_2\text{H}_5\text{OH}$

1

M3 $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_3 + \text{H}_2\text{O}$
allow $\text{C}_3\text{H}_7\text{COOC}_2\text{H}_5$
penalise M3 for wrong products and unbalanced equation

1

M4 H_2SO_4 or HCl or H_3PO_4 conc or dil or neither
not HNO_3

1

(b) **M1** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
not $\text{C}_4\text{H}_9\text{OH}$

1

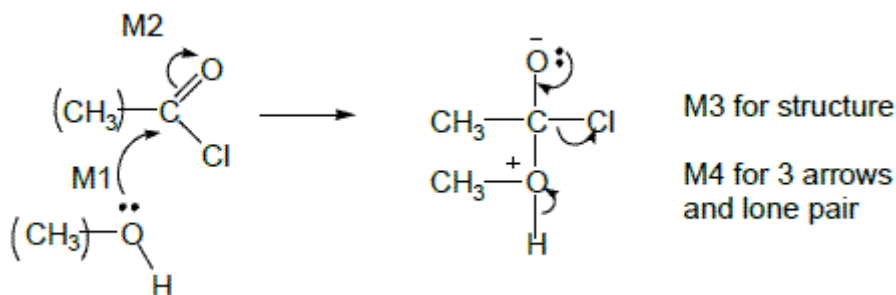
M2 $(\text{CH}_3\text{CO})_2\text{O}$

1

M3 $\rightarrow \text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_3 + \text{CH}_3\text{COOH}$
allow $\text{CH}_3\text{COOC}_4\text{H}_9$
penalise M3 for wrong products and unbalanced equation

1

(c) (nucleophilic) addition-elimination



not acylation alone

M2 not allowed indep of M1 but allow M1 for correct attack on C+

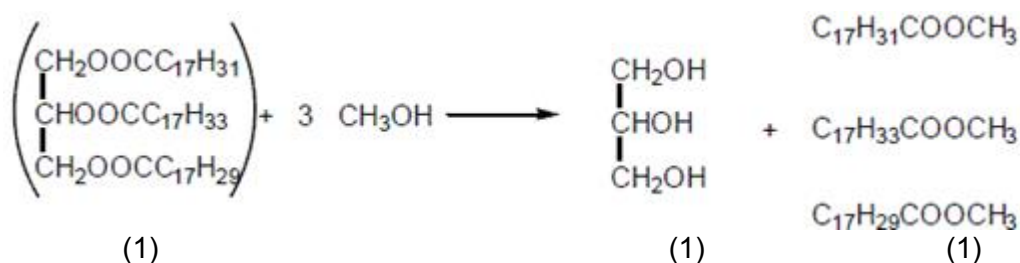
+C=O loses M2

only allow M4 after correct or v close M3

ignore Cl- removing H+

5

(d)



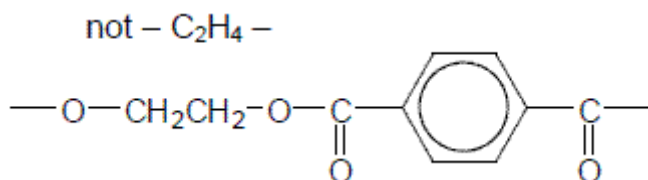
ignore errors in initial triester

First mark for 3CH₃OH

Third mark for all three esters

3

(e)



First mark for correct ester link second mark for the rest including trailing bonds

If ester link wrong, lose second mark also

2

Adv reduces landfill
saves raw materials
lower cost for recycling than making from scratch
reduces CO₂ emissions by not being incinerated

not allow cost without qualification

ignore energy uses

1

Disad difficulty/cost of collecting/sorting/processing
product not suitable for original purpose, easily contaminated

not allow cost without qualification

ignore energy uses

1

[19]

Q9.

(a) (i) **W** 3

1

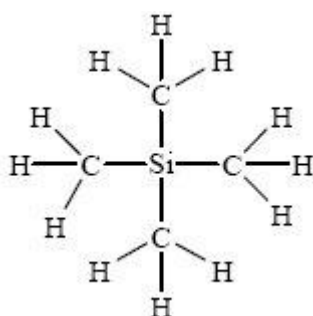
X 4

1

Y 2

1

(ii)



displayed formula shows ALL bonds

1

(b) (i) **NO₂⁺**

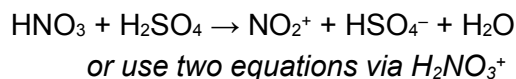
*allow + anywhere
can score in equation*

1



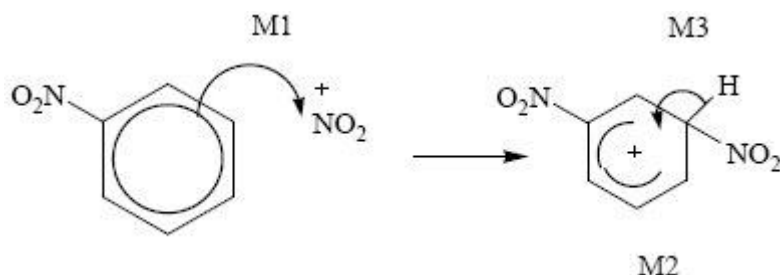
1

OR



- (ii) electrophilic substitution
Not Friedel Crafts

1

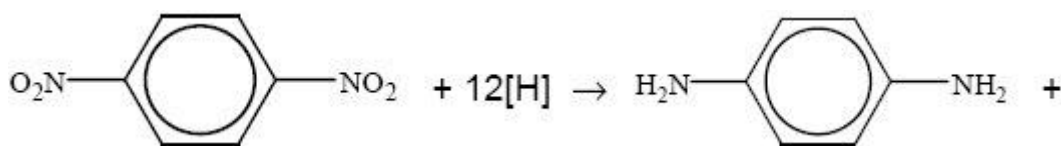


Allow Kekule structures
+ must be on N of $^+\text{NO}_2$ (which must be correct)
both NO_2 must be correctly positioned and bonded to gain M2
M1 arrow from circle or within it to N or to + on N
horseshoe must not extend beyond C2 to C6 but can be smaller
+ not too close to C1
M3 arrow into hexagon unless Kekule
allow M3 arrow independent of M2 structure
ignore base removing H in M3

3

- (c) (i) H_2/Ni or H_2/Pt or Sn/HCl or Fe/HCl (conc or dil or neither)
allow dil H_2SO_4
ignore mention of NaOH
Not NaBH_4
Not LiAlH_4
Not $\text{Na}/\text{C}_2\text{H}_5\text{OH}$
not conc H_2SO_4 or any HNO_3

1

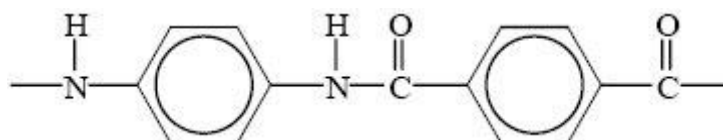


$4\text{H}_2\text{O}$
Or 6H_2

allow $\text{C}_6\text{H}_4(\text{NO}_2)_2$ etc ,
allow NO_2-NH_2-
i.e. be lenient on structures, the mark is for balancing equ

1

- (ii)



allow –CONH
ignore []_n as in polymer

1st mark for correct peptide link
2nd mark for the rest correct including trailing bonds

2

- (iii) **M1** Kevlar is biodegradeable but polyalkenes not
allow Kevlar is more biodegradeable

1

M2 Kevlar has polar bonds/is a (poly) amide/has peptide link
comment on structure of Kevlar

1

M3 can be hydrolysed/attacked by nucleophiles/acids/
bases/enzymes

1

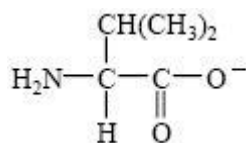
M4 polyalkenes non polar/has non-polar bonds
comment on structure of polyalkenes but not just strong
bonds

1

[18]

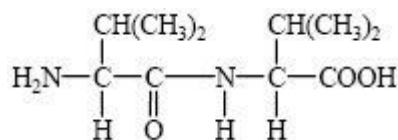
Q10.

- (a) (i)



1

- (ii)

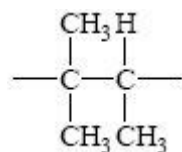


1

- (iii) hydrogen bonding (do not allow H-bonding) QWC
do not penalise any error twice.

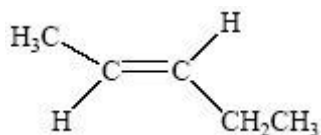
1

- (b) (i)



1

- (ii)

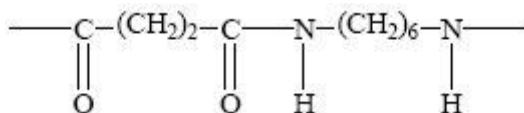


1

(iii) Isomer must be saturated or must not contain a double bond

1

(c)



2

(d) (i) heat/reflux with aqu NaOH

1

poly(alkene) is inert/ no reaction

1

polyamide is hydrolysed (or undergoes hydrolysis)
to form acid salt and alcohol QWC

1

(ii) e.g combustion

1

heat energy produced

1

toxic gases produced

1

[14]

Q11.

(a) 1, 4-diaminobutane or butane -1, 4-diamine (1)

A: BrCH₂CH₂Br **or** ClCH₂CH₂Cl (1)

B: NC CH₂CH₂CN

Step 1: Br₂ or Cl₂ (1) (**ignore aq**)

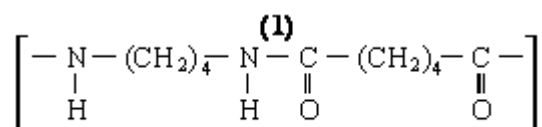
Step 2: KCN (1) (**NOT HCN**)

Step 3: H₂ / Ni **or** LiAlH₄ **or** Na / C₂H₅OH (1) (**NOT NaBH₄**)

Hydrogenation only for H₂ / Ni, **or** nucleophilic addition only for LiAlH₄(1)

OR reduction or addition

7



(b)

(1)

QL hydrogen bonding (1)

Polarity of H-bonding shown or discussed (1)

4

- (c) Polyamides / peptide link can be hydrolysed **(1)**
OR polyalkenes cannot be hydrolysed

QL OH⁻ attacks peptide link or C^{δ+} **(1)**
poly(ethene) non-polar **(1)**

3

[14]

Examiner reports

Q1.

A was the commonest incorrect response suggesting that students failed to realise that hydrogen must be directly attached to an electronegative atom in order to take part in hydrogen bonding. 51.2% of students gained this mark.

Q4.

Apart from the occasional suggestion of AlCl_4^- as the electrophile, part (a)(i) was answered well as was the mechanism in (a)(ii). Marks are still lost by some students who draw curly arrows that lack the precise start and end positions required to gain the mark. About a third of students scored full marks in part (b). The vast majority of incorrect answers involved oxidation: using Tollens or Fehling's or acidified potassium dichromate solution. Students should be reminded that when asked to give an observation, those who write the word "nothing" or "no observation" will not gain a mark.

Part (c)(i) was answered well although a few students drew more than one repeating unit. Part (c)(ii) was also answered well. About a third of students did not answer part (d)(i) correctly. Part (d)(ii) proved a good differentiator with many gaining a mark for noting that PGA is biodegradable, but only the best students were able to link this to the presence of polar bonds in PGA. Some students included the term polar but applied it to the whole molecule and not a specific bond.

Q5.

Parts (a), (b)(i) and (b)(ii) were answered well. In part (b)(iii), students often correctly identified that polarised light could be used but then failed to gain the marks because they did not mention the effect of a racemic mixture on the light. Another concern was that answers appeared to suggest that the light caused the molecules themselves to rotate.

Parts (c)(i) and (c)(ii) were answered well but very few students scored full marks for part (c)(iii) where explanations were often muddled or referred to unspecified equilibria.

Part (d) was generally well attempted, with the main errors being in part (d)(i), where many gave three or more repeating units or failed to show an ester linkage, in part (d)(iv), where many gave the formula of the polymer or missed this part out completely, and in part (d)(v), where hydrogen bonding was often offered as an explanation.

Part (d)(iii) contained an unfortunate typographical error, which was identified after the examination had taken place. The end of the first sentence should have read "...from two lactic acid molecules" rather than "....from two PLA molecules". AQA apologises for this error. The expected answer was given by about a quarter of the students. To ensure that students were not disadvantaged, a mark was also awarded to those students who drew any correct cyclic compound with molecular formula $\text{C}_6\text{H}_8\text{O}_4$. The number of students who did not attempt this question was low and in line with other question parts on this paper. The most common errors involved attempts to draw a cyclic compound but with one or more carbons having fewer than four bonds or oxygens with fewer than two bonds.

Q6.

Part (a)(i) was only answered correctly by 28% of students but the rest of part (a) was well done including the name in part (a)(iii) although some had the prefixes in the wrong order or had the numbers reversed.

Part (b)(ii) was not well done. The 'e' is required in the names of diols, triols etc as in the example here, propane-1,3-triol.

There were very few wrong answers in part (c).

Many students scored 1 mark in part (d) for identifying the correct compound as 'c', but the explanations were almost always incorrect. The C-F bond in the copolymer is polar but is not hydrolysed because it and all other bonds in the compound are strong.

Q7.

There were very few correct answers to part (a), but part (b) was well answered, although some misread the question here and tried to use benzene-1,2-dicarboxylic acid or tetrachloroethene.

Part (c)(i) was quite well done although many wrong answers included $\text{CH}_2\text{CH}_3\text{OH}$ for ethanol or two moles of water.

In part (d), many candidates missed the +. from the molecular ion or put the . on the radical in the wrong place. Several of those who chose to write a formula for the benzene ring in DEP, rather than use the structure given, lost the mark if they gave C_6H_6 rather than C_6H_4 in the formula for the molecular ion and fragment ion.

A surprising number of candidates wrote a chemical equation or included $[\text{H}_2\text{O}]$ in the rate equation in part (e)(i). Not many candidates scored both marks in part (e)(ii), with many simply referring to more repeats.

Q8.

A few candidates were unsure of the names of the esters involved and confused butyl ethanoate with ethyl butanoate. In parts (a) and (b) a common error was the failure to balance the equations due to the omission of water or ethanoic acid respectively. Weaker candidates were also unsure of the structure of ethanoic anhydride.

The mechanism in part (c) was well answered although several omitted to give its name. The reaction in part (d) proved unfamiliar to many candidates; some attempted to answer the question in terms of alkaline hydrolysis of the ester to form soap rather than the reaction with methanol to form the mixture of methyl esters which make up biodiesel. The repeating unit was well answered in part (e).

Q9.

Part (a)(i) was answered well by most candidates who showed a good understanding of the numbers of peaks in ^{13}C spectra. By contrast, large numbers did not draw a displayed formula in part (a)(ii). The topic of electrophilic substitution involving nitration in part (b) was familiar to most candidates and high marks were frequently scored. However, many marks were lost by careless drawing of intermediate structures with incorrect positioning of + charges in the mechanism and also by a failure to give the name of the mechanism. Similarly, an equation for the reduction of a nitro compound to an amine should be very familiar to candidates but only about a quarter gained both marks in part (c)(i) where two such nitro groups were involved. The repeating unit of Kevlar was much better known and both marks were gained by three-fifths of candidates.

In part (c)(iii), many candidates discussed the polarity of bonds in Kevlar but failed to note that the bonds in polyalkenes are non-polar and therefore lost the final mark.

Q11.

This question was found difficult by many candidates. The synthetic route in part (a) ended with butane-1,4-diamine and many candidates were able to deduce that Compound **B** was

$\text{NC}-\text{CH}_2\text{CH}_2-\text{CN}$ which would be reduced or hydrogenated to produce butane-1,4-diamine. To form $\text{NC}-\text{CH}_2\text{CH}_2-\text{CN}$ in two steps from ethene was found more difficult. The use of hydrogen bromide or even hydrogen were suggested as reagents with ethene by many candidates who forgot that a CN group was required at both ends of the molecule. An appreciable number of candidates also wrote equations and mechanisms in this question, when only reagents and structures were required. This used up precious minutes of their exam time for no reward.

In part (b), the repeating unit of the polyamide was deduced well, although some candidates drew nylon (6,6) rather than the polymer required. A brief statement to show that the chains were linked by hydrogen bonding was then all that was required. Details of the secondary structure of peptides was not necessary. Part (b) was worth 4 marks in total so candidates should be aware that they should spend only about 4 minutes on their answer.

In part (c) many answers contained details of the type of polymerisation involved in the formation of these polymers rather than the explanation that the non-polar polyalkenes are not attacked by hydroxide ions and are therefore not hydrolysed.