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Examiners' report

CHEMISTRY A

H432

For first teaching in 2015

H432/02 Summer 2022 series

Version 1

ocr.org.uk/science

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers are also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our website.

Paper 2 series overview

H432/02 is the second of the three examination components for GCE Chemistry A. This component is focused on organic chemistry and brings together topics from modules 4 and 6 of the specification, including relevant practical techniques. There is a synoptic element to all of the three of the A Level examination and as such this paper also contains some content of modules 1 and 2 set in the context of organic chemistry. The paper consists of two sections comprised of multiple choice and a mixture of short and long response questions respectively.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• Applied knowledge to reactions of unfamiliar compounds • Solved mathematical problems in a logical and clean manner • Could distinguish between monomer and polymer structures and could draw repeating units clearly • Demonstrated knowledge of reagents, conditions and reaction mechanisms in organic reactions	• Showed poor presentation of organic structures and reaction mechanisms • Showed poor presentation of the steps in their mathematical calculations • Found it difficult to apply their knowledge to unfamiliar compounds

Section A overview

Section A comprises 15 multiple choice questions that assess many different areas of the specification, including practical techniques. This section of the paper is worth 15 marks.

Question 1

1 Which statement is correct for the different rates of hydrolysis of RC*l* and RBr?

A RBr is hydrolysed faster because C*l* is more electronegative than Br.

B RBr is hydrolysed faster because the C–C*l* bond enthalpy is greater than C–Br.

C RC*l* is hydrolysed faster because C*l* is more electronegative than Br.

D RC*l* is hydrolysed faster because the C–Br bond enthalpy is greater than C–C*l*.

Your answer

[1]

The majority of candidates identified B as the correct answer.

Question 2

2 Which statement about absorption of radiation is correct?

A Infrared radiation can result in the breakdown of the ozone layer.

B Ultraviolet radiation can cause some polymers to photodegrade to benefit the environment.

C Ultraviolet radiation is linked to global warming.

D Ultraviolet radiation is used in modern breathalysers to measure ethanol in the breath.

Your answer

[1]

Candidates found this multiple choice question challenging. While some identified B as the correct answer, many candidates selected C.

Question 3

3 What is the number of sigma bonds in a molecule of methylbenzene?

A 7

B 10

C 12

D 15

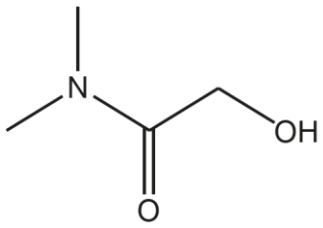
Your answer

[1]

This question discriminated well, with higher ability candidates correctly identifying D. Often students overlooked the sigma bonds in the aromatic ring and selected B.

Question 4

4 The skeletal formula of an organic compound is shown below.



Which functional groups are present?

A amide and alcohol

B amide and carboxylic acid

C amine and carboxylic acid

D amine, ketone and alcohol

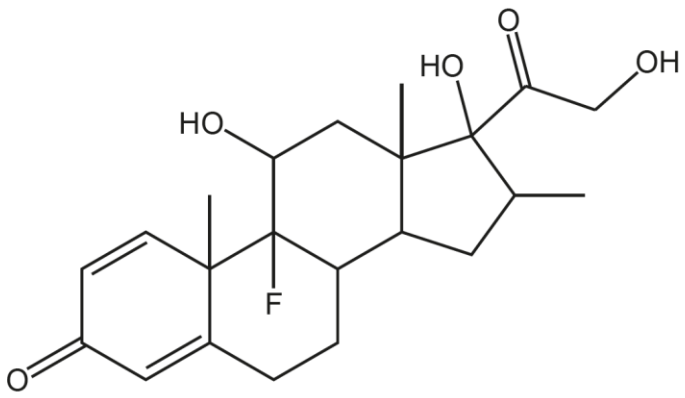
Your answer

[1]

Most candidates correctly selected A. The most common incorrect response was option D as candidates had misinterpreted the amide group as a ketone and an amine.

Question 5

5 The structure of a drug is shown below:



How many chiral carbon atoms are there in a molecule of the drug?

A 5

B 6

C 7

D 8

Your answer

[1]

Many candidates correctly answered D, with those selecting the correct response showing annotations on the given structure to identify the chiral carbons. C proved a good distractor.

Question 6

6 Which process has the highest atom economy for preparing ethene, C_2H_4?

In each process, assume that ethene is the only product that is used.

A $C_{10}H_{22} \longrightarrow 3C_2H_4 + C_4H_{10}$

B $C_6H_{14} \longrightarrow 2C_2H_4 + C_2H_6$

C $C_2H_5Cl \longrightarrow C_2H_4 + HCl$

D $C_2H_5OH \longrightarrow C_2H_4 + H_2O$

Your answer ☐

[1]

The majority of candidates identified B as the correct answer, with candidates frequently showing their calculations alongside each option to aid their choice.

Question 7

7 Complete combustion of 0.050 mol of an alkane produces 5.40 g of H_2O.

What is the molecular formula of the alkane?

A C_2H_6

B C_3H_8

C C_4H_{10}

D C_5H_{12}

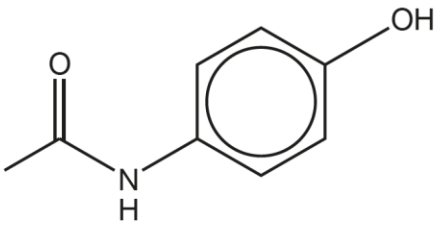
Your answer ☐

[1]

Most candidates correctly identified D as the correct response.

Question 8

8 The structure of the painkiller, paracetamol, is shown below.



paracetamol

A tablet contains 3.31×10^{-3} mol of paracetamol.

What is the mass of paracetamol in the tablet?

A 493 mg

B 497 mg

C 500 mg

D 506 mg

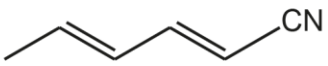
Your answer ☐

[1]

The majority of candidates correctly calculated C as the mass of paracetamol in the tablet.

Question 9

9 The compound below reacts with hydrogen gas to form a saturated compound.



What is the volume of hydrogen, measured at room temperature and pressure, that reacts with 0.0500 mol of the compound?

A 2.40 dm^3

B 3.60 dm^3

C 4.80 dm^3

D 6.00 dm^3

Your answer

[1]

This question discriminated well, with higher ability candidates correctly identifying C as the volume of hydrogen produced. Many candidates overlooked the hydrogenation of the CN group and incorrectly selected option A.

Question 10

10 Butyl propanoate is hydrolysed by aqueous sodium hydroxide.

Which compound is one of the products of this hydrolysis?

A C_3H_7ONa

B $C_3H_5O_2Na$

C C_4H_9ONa

D $C_4H_7O_2Na$

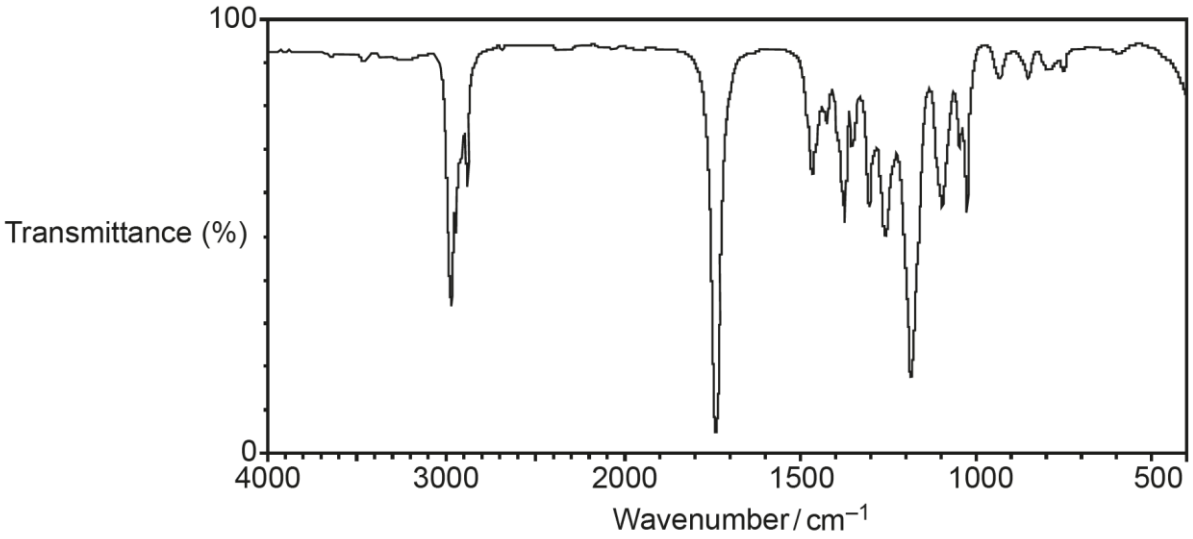
Your answer

[1]

Most candidates correctly identified B as one of the products. These candidates often drew out the structures of butyl propanoate and the product options to aid in their selection.

Question 11

11 The infrared spectrum of an organic compound is shown below.



Which compound could have produced this spectrum?

A $H_2C{=}CHCH_2CH_2OH$

B $CH_3COOCH_2CH_3$

C $H_2NCH_2COOCH_3$

D $(CH_3)_2CHCONH_2$

Your answer ☐

[1]

Most candidates correctly identified C as the compound after labelling the peaks in the spectrum.

Question 12

12 Which compound produces two triplets in its ^1H NMR spectrum?

A $CH_3CH_2COOCH_2CH_3$

B $CH_3CH_2COCH_2CH_3$

C $HOOCCH_2CH_2COOH$

D $HOOCCH_2CH_2CH_2COOH$

Your answer

[1]

This question proved challenging. Candidates who drew out the different compounds were able to identify A as the correct response.

Question 13

13 Which equation(s) could be part of the propagation step in the radical substitution of C_5H_{12} to form $C_5H_{11}Cl$?

1 $C_5H_{11}\bullet + Cl_2 \longrightarrow C_5H_{11}Cl + Cl\bullet$

2 $C_5H_{12} + Cl\bullet \longrightarrow C_5H_{11}Cl + H\bullet$

3 $C_5H_{11}\bullet + Cl\bullet \longrightarrow C_5H_{11}Cl$

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer

[1]

Most candidates identified D (only 1) for an equation that could be part of a propagation step.

Question 14

14 Which species could react as a nucleophile?

1 NH_3

2 OH^-

3 CH_3NH_2

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

Many candidates did not identify CH_3NH_2 as a nucleophile and selected option B.

Question 15

15 Which isomer(s) of $C_5H_{12}O$ has/have 4 peaks in its/their ^{13}C NMR spectrum?

1 3-methylbutan-2-ol

2 2-methylbutan-2-ol

3 2-methylbutan-1-ol

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

Candidates found this question difficult. Those who drew out the different compounds were able to identify B as the correct response.

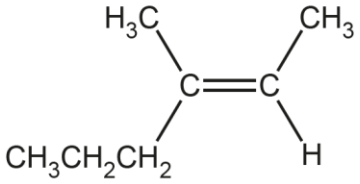
Section B overview

Section B includes a mixture of short answer and extended response questions, including two questions marked using a level of response mark scheme (19e and 21). This section of the paper is worth 85 marks.

Question 16 (a) (i)

16 This question is about unsaturated hydrocarbons.

(a) The unsaturated hydrocarbon **A**, shown below, is reacted with bromine.



Hydrocarbon A

(i) What is the systematic name of hydrocarbon **A**?

..... **[1]**

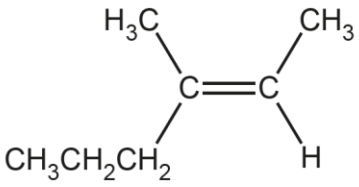
The majority of candidates were able to correct name hydrocarbon **A** as 3-methylhex-2-ene. A number of responses used incorrect numbering or suggested 3-methylhexan-2-ene as the name.

Question 16 (a) (ii)

(ii) Outline the mechanism for the reaction of hydrocarbon **A** with bromine.

The structure of hydrocarbon **A** has been provided.

Include curly arrows and relevant dipoles.



[3]

Candidates are familiar with the mechanism for the bromination of hydrocarbons. So, the majority of candidates scored 3 marks. Common errors included the use of HBr rather than Br_2 or putting a dipole on the carbon-carbon double bond.

Question 16 (b) (i)

(b) Compounds **B** and **C** are **branched** hydrocarbons that are structural isomers of C_6H_{12}.

Compounds **B** and **C** both have stereoisomers.

- Compound **B** has *cis* and *trans* isomers but does **not** have optical isomers.
- Compound **C** has optical isomers but does **not** have *cis* and *trans* isomers.

(i) What is meant by the term **structural isomers**?

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.....

..... **[1]**

The majority of candidates were able to correctly define a structural isomer.

Question 16 (b) (ii)

(ii) What is meant by the term **stereoisomers**?

.....

.....

..... **[1]**

This definition was well known by candidates with the majority of responses given the mark. Some candidates omitted the reference to structural formula.

Question 16 (b) (iii)

(iii) Draw structures for the *cis* and *trans* isomers of the branched hydrocarbon **B**.

***cis* isomer**	***trans* isomer**

[2]

This question required candidates to link their knowledge of *cis* and *trans* isomers with branched hydrocarbons. Higher ability candidates were able to do this. The majority of candidates scored 1 mark for correctly drawing *cis* and *trans* isomers of an unbranched hydrocarbon.

Question 16 (b) (iv)

(iv) Draw 3D structures for the optical isomers of compound **C**.

Optical isomers	

[2]

This question discriminated well. Candidates were required to identify the groups around a chiral carbon and then draw the two corresponding optical isomers. Incorrect responses frequently had incorrect connectivity around the chiral carbon, bond angles of 180° or 2D structures.

Question 16 (b) (v)

(v) Compounds **D** and **E** are two more structural isomers of C_6H_{12}.

Compounds **D** and **E** do **not** show stereoisomerism.

Table 16.1 shows NMR and infrared (IR) spectral data for **D** and **E**.

	Number of peaks in ^{1}H NMR spectrum	**Number of peaks in ^{13}C NMR spectrum**	**IR peak at 1620–1680 cm^{-1}**
D	1	1	No
E	1	2	Yes

Table 16.1

Draw the structures of **D** and **E** and explain how the spectral data in **Table 16.1** provides evidence for the structures.

D	**E**

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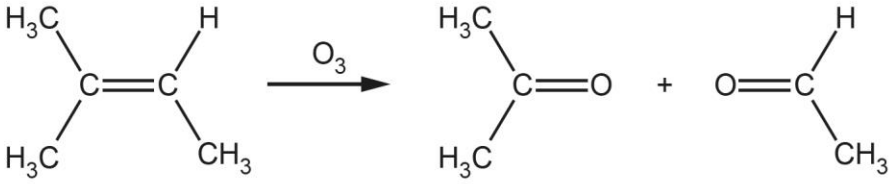
..... **[4]**

Most candidates were able to correctly draw the structure of D and E. Many candidates did not explain their answers in terms of the number of different hydrogen and carbon environments or the presence/ absence of a carbon-carbon double bond.

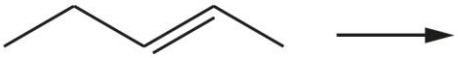
Question 16 (c) (i)

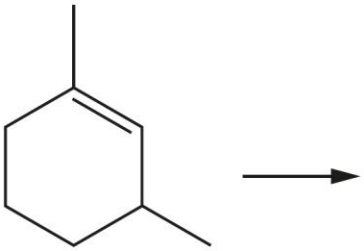
(c) 'Ozonolysis' is used in organic synthesis. Ozone breaks C=C bonds to form carbonyl compounds.

For example, the complete ozonolysis of methylbut-2-ene is shown below.



(i) Draw the structures of the products you would expect from the ozonolysis of the **two** compounds below.





[2]

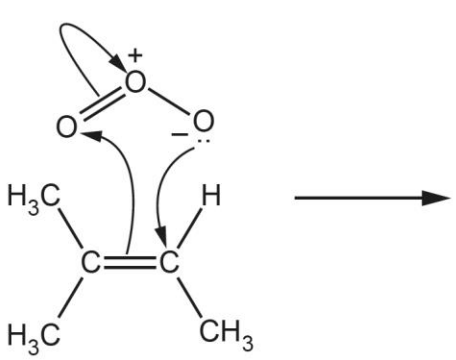
Most candidates were able to score 1 mark for correctly drawing the structures of the two aldehyde products of the first reaction. The second reaction proved more challenging, with most candidates incorrectly drawing two products.

Question 16 (c) (ii)

(ii) The mechanism for ozonolysis takes place in several steps.

The curly arrows in the first step in the ozonolysis of methylbut-2-ene are shown below.

In the box, draw the structure(s) for the product(s) of this step.



[1]

Few candidates were given this mark. A common error was to produce multiple products (rather than a ring structure) or to put positive/negative charges on the oxygen atoms within the ring structure.

Question 17

17 This question is about an analysis of an unknown organic **Compound X**.

Some properties of **Compound X** are shown in the table.

Molecular formula	Functional groups	Chirality
$C_xH_yF_6O$	C–F C–O–C	1 chiral carbon

At a pressure of 1.07×10^5 Pa at 30 °C, 1.327 g of **Compound X** is a gas with a volume of 186 cm^3.

Determine the molar mass of **Compound X** and its molecular formula.

Draw a possible structure for a molecule of **Compound X**.

molar mass ..... g mol^{-1}

molecular formula .....

Structure of Compound X

[6]

This question proved difficult and discriminated well. Higher ability candidates correctly used SI units and showed each step of their calculation and then using this to correctly identify a structure of compound X. Candidates frequently used the wrong interconversions and gave structures that lacked a chiral centre. A small number of candidates used molar gas volume rather than PV=nRT for their calculation.

Question 18 (a) (i)

18 This question is about carbonyl compounds.

(a) (i) Describe a chemical test to confirm the presence of a carbonyl group.

How could the product of this test be used to identify the carbonyl compound?

Your answer should **not** include spectroscopy.

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..... **[3]**

The use of 2,4-dinitrophenylhydrazine as a test for the carbonyl group is well known by candidates at this level. The majority of the cohort correctly identified this test and the subsequent analysis of the melting point of the products as a method of identifying each compound. Lower ability candidate responses made reference to analysis of the boiling points or omitted the reference to analysis of the melting points.

Question 18 (a) (ii)

(ii) Describe a chemical test that would identify whether a carbonyl compound is an aldehyde.

Your answer **should** include the reagent and observations.

.....

.....

..... **[1]**

Almost all candidates were able to correctly describe the use of Tollens' reagent as a test for an aldehyde fictional group

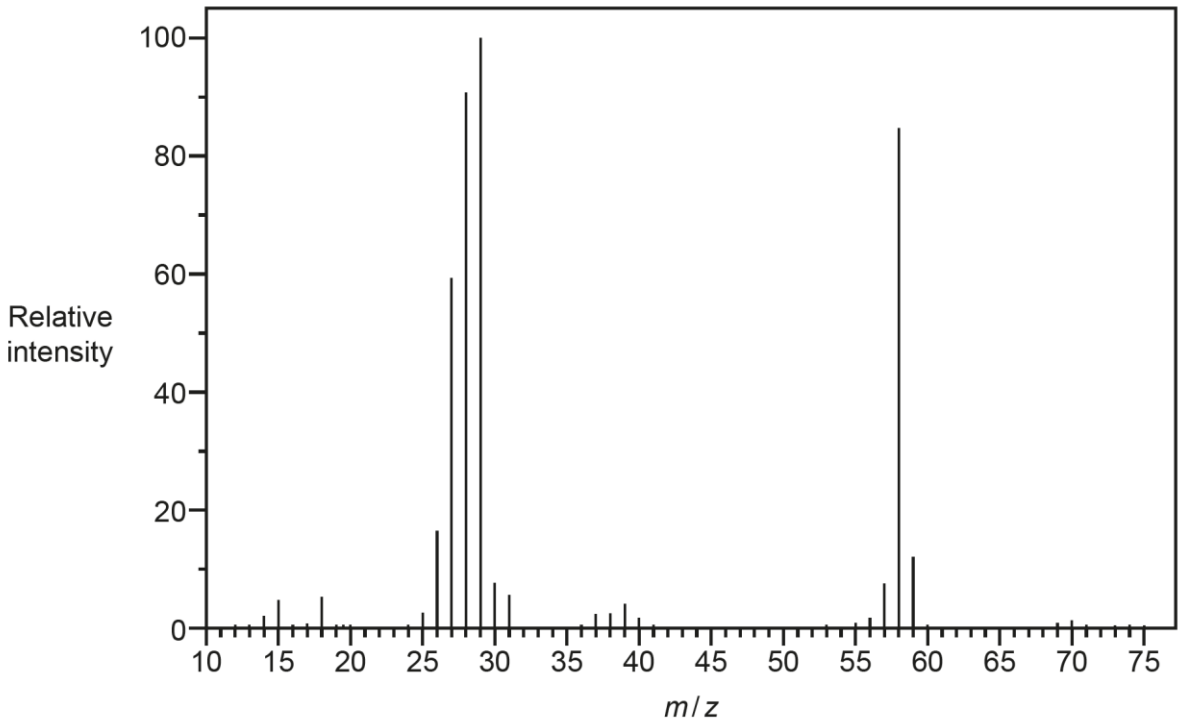
Question 18 (b)

(b) A student is provided with two unknown carbonyl compounds, **F** and **G**.

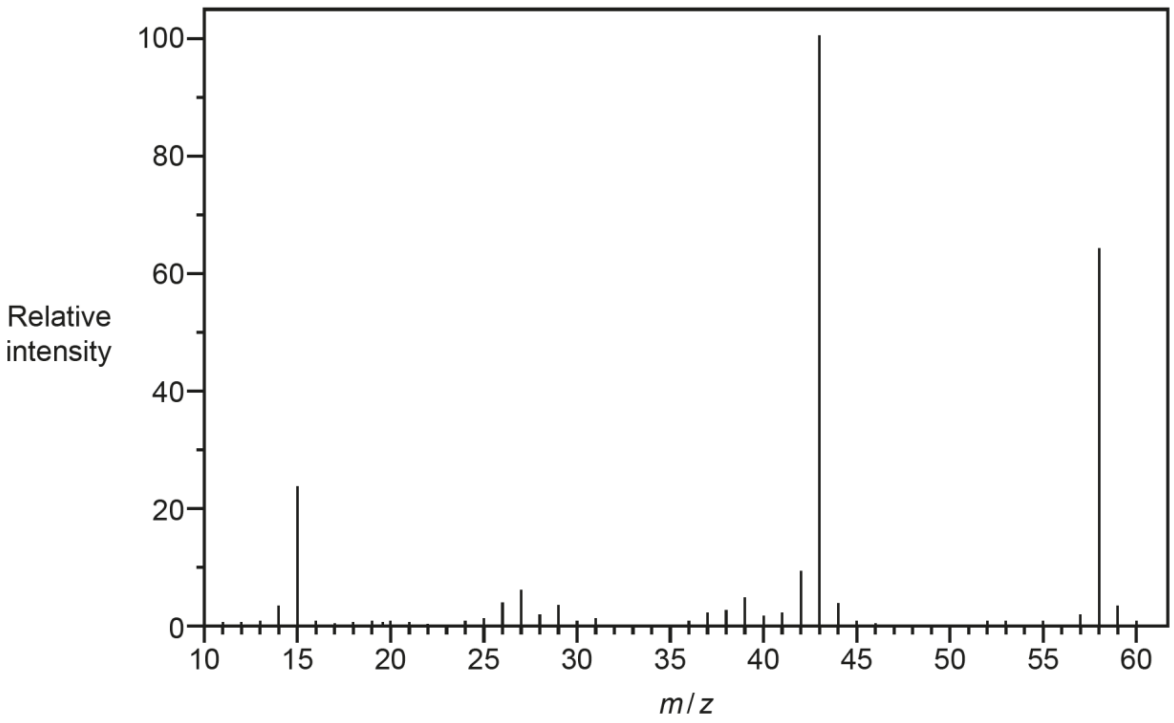
The compounds are analysed and found to have identical percentage compositions by mass:
C: 62.07%; H: 10.34%; O: 27.59%

The mass spectra of the two compounds are shown below.

Mass spectrum of F



Mass spectrum of G



Use the results to identify the structures of the two compounds.

Include relevant peaks present in the mass spectrum of each compound.

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F	G

[4]

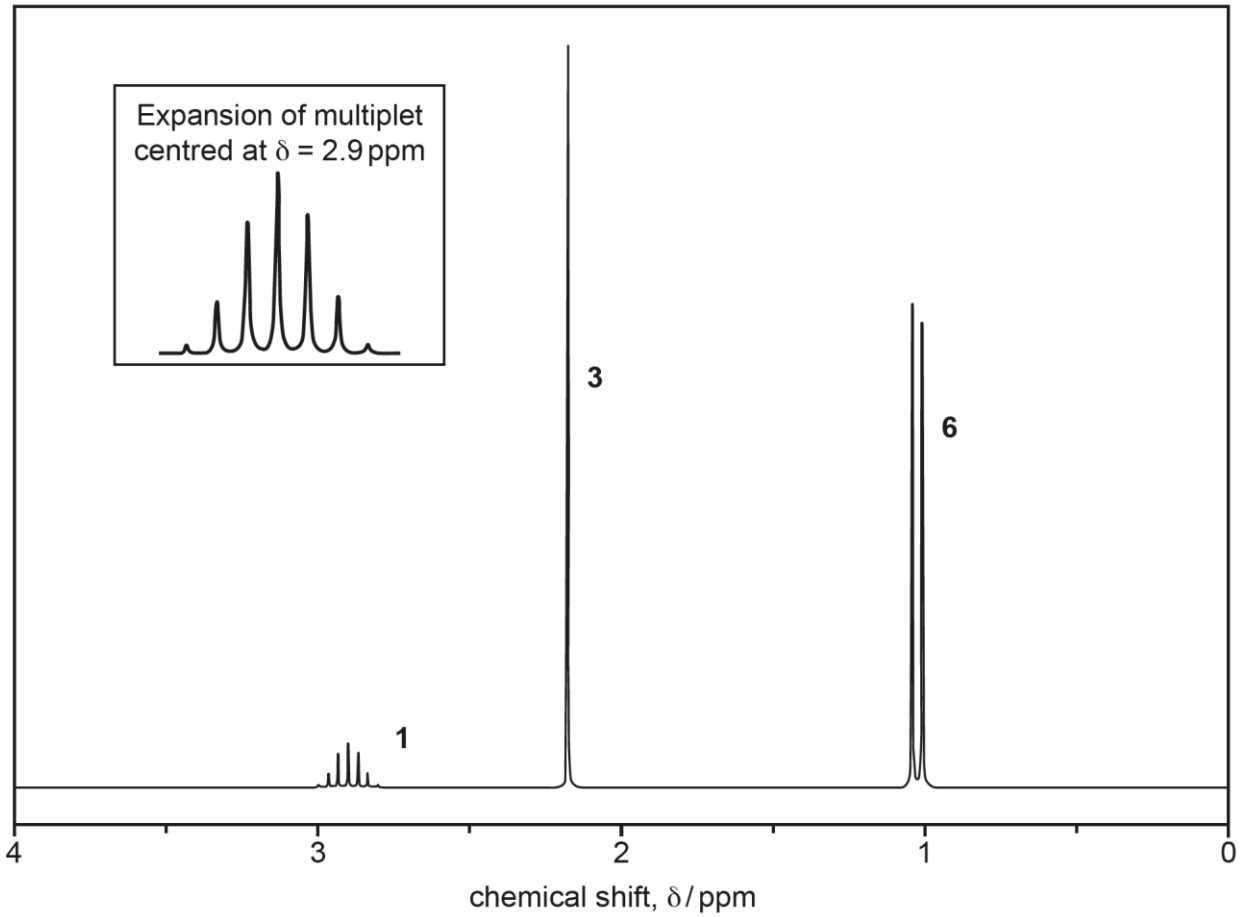
Most candidates were able to calculate the initial ratios and then use this to calculate the molecular formula, linking to the m/z peak at 58. The most common error seen was for the structures of F and G to the in the incorrect boxes, suggesting that candidates have not interpreted the fragment ions to work out F was the aldehyde.

Question 18 (c)

(c) The organic compound **H** contains carbon, hydrogen and oxygen only and has an M_r of 114.0.

Compound **H** has two carbonyl groups and no other functional groups.

The ^{1}H NMR spectrum of organic compound **H** is shown below.



The numbers by the peaks are the relative peak areas.

Analyse the spectrum to suggest a possible structure for compound **H**.

Show all your reasoning.

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Compound H

[4]

This question proved difficult and although most candidates score some marks, only the very best responses secured all 4 marks. Candidates often did not link the doublet to two CH_3 groups and many only scored 1 mark for their suggested structure as the carbonyl groups were not side by side within the molecule.

Question 19 (a)

19 This question is about compounds that contain the carboxylic acid functional group.

(a) Carboxylic acids react with alkalis, metals and carbonates to form salts.

Write full equations for the following **three** reactions. Show structures for organic compounds.

- the reaction of propanoic acid with aqueous potassium hydroxide:

- the reaction of aqueous methanoic acid with magnesium:

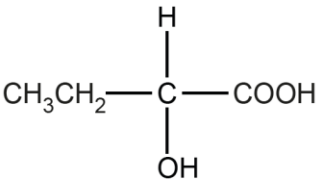
- the reaction of the α–amino acid, aspartic acid ($R=CH_2COOH$), with an excess of aqueous sodium carbonate, Na_2CO_3:

[4]

This question proved challenging for candidates. The first equation was often answered correctly, although some candidates used sodium hydroxide rather than potassium hydroxide in their response. The second equation was frequently incorrect. Candidates frequently missed a hydrogen from the structure for methanolic acid or did not recognise that hydrogen was a product. Many candidates did not account for magnesium having a 2+ charge when working out the product. For the third equation, the majority of candidates identified that carbon dioxide and water would be produced but were unable to give the correct formula of the salt as they did not interpret the information given regarding the R group.

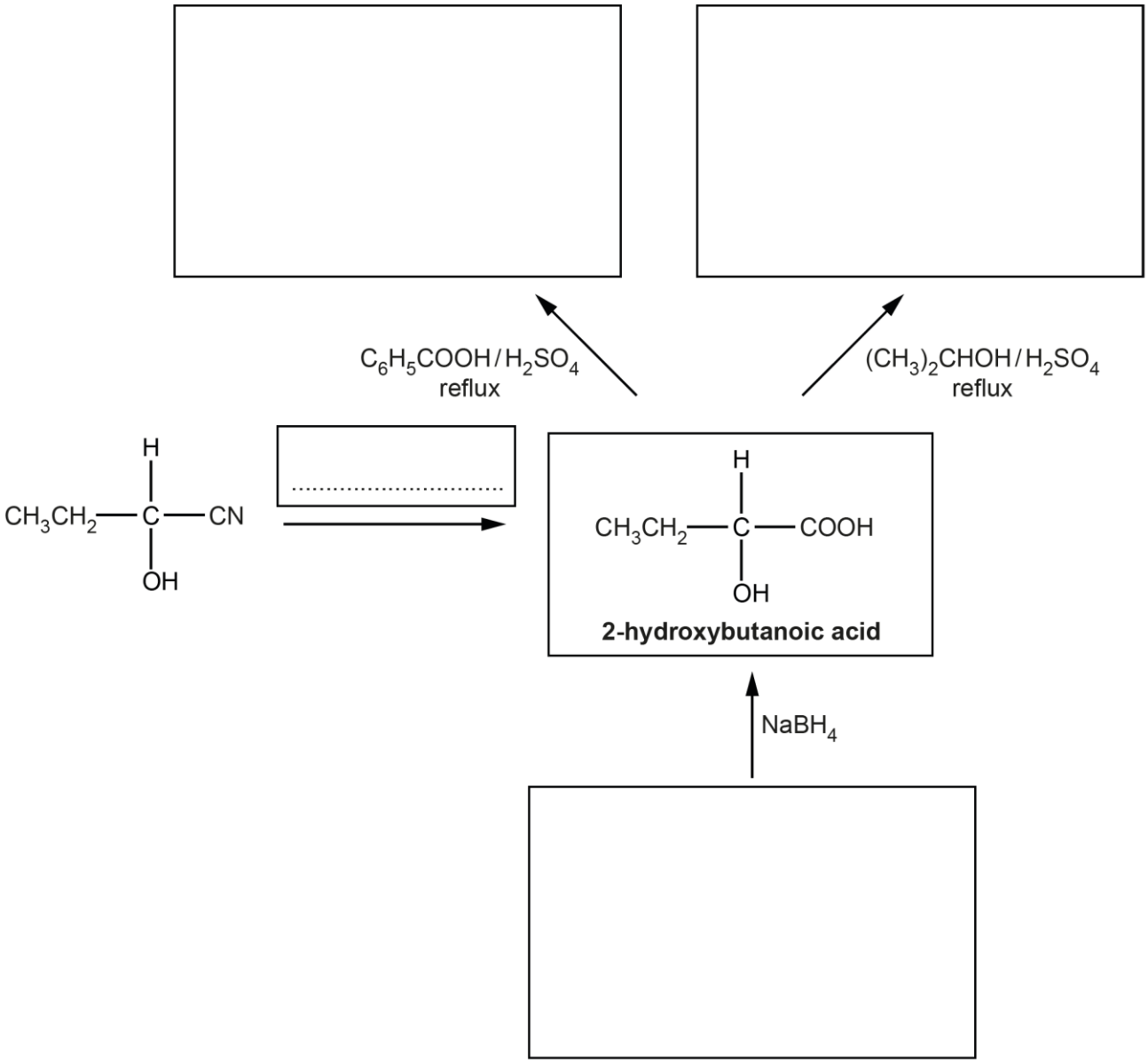
Question 19 (b)

(b) The structure of 2-hydroxybutanoic acid is shown below.



2-hydroxybutanoic acid

Fill in the flowchart for reactions involving 2-hydroxybutanoic acid.



[4]

The majority of candidates were able to identify at least one of the structures. A significant number of candidates did not check the number of bonds of each atom in their structures and frequently had too many or too few hydrogen atoms attached. Most candidates identified that acidic conditions were required but some missed the aqueous condition that was also required for the mark.

Question 19 (c) (i)

(c) This part is about polymers derived from carboxylic acid monomers.

(i) Poly(pent-3-enoic acid) is an addition polymer.

Draw the structure of pent-3-enoic acid and **two** repeat units of this polymer.

Pent-3-enoic acid	
Two repeat units of poly(pent-3-enoic acid)	

[2]

Most candidates were given at least 1 mark with many correctly drawing the structure of pent-3-enoic acid. Common errors included drawing pent-2-enoic acid or propenoic acid, suggesting a lack of

knowledge of prefixes. The second mark required candidates to draw two repeat units, frequently candidates tried to draw repeat units linking the carboxylic acid groups rather than identifying that it is the carbon-carbon double bond that breaks.

Question 19 (c) (ii)

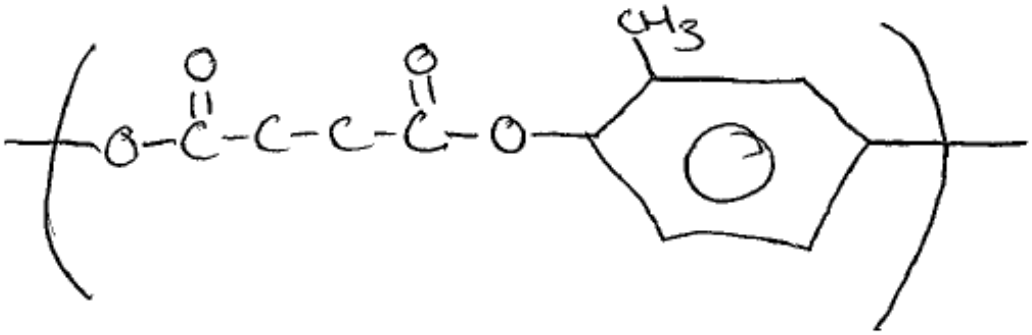
(ii) Butanedicarboxylic acid and 1,4-dihydroxy-2-methylbenzene react to form a condensation polymer.

Draw **one** repeat unit of this condensation polymer.

[2]

This question differentiated well. Candidates who scored 1 mark had often shown an ester link but their structure was missing hydrogen atoms from the carbon chain (as shown in exemplar 1) or the methyl group was missing from the ring.

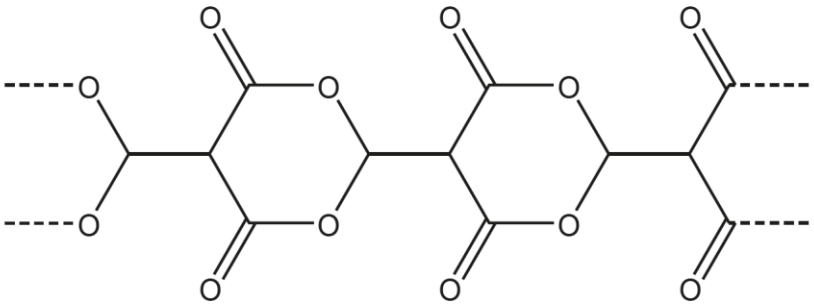
Exemplar 1



This type of response was seen frequently by examiners. The candidate has correctly drawn the ester link but has omitted the hydrogen atoms from the carbon chain.

Question 19 (c) (iii)

(iii) Three repeat units of a condensation polymer are shown below.



Draw the structure of the monomer required to form this polymer.

[1]

This question proved difficult for candidates with the majority of candidates not scoring the mark. A significant proportion of candidate had identified the monomer but drew structures that combined skeletal and displayed formulae. This resulted in ambiguous structures being given that had missing hydrogen atoms on the carbons.

Drawing of organic structures

Candidates need practice at drawing structures that are not ambiguous. They should check the number of bonds on each atom and make sure the appropriate number of hydrogen atoms are drawn.

Question 19 (d) (i)

(d) A polymer is formed from 400 molecules of 2-aminopropanoic acid.

(i) Draw **one** repeat unit of this polymer.

[1]

Few candidates were given the mark for this question. Frequently candidates drew structures with two repeat units or the did not remove the oxygen atom from the OH group.

Question 19 (d) (ii)

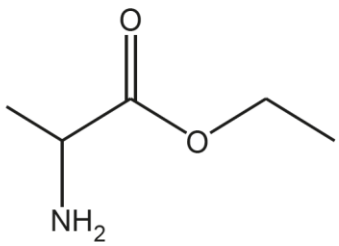
(ii) What is the relative molecular mass, M_r, of the polymer?

M_r = ... **[2]**

A variety of responses were seen in this demanding question. In general candidates adopted one of two approaches. The most common was to multiply the Mr of the repeat unit by 200 and then add the mass of H and OH at each end of the polymer. The other approach used the Mr of the monomer by 200 and then subtract the mass of the 199 water molecules removed in the polymerisation. Many candidates were successful with the first step of their approach, but the best responses included the second step taking into account the Mr of water. A significant number of candidates used an incorrect value for the Mr.

Question 19 (e)

(e)* A student intends to synthesise compound **I**.



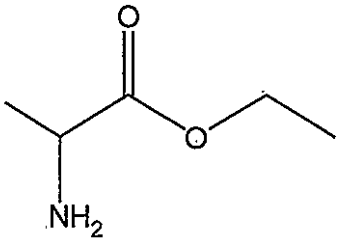
Compound I

Plan a synthesis to prepare 9.36 g of compound **I** starting from 2-chloropropanoic acid, $CH_3CHClCOOH$. The overall percentage yield of compound **I** from 2-chloropropanoic acid is 64%.

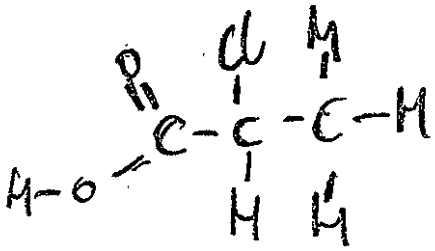
In your answer, include starting mass of 2-chloropropanoic acid, reagents, conditions and equations where appropriate. **[6]**

This question was marked using a level of response mark scheme. Most candidates gave an answer worth of at least Level 2 (3-4 marks) by providing the synthetic steps with reagents and equations for the synthesis of compound I. Exemplar 2, below, shows a frequent Level 2 response. The best performing candidates correctly determined the mass attempting to calculate the mass and showed the synthesis efficiently, using equations to communicate the preparation of compound I, with these responses being given Level 3 (5-6 marks). A number of responses omitted the mass calculation, such responses received Level 2 (1-2 marks).

Exemplar 2



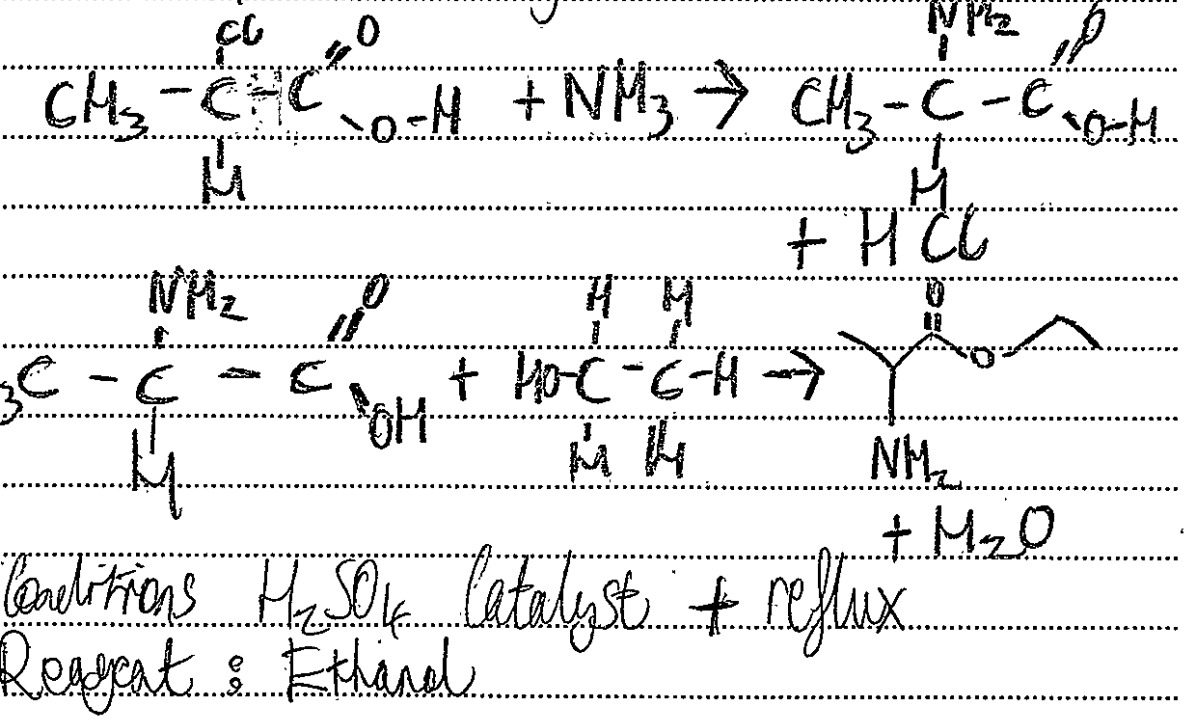
Compound I



Plan a synthesis to prepare 9.36 g of compound **I** starting from 2-chloropropanoic acid, $CH_3CHClCOOH$. The overall percentage yield of compound **I** from 2-chloropropanoic acid is 64%.

In your answer, include starting mass of 2-chloropropanoic acid, reagents, conditions and equations where appropriate. **[6]**

$9.36 \times \frac{100}{64} = 14.625$ g to start

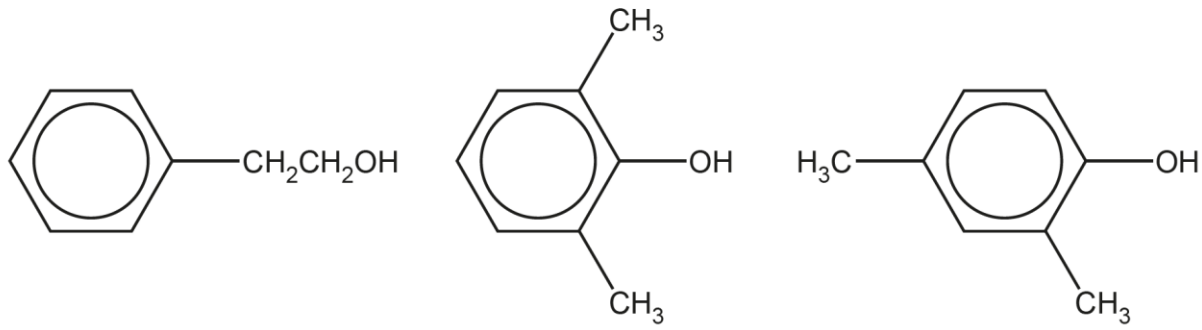


In this response the candidate has attempted to calculate the starting mass but has made little progress. Two stages of the synthesis have been covered with the reagents and most of the conditions identified. Both equations are complete. This is a Level 2 response and 4 marks have been given as the repones is logical and well communicated

Question 20 (a) (i)

20 This question is about the chemistry of aromatic compounds.

(a) Compounds **J**, **K** and **L**, shown below, are structural isomers.



Compound J **Compound K** **Compound L**

(i) What chemical test(s) could be used to confirm the presence of the phenol group in compounds **K** and **L**?

.....

.....

..... **[1]**

Few candidates knew the test for a phenol group. Frequent incorrect responses involved the production of a gas with a carbonate or stating that bromine water is decolourised but failing to state that a white precipitate is also formed. A significant number of candidates also stated that the reaction with sodium hydroxide confirms the presence of the phenol group.

Question 20 (a) (ii)

(ii) A student thought that ^{13}C NMR spectroscopy could be used to distinguish between compounds **J**, **K** and **L**.

Explain, with reasoning, whether the student is correct.

.....

.....

.....

.....

.....

..... **[3]**

This question proved challenging to candidates with few scoring all 3 marks. Where no marks were given, this was frequently because candidates did not state the number of carbon environments in compounds J, K and L. Candidates who were given 1 or two marks frequently stated the incorrect number of peaks that would be observed.

Question 20 (a) (iii)

(iii) Compound **J** is substituted at the 2- and 4- positions by chlorine in the presence of a catalyst.

Outline the mechanism for the 4 substitution of compound **J** by chlorine in the presence of a catalyst.

Show the role of the catalyst.

[4]

This question required candidates to apply their knowledge of the mechanism of electrophilic substitution. Examiners were encouraged by the number of excellent responses to this question, with the majority of candidates securing 3 out of 4 marks. Common errors included the omission of HCl as product from the regeneration of the catalyst or candidates attempting to substitute at the 2 position.

Question 20 (b)

(b) Compounds **K** and **L** react with chlorine much more readily than compound **J**.

Explain why.

.....

.....

.....

.....

.....

..... **[3]**

The most able candidates scored well on what proved a difficult question for many. Although the vast majority of candidates knew about the reasons behind compounds K and L's increased reactivity many were unable to express themselves clearly to gain credit. Often answers lacked the specific detail about the lone pair on the oxygen atom in the –OH group being delocalised into the ring. Less successful answers discussed electrons being supplied to the ring, the -OH group providing the electrons to the ring or just that –OH is an activator. More successful answers expressed the increase in electron density and the subsequent increase in compound K and L's susceptibility to electrophilic attack.

Exemplar 3

The lone pair from the OH group becomes delocalised onto the ring / Π bond, which makes K and L more electron dense than J, so they are more susceptible to electrophilic attack.

This response correctly states that the electron density is higher which result in K and L being more susceptible to electrophilic attack and receives 2 marks. To score the third mark, the candidate needed to identify that that the lone pair is on the oxygen of the OH group.

Question 20 (c)

(c) Compound **J**, $C_6H_5CH_2CH_2OH$, is reacted with acidified potassium dichromate(VI) under reflux to form organic product **M**.

Write an equation for this reaction.

Use [O] to represent the oxidising agent and show the structure of **M**.

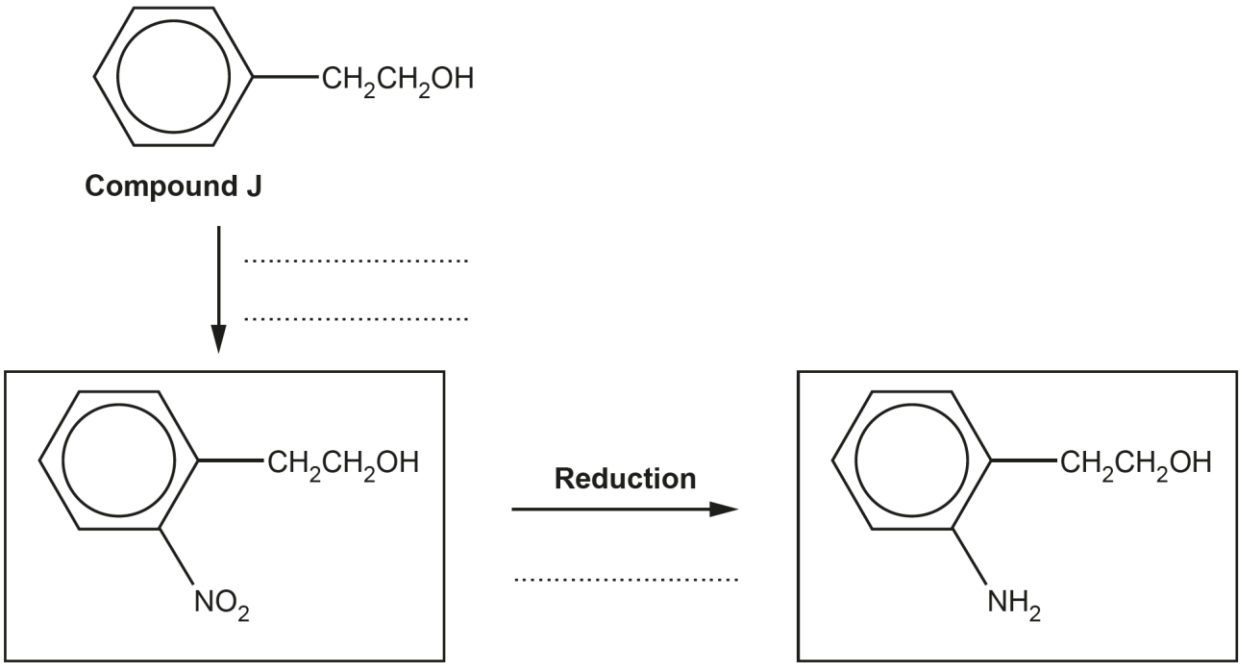
[2]

Most candidates were able to score at least 1 mark for this question. Common errors included candidates producing two water molecules or failing to balance [O]. A significant proportion of candidates did not score any marks, frequently due to the organic product having too many carbon atoms in it.

Question 20 (d) (i)

(d) A two-stage synthesis of an amine from compound **J** is shown below.

(i) Add the reagents for each stage of this synthesis.

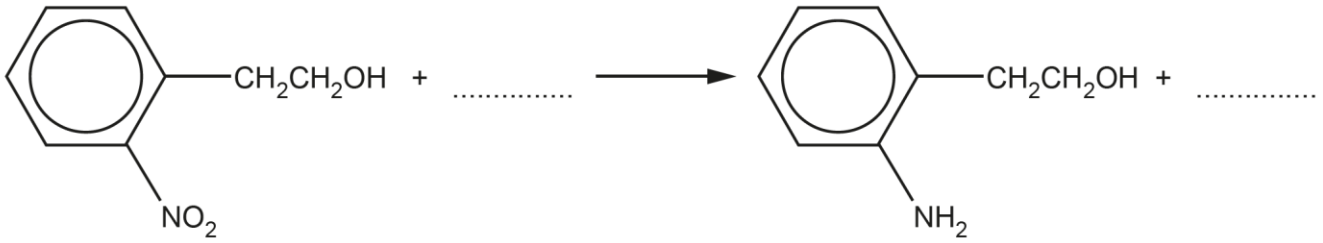


[2]

Candidates were familiar with the reagents required in these two reactions.

Question 20 (d) (ii)

(ii) Fill in the equation for the reduction stage of this synthesis.



[1]

The most able candidates were able to identify the use of 6[H] as the reducing agent and the production of 2 water molecules. Incorrect responses commonly included the use of HCl and $NaBH_4$ as a reactant.

Question 20 (e)

(e) 1-phenylethanol is a naturally occurring compound found in many vegetables and flowers.

1-phenylethanol can be synthesised from 2-phenylethanol in two stages.

2-phenylethanol **1-phenylethanol**

Suggest reagents, conditions and equations for each stage in the synthesis.

Show structures for organic compounds.

Stage 1

reagents and conditions .....

equation:

Stage 2

reagents and conditions .....

equation:

[4]

This question proved challenging with only the most able being given full marks. The reagents and conditions were not well known and candidates did not include water in their equations to make sure they were balanced.

Question 20 (f)

(f) Acid anhydrides react in a similar way to acyl chlorides with phenols.

Benzoic anhydride is the acid anhydride of benzoic acid, C_6H_5COOH.

Benzoic anhydride reacts with butan-2-ol to form an ester.

Suggest an equation for this reaction. Show structures for organic compounds. Use C_6H_5 for any phenyl groups.

[2]

Most candidates did not secure a mark in this question. Many candidates used butan-1-ol in their equations or used benzoic acid rather than benzoic anhydride as the reactant. The most able candidates suggested that the benzoic acid product would then further react with butan-2-ol to produce a second ester molecule and water. This was an acceptable alternative response.

Question 21

21* Carbon-carbon bond formation is used in synthesis to increase the length of a carbon chain.

Describe the formation of carbon–carbon bonds in aliphatic compounds by **two** different mechanisms.

Your answer should include mechanisms for each aliphatic compound. **[6]**

This question differentiated well. Candidates who were given Level 3 (5-6 marks) understood the term aliphatic and were able to provide two different mechanisms that produced a C-C bond. The most common responses seen involved the nucleophilic substitution of a halogenoalkane and a cyanide ion and the nucleophilic addition of a carbonyl with a cyanide ion. Some candidates offered radical substitution mechanisms, detailing initiation, propagation and termination steps, with the termination step producing a C-C bond. Candidates who scored Level 2 (3-4 marks) frequently detailed a reaction involving aromatic compounds or polymerisation of alkenes for which they were unable to give a mechanism.

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