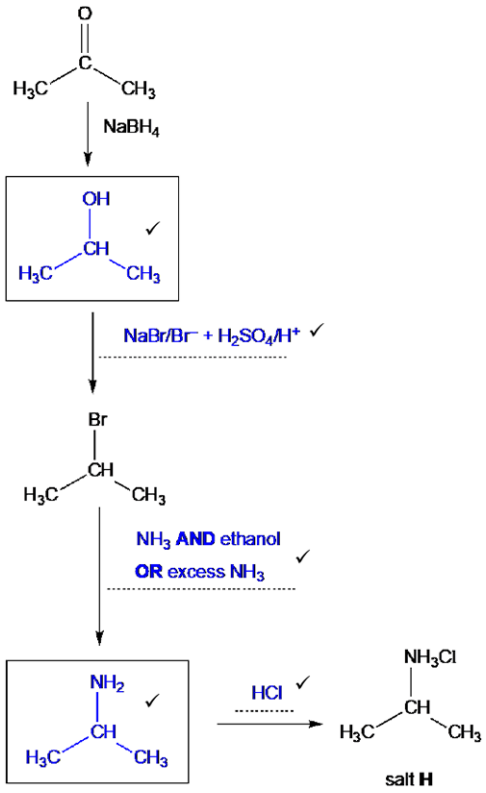
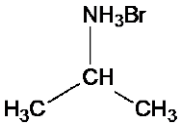
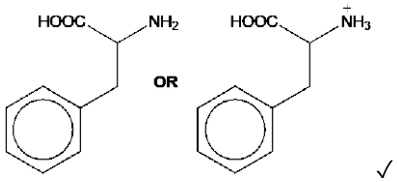
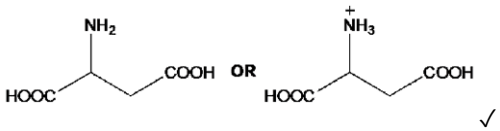
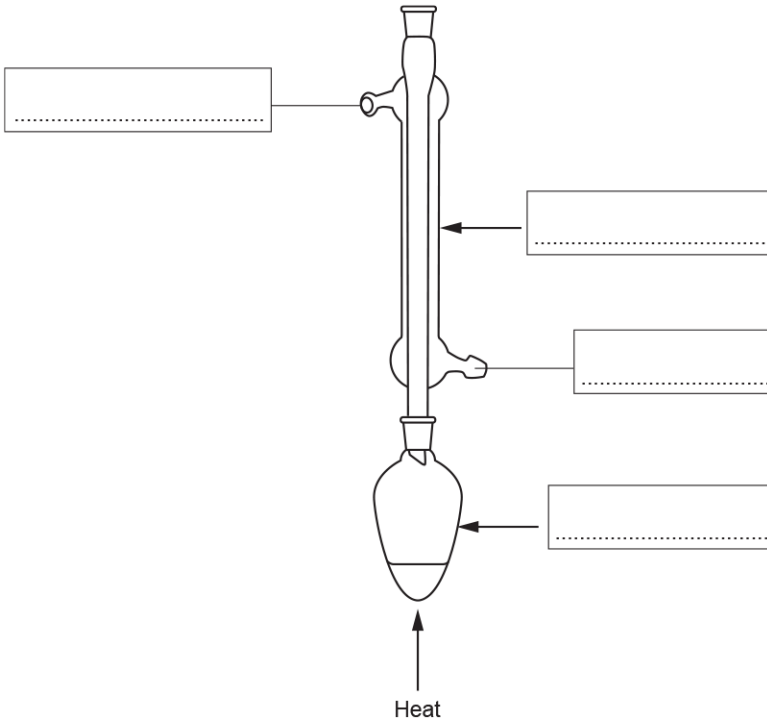
Mark scheme - Synthesis

Question			Answer/Indicative content	Marks	Guidance
1	a			5 (AO2.5 ×5)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** HBr **ALLOW** for the bottom left structure 
	b	i	Ester Amide Amine Carboxylic acid 4 groups correct ✓ ✓ ✓ 3 groups correct ✓ ✓ 2 groups correct ✓	3 (AO1.2 ×3)	**IGNORE** amino acid **ALLOW** carboxyl **IGNORE** attempt to classify amide, e.g. secondary **IGNORE** formulae (question asks for names) **IF > 4** functional groups are shown, • Count 4 groups max but incorrect groups **first** **IGNORE** aryl **OR** alkyl group e.g. benzene, phenyl, aryl, arene, methyl
		ii	**Methanol 1 mark** H_3C — OH ✓  ✓	4 (AO2.5 ×4)	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** + charge on H of NH_3 group, i.e. NH_3^+

			 ✓ Both amino acids shown with NH_3^+ ✓		If **BOTH** amino acids are shown with NH_3 groups (without the + charge) **OR** as NH_2^+ groups, award 2 of the 3 marks for the amino acids If **BOTH** amino acids are shown as correctly balanced salts, e.g NH_3Cl, all marks can be awarded.
		ii i	**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 22.4 OR 22 OR 23 award 3 marks** n(aspartame) in 1 can = 0.167 / 294 = 5.68 x 10^{-4} (mol) ✓ n(aspartame) limit per day = 1.7x10^{-4} x 75 = 0.01275 (mol) ✓ number of cans = 0.01275 / 5.68 x 10^{-4} = 22.4 ✓	3 (AO2.2 ×3)	**If there is an alternative answer, apply ECF and look for alternative methods** **Alternative methods** n(aspartame) in 1 can = 0.167 / 294 = 5.68 x 10^{-4} (mol) ✓ n(aspartame) per kg = 5.68 x 10^{-4} / 75 = 7.57 x 10^{-6} (mol) ✓ number of cans = 1.7 x 10^{-4} / 7.57 x 10^{-6} = 22.4✓ **OR** n(aspartame) limit per day = 1.7x10^{-4} x 75 =0.01275 (mol) ✓ mass(aspartame) limit per day =0.01275 x 294 = 3.7485 (g) ✓ number of cans = 3.7485 / 0.167 = 22.4 ✓
			Total	**15**	
2		i		2 (AO 1.2x2)	



Water flow AND condenser

Water in at bottom and out at top
AND condenser ✓

Flask and technique

Pear-shaped/round-bottom flask
AND reflux ✓

DO NOT ALLOW conical flask, volumetric flask, beaker in place of round bottom/pear shaped flask

Examiner's Comments

Most candidates labelled some of the apparatus correctly and identified the reflux technique. A significant number showed water flowing in the wrong direction and 'distillation' was given as the name of the technique. The 'condenser' was sometimes labelled incorrectly, e.g. 'condensation tube, 'distillation tube' and 'water jacket'. Only just over half the candidates were given both marks.

OCR support

Candidates are advised to learn the names of chemical apparatus and the practical techniques involved. Diagrams of distillation and reflux apparatus are provided in our Practical Activities Support Guide: https:/www.ocr.org.uk/Images/598371-practical-activities-support-guide.pdf

ii

Diagram showing knowledge of filtration under reduced pressure

Diagram showing Buchner flask
*must have **ONE** side arm*
AND
Buchner/Hirsh funnel on top of flask ✓
Labels not required

Further details:

- Funnel sealed or stoppered to flask

AND

- Apparatus capable of filtering under reduced pressure

AND

2

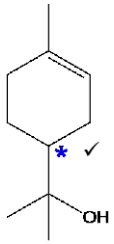
(AO 2.3)

Labels **NOT** required for diagram

ALLOW diagram of a conical flask with a filtering setup above
AND
Side arm either in conical flask **OR** between flask and filter paper of funnel

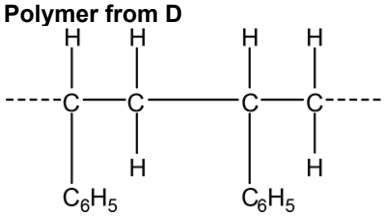
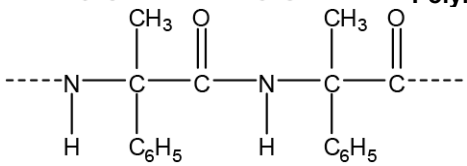
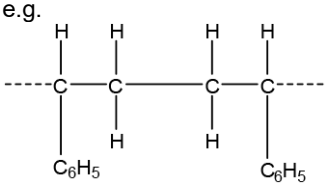
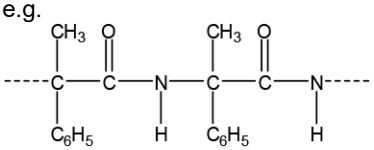
IGNORE absence of seals

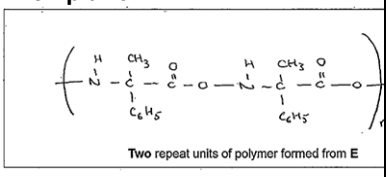
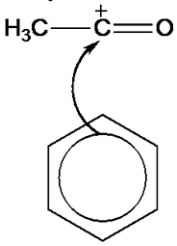
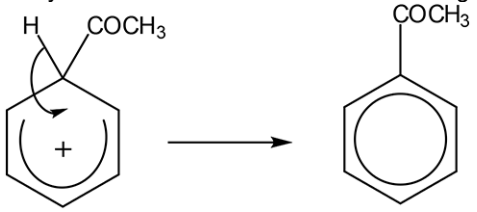
MUST imply some type of seal between filter setup and flask.
ALLOW **small** gaps

			• Label for setup from side arm to indicate reduced pressure **AND** • Label for Buchner flask **OR** Buchner/Hirsh funnel ✓ *ALLOW slips in spelling of 'Buchner'*	(AO 2.7)	Examples of suitable labels (may have arrow from side arm or tube attached) • to pump • to vacuum • air out • suction • reduced pressure • etc. For Buchner flask and Buchner funnel **DO NOT ALLOW** just 'flask **OR** 'funnel' *Flask and funnel used in normal filtration* **Examiner's Comments** Many diagrams were incomplete and it was comparatively rare for both of the two available marks to be given. Important labels were often missing. Some candidates drew diagrams of other techniques, such as distillation. Many responses were not credited with marks and this question was often omitted. Candidates need practice in recognising practical techniques and in drawing acceptable diagrams.
			Total	**4**	
3		i		1 AO 2.5	**DO NOT ALLOW** more than one * **ALLOW** a circle for * **Examiner's Comments** Most candidates showed one asterisk at the base of the cyclic part of the structure. The most common error was to show two asterisks, the second being on *$C(CH_3)_2OH$, despite this carbon not being connected to four different groups.

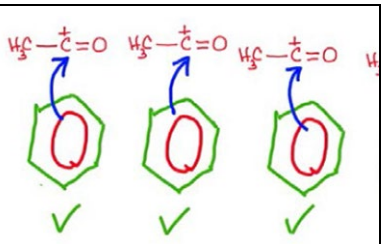
		ii	**MAXIMUM OF 4 MARKS FROM 5 MARKING POINTS** **Requirement for *E/Z* isomerism** **2 *marks*** C=C/double bond ✓ Each C (in C=C) is attached to (two) different groups/atoms ✓ **Identification as *E*- or *Z*- isomer** **2 *marks*** *E/Z* isomerism linked to (high) priority groups ✓ *Z*- **isomer AND** groups are on **same side** **OR** the ring carbons ✓ **Reason why other *E/Z* isomer does not exist 1 *mark*** ring would be strained **OR** ring would break/deform **OR** Cannot form ring if high priority groups are on opposite sides **OR** ring locks groups on one side of C=C bond ✓	4 AO1.2 x2 AO2.5 x2	**IGNORE** no H attached to C=C **IGNORE** functional', i.e. **ALLOW** different functional groups **ALLOW** in context of groups with largest atomic number ***ORA*** ***Award BOTH identification marks for:*** *Z*- isomer **AND** (high) priority groups on same side Mark independently of previous part Response **MUST** be linked to the ring/cyclic structure **IGNORE** just '*E* isomer is impossible' **IGNORE** C=C bond cannot rotate **IGNORE** Groups can't swap sides **Examiner's Comments** Candidates displayed a good knowledge of the requirements for *E/Z* isomerism in terms of a C=C double bond and different groups on the carbon atoms of the C=C bond. Many assigned terpineol as the Z isomer explained in terms of the priority groups being on the same side of the C=C bond. Candidates found it difficult to explain why terpineol has only one *E/Z* isomer. Many candidates thought that the C=C bond could not rotate because it was part of the ring. however, a C=C bond cannot rotate whether it is in a ring or not. Few candidates considered the strain put on the ring if the priority groups (being part of the ring) were to be placed in an *E* conformation.

		ii i	**First group:** **Reagent** **AND** **Functional group**: Alkene **OR** cycloalkene ✓ ***Examples of reagents*** Br_2 or other halogen, HBr, H_2 **AND** Ni (catalyst), H_2O(**g**)/steam **AND** H^+ (catalyst) **Organic product** for reagent with **C=C** in α-terpineol ✓ ***ALLOW*** *product from H_2 or H_2O if H^+ catalyst has been omitted from reagent.* ---------- **Second group** **Reagent** **AND** **Functional group**: (Tertiary) alcohol ✓ ***Examples of reagents*** NaBr/KBr/Br^- **AND** acid/H^+ (substitution), **OR** HBr Acid/H^+ (catalyst) (elimination), CH_3COOH **AND** acid/H^+ (catalyst) (esterification) $CH_3COOCOCH_3$ (esterification) CH_3COCl (esterification) **Organic product** for reagent with **OH** in α-terpineol ✓ **ALLOW product if catalyst omitted from reagent**	4 AO3.2 ×4	**CONTACT TEAM LEADER FOR OTHER REACTIONS** ---------- **ALLOW GROUPS EITHER WAY ROUND IN BOXES** Functional group **MUST** be **named** **DO NOT ALLOW** UV with halogens **ALLOW** H_2SO_4/H_3PO_4/acid for H^+ **ALLOW** addition of HBr/ H_2O either way across C=C **ALLOW ANY HALIDE**, i.e. Cl^-, Br^-, I^- **ALLOW** H_2SO_4/H_3PO_4/acid for H^+ **ALLOW** HBr for H^+ and Br^- **ALLOW** name or formula of any carboxylic acid or acyl chloride for esterification **ALLOW** Na → product with –ONa **OR** $-O^-$ **DO NOT ALLOW** $Cr_2O_7^{2-}/H^+$ (tertiary alcohol) **Examiner's Comments** In this question, candidates were given the opportunity to demonstrate some knowledge of organic reaction in a new context. The choice of reaction was up to the candidate. Most candidates were able to identify the alkene group in terpineol and to suggest a reagent that would react with this functional group. A correct structure for the organic product then usually followed. Although most candidates identified the alcohol group, many struggled with a reagent and resulting product. Although the

					alcohol –OH group has many reactions, (e.g. elimination, substitution, esterification) many candidates were fixated on oxidation with acidified dichromate despite a tertiary alcohol not being capable of oxidation with this reagent. Some candidates quoted acidified dichromate but then copied the structure of terpineol, stating that there was no reaction, despite the question directing them to select a reagent that would react with their chosen group.
			Total	**9**	
4		i	**Polymer from D**  ✓**Polymer from E**  Amide link ✓ 2 repeat units of correct polymer ✓	3 (AO 2.5) (AO 1.2) (AO 2.5)	--- For **BOTH** structures, **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous 'End bonds' **MUST** be shown **BUT ALLOW ECF IF** end bonds omitted in both structures **DO NOT ALLOW** more than 2 repeat units **BUT ALLOW ECF** in subsequent structure **IGNORE** connectivity of C_6H_5 --- **CARE: ALLOW** any consistent repeat unit: C_6H_5 and H groups can alternate or be on opposite sides of chain e.g.  end –NH– may be at either side e.g.  **IGNORE** brackets **IGNORE** *n* **Examiner's Comments** The majority of candidates were

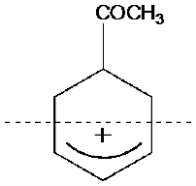
					able to draw two repeats units of the polymer formed from D and scored at least one mark. While most candidates drew the polymer from E correctly, securing full marks, some candidates were unable to show the amide link correctly. This common error is demonstrated in Exemplar 6. **Exemplar 5**  **Two** repeat units of polymer formed from **E** This response demonstrates a common error seen by examiners. The candidate has included an O atom as part of the amide link. So they have also included an O atom before the 'end bond'. This is a costly error as the candidate is unable to be given either of the marks available for this polymer.
		ii	**D** Addition / polyalkene **AND** **E**: Condensation / polyamide ✓	1(AO 1.1)	**DO NOT ALLOW** 'additional'
		ii i	**Formation of electrophile** $CH_3COCl + AlCl_3 \rightarrow CH_3–C^+=O + AlCl_4^-$ ✓ **Mechanism** Curly arrow from π-bond to $CH_3C^+=O$ ✓  --- Correct intermediate ✓ Curly arrow from C–H bond to reform π-ring ✓ 	5 (AO 2.5) (AO 2.5) (AO 3.1) (AO 2.5)	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** '+' charge anywhere on CH_3C^+O i.e. CH_3CO^+ **NOTE**: curly arrows can be straight, snake-like, etc. but **NOT** double headed or half headed arrows **1st curly arrow** must • go to the C of C=O **AND** • start from, **OR** close to **circle of benzene ring**

(AO 1.2)



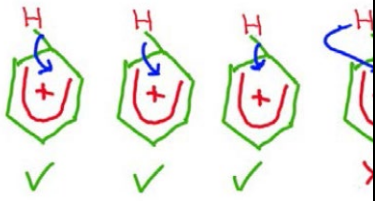
IGNORE curly arrow shown on C=O

DO NOT ALLOW the following intermediate:



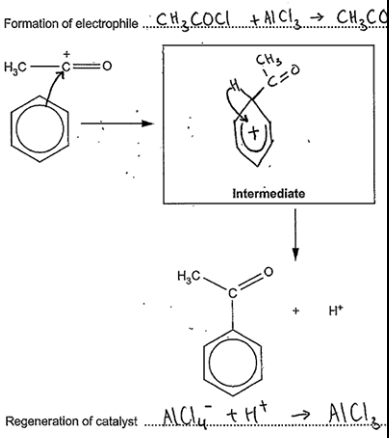
π-ring should cover approximately 4 of the 6 sides of the benzene ring structure
AND
the correct orientation, i.e. gap towards C with $COCH_3$
ALLOW + sign anywhere inside the 'hexagon' of intermediate

curly arrow must start from, **OR** be traced back to, **any part of** C-H bond and go inside the 'hexagon'



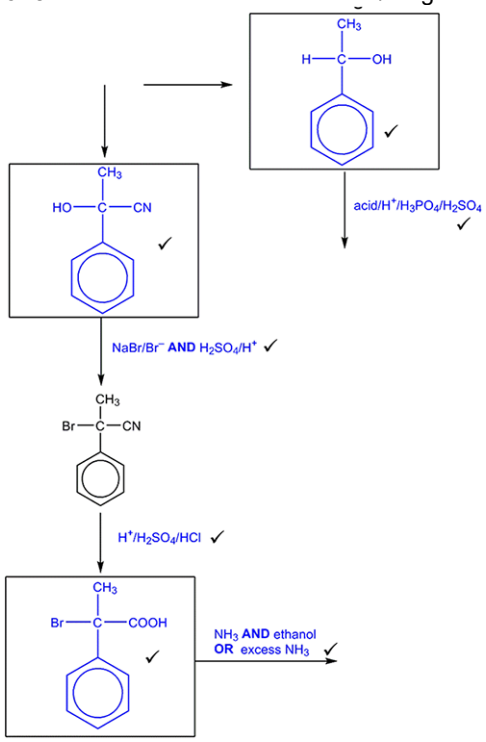
Examiner's Comments

This question required candidates to apply their knowledge of the mechanism of electrophilic substitution to the formation of phenylethanone from benzene. Examiners were encouraged by the number of excellent responses to this question, with the majority of candidates securing four out of five marks. Common errors included accuracy of curly arrows (Exemplar 7 below) and omission of HCl as product from the regeneration of the catalyst. The responses of lower ability candidates also contained errors in

					the equation for the formation of the electrophile. Such responses used chlorine rather than ethanoyl chloride. **Exemplar 6**  This response demonstrates a near perfect attempt at this question. The equations for the formation of the electrophile and regeneration of the catalyst are correct. The first curly arrow is drawn accurately from the circle of the benzene ring to the correct carbon atom of the electrophile. The intermediate is correct, with the π ring over the five carbon atoms and in the correct orientation. Unfortunately the curly arrow drawn to reform the π bond starts at the H atom rather than from the bond. This small error has prevented this candidate from being given full marks.

i v

one mark for each correct structure/reagent



7(AO 2.5 ×7)

ALLOW any vertical bond to the OH **OR** NH2 groups
e.g. **ALLOW**

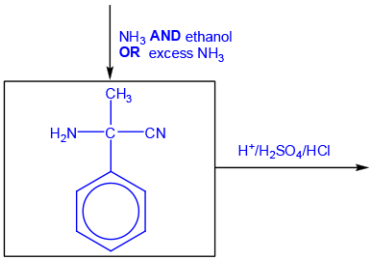
DO NOT ALLOW OH–, **OR** NH_2– but
ALLOW ECF for subsequent use in this part

For elimination,
IGNORE 'concentrated', 'dilute' with acids
BUT DO NOT ALLOW H_2O/steam/(aq)

ALLOW HBr for $NaBr/H_2SO_4$

For hydrolysis.
IGNORE missing (aq)
ALLOW HNO_3 for hydrolysis but
DO NOT ALLOW 'HNO_3 and H_2SO_4'

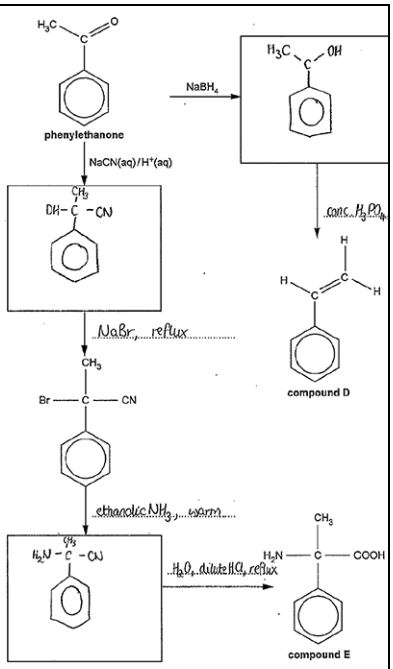
ALLOW final 2 stages in opposite order
i.e. NH_3 before acid hydrolysis



Examiner's Comments

This question required candidates to apply knowledge of organic reactions from across the specification and discriminated well. Candidates with a good knowledge of reagents and conditions frequently scored over five marks. More detailed feedback is discussed with Exemplar 7, below.

Exemplar 7



Phenylethanone is the starting point of this flowchart which shows the synthesis of compounds **D** and **E**.

Synthesis of **D**

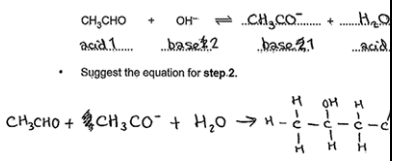
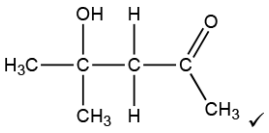
The first step in the synthesis of D is the reduction of the ketone group. This response demonstrates a common error seen by examiners. The candidate has correctly deduced that than alcohol is formed but has omitted a hydrogen atom. Candidates are advised to take care when drawing structures. If a carbon atom is displayed it should be shown to be making four bonds. The final step of the synthesis is the dehydration of the alcohol with an acid. This candidate has used H_3PO_4. H_2SO_4 was also frequently seen. Lower ability responses included reference to water or steam and this was not credited.

Synthesis of **E**

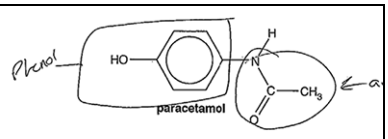
The first step of the synthesis of **E** from phenylethanone is the reaction with NaCN(aq)/H^+(aq). This candidate identifies that the product of the reaction is a hydroxynitrile but unfortunately this cannot be credited due to the incorrect linking of the OH group

					via the H atom. Candidates should be aware that, when drawing structures, groups must be bonded via the correct atoms. The next step of the synthesis is the substitution of the OH group. The candidate correctly recognises that NaBr is a suitable reagent but omits an acid, e.g. H_2SO_4, which is also required for this reaction. This error was seen frequently by examiners. The final two steps involve the substitution of the Br atom and acid hydrolysis of the nitrile group. In this case the candidate chooses the reaction with excess NH_3. The structure of the correct product of this reaction is shown and the synthesis is completed by identifying a suitable reagent for the final step. Other candidates opted to perform these steps in the reverse order and the mark scheme allowed full credit for either approach. Common errors in the final steps were omissions. Some candidates simply stated NH_3 without mentioning ethanol. Others identified water as important for the hydrolysis but did not include reference to an acid.
			Total	**16**	
5		i	3-hydroxybutanal ✓	1	**ALLOW** 3-hydroxybutan-1-al **IGNORE** lack of hyphens or addition of commas **ALLOW** 4-oxobutan-2-ol **OR** 1-oxobutan-3-ol **DO NOT ALLOW** • 3-hydroxybutal • 3-hydroxylbutanal **Examiner's Comments** Most candidates made good

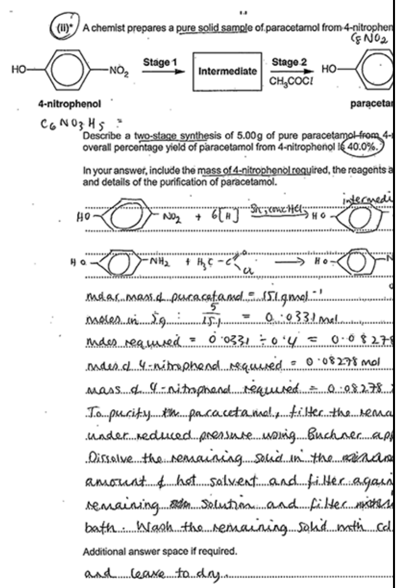
					attempts at the name, the difficulty being that hydroxyl group needed to be shown as a hydroxy- prefix, rather than the suffix -ol. Common errors included 2-hydroxybutanal (counting the carbon chain from the wrong end) and 2- or 3-hydroxybutanoic acid (reading the aldehyde group as a carboxylic acid).
		ii	Addition ✓	1	**IGNORE** nucleophilic **OR** electrophilic **OR** radical **DO NOT ALLOW** addition–elimination, condensation, polymerisation **Examiner's Comments** This part was answered well with most choosing nucleophilic addition. Credit was given just for 'addition'.
		ii i	**ALLOW** any formula provided that number and type of atoms and charge are correct, e.g. For CH_3CHO, **ALLOW** CH_3COH, C_2H_4O, etc. _____ **Step 1**: • Correct equation ✓ One correct acid–base pair ✓ • i.e. A1 and B1 **OR** A2 and B2 $CH_3CHO + OH^- \rightleftharpoons {}^-CH_2CHO + H_2O$ **OR** $CH_3CHO + OH^- \rightleftharpoons CH_3CO^- + H_2O$ ✓ **A1 B2 B1 A2** **OR A2 B1 B2 A1** **Step 2**: $CH_3CHO + {}^-CH_2CHO + H_2O \rightarrow CH_3CHOHCH_2CHO + OH^-$ ✓ For $^-CH_2CHO$: **ALLOW** CH_2CHO^-; CH_3CO^-; $C_2H_3O^-$ For $CH_3CHOHCH_2CHO$, **ALLOW** $C_4H_8O_2$	3	Throughout, **IGNORE** 'connectivity in any formula or structures shown. Examples in Answer column and in 6a(iv) guidance below _____ **Step 1: ALLOW** H^+ transfer from OH^-, i.e. $CH_3CHO + OH^- \rightleftharpoons CH_3CH_2O^+ + O^{2-}$ ✓ **B2 A1 A2 B1** **OR B1 A2 A1 B2** **Step 2:** $CH_3CHO + CH_3CH_2O^+ + O^{2-} \rightarrow CH_3CHOHCH_2CHO + OH^-$ ✓ For $CH_3CH_2O^+$: **ALLOW** CH_3CHOH^+, $C_2H_5O^+$ **Examiner's Comments** This novel question linked together

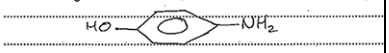
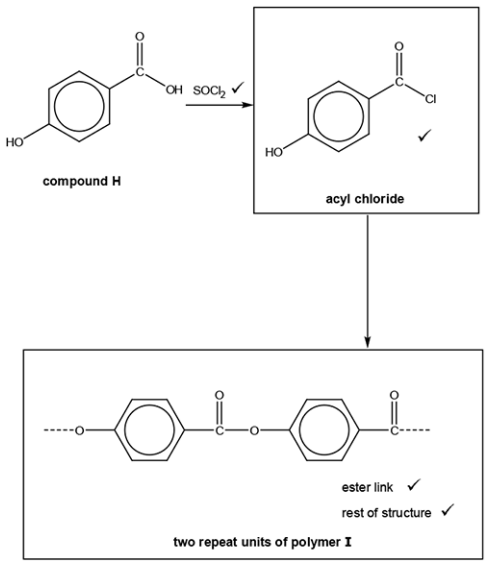
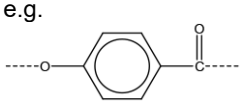
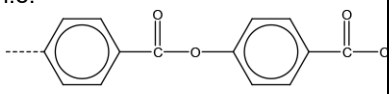
					acid–base equilibria with a multi-step process. Many candidates completed an equation to generate acid–base pairs, which were then usually assigned correctly. The final equation was challenging but the highest ability candidates were able to combine together all the information with their earlier responses to arrive at the correct equation. See Exemplar 15. **Exemplar 15** 
		iv	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous For connectivity, **ALLOW** OH, CH_3–, C_3H– *(Connectivity not being assessed)* **Examiner's Comments** This part was one of the most challenging on the paper. Candidates needed to link the earlier information for combining two ethanal molecules to derive the product for combining two propanone molecules. Despite the challenge, the highest ability candidates were able to come up with the correct structure.
			Total	**6**	
6		i	Phenol ✓ Amide ✓	2	**IF > 2** functional groups are shown,

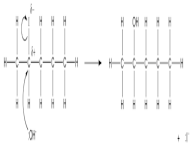
			• **IGNORE** attempt to classify amide, e.g. secondary		• Mark 2 groups **ONLY** • Mark incorrect groups **first** Treat carbonyl with aldehyde **OR** with ketone as one functional group, i.e. • carbonyl, aldehyde • carbonyl, ketone • carbonyl **IGNORE** aryl **OR** alkyl group e.g. benzene, phenyl, aryl, arene, methyl **IGNORE** hydroxyl/hydroxy **Examiner's Comments** This part assessed knowledge of functional groups and proved to be a very good discriminator. Able candidates usually identified the phenol and amide functional groups, with 'secondary amide' also seen. In Exemplar 9, the candidate has identified the correct functional groups. The candidate's working by circling the functional groups in the structure shows good examination technique, helping the candidate to arrive at the correct conclusion. The phenol group was often incorrectly identified as an alcohol and the amide group as a combination of 'amine', 'ketone', 'keytone' or 'carbonyl'. Neutral responses such as 'hydroxyl' and 'benzene' were ignored. Candidates need to be careful that they do not present an extensive list of many functional groups in the hope that the correct groups are amongst them, as shown in Exemplar 10. Incorrect groups are marked first. **Exemplar 9**

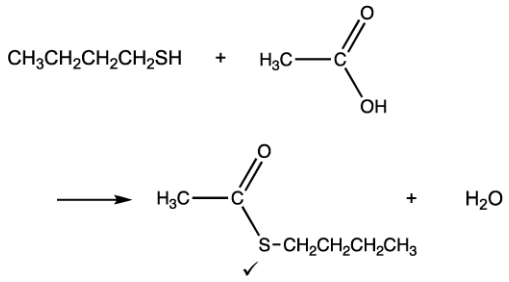
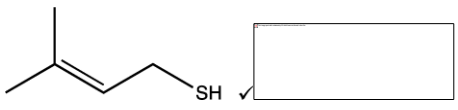
					 (i) Name the functional groups present in paracetamol. phenol ✓ amide ✓ **Exemplar 10** phenol, ketone, benzene ✗ alkyl, amine ✗
		ii	*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5-6 marks)** A correct calculation of the mass of 4-nitrophenol. **AND** Identifies the reagents **AND** intermediate. **AND** A **detailed** description of most purification steps. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3-4 marks)** Calculates the mass of 4-nitrophenol with some errors **AND** suggests reagents and intermediate with some omissions. **OR** Calculates the mass of 4-nitrophenol with some errors **AND** describes some purification steps, with some detail. **OR** Suggests reagents and intermediate with some omissions **AND** describes some purification steps, with some detail. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1-2 marks)** Attempts to calculate the mass of 4-nitrophenol **OR** Suggests reagents **OR** intermediate but may be incomplete **OR** Describes few purification steps. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include:** **<u>Calculation of mass of 4-nitrophenol</u>** **Using moles** • n(paracetamol) = $\frac{5.00}{151}$ = 0.0331 (mol) • n(4-nitrophenol) = 0.0331 × $\frac{100}{40}$ = 0.082 • Mass of 4-nitrophenol = 139 × 0.0828 = 11.5 g **ALLOW** 11.4−11.6 for small slip/rounding **Using mass** • Theoretical mass paracetamol = 5.00 × - • Theoretical n(4-nitrophenol) = $\frac{12.5}{151}$ = 0.(• Mass of 4-nitrophenol = 139 × 0.0828 = **11.5** g **NOTE**: Incorrect inverse ratio of $\frac{100}{40}$ gives: • 0.0331 × $\frac{40}{100}$ = 0.0132 (mol) • Mass = 139 × 0.0132 = 1.84 g **<u>Reagents and intermediate</u>** • **Reagents**: Sn + (conc) HCl (then NaOH) • **Intermediate**: 4-aminophenol or structure **<u>Purification</u>** • Dissolve impure solid in **minimum volume of** hot solvent • **Cool** solution and filter solid • **Scratch with glass rod** • **Wash** with cold solvent/solvent and **dry**

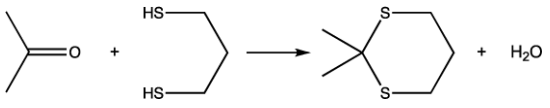
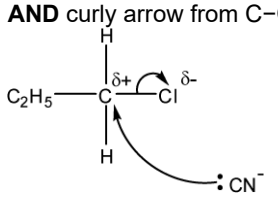
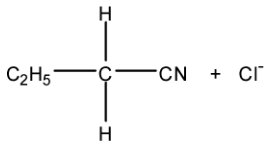
					Examples of detail in **bold (NOT INCLUSIVE)** **NOTE**: 'Recrystallisation' on its own is **NOT** a detailed description **Examiner's Comments** This part assessed practical aspects of a two-stage organic synthesis. Overall, candidates responded well, and this part was discriminating. Many candidates produced well-structured responses although lower ability candidates do have problems with constructing a cohesive response. Most candidates identified the correct reagents (Sn and concentrated HCl) and the intermediate (4-aminophenol), which was usually shown as its structure. Able candidates usually showed that 11.5 g of 4-nitrophenol is needed for the synthesis. A common error used the 'inverse percentage' ratio of 40/100, resulting in an incorrect mass of 1.84 g. Candidates are recommended to check whether a calculated answer looks sensible. Looking at the structures and with a percentage yield of 40%, 1.84 g does not look to be enough of the starting chemical. Some lower ability candidate responses assumed that 5.00 g was 40% of the required mass and responded with 5.00 × 100/40 = 12.5 g. There were some good descriptions of purification, although finer details such as using a minimum volume of hot solvent, washing with cold solvent, and drying) were often omitted. Candidates needed to respond with more than just 'recrystallisation'. In the purification, common errors

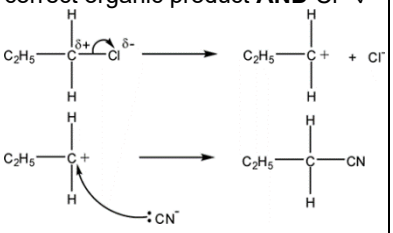
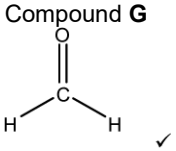
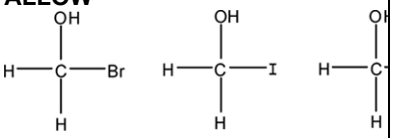
					were showing the correct steps but in the wrong order and use of a drying agent such as $CaCl_2$ (confusion with part of the purification of an organic liquid). These candidates seemed unaware that adding a solid drying agent to an organic solid would result in impure paracetamol rather than purifying. Exemplar 11 shows an excellent response that addresses all aspects of the problem. In comparison, Exemplar 12 is much less detailed: concentrated HCl has not been shown as a reagent for step 1, the candidate has not shown that they know how to carry out a percentage yield calculation, and the purification is confused, and lacks detail. **Exemplar 11**  **Exemplar 12**

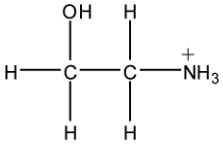
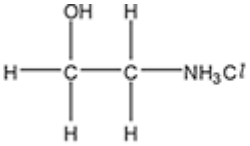
					In your answer, include the mass of 4-nitrophenol required, the reagents and and details of the purification of paracetamol. 4-nitrophenol is ~~reacted with~~ reduced (Sn) tin in presence of and acid and ~~4-phenyl~~ 4-phenylamide under high  $\frac{109}{140} \times 5.00 = 12.5g$ from the begin required A pure sample of paracetamol was by crystallisation. The impure solution w with a bunsen burner and stirred until start forming. ~~an~~ After formation in left to cool and and oven was to evaporate any water left
			Total	**8**	
7			One mark for each correct structure/reagent as shown below  	**4**	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** PCl_5 **OR** PCl_3 for reagent mark. **IGNORE** references to temperature for reagent mark **IGNORE** additional reagents shown with $SOCl_2$/PCl_5/PCl_3 e.g. H_2O, $AlCl_3$, HCl etc. **IGNORE** names *(question asks for structures of organic compounds and formula of reagent)* **DO NOT ALLOW** more than two repeat units **ALLOW** 1 mark for one correct repeat unit e.g.  'End bonds' **MUST** be shown (do not have to be dotted) **ALLOW** the 'O' at either end i.e.  **IGNORE** brackets **IGNORE** *n* **Examiner's Comments** Compound **H** was also the focus for this question. Most candidates were able to provide the structure of the acyl chloride obtained from

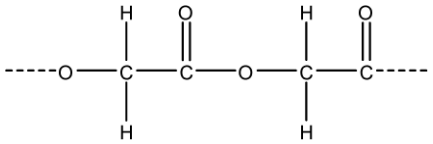
					H but only some identified $SOCl_2$ as the correct reagent. Common incorrect reagents included HCl and $AlCl_3$. Most candidates recognised that polymer **I** was a polyester but only some were able to draw two repeat units correctly. Candidates are advised to practice drawing different polymers, taking care to ensure the correct number of repeat units are present when a specific number is required.
			Total	**4**	
8		i	Reflux	1	
		ii	Nucleophilic substitution (1) *Mechanism* Curly arrow from lone pair on OH^- to δ+ carbon atom (1) Curly arrow and dipole on C–I bond (1) Correct products (1)	4	The curly arrow must start from the oxygen atom of the OH^- and must start from either the lone pair or the negative charge  **do not allow** attack by NaOH
			Total	**5**	
9		i	$K_a = \frac{[H^+]\,[C_4H_9S^-]}{[C_4H_9SH]}$ ✓ *Square brackets required*	**1**	**ALLOW** correct structural **OR** skeletal **OR** displayed formula **OR** mixture of the above as long as non- ambiguous **Examiner's Comment:** This part was very well answered. Candidates responded with either near molecular formulae, such as C_4H_9SH, structural formulae or with skeletal formulae. Some candidates made careless errors such as omitting the negative charge or showing $[H^+]^2$ as numerator rather than $[C_4H_9S^-]$ $[H^+]$.

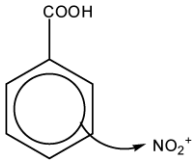
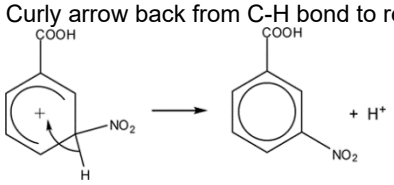
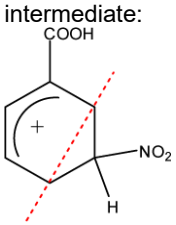
		ii	 Structure of thioester ✓ Complete equation ✓	2	**ALLOW** correct skeletal **OR** displayed formula **OR** mixture of the above as long as non-ambiguous **ALLOW** C_4H_9SH **ALLOW** CH_3COOH Thioester functional group **must** be fully displayed, **OR** as a skeletal formula but allow SC_4H_9 in thioester **Examiner's Comment:** In this part, candidates were expected to apply their knowledge and understanding of esterification to thiols and thioesters. Over half the candidates obtained a correct structure of the thioester. Most of these candidates constructed a balanced equation although some omitted the water product. Common errors included formation of a conventional ester and H_2S, and retaining the O atom from the OH in the carboxyl group to form –COOS–. As with 4(b)(i), structural and skeletal formulae were used. Candidates are less likely to omit H atoms if the skeletal formula is used.
		ii i		1	**IF** correct **skeletal** formula is shown, **IGNORE** displayed formula in a second structure **Examiner's Comment:** Just over half the candidates drew the correct structure, displaying a good understanding of interpreting organic nomenclature when drawing a structure. Common errors included omission of the CH_2 adjacent to the terminal –SH group and placing the branch or double bond in wrong positions. Some candidates spoilt an otherwise good response by showing a structural formula or a

					mixture of skeletal and structural formulae.
		i v	 Reactants ✓ Products **AND** balanced equation ✓	**2**	**ALLOW** correct structural **OR** skeletal **OR** displayed formula **OR** mixture of the above as long as non-ambiguous **Examiner's Comment:** In this part, candidates were expected to apply their knowledge and understanding of condensation to an entirely new context. One mark was allocated for the reactants and this was usually scored. The second mark for the novel cyclic compound and water was much more difficult, aimed at stretch and challenge. A significant number of candidates interpreted the information to obtain a correct cyclic structure but this mark was the domain of the most able candidates.
			Total	**6**	
10		i	curly arrow from $^{-}$CN to carbon atom of C−C*l* bond ✓ Dipole shown on C–C*l* bond, $C^{\delta+}$ and $Cl^{\delta-}$, **AND** curly arrow from C−C*l* bond to C*l* atom ✓  correct organic product **AND** C*l*-✓ 	**2**	**ANNOTATE ANSWER WITH TICKS AND CROSSES** Curly arrow must come from lone pair on C of $^{-}$CN OR CN^{-} **OR** from minus sign on C of $^{-}$CN ion (then lone pair on CN^{-} does not need to be shown) **IGNORE** NaCl **ALLOW** S_N1 mechanism: Dipole shown on C–Cl bond, $C^{\delta+}$ and $Cl^{\delta-}$, **AND** curly arrow from C–C*l* bond to C*l* atom ✓ Correct carbocation **AND** curly arrow from $^{-}$CN to carbocation. Curly arrow must come from lone pair on C of $^{-}$CN **OR** CN^{-} **OR** from minus sign on C of $^{-}$CN ion (then lone pair on CN^{-} does

					not need to be shown) ✓ correct organic product **AND** Cl^- ✓  **Examiner Comments** The mechanism for the reaction of 1-chloropropane was well done with the majority of candidates scoring two or three of the marks. Marks were not awarded when candidates used a negative charge or a lone pair sited on the nitrogen as the starting point for a curly arrow in the first stage of the reaction mechanism. The final marking point was awarded for the production of a Cl^- ion. The placing of curly arrows, dipoles and lone pairs of electrons are important when communicating by mechanisms.
		ii	Compound **G**  ✓ **Reagents** **Reaction 2:** H_2 **AND** Ni ✓ **Reaction 3:** Correct formula of an aqueous acid e.g. HCl(aq)/H_2SO_4(aq) ✓	**3**	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **IGNORE** name(s) **ALLOW**  **ALLOW** any suitable metal catalyst e.g. Pt **ALLOW** $LiAlH_4$ for reagent in reaction 2 **DO NOT ALLOW** $NaBH_4$ for reagent in reaction 2 **IGNORE** names *(question asks for formulae)* **IGNORE** references to temperature and/or pressure **ALLOW** H^+(aq) **IGNORE** dilute **ALLOW** formula of an acid **AND** water e.g. HCl **AND** H_2O H_2SO_4 **AND** H_2O

					Examiner Comments Although many candidates were able to provide the structure of methanal as the starting material for this synthesis, the structures of chloromethanol, bromomethanol and iodomethanol were accepted as suitable alternatives. It should be noted that hydrolysis is carried out using aqueous acid and that dilute acid is not a suitable alternative.
		ii i	**Explanation** Nitrogen electron pair **OR** nitrogen lone pair **AND** accepts a proton / H^+✓ **Structure of salt**  **AND** Cl^- ✓	**2**	**IGNORE** NH_2 group donates electron pair **ALLOW** nitrogen donates an electron pair to H^+ **DO NOT ALLOW** nitrogen donates lone pair to acid **IGNORE** comments about the O in the –OH group Compound **H** is a base is **not sufficient** *(role of lone pair required)* **DO NOT ALLOW** nitrogen/N lone pair accepts hydrogen (*proton/H^+ required*) **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW**  *i.e.* charges n **IF** charges are shown **both** need to be present **ALLOW** charge either on **N** atom or NH_3^+ **IF** displayed then + charge must be on the nitrogen **Examiner Comments** Only 20% of candidates were awarded both marks for this question. The commonest error was a failure to state that the N atom has a lone pair of electrons that can gain a proton. Answers

					stating that amines accept protons or that a salt is produced when an acid reacts with a base were not credited. Where a full displayed structure is given the positive charge must be shown on the nitrogen atom, although $-NH_3^+$ is acceptable. As the question required the formula of the salt, the Cl^- had to be included.
		iv	 Ester link ✓ Rest of structure✓ (polymer **J** is biodegradable because) the ester / ester bond / ester group / polyester can be hydrolysed✓	**3**	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW** more than two repeat units for second marking point. 'End bonds' **MUST** be shown (do not have to be dotted) **IGNORE** brackets **IGNORE** ***n*** Broken down by water is **not** sufficient **IGNORE** references to photodegradable **Examiner Comments** The most common mark for this question was two out of the three marks available, with candidates giving a correct structure of the polymer but failing to express that the polymer was biodegradable due the ability of the ester functional group to undergo hydrolysis.
			Total	**11**	
11	a	i	**Generation of electrophile** $HNO_3 + H_2SO_4 \longrightarrow H_2O + HSO_4^- + NO_2^+$ ✓ **Electrophilic substitution** Curly arrow from p-bond to NO_2^+ ?	**5**	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** $HNO_3 + 2H_2SO_4$? $H_3O^+ + 2HSO_4^- + NO_2^+$ **ALLOW** $HNO_3 + H_2SO_4$? $H_2NO_3^+ + HSO_4^-$ Then $H_2NO_3^+$? $H_2O + NO_2^+$

			 --- Correct intermediate ? Curly arrow back from C-H bond to reform p-ring **AND** H^+ as product ?  **Regeneration of catalyst** $H^+ + HSO_4^- \longrightarrow H_2SO_4$ ✓		**ALLOW** $^+NO_2$ **OR** NO_2^+ First curly arrow must come from the ring to NO_2^+ **DO NOT ALLOW** the following intermediate:  p-ring should cover approximately 4 of the 6 sides of the benzene ring structure **AND** the correct orientation, *i.e.* gap towards C with NO_2 **ALLOW** + sign anywhere inside the 'hexagon' of intermediate **Examiner Comments** The majority of candidates were well prepared for this standard mechanism and frequently scored marks of four or five. Most were able to show equations to generate the electrophile and regenerate the catalyst. Candidates should note the importance of the correct placement of curly arrows and the horseshoe in the intermediate to show the remaining electrons present in the ring structure. These were often poorly represented, leading to marks not being awarded.
		ii	*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Outlines the main steps of recrystallisation to produce a pure sample of 3-nitrobenzoic acid from the impure solid. **AND** Calculates correct percentage yield of 3-nitrobenzoic acid. **AND** Method of checking purity to include comparison to relevant data. *A well-structured response with the steps for recrystallisation and the determination of purity being given in the correct order. Correct use of*	**6**	**Indicative scientific points, with bulleted elements, may include:** **1. Purification** • Recrystallisation • Dissolve impure solid in minimum volume of hot water/solvent • Cool solution and filter solid

terminology throughout.

Level 2 (3–4 marks)
Attempts all three scientific points but explanations may be incomplete.
OR

Explains two scientific points thoroughly with very few omissions.

The description of checking for purity or recrystallisation is clear and any calculations structured. Key terminology used appropriately.

Level 1 (1–2 marks)
A simple explanation based on at least two of the main scientific points.
OR
Explains one scientific point thoroughly with few omissions.
There is an attempt at a logical structure. The description of the practical techniques provides some detail but may not be in the correct order.

- *Purification step is unclear with few scientific terms and little detail, e.g. just 'recrystallise'.*
- *Calculation is difficult to follow, may just include a calculation of moles of reactants and/or products.*
- *Purity check specifies a method but this is unclear with little detail, e.g. take melting point.*

0 marks
No response or no response worthy of credit.

- Wash with cold water/solvent and dry

2. Percentage yield

- n(benzoic acid) used $= \frac{4.97}{122} = 0.040$
- n(3-nitrobenzoic acid) made $= \frac{4.85}{167} = 0.0$
- percentage yield $= \frac{0.0290}{0.0407} \times 100 = 71.3$ (%

ALLOW 71 to calculator value of 71.29001554 correctly rounded.

CHECK for extent of errors by **ECF**

Alternative correct calculation may calculate theoretical mass of 3-nitrobenzoic acid that can be produced as 0.0407 × 167 = 6.80 (g) followed by:
$\text{percentage yield} = \frac{4.85}{6.80} \times 100 = 71.3$

Calculation **must** attempt to calculate n(benzoic acid) in mol.

3. Checking purity

- Obtain melting point
- Compare to known values
- Pure sample will have a (sharp) melting point very close to data book value

ALLOW alternative approach based on spectroscopy or TLC

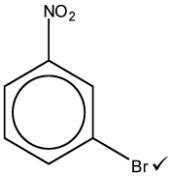
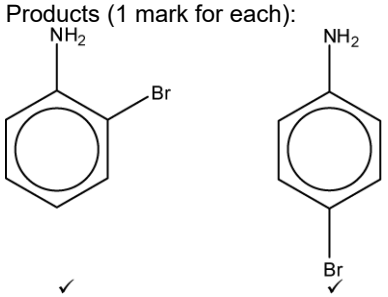
Spectroscopy

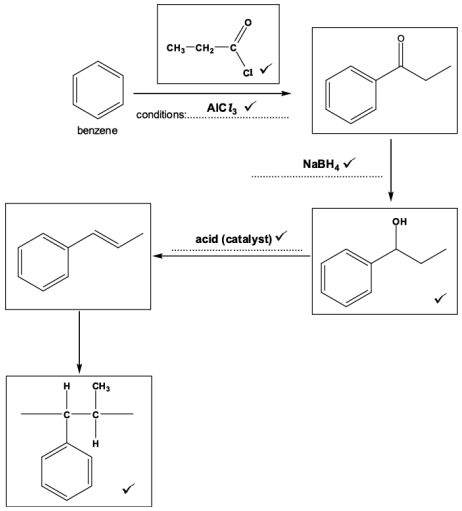
- Run an NMR/IR spectrum
- Compare to (spectral) database
- Spectrum of pure sample will contain same peaks and not others

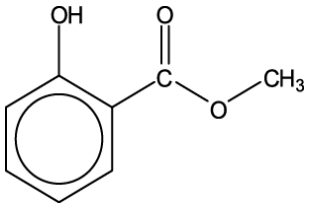
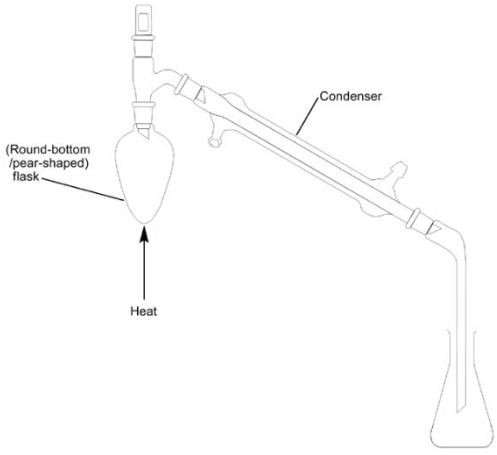
TLC

- Run a TLC
- Compare (R_f value) to known data

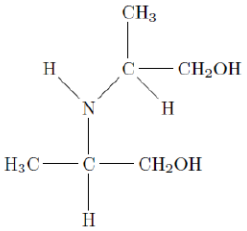
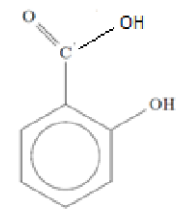
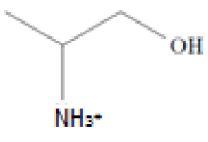
					• Pure sample will have a very similar R_f **Examiner Comments** This question tested some of the practical techniques covered as part of the practical endorsement as well as requiring candidates to calculate a percentage yield for the reaction. This proved to be quite a challenging question with some candidates giving little detail of how to carry out a recrystallisation. Common answers included a statement that the solid should be allowed to dissolve in a solvent and then filtered to obtain crystals. This did not gain credit for the scientific content as there was no indication of the solid dissolving in a hot solvent and then being allowed to cool before carrying out filtration. High quality answers often went above and beyond the requirements of the marking scheme with some candidates discussing the importance of dissolving in the minimum amount of hot solvent to obtain a saturated solution, the need to wash and dry the crystals and provided detail of the apparatus and or method required. Most candidates discussed that purity could be determined by taking the melting point of the product and comparing this to a value obtained from data book. The most comprehensive answers gave an indicated of the apparatus required to carry out the melting point determination and discussed how the melting point becomes higher and sharper as impurities are removed. Common errors included comments about carrying out a boiling point determination. When carrying out a percentage yield calculation, it is important to round answers only at the last stage of the calculation. Early rounding frequently led candidates to obtain answers, which did not

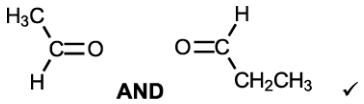
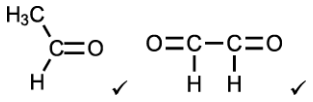
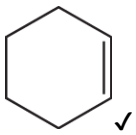
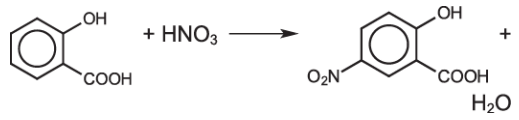
					gain credit. Weaker Candidates divided the mass of 3-nitrobenzoic acid by the mass of benzoic acid and obtained an answer of 97.6%. Answer = 71.3%
	b	i	**Bromination:** Br_2 **AND** A/Br_3/$FeBr_3$/Fe ✓ **Intermediate**  **Reduction:** Sn **AND** (concentrated) HC*l* ✓	**3**	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** any suitable halogen carrier catalyst **ALLOW** Kekulé structure **IGNORE** names *(question asks for formulae)* **IGNORE** reaction conditions even if incorrect **IGNORE** 'dilute' for HC*l* **IGNORE** H_2 **IGNORE** NaOH if seen as a reagent to convert nitro group into amine e.g 'Sn/(concentrated) HC*l* then NaOH' scores the mark **Examiner Comments** Candidates were able, in the main, to provide the reagents for bromination and reduction. The structure of the intermediate compound in the preparation of 3-bromophenylamine proved to be straightforward, however common errors involved the omission of the halogen carrier catalyst for bromination or stating names rather than formulae as indicated in the question.
		ii	NH_2 is 2,4 directing ✓ Products (1 mark for each):  	**3**	**IGNORE** references to electron donating/withdrawing groups **ALLOW** –NH_2 activates the ring causing the new group to join at positions 2 and 4. **ALLOW** ortho and para directing for 2,4 directing **IGNORE** 6-directing **ALLOW** Kekulé structure **IGNORE** names

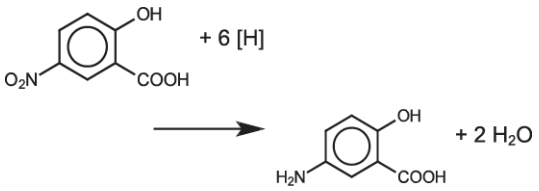
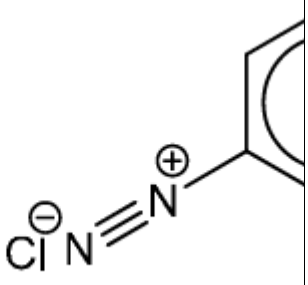
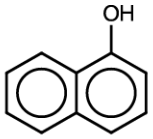
					Examiner Comments The most able candidates completed this question with a clear statement that the $–NH_2$ group was 2,4 directing and provided two clearly drawn structures of 2-bromophenylamine and 4-bromophenylamine. The most common errors observed included drawing two structures that were identical and explaining the two structures in terms of electron donation from the $–NH_2$ without any indication of positioning. Candidates using the terms ortho and para directing were awarded full marks for their answers.
			Total	**17**	
12	a		One mark for each correct structure/reagent/condition as shown below  	6	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **IGNORE** names of organic compounds *(question asks for structures)* **ALLOW** aluminium(III) chloride **OR** aluminium trichloride **ALLOW** $FeCl_3$ **OR** Fe as halogen carrier in first step. **ALLOW** sodium borohydride **OR** sodium tetrahydridoborate **IGNORE** [H] for reducing agent in second step **ALLOW** H^+ / H_2SO_4 / H_3PO_4 / named mineral acid for reagent in third step

	b		Use as an organic feedstock ✓ **OR** Combustion for energy production ✓	1	**ALLOW** the production of plastics or monomers or new polymers Combustion alone is **not** sufficient
			Total	**7**	
13		i	 **AND** Acid (catalyst) ✓	1	**Note:** both the structure and condition are required for the mark **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** H^+ / H_2SO_4 / H_3PO_4 / named mineral acid
		ii	**Diagram** Diagram showing correct apparatus for distillation ✓ *i.e.* • Round-bottom/pear-shaped flask • Condenser (correctly orientated) • Stopper/thermometer • Delivery tube and suitable collection vessel  **Labels** (Round-bottom/pear-shaped) flask **AND** condenser **AND** heat (source) ✓	2	**DO NOT ALLOW** conical flask, volumetric flask, beaker in place of round bottomed/pear shaped flask **DO NOT ALLOW** diagram mark if top of distillation head not closed **Note:** suitable collection vessels include: conical flask, boiling tube, test-tube, beaker etc.
			Total	**3**	

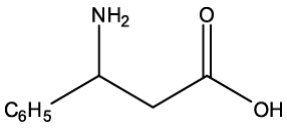
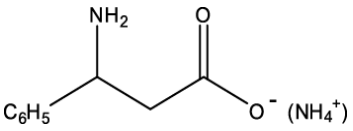
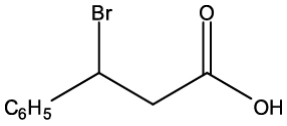
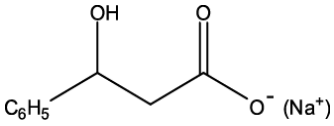
14	a	i	<table><tr><th colspan="3">^{1}H NMR spectrum for 2-aminopropan-1-ol</th></tr><tr><th>Chemical shift, δ/ppm</th><th>Relative peak area</th><th>Splitting pattern</th></tr><tr><td>0.8 – 2.0</td><td>3</td><td>doublet</td></tr><tr><td>2.3 – 3.0</td><td>1</td><td>multiplet</td></tr><tr><td>3.3 – 4.2</td><td>2</td><td>doublet</td></tr></table> ✓✓✓	3	One mark for each correct row **ALLOW** δ values as a range or a value within the specified range. **ALLOW** δ values +/− 0.2 ppm. **ALLOW** a response that implies a splitting into two for a doublet etc. **ALLOW** sextet/hextet/six (or more than 5) as alternative to multiplet Relative peak area = CH /3H etc. penalise once **Examiner's Comments** Although it could be argued that this question tested the same skill three times, the full range of marks was awarded and errors were seen in the chemical shift, relative peak area and splitting pattern. Fully correct responses included either a chemical shift value within the range specified on the data sheet or a range that matched the one given on the data sheet.
		ii	$\underline{M^+ \text{ peak at } 75}$ (peak 1) $CH_3CH(NH_2)CH_2OH^+/C_3H_9NO^+$ ✓ $\underline{\text{Fragment peak at } 44}$ (peak 2) $CH_3CH(NH_2)^+/C_2H_6N^+$ ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous Positive charge is essential but **ALLOW** maximum of one mark if both formulae are correct **AND** neither species has a positive charge **Examiner's Comments** Although peak 2 was often correct, the species responsible for the M+ peak was often missing a positive charge. Possibly students have learned that the particles become charged as part of the fragmentation process and don't realise that only charged particles can be detected by a mass spectrometer.
	b	i	Ethanolic ammonia **OR** ammonia/NH_3 **AND** ethanol ✓	1	**ALLOW** ammonia in a sealed tube **ALLOW** dilute ethanolic

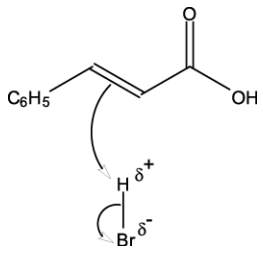
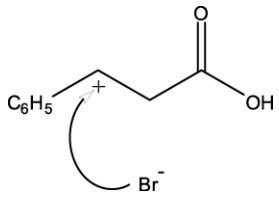
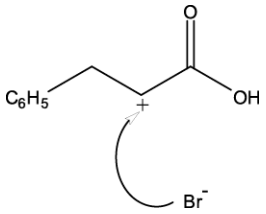
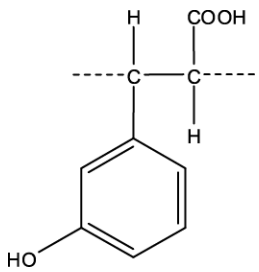
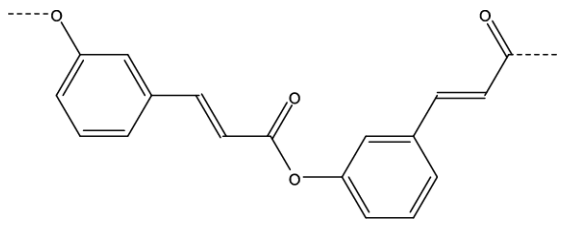
					ammonia/NH_3 **IGNORE** heat **ALLOW** alcohol for ethanol **DO NOT ALLOW** any reference to water or hydroxide ions **Examiner's Comments** A well answered question. Some candidates forgot to use a solvent or suggested the use of aqueous ammonia.
		ii	(compound D)  ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous **Examiner's Comments** This question discriminated well. Although there were very few blank pages, many incorrect structures were seen.
	c	i	Alcohol **AND** Amide/peptide ✓	1	**IGNORE** phenol **IGNORE** hydroxyl/hydroxy **IGNORE** attempts to classify alcohol or amide as primary, secondary or tertiary **DO NOT ALLOW** hydroxide **Examiner's Comments** Generally well answered but incorrect functional groups included carbonyl and amine.
		ii	 	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above **ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **ALLOW** + on N or H i.e. $^{+}NH_3$ or NH_3 $^{+}$**ALLOW** $NH_3^{+}Cl^{-}$ **Examiner's Comments**

					Many candidates were able to score one mark for this question but the amine group was often not protonated and it was surprisingly common to see the amine group as NH_2^+.
			Total	**10**	
15		i	• pent-2-ene  **AND** ✓ • hexa-2,4-diene  ✓ ✓	3	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **ALLOW** C_2H_5CHO and CH_3CHO **Examiner's Comments** Many candidates responded well when asked to apply information in a unfamiliar situation. The question discriminated well but a high proportion scored all three marks. Some candidates lost marks in the second part by providing a list of three or more different structures, some of them being incorrect.
		ii	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **Examiner's Comments** This was a challenging question. Only more able candidates predicted the correct cyclic structure.
			Total	**4**	
16		i	**Step 1** Add HNO_3 ✓  ✓ **Step 2** Tin **AND concentrated** HCl/ ✓	4	**ALLOW** reagent mark if HNO_3 in equation **IGNORE** H_2SO_4 (**NOTE**: H_2SO_4 not required with phenols) **IGNORE** concentrations of acids / temperature **ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous

			 ✓		Equations **MUST** be completely correct for **one** mark each **DO NOT ALLOW** $3H_2$ **Examiner's Comments** This question discriminated well. Most candidates knew that nitric acid was involved in the first reaction but some also included sulfuric acid and tried to construct a mechanism involving the nitronium ion, rather than write the expected equation for the reaction. The omission of water as a product was an occasional error. Many correct equations were seen for Step 2, but tin and *concentrated* hydrochloric acid was required to score the reagent mark.
		ii	Nitrogen electron pair **OR** nitrogen lone pair accepts a proton / H^+ ✓	1	**DO NOT ALLOW** nitrogen / N lone pair accepts hydrogen (proton/H^+ required) **ALLOW** nitrogen donates an electron pair / lone pair to H^+ **IGNORE** NH_2 group donates electron pair **Examiner's Comments** Candidates needed to mention the electron pair on the nitrogen atom to score this mark.
		ii i	compound **A** ✓  compound **B**  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **ALLOW** —N_2Cl **OR** —$N_2^+Cl^-$ **DO NOT ALLOW** —$N{\equiv}N^+$ **OR** —$N{\equiv}N^+$ Cl^- **DO NOT ALLOW** —N_2-Cl (covalent bond) **Examiner's Comments**

					The vast majority of candidates gave the correct structure for compound B, but common errors were the omission of the chloride ion in the formulae of the diazonium salt, or placing the positive charge on the wrong nitrogen atom.
			Total	**7**	
17			*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Correctly calculates mass of 2-hydroxybenzoic acid. **AND** Outlines full details of the two steps to obtain a pure sample of aspirin from the hot reaction mixture • *Calculation shows all relevant steps.* • *Purification steps are detailed and clear, in the correct order, using appropriate scientific terms, e.g. filter under reduced pressure / using a Buchner flask; dissolve in the minimum volume of solvent.* **Level 2 (3–4 marks)** Attempts a calculation which is mostly correct **AND** Some details of steps to obtain impure aspirin from the hot reaction mixture and recrystallisation • *Calculation can be followed but lacks clarity.* • *Purification steps lack detail, e.g. filter without reduced pressure; dissolve without minimum volume of solvent.* **Level 1 (1–2 marks)** Attempts to calculate the mass of **B** using mole approach but makes little progress with only 1 step correct. **AND** Few or imprecise details about steps to obtain impure aspirin from hot reaction mixture and recrystallisation • *Calculation is difficult to follow and lacks clarity* • *Purification steps are unclear with few scientific terms and little detail, e.g. just 'filter and crystallise'.* **0 marks:** No response or no response worthy of credit.	6	**Indicative scientific points, with bulleted elements, may include:** **1. Mass of 2-hydroxybenzoic acid** • $n(\text{aspirin}) \text{ needed} = \frac{8.10}{180} = 0.0450 \text{ (mol)}$ • *n*(2-hydroxybenzoic acid) needed $= 0.0450 \times \frac{100}{90} = 0.0500 \text{ (mol)}$ • Mass = 0.0500 × 138 = 6.9(0) g **2. Purification** **Impure aspirin from hot reaction mixture** • **Cool** reaction mixture • **Filter** product under **reduced pressure** **Recrystallisation of impure aspirin:** • Dissolve impure solid in **minimum volume of hot** water / solvent • **Cool** solution and **filter** solid • **Wash** with cold water / solvent and **dry** **NOTE** *Filtration of hot solution to remove solid particles is **not** required.*
			Total	**6**	

18	a			3	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous
			Product from NH_3/ethanol  		**ALLOW** 
			.....		**ALLOW ECF** from 2-bromo compound as product from Reaction 1 .....
			Product from Reaction 1  		**DO NOT ALLOW** 2-bromo compound *(inconsistent with final product shown)* .....
			.....		**DO NOT ALLOW ECF** from 2-bromo compound as product from Reaction 1 *(inconsistent with final product shown)*
			Product from NaOH(aq)  		
	b		Curly arrow from C=C bond to H of H-Br Correct dipole shown on H–Br **AND** curly arrow showing the breaking of H-Br bond		**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous

			 …… Correct carbocation **AND** curly arrow from Br^- to C^+ of carbocation  …… Electrophilic addition		**DO NOT ALLOW** partial charges shown on C=C double bond **DO NOT ALLOW** δ+ on C of carbocation **ALLOW** formation of the 2-bromo isomer  Curly arrow must come from a lone pair on Br^- **OR** from the negative sign of Br^- ion (then lone pair on Br^- ion does not need to be shown)
	c	i		1	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous 'End bonds' **MUST** be shown (do not have to be dotted) **IGNORE** brackets **IGNORE** *n*
		ii	 Ester link Rest of structure	2	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous 'End bonds' **MUST** be shown (do not have to be dotted)
			Total	**10**	