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Mark Scheme (Results)

Summer 2022

Pearson Edexcel GCE
In Chemistry (9CH0)
Paper 02 Advanced Organic and Physical Chemistry

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Summer 2022
Question Paper Log Number P67904RA
Publications Code 9CH0_02_2206_MS

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

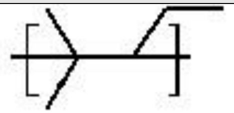
/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

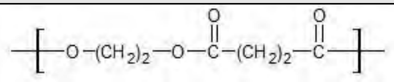
Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Answer	Mark
1(a)	**The only correct answer is A** () **B** *is not correct because there is no C=C in the repeat unit* **C** *is not correct because the extension bonds are not from the correct carbon atoms of the chain and there should not be a C=C in the repeat unit* **D** *is not correct because the extension bonds are not from the correct carbon atoms of the chain*	**(1)**

Question Number	Answer	Mark
1(b)	**The only correct answer is B** (generation of biodegradable materials) ***A*** *is not correct because some poly(alkenes) may be used as a feedstock for cracking* ***C*** *is not correct because some poly(alkenes) may be used for energy from incineration* ***D*** *is not correct because some poly(alkenes) may be used for recycling to make new materials*	**(1)**

Question Number	Answer	Mark
1(c)	**The only correct answer is B** () ***A*** *is not correct because there is an additional oxygen atom in the repeat unit* ***C*** *is not correct because there is an incorrect number of CH_2 groups in one of the monomers and there is an additional oxygen atom in the repeat unit* ***D*** *is not correct because there is an incorrect number of CH_2 groups in one of the monomers*	(1)

Question Number	Answer	Mark
1(d)	**The only correct answer is D** (use a higher temperature for a faster reaction rate) ***A*** *is not correct because efficient use of energy does contribute to sustainability* ***B*** *is not correct because efficient use of resources does contribute to sustainability* ***C*** *is not correct because use of catalysts do contribute to sustainability*	(1)

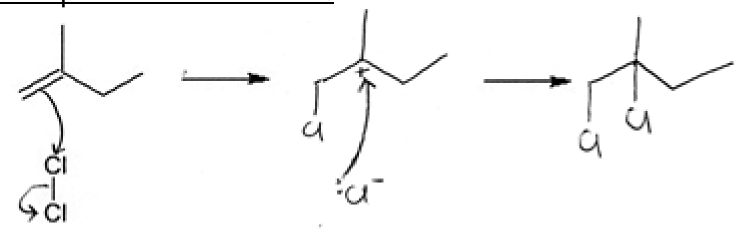
(Total Question 1 = 4 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)	An answer which makes reference to: • a compound of hydrogen and carbon only	Allow absence of 'only' Allow substance/molecule/chain/species for compound Do not award reference to a carbon and/or a hydrogen Do not award 'an element made of carbon and hydrogen' Do not award a mixture of carbon and hydrogen Do not award contains carbon and hydrogen molecules	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)	An explanation which makes reference to the following points: • branching results in fewer/weaker London forces **(1)** • due to less surface area/points of contact **(1)**	Accept reverse argument Allow van der Waals / instantaneous dipole-induced dipole / dispersion forces Ignore just intermolecular forces Do not award 'fewer electrons' Do not award if **covalent** bonds broken Allow reference to less close packing of molecules together	**(2)**

Question Number	Answer	Mark
2(c)	**The only correct answer is D** (ions) ***A*** *is not correct because both anions and cations are produced* ***B*** *is not correct because homolytic fission produces free radicals* ***C*** *is not correct because homolytic fission produces free radicals and heterolytic fission also produces anions*	**(1)**

(Total Question 2 = 4 marks)

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	• curly arrow from C=C to chlorine **and** curly arrow from Cl−Cl to 'bottom' chlorine atom**(1)** • structure of carbocation intermediate **and** structure of final product **(1)** • chloride ion with lone pair **and** curly arrow from lone pair to C+ of carbocation **(1)**	<u>Example of mechanism:</u>  Ignore dipoles even if incorrect Allow correct structural/displayed formulae for intermediate and/or product Allow TE on incorrect primary carbocation	**(3)**

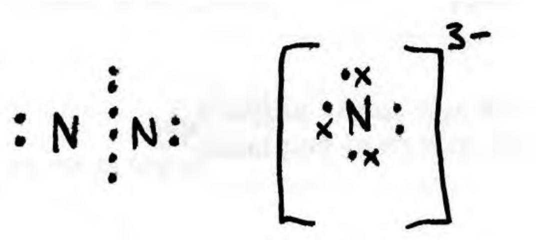
Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	• 1,2-dichloro-2-methylbutane	Allow name shown on mechanism Ignore missing hyphens and commas Do not allow 2-methyl-1,2-dichlorobutane TE on structure in (a)(i) Allow correct name even if incorrect structure in (i)	**(1)**

Question Number	Answer	Mark
3(b)	**The only correct answer is A** (primary) ***B*** *is not correct because there is no chlorine atom bonded to a carbon atom which is bonded to two other carbon atoms* ***C*** *is not correct because there is no chlorine atom bonded to a carbon atom which is bonded to three other carbon atoms* ***D*** *is not correct because both chlorine atoms are bonded to carbon atoms which are bonded to only one carbon atom*	**(1)**

(Total Question 3 = 5 marks)

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	• evaluation of number of moles of nitrogen **(1)** • conversion of pressure and temperature to correct units **(1)** • rearrangement of ideal gas equation so $V = nRT \div P$ and evaluation of volume **(1)** • answer converted into cm^3 **(1)**	<u>Example of calculation</u>: n = 0.42 ÷ 28 = 0.015 (mol) 120 kPa = 120 000 Pa, 20°C = 293 K $V = \frac{0.015 \times 8.31 \times 293}{120\,000}$ $= 3.0435 \times 10^{-4}$ (m^3) $= 3.0435 \times 10^{-4} \times 10^{6}$ = 304 (cm^3) Ignore SF except 1SF TE throughout Correct answer without working scores (4)	**(4)**

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	An answer that makes reference to • prevents oxidation (of the crisps)	Allow answers such as ‘keep the crisps fresh’ or ‘prevents the crisps from going off/stale’ Allow reference to ‘crisps not reacting with nitrogen but will with air’ Ignore reference to gas prevents crisps from getting squashed/broken Ignore nitrogen is less reactive than air/oxygen or nitrogen is inert Ignore reference to effects of moisture	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(b)	• dot-and-cross diagram of nitrogen gas **(1)** • dot-and-cross diagram of nitride ion **(1)**	<u>Example of dot-and-cross diagrams</u>  **Nitrogen molecule** **Nitride ion** Allow electrons to be paired horizontally Allow the crosses to be paired in any way Allow representation of inner shell with two electrons Allow any pairing of dots and crosses Ignore lines representing covalent bonds Ignore missing circles Ignore absence of brackets and charge on nitride ion Ignore any diagram of the sodium ion	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(c)	An explanation that makes reference to the following points: • the lone pair (of electrons) in ammonia repels more than the bonded pairs (of electrons) **(1)** The further three marks are scored as follows: Six of the following scores (3) four or five scores (2) and two or three scores (1) • the ammonia molecule has three bond pairs and one lone pair • the ammonium ion has four bond pairs • the ammonia molecule is (trigonal) pyramidal • ammonium ion is tetrahedral • the bond angle in ammonia is 107(°) • the bond angle in the ammonium ion is 109.5(°)	Standalone mark Accept points made on labelled diagrams	**(4)**

Question Number	Answer	Additional Guidance	Mark
4(d)	An explanation that makes reference to the following points: • nucleophiles are electron **pair** donors / attack areas of low electron density / the nitrogen donates its lone **pair** of electrons **(1)** • so the amine group attacks as a (nucleophile) by attacking the $C^{\delta+}$ of the acyl chloride **(1)** • which produces hydrogen chloride **(1)** • it's a base because amine group reacts with the acid / protons (to produce the salt / $C_4H_9NH_3Cl$) **(1)**	Allow the N/ butylamine for 'the amine group' Allow shown in a mechanism Do not award attacks carbocation Allow hydrochloric acid Allow the N/ butylamine for 'the amine group' Allow base is a proton acceptor Do not award just 'hydrogen' for proton Do not award reference to ethanoyl chloride as an acid/donating a proton	**(4)**

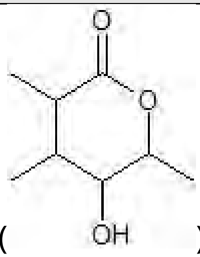
(Total Question 4 = 15 marks)

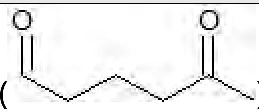
Question Number	Answer	Additional Guidance	Mark
5(a)	An answer which makes reference to the following points: • density between 0.92 and 1.00 (g cm^{-3}) **(1)** • because water is the bottom layer so more dense **and** ice floats on oil so is less dense **(1)**	Accept any value or range between 0.92 − 1.00 Ignore units even if incorrect Accept reverse arguments Reference to the layers is required	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)	An answer that give evidence of the following: • use of **both** densities to get two masses **and** division by 18 to give moles **(1)** • subtraction to give either mass or moles or number of molecules **(1)** • multiplication by Avogadro constant to give number of molecules **(1)**	Multiple correct methods are possible which process the data in different sequences. The correct final answer is 1.34×10^{22} / 1.338×10^{22} which can be awarded (3) regardless of working If this answer is not given then look for evidence of each of the given mathematical processes and give one mark for each The use of both densities must be carried out **first** Note that the use of 5 for the mass of water implies the use of a density of 1.00 g cm^{-3} Depending on the method used this can be done at the beginning, the middle or at the end of the calculation but **must** be of (water – ice) This must be evidenced **after** moles have been calculated Allow TE throughout Ignore SF except 1SF for the final answer Allow use of 6×10^{23} which gives 1.33×10^{22} for (3) Correct answer without working scores (3) Do not allow a number of molecules <1	(3)

	Marking points Subtraction (1) Use of both densities and division by 18 to give moles (1) Multiplication by Avogadro constant (1) **or** Multiplication by Avogadro constant (1) Use of both densities and division by 18 to give moles (1) Subtraction (1) **or** Use of both densities and division by 18 to give moles (1) Subtraction (1) Multiplication by Avogadro constant (1)	<u>Example of calculation vs1</u> m(water) = (5 x 1.00) − (5 x 0.92) = 0.40 (g) $n(H_2O)$ = (0.40 ÷ 18) = 0.022222 / 2.2222×10^{-2} (mol) N = ($2.2222 \times 10^{-2} \times 6.02 \times 10^{23}$) =$1.34 \times 10^{22}$ / 1.338×10^{22} <u>Example of calculation vs2</u> N(water molecules) = ((5x 1) ÷ 18) x 6.02×10^{23} = 1.667×10^{23} N(ice molecules) = ((5 x 0.92) ÷ 18) x 6.02×10^{23} = 1.533×10^{23} N(Extra) = $1.667 \times 10^{23} - 1.533 \times 10^{23} = 1.34 \times 10^{22}$ <u>Example of calculation vs3</u> n(water) = ((1.00 x 5.00) ÷ 18) = 0.27778 (mol) n(ice) = ((0.92 x 5.00) ÷ 18) = 0.25556 (mol) Difference in mol = (0.27778 − 0.25556)= 0.022222(mol) Extra molecules = 0.022222 x $6.02 \times 10^{23} = 1.34 \times 10^{22}$	

(Total Question 5 = 5 marks)

Question Number	Answer	Mark
6(a)	**The only correct answer is D (**  **)** ***A*** *is not correct because there is a ketone group present* ***B*** *is not correct because there is a ketone group present* ***C*** *is not correct because there is a ketone group present*	**(1)**

Question Number	Answer	Mark
6(b)	**The only correct answer is C (**  **)** ***A*** *is not correct because there are two ketone groups but no aldehyde group* ***B*** *is not correct because there are two ketone groups but no aldehyde group* ***D*** *is not correct because there are two aldehyde groups but no ketone group*	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	An explanation that makes reference to • propanal is condensed back (to the pear-shaped flask) **(1)** • so propanal is (further) oxidised (to propanoic acid) or propanal is more readily oxidised than propan-1-ol **(1)**	Allow aldehyde for propanal Allow 'apparatus is reflux' Allow propanal is not being removed /distilled off (from the oxidising agent) Ignore just 'reacts further' Do not award reference to propanal being completely oxidised	**(2)**

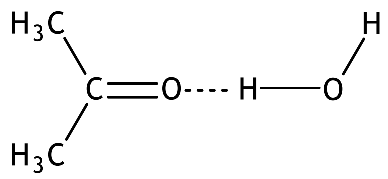
Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	• (+)VI	Allow (+) six / (+)6 / six (+) / 6(+)	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(c)(iii)	• balanced equation	<u>Example of equation</u> $CH_3CH_2CH_2OH \rightarrow CH_3CH_2CHO + 2H^+ + 2e^-$	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(c)(iv)	• provides a surface for bubbles to form / enables smaller bubbles to form / provides nucleation sites for bubbles or to prevent large bubbles forming	Allow distribution of heat more evenly / to prevent superheating Ignore mixing / to stop bumping / spitting / explosion / liquid splashing out / vigorous reaction / loss of reactants Do not award reference to large gas molecules	(1)

Question Number	Answer	Additional Guidance	Mark
6(c)(v)	• (**M1**) evaluation of number of moles of propan-1-ol **(1)** Method one using masses for percentage calculation • (**M2**) evaluation of maximum mass of propanal **(1)** • (**M3**) percentage yield **(1)** or Method two using moles for percentage calculation • (**M2**) evaluation of actual moles of propanal **(1)** • (**M3**) percentage yield **(1)**	<u>Example of calculation</u> n(propan-1-ol) = (1.50 ÷ 60) = 0.025 (mol) n(propan-1-ol) = n(propanal) max m(propanal) = (0.025 x 58) = 1.45 (g) %Yield = ((0.609 ÷ 1.45) x 100) = 42 % n(propanal) = (0.609 ÷ 58) = 0.0105 (mol) %Yield =((0.0105 ÷ 0.025) x 100) = 42 % Allow TE at each stage Ignore SF except 1SF Penalise incorrect M_r values once only Correct answer without working scores (3)	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	An explanation that makes reference to the following points: • similar molar masses so the number of electrons is similar/same resulting in similar London forces **(1)** • propanone (and ethanoic acid) form permanent dipole(-dipole) forces **(1)** • (only) ethanoic acid forms (intermolecular) hydrogen bonding **(1)** • which is stronger so requires more **energy** to break (giving a higher boiling temperature) **(1)**	Allow van der Waals' forces / dispersion forces / instantaneous dipole-induced dipole forces Ignore reference to ethanoic acid having greater London forces Ignore reference to hydrogen bonding to water by propanone Penalise abbreviation pd-d once only Ignore references to ethanoic acid dimerization Reference to energy must be linked to the breaking of hydrogen bonds	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	An explanation that makes reference to the following points: • forms hydrogen bonds with water **(1)** • diagram of hydrogen bond **(1)**	Allow H bonds for hydrogen bonds  Ignore bond angle and missing dipoles and missing lone pair Do not award incorrect dipoles Do not award incorrect propanone and/or water structure Do not award if second hydrogen bond drawn to the hydrogen of the CH_3	**(2)**

(Total Question 6 = 16 marks)

Allow annotated equations to score these marks in both (i) and (ii) Allow any unambiguous formulae for the organic molecules in both (i) and (ii) such as C_2H_5CN for CH_3CH_2CN			
Question Number	**Answer**	**Additional Guidance**	**Mark**
7(a)(i)	A description which includes • equation **(1)** • $LiAlH_4$ in (dry) ether (followed by dilute acid) or H_2 with Ni / Pt / Pd **(1)**	<u>Example of equation</u> $CH_3CH_2CN + 4[H] \rightarrow CH_3CH_2CH_2NH_2$ $CH_3CH_2CN + 2H_2 \rightarrow CH_3CH_2CH_2NH_2$ Allow names or formulae but both must be correct if given together Allow Lithal Allow hydrogen to be given in the equation or written over the arrow Ignore references to heat or a temperature	**(2)**
Question Number	**Answer**	**Additional Guidance**	**Mark**
7(a)(ii)	A description which includes • equation from any halogenoalkane **(1)** • ethanolic/alcoholic ammonia **(1)** • heat **and** under pressure **(1)**	<u>Example of equation</u> $CH_3CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HBr$ or $CH_3CH_2CH_2Br + 2NH_3 \rightarrow CH_3CH_2CH_2NH_2 + NH_4Br$ Allow use of state symbol (alc)/(EtOH)/(eth) with NH_3 Allow ammonia to be given in equation or written over the arrow Accept heat **and** in a sealed tube Ignore mechanisms If a contradictory chemical is stated then penalise once against M2 or M3	**(3)**

Question Number	Answer	Mark
7(b)	**The only correct answer is A** (an amide) ***B*** *is not correct because the amine range does not include* 3220 cm^{-1} ***C*** *is not correct because the amine range does not include* 3220 cm^{-1} ***D*** *is not correct because the amide range does include* 3220 cm^{-1}	**(1)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>7(c)</td><td>This question assesses the student’s ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

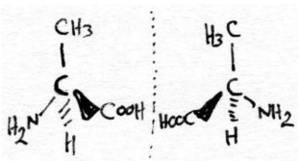
The following table shows how the marks should be awarded for indicative content.
<table><tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr><tr><td>6</td><td>4</td></tr><tr><td>5-4</td><td>3</td></tr><tr><td>3-2</td><td>2</td></tr><tr><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td></tr></table>
The following table shows how the marks should be awarded for structure and lines of reasoning</td><td>Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with four indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there were no linkages between the points, then the same indicative marking points would yield and overall score of 3 marks (3 marks for indicative content and zero marks for linkages).</td><td>(6)</td></tr>
</table>

		Number of marks awarded for structure of answer and sustained lines of reasoning		
	Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2		
	Answer is partially structured with some linkages and lines of reasoning	1		
	Answer has no linkages between points and is unstructured	0		

More than one indicative marking point may be made within the same comment or explanation

Accept annotated diagrams to illustrate the indicative points

Ignore reference to other amino acid properties

	Indicative content IP1 (Similarity) • they are **both** 2-amino acids / alpha amino acids / naturally occurring/ zwitterions	The zwitterions can be evidenced from each amino acid zwitterion in an equation e.g. $NH_3^+CH(CH_3)COO^-$ / $NH_3^+CH_2COO^-$	
	IP2 • equation for the reaction with an acid	e.g. $H^+ + NH_3^+CH_2COO^- \rightarrow NH_3^+CH_2COOH$ or $H^+ + NH_3^+CH(CH_3)COO^- \rightarrow H_3N^+CH(CH_3)COOH$	
	IP3 • equation for the reaction with a base	$OH^- + NH_3^+CH_2COO^- \rightarrow NH_2CH_2COO^- + H_2O$ or $OH^- + NH_3^+CH(CH_3)COO^- \rightarrow NH_2CH(CH_3)COO^- + H_2O$ Allow use of un-ionised amino acid structures If IP2 and 3 not scored then allow 1IP for a suitable description of acid and base behaviour	
	IP4 • alanine has a chiral centre/ asymmetric carbon atom/ non-superimposable mirror images **and** glycine does not	Allow reference to four different atoms/groups bonded to central carbon for chiral centre 'Plane' must be stated at least once	
	IP5 • (an aqueous solution of) alanine rotates the plane (of polarisation) of plane-polarised (monochromatic) light but glycine does not IP6 • diagram to show enantiomers of alanine	Wedges must be drawn e.g. Ignore angles and connectivity 	

Question Number	Answer	Additional Guidance	Mark
7(d)	An explanation which includes • lysine requires twice (the volume of HCl) **(1)** • (because) lysine has two (basic) amine/NH_2 groups whereas serine has one **(1)**	Allow lysine requires 20.0 cm^3 and serine requires 10 cm^3 Allow lysine has one more (basic) / another amine/ NH_2 group Allow lysine can accept two protons whereas serine can only accept one	**(2)**

(Total Question 7 = 14 marks)

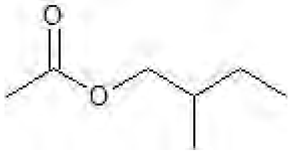
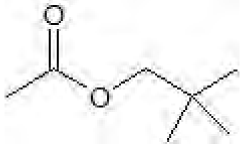
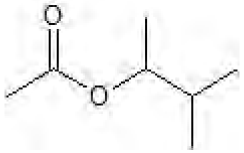
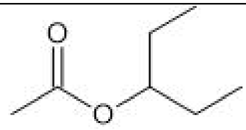
Question Number	Answer	Mark
8(a)	**The only correct answer is C** (6 ……. 7) ***A*** *is not correct because there are six non-equivalent carbons in isoamyl acetate and seven in amyl acetate* ***B*** *is not correct because all carbons of amyl acetate generate their own peak in the spectrum* ***D*** *is not correct because the two methyl groups on the branched chain are equivalent*	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)	• $C_7H_{14}O_2$	Accept atoms in any order	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(c)	• CH_3COOH	Allow displayed, skeletal or combination of Do not award molecular formula	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(d)	• 3-methylbutan-1-ol	Allow 'methly' for methyl Allow name with missing hyphens Allow 3-methylbutane-1-ol Allow 3-methylbut-1-anol Allow 1-hydroxy-3-methylbutane Do not allow 3-methylbut-1-ol Ignore formulae even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(e)	• pentyl ethanoate	Allow pentanyl ethanoate	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(f)(i)	Any three of the following four structures  **(1)**  **(1)**  **(1)**  **(1)**	Accept formulae in any order Award (2) if 3 correct displayed/structural formulae given Award (1) if 2 correct displayed/structural formulae given	**(3)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>8(f)(ii)</td><td>An equation that has
ethanoyl chloride (1)
alcohol
and ester+ HCl product (1)</td><td><u>Example of equation</u>


Allow structural, displayed formulae in any combination
Ignore connectivity to OH except horizontal
Ignore state symbols even if incorrect
If molecular formulae used then allow (1) for correct equation

Allow (1) for a correct equation to form ester A from ethanoic acid
e.g.
$CH_3COOH + CH_3CH(OH)CH_2CH_2CH_3 \rightleftharpoons CH_3COOCH(CH_3)\ CH_2CH_2CH_3 + H_2O$</td><td>(2)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
8(g)	An answer that makes reference to the following points: (similarity) • both make the (same) alcohol / pentan-1-ol **(1)** (differences) • acid hydrolysis is reversible, alkaline hydrolysis is irreversible **(1)** • acid hydrolysis produces the carboxylic acid/ ethanoic acid **and** alkaline hydrolysis produces the carboxylate / ethanoate (ion) **(1)** • the acid is a catalyst and the alkali is a reactant **(1)**	Points can be made in equations Accept acid hydrolysis is an equilibrium and alkaline hydrolysis goes to completion Allow just acid for carboxylic acid Allow salt for carboxylate Allow the acid will be regenerated /not used up but the alkali will be used up Ignore references to rate differences Ignore references to a need for the product of alkaline hydrolysis to be acidified which is different to acid hydrolysis	**(4)**

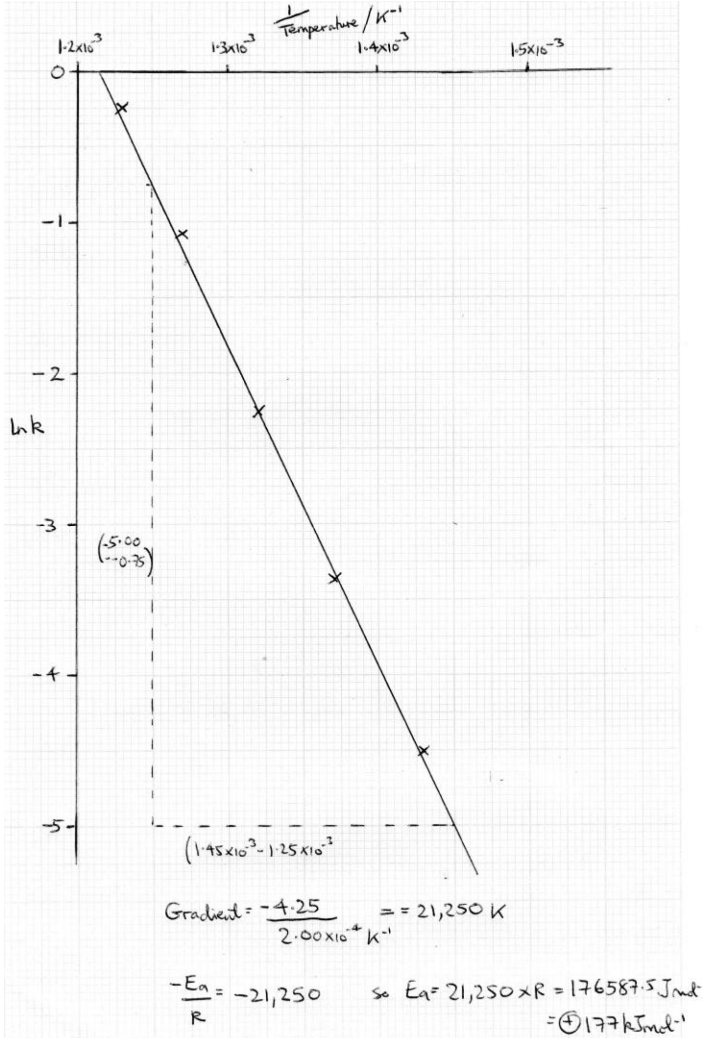
(Total Question 8 = 14 marks)

Question Number	Answer	Additional Guidance	Mark
9(a)	• rate equation	Rate = $k[CH_3CHO]^2$ Allow K for *k* Allow r or R for Rate Allow displayed, semi-structural or skeletal formula for ethanal Do not allow rounded brackets Do not allow missing rate Do not allow "rate equation = "	**(1)**

Question Number	Answer	Additional Guidance	Mark
9(b)	• rate constant units	$dm^3\ mol^{-1}\ s^{-1}$ Allow units in any order Do not penalise use of mol^- / s^- No TE on incorrect equation in (a)	**(1)**

Question Number	Answer	Additional Guidance	Mark
9(c)	• calculation of average rate between 0 – 420 s to 1/2 SF **(1)** • calculation of average rate between 420 – 1260 s to 1/2 SF **(1)**	<u>Example of calculation</u> Rate = ((0.72- 0.36) ÷ (420 - 0) = 8.5714 x 10^{-4}) = 9 x 10^{-4} / 8.6 x 10^{-4} (mol dm^{-3} s^{-1}) Rate = ((0.36 - 0.18) ÷ (1260 – 420) = 2.1429 x 10^{-4}) = 2 x 10^{-4} / 2.1 x 10^{-4} (mol dm^{-3} s^{-1}) Penalise lack of 1/2 SF once only Ignore units even if incorrect Ignore negative sign in front of rate	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(d)	An explanation that makes reference to • not zero order because the rate is not constant **(1)** • not first order because the time taken for the concentration to halve is not equal/ half lives are not constant or not first order because the rate change is not (directly) proportional to the concentration change **(1)**	Allow the rates calculated in (c) are not the same Allow different times are taken for the concentration to halve Allow the concentration is halved but the rate decreases by a quarter If no other mark awarded allow (1) for reference to justification of second order due to concentration decreasing by ½ but rate decreasing by ¼ or due to rate change proportional to concentration squared/ exponential change	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(e)		Example of suitable graph: 	(7)

	• calculation of $1/T$ value **(1)** • calculation of $\ln k$ value **(1)** • axes: correct way round and in the correct direction, labelled with units, suitable scale **(1)** • all points plotted correctly, with best-fit straight line **(1)** • calculation of gradient **(1)** • sign **and** units of gradient **(1)** • use of gradient to calculate activation energy **(1)**	1.27×10^{-3} −1.07 Penalise values not to 3 SF once only in M1 and M2 Accept use of 1×10^{3} or 1×10^{-3} on x axis Do not award 1/t for 1/T Plotted points must cover at least ½ the graph paper on each axis Allow ±1 square Gradient = (−) 21250 Allow ±900 − and K $E_a = -(-21250 \times 8.31) / 1000$ = **(+)** 177 (kJ mol^{-1}) Allow ±7 Allow 177000 **J mol^{-1}** ±7000 Ignore SF except 1 SF Do not penalise mol^{-} TE on numerical value of gradient Final answer must be positive	

(Total Question 9 = 13 marks)