Practice Paper – Set 2

A Level Chemistry A

H432/02 Synthesis and analytical techniques

MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 100

Final

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit.

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your Team Leader, use the phone, the RM Assessor messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance.

Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme.

Once the level is located, award the higher or lower mark.

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

- **The science content determines the level.**
- **The communication statement determines the mark within a level.**

Level of response questions on this paper are **16(e)** and **21**.

11. **Annotations**

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

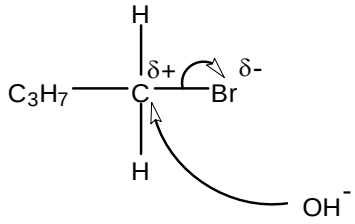
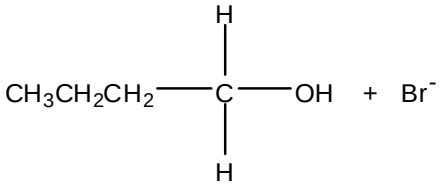
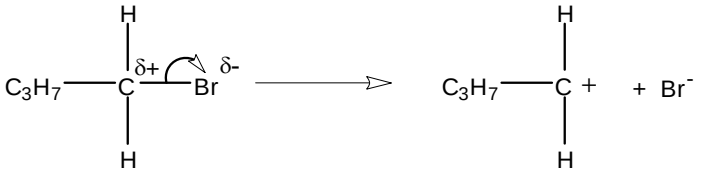
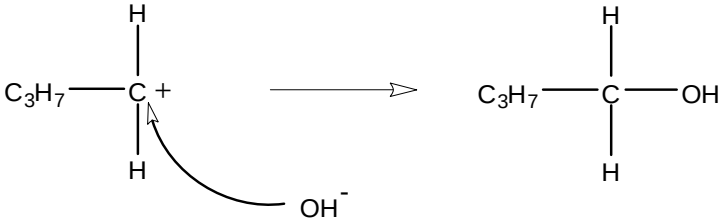
You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

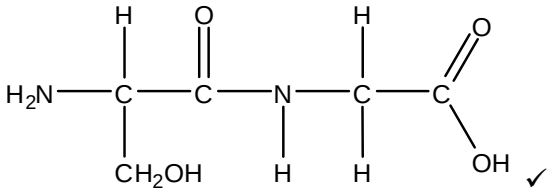
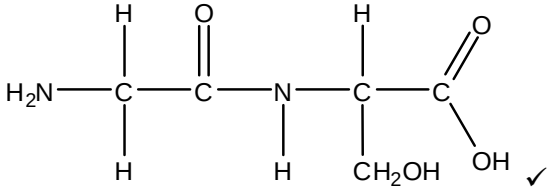
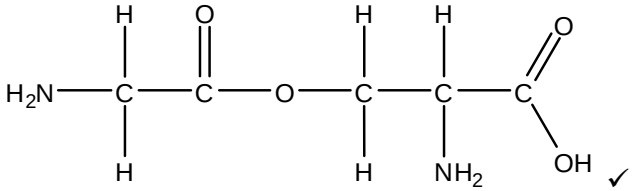
Question	Key	Marks	Guidance
1	C	1	
2	B	1	
3	A	1	
4	D	1	
5	C	1	
6	A	1	
7	C	1	
8	D	1	
9	D	1	
10	C	1	
11	D	1	
12	C	1	
13	A	1	
14	A	1	
15	B	1	

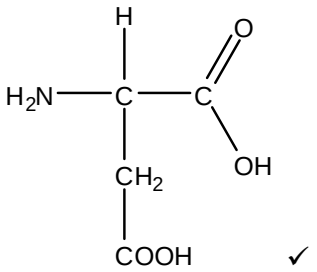
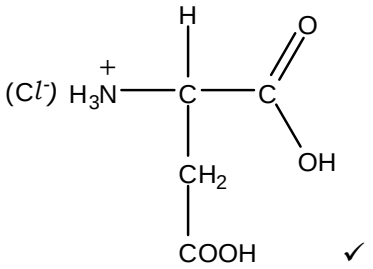
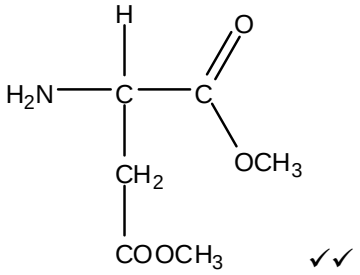
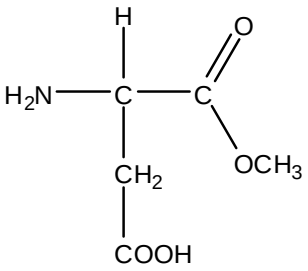
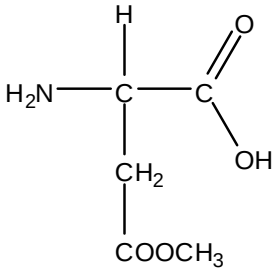
Question			Answer	Marks	Guidance
16	(a)	(i)	(series of compounds with the) same functional group **OR** same/similar chemical properties/reactions ✓ each **subsequent/successive** member differing by CH_2 ✓	2	**IGNORE** reference to physical properties **IGNORE** same general formula Differs by CH_2 is **not** sufficient *(no successive)* **DO NOT ALLOW** same empirical **OR** molecular formula
		(ii)	$C_nH_{2n+2}O$ ✓	1	**ALLOW** $C_nH_{2n+1}OH$
	(b)		*m/z* molecular ion peak = 60 ✓ Alcohol **A** identified as $CH_3CH_2CH_2OH$ **OR** $CH_3CHOHCH_3$ ✓ Peak **X** identified as CH_2OH^+ **AND** Alcohol **A** identified as $CH_3CH_2CH_2OH$ ✓	3	**ALLOW** labelling on spectrum **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW** CH_3O^+
	(c)	(i)	curly arrow from HO^- to carbon atom of C−Br bond ✓ Dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$, **AND** curly arrow from C−Br bond to Br atom ✓	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES** Curly arrow must come from lone pair on O of HO^- **OR** OH^- **OR** from minus on O of HO^- ion (no need to show lone pair if curly arrow came from negative charge) **IGNORE** alkyl group in the first marking point --- **ALLOW** S_N1 mechanism **First mark** Dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$,

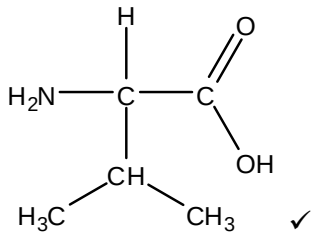
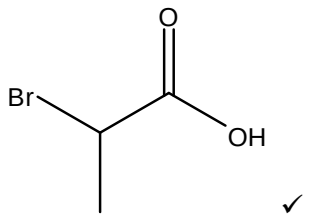
Question			Answer	Marks	Guidance
			 --- correct organic product **AND** Br^- ✓ 		**AND** curly arrow from C−Br bond to Br atom ✓  **Second mark** Correct carbocation **AND** curly arrow from HO^- to carbocation  Curly arrow must come from lone pair on O of HO^- **OR** OH^- **OR** from minus on O of HO^- ion (no need to show lone pair if curly arrow came from negative charge) ✓ **Third mark** correct organic product **AND** Br^- ✓ ---
		(ii)	Nucleophilic substitution ✓	**1**	
		(iii)	1-iodobutane **AND** C–I bonds are weaker (than C-Br) **OR** C–I bond has a lower bond enthalpy **OR** C–I bond needs less energy to break **OR** C–I bond is easier to break ✓	**1**	**Note:** the haloalkane could be identified by a correct structure e.g. $CH_3CH_2CH_2CH_2I$ **IGNORE** molecular formula **IGNORE** iodobutane *(no locant number)* Statement **must** be comparative **ALLOW ORA** **IGNORE** C–I bond is longer **IGNORE** polarity and references to electronegativity

Question			Answer	Marks	Guidance
	(d)	(i)	$CF_3Cl \longrightarrow CF_3\bullet + Cl\bullet$ ✓	1	**Note:** dots are **required**
		(ii)	Step 1: $Cl\bullet + O_3 \longrightarrow ClO\bullet + O_2$ ✓ Step 2: $ClO\bullet + O \longrightarrow Cl\bullet + O_2$ ✓ Overall equation: $O_3 + O \longrightarrow 2O_2$ ✓	3	**ALLOW** one mark for both correct symbol equations in propagation steps with (any or all) dots missing or extra dots e.g. $Cl\bullet + O_3\bullet \longrightarrow ClO + O_2$ $ClO\bullet + O\bullet \longrightarrow Cl + O_2\bullet$
		(iii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **IF** answer = 9.98×10^4 award 3 marks $n(Cl\bullet) = \frac{1}{35.5} = 0.02817$ (mol) ✓ $n(O_3) = \frac{135000}{48} = 2812.5$ (mol) ✓ $n(Cl\bullet) : n(O_3) = \frac{2812.5}{0.02817} = 9.98 \times 10^4$ ✓ *Must be in standard form **AND** to 3SF*	3	**If there is an alternative answer, check to see if there is any ECF credit possible** **ALLOW** 0.0282 up to calculator value of 0.02816901408 correctly rounded to 3 or more sig. fig. **ALLOW 3SF:** 2810 up to calculator value of 2812.5 correctly rounded **Note:** use of 0.0282 mol $Cl\bullet$ gives 9.97×10^4

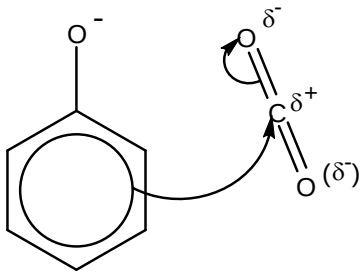
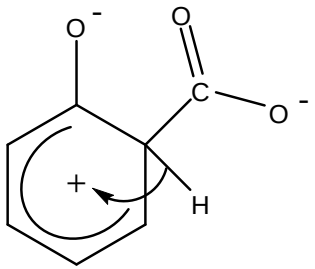
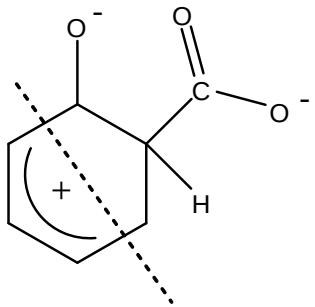
Question	Answer	Marks	Guidance
(e)*	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Identifies most of the compounds. **AND** A comprehensive explanation with most of the scientific points and few omissions. *There 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)** Identifies some of the compounds. **AND** Explanation covers some of the scientific points and few omissions. *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 identify a few of the compounds. **AND** A basic explanation based on intermolecular forces. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	**6**	**Indicative scientific points may include:** **Compounds B-F** • **B** is $CH_3CH(CH_3)CH_3$ • **C** is $CH_3CH_2CH_2CH_3$ • **D** is $CH_3CHClCH_3$ • **E** is $CH_3CH_2CH_2NH_2$ • **F** is $CH_3CH_2CH_2OH$ **Intermolecular forces** • $CH_3CH(CH_3)CH_3$ and $CH_3CH_2CH_2CH_3$ have London dispersion/induced dipole-dipole forces. • $CH_3CHClCH_3$ has permanent dipole-dipole (and London dispersion/induced dipole-dipole forces). • $CH_3CH_2CH_2NH_2$ and $CH_3CH_2CH_2OH$ have hydrogen bonding (and London dispersion/induced dipole-dipole forces). • The stronger the intermolecular force, the higher the boiling point as more energy is required to overcome intermolecular forces. • Relative strength: hydrogen bonds > permanent dipole-dipole > London dispersion forces. **Affect of structure** • $CH_3CH(CH_3)CH_3$ is branched and $CH_3CH_2CH_2CH_3$ is straight chain. • $CH_3CH(CH_3)CH_3$ has less points of contact. • London dispersion/induced dipole-dipole forces are weaker in branched structures. • $CH_3CH_2CH_2OH$ has stronger H bonds than $CH_3CH_2CH_2NH_2$ **OR** more H bonds than $CH_3CH_2CH_2NH_2$ • O is more electronegative than N **OR** O has two lone pairs (and N has one)
	Total	**24**	

Question			Answer	Marks	Guidance
17	(a)	(i)	(optical isomers are) non-super imposable mirror images ✓ Two 3D structures of serine that are mirror images irrespective of connectivity ✓  Correct connectivity in both structures ✓	3	
		(ii)	Dipeptide Ser-Gly  ✓ Dipeptide Gly-Ser  ✓ Esterification of OH on Ser  ✓	3	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** structures in any order
	(b)	**(i)**	**Structure of aspartic acid**	**4**	**ALLOW** any combination of skeletal **OR** structural **OR**

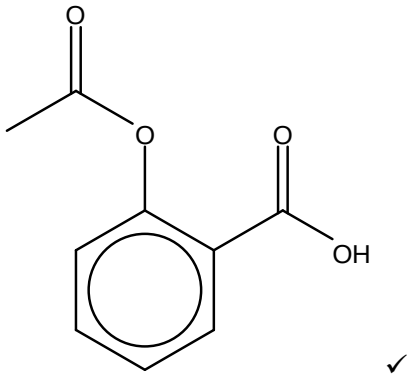
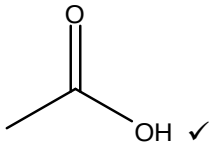
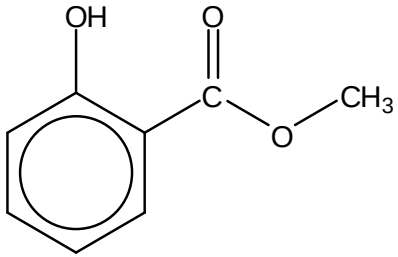
Question			Answer	Marks	Guidance
			 ✓		displayed formula as long as unambiguous
			Product from HC*l*(aq)  ✓		
			Product from excess CH_3OH/H_2SO_4  ✓✓		**Note:** the amine group could be shown as either NH_2 or NH_3^+ *(acidic conditions)* **ALLOW** one mark for  **OR** 
		(ii)		**2**	

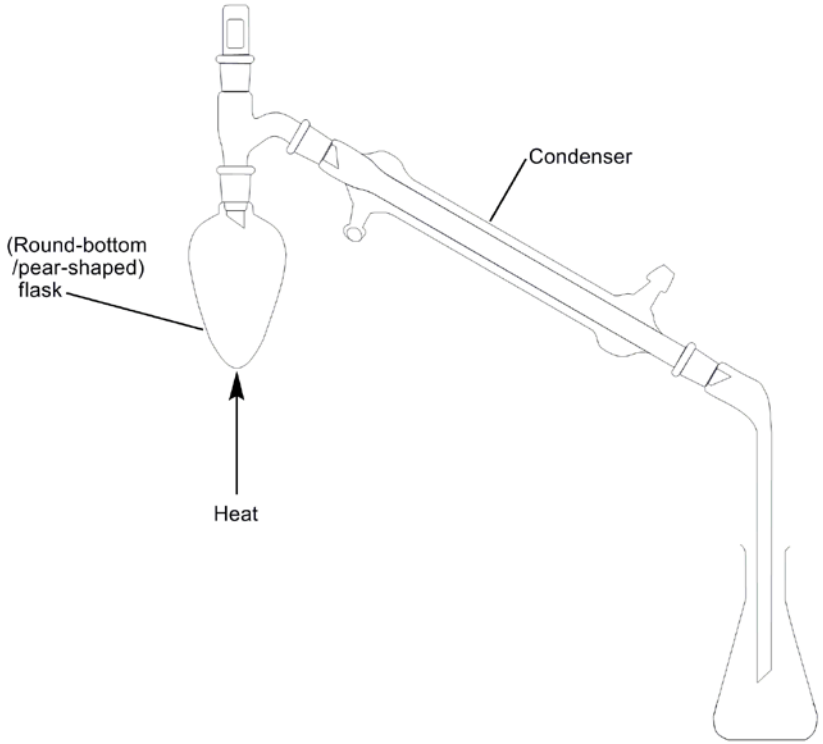
Question			Answer	Marks	Guidance
			Molar mass of **G** = $\frac{3.51}{0.0300}$ = 117(.0) (g mol^{-1}) ✓ **Structure of G**  ✓		**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** R (group of **G**) is –$CH(CH_3)_2$ if structure of amino acid is not given
	(c)	**(i)**	Leucine **AND** valine ✓	**1**	
		(ii)	R_f values would be larger ✓ (amino acids) are more soluble (in more polar solvent so would travel further up the plate) ✓	**2**	
	(d)		**Reagents for first stage** $NaBr/H_2SO_4$ ✓ **Compound H**  ✓ **Reagent for second stage**	**3**	**ALLOW** any suitable halide salt/sulfuric acid combination **ALLOW** HC*l* **OR** HBr **OR** HI **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **Note:** the halogen in compound **H** can be C*l*, Br or I, but **must** be consistent with halide salt used

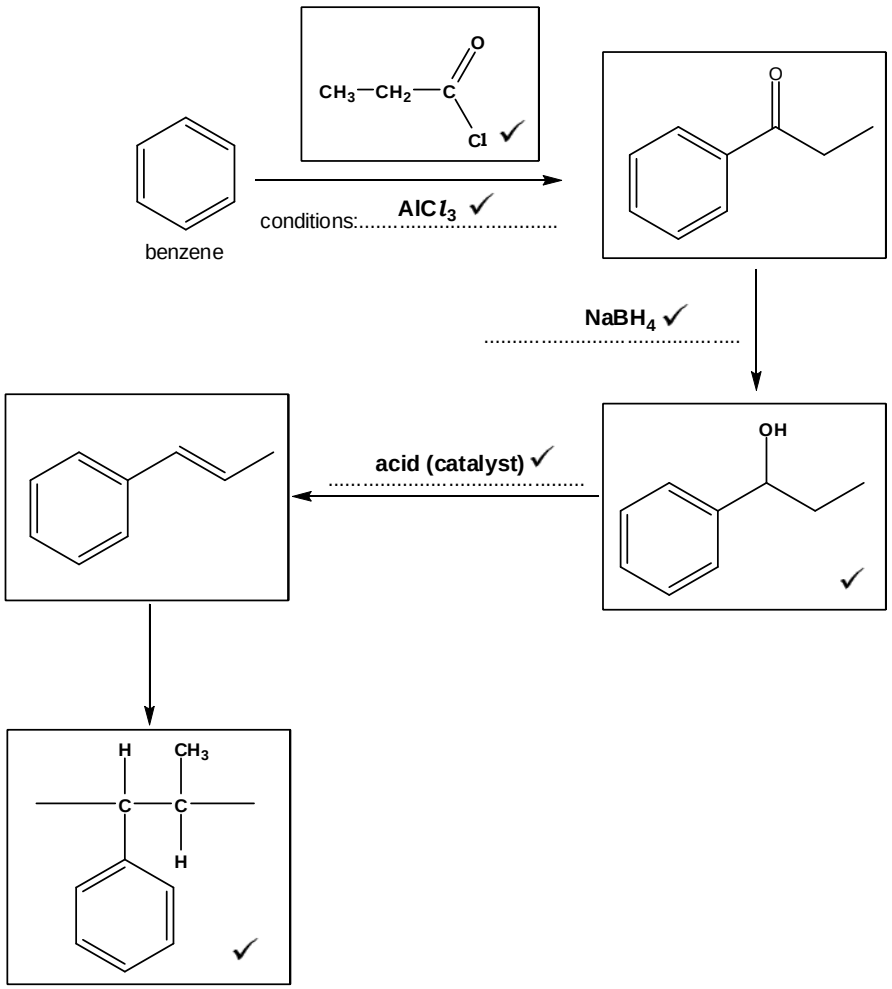
Question			Answer	Marks	Guidance
			(excess ethanolic) NH_3 ✓		
			Total	**18**	

Question			Answer	Marks	Guidance
18	(a)	(i)	Dipole shown on C=O bond, $C^{\delta+}$ and $O^{\delta-}$, **AND** curly arrow from the C=O bond to the $O^{\delta-}$ atom **AND** Curly arrow from π-bond to C in CO_2 ✓  --- Correct intermediate ✓ Curly arrow back from C–H bond to reform π-ring ✓ 	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **DO NOT ALLOW** the following intermediate:  π-ring must cover more than 1/2 of the ring **AND** 'horseshoe' in the correct orientation, *ie* gap towards C with COO^- **ALLOW** + sign anywhere inside the 'hexagon' of intermediate

Question	Answer	Marks	Guidance
(ii)	Neutralisation ✓ (In Stage 1) phenol loses H^+ **AND** (In Stage 3) carboxylate ion gains H^+ ✓	2	**ALLOW** acid-base **ALLOW** both Stage 1 **AND** Stage 3 involve proton transfer
(iii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **IF** answer = 7.31 (g) award 3 marks --- **actual** *n*(salicylic acid) produced = $\frac{4.83}{138}$ = 0.035(0) (mol) ✓ **theoretical** *n*(phenol) = *n*(salicylic acid) = 0.035(0) × $\frac{100}{45.0}$ = 0.0778 (mol) ✓ Mass of phenol = 0.0778 × 94.0 = 7.31 (g) ✓	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW ECF** at each stage **ALLOW 3 SF** up to calculator value correctly rounded for intermediate values **ALLOW** expected mass compound **E** = 4.83 × $\frac{100}{45.0}$ = 10.733 (g) **ALLOW** Mass phenol reacted = 0.035 × 94.0 = 3.29 (g) **ALLOW** Mass of phenol used = 3.29 × $\frac{100}{45.0}$ = 7.31 (g) **Note:** 1.48 g would get 2 marks *(use of 45.0/100 instead of 100/45.0)* 7.30 g would get 2 marks *(use of 0.0777 for moles phenol)*

Question			Answer	Marks	Guidance
	(b)		Skeletal formula of aspirin  ✓ Skeletal formula of ethanoic acid  ✓	2	**IF** skeletal formulae are not used **ALLOW** one mark if both the structures of aspirin **AND** ethanoic acid are correct **IGNORE** names
	(c)	(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**	2	

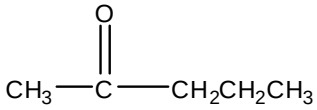
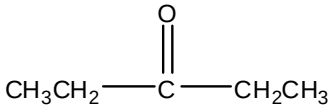
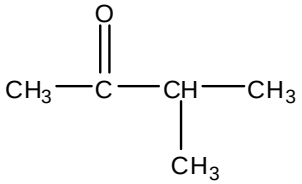
Question			Answer	Marks	Guidance
			Diagram showing correct apparatus for distillation ✓ *i.e.* • Round-bottom/pear-shaped flask • Condenser (correctly orientated) • Stopper/thermometer • Delivery tube and suitable collection vessel  **Labels** (Round-bottom/pear-shaped) flask **AND** condenser **AND** heat (source) ✓		**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	**13**	

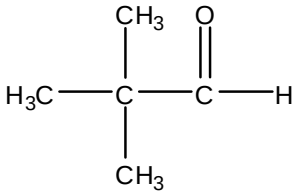
Question			Answer	Marks	Guidance
19	(a)		One mark for each correct structure/reagent/condition as shown below  	6	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **IGNORE** names of organic compounds *(question 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 ✓	1	**ALLOW** the production of plastics or monomers

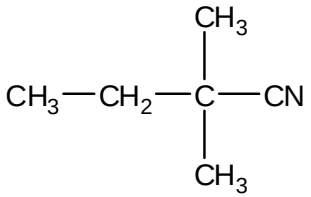
Question			Answer	Marks	Guidance
			OR Combustion for energy production ✓		or new polymers Combustion alone is **not** sufficient
			Total	**7**	

Question			Answer	Marks	Guidance
20	(a)	(i)	**Reagent and observation** sodium carbonate **AND** Fizzing/effervescence/bubbling ✓ **Equation** Correctly balanced equation ✓ e.g. $2RCOOH + Na_2CO_3 \longrightarrow 2RCOONa + CO_2 + H_2O$	2	**Note:** both reagent and observation are required for first mark **ALLOW** name or formula for any suitable carbonate e.g $NaHCO_3$, potassium carbonate etc. **ALLOW** reagent from equation if not stated elsewhere
		(ii)	**Reagent and observation** Tollens' (reagent) **AND** Silver (mirror) ✓ **Equation** $RCHO + [O] \longrightarrow RCOOH$ ✓	2	**Note:** both reagent and observation are required for first mark **ALLOW** ammoniacal silver nitrate **OR** Ag^+/NH_3 **ALLOW** $H^+/Cr_2O_7^{2-}$ **OR** acidified (potassium/sodium) dichromate **AND** Orange to green *(this would identify the aldehyde from the carboxylic acid, ketone and esters)*
	(b)		2,4-dinitrophenylhydrazine **AND** Orange/yellow/red precipitate ✓	1	**ALLOW** errors in spelling **ALLOW** 2,4(-)DNP **OR** 2,4(-)DNPH **ALLOW** Brady's reagent or Brady's Test **ALLOW** solid **OR** crystals **OR** ppt as alternatives for precipitate
	(c)	(i)	$CH_3COOC(CH_3)_3 + NaOH \rightarrow CH_3COONa + (CH_3)_3COH$ CH_3COONa ✓ Rest of equation correct ✓ **OR**	2	**Note:** the hydrolysis of either ester may be given **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous

Question			Answer	Marks	Guidance
			$(CH_3)_3CCOOCH_3 + NaOH \rightarrow (CH_3)_3CCOONa + CH_3OH$ $(CH_3)_3CCOONa$ ✓ Rest of equation correct ✓		**DO NOT ALLOW** molecular formulae of products *(question requires structures of products to be shown)*
		(ii)	**Reagent and observation** $H^+/Cr_2O_7^{2-}$ **OR** acidified (potassium/sodium) dichromate **AND** Orange to green (with CH_3OH) ✓ **Equation** $CH_3OH + [O] \longrightarrow HCHO + H_2O$ **OR** $CH_3OH + 2[O] \longrightarrow HCOOH + H_2O$ ✓	**2**	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW** molecular formulae *(question requires structures of organic compounds to be shown)*
		(iii)	**^{13}C NMR (1 mark)** (It is) not possible to identify (the esters) with ^{13}C NMR **AND** (both) spectra would contain four peaks (with similar chemical shifts) ✓ **^{1}H NMR (2 marks)** (It is) possible to identify (the esters) with ^{1}H NMR (^{1}H NMR spectrum of) $CH_3COOC(CH_3)_3$ has a singlet/peak between 2.0-3.0 (ppm) (^{1}H NMR spectrum of) $(CH_3)_3CCOOCH_3$ has a singlet/peak	**3**	**ALLOW** ‘same number of peaks’ in place of ‘four peaks’ **ALLOW** any value or range of values within 2.0-3.0 **ALLOW** any value or range of values within 3.0-4.3

Question			Answer	Marks	Guidance
			between 3.0-4.3 (ppm) All **three** correct statements✓✓ Any **two** correct statements ✓		
	(d)		**Possible structures for ketone (2 marks)**    All **three** correct ✓✓ Any **two** correct ✓ **Aldehyde (3 marks)** Peak at (δ) 1.2 shows HC–R **AND** No H on adjacent C atom as peak is singlet ✓ Peak at (δ) 9.6 shows H–C=O **AND** No H on adjacent C atom as peak is singlet ✓	**5**	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **IGNORE** names of ketones

Question			Answer	Marks	Guidance
			 **OR** (2,2-)dimethylpropanal ✓		
			Total	**17**	

Question	Answer	Marks	Guidance
21*	*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)** Structure of **J** identified as $CH_3CH_2C(CH_3)_2CN$ **AND/OR** A comprehensive analysis with most of the spectral data analysed and few omissions. *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)** Analysis may be incomplete and structure of **J** identified. **OR** Thorough analysis of one aspect of the information given in question and structure of **J** may be incorrectly identified. *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)** An attempt at a simple analysis. **OR** Explains one scientific point thoroughly with a few omissions. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	6	**LOOK ON THE SPECTRA for labelled peaks.** **Indicative scientific points may include:** **Empirical and Molecular Formula of J** • C : H : N = 74.17/12 : 11.41/1 : 14.42/14 6.18 : 11.41 : 1.03 6 : 11 : 1 • Empirical formula of **J** = $C_6H_{11}N$ • uses *m/z* = 97.0 and empirical formula to determine molecular formula of **J** as $C_6H_{11}N$ **^{1}H NMR spectrum** • δ = 0.9 ppm, triplet, **CH_3**–CH_2–(C-) • δ = 1.4 ppm, singlet, **$(CH_3)_2$**C– • δ = 1.6 ppm, quartet, CH_3–**CH_2**–(C-) **IR Spectrum and Structure of J** • peak at 2220-2260 (cm^{-1}) is C≡N • Correct structure of **J**  **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous
	Total	**6**	