Mark Scheme (Results)

Summer 2024

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

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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.

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

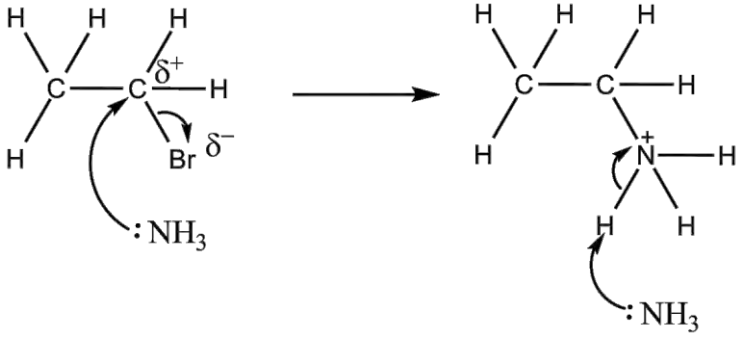
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information 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 D (**2-bromo-2-methylpropane) ***A** is not correct because 1-bromobutane is a primary halogenoalkane so hydrolyses more slowly than the tertiary halogenoalkane* ***B** is not correct because 2-bromobutane is a secondary halogenoalkane so hydrolyses more slowly than the tertiary halogenoalkane* ***C** is not correct because 1-bromo-2-methylpropane is a primary halogenoalkane so hydrolyses more slowly than the tertiary halogenoalkane*	**(1)**

Question Number	Answer	Mark
1(b)	**The only correct answer is C** (CH_3COCl and CH_3NH_2) ***A** is not correct because the reactants will form a primary amide* ***B** is not correct because the reactants will not form an N-substituted amide as there is no reaction* ***D** is not correct because the reactants will not form an N-substituted amide as there is no reaction*	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(c)(i)	An explanation that makes reference to three of the following points: • one (molecule of) ammonia acts as a nucleophile **(1)** • to attack the carbon with a (partial) positive charge **(1)** • a (second) molecule (of ammonia) acts as a base **(1)** • to remove a H^+ /H ion / proton from the intermediate **(1)**	Correctly drawn mechanism with no reference to nucleophile and base scores 2 max (see diagram) Allow 'ammonia donates its lone pair' / 'ammonia reacts in a nucleophilic substitution reaction' Allow 'attacks the carbocation' Do not award NH_3 acting as a base in an incorrect context (e.g. with Br^-) If intermediate drawn then this must be correct Allow ammonia gains a H^+ (ion) / proton from the intermediate Ignore comments related to oxidation and reduction	**(3)**



1 mark for left hand side, including dipole, curly arrow from lone pair on N and arrow from bond to Br

1 mark for right hand side including structure of intermediate with charge, arrow from lone pair on NH_3 to H, and arrow from bond to N+

Question Number	Answer	Mark
1(c)(ii)	**The only correct answer is A** (heat in a sealed tube, ethanol) ***B*** *is not correct as the reaction is carried out in a closed system* ***C*** *is not correct as the bromoethane is not soluble in water* ***D*** *is not correct as the reaction is carried out in a closed system and bromoethane is not soluble in water*	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(d)	• calculation of total relative mass of all reactants or calculation of total relative mass of all products **(1)** • calculation of atom economy to 1 dp **(1)**	Example of calculation 74 + 102.9 + 98.1 / = 275 or 136.9 + 120.1 + 18 / = 275 (136.9 ÷ 275) × 100 = 49.782 (%) = 49.8 (%) Correct answer with no working scores 2 TE from M1 to M2 Incorrect rounding for final answer does not score M2	**(2)**

(Total for Question 1 = 8 marks)

Question Number	Answer	Mark
2(a)	**The only correct answer is B** (ether) ***A*** *is not correct because cyclohexane is not a good solvent for Grignard reagents as it is not polar* ***C*** *is not correct because ethyl ethanoate would react with Grignard reagents* ***D*** *is not correct because hexane is not a good solvent for Grignard reagents as it is not polar*	**(1)**

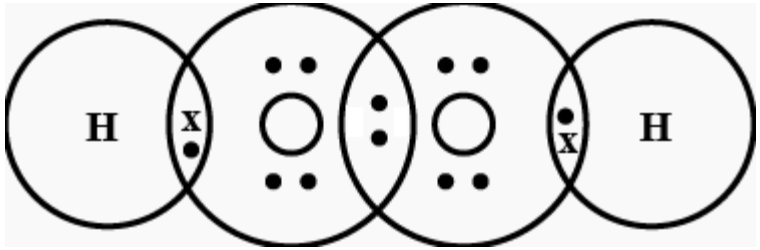
Question Number	Answer	Additional Guidance	Mark
2(b)	An answer that makes reference to the following point: • to increase the length of a **carbon** chain (in a molecule) / extend the **carbon** chain	Accept to form a (new) carbon- carbon (single) bond Allow to increase the number of **carbon**(s) (atoms) (in the starting material) / Ignore to increase chain length / add to the carbon chain Ignore adding alkyl groups	**(1)**

Question Number	Answer	Mark
2(c)	**The only correct answer is C** (a nucleophile) ***A*** *is not correct because the reactive carbon has a partial negative charge* ***B*** *is not correct because the reactive carbon has a partial negative charge* ***D*** *is not correct because the reactive carbon has a partial negative charge*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(d)	An answer that makes reference to the following points: • ethane **(1)** • (partially) negative carbon (in Grignard reagents) is attracted to / reacts with the (partially) positive hydrogen (in water) **(1)**	Accept CH_3CH_3 / C_2H_6 Allow use of symbols e.g. δ^- C, δ^+ H Allow use of full negative charges on C and H	**(2)**

Question Number	Answer	Mark
2(e)	**The only correct answer is D** (CH_3COCH_3) ***A*** *is not correct because* CO_2 *would form a carboxylic acid with a Grignard reagent* ***B*** *is not correct because HCHO would form a primary alcohol with a Grignard reagent* ***C*** *is not correct because* CH_3CHO *would form a secondary alcohol with a Grignard reagent*	**(1)**

(Total for Question 2 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
3(a)		Ignore omission of circles Ignore line to show covalent bonds Allow reversal of dots and crosses Allow all dots or all crosses	(1)

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation that makes reference to the following points: • oxidation number of oxygen has changed from −1 (in H_2O_2) **(1)** • to −2 in water, so reduced **(1)** • and 0 in (elemental) oxygen, so is oxidised **(1)**	**Oxidation numbers may be shown above / below species in equation** Allow Roman numerals to show oxidation numbers Allow 1 rescue mark for correct oxidation numbers of oxygen in both products if references to oxidation and reduction incorrect or omitted or not linked to a specific reaction in M2 and M3 Allow 1 rescue mark for correct oxidation numbers and references to oxidation and reduction if products omitted in M2 and M3	(3)

Question Number	Answer	Additional Guidance	Mark
3(c)(i)	An answer that makes reference to the following points: • (order with respect to hydrogen peroxide =) 1 / first **(1)** • (order with respect to iodide ions =) 1 / first **(1)**		**(2)**

Question Number	Answer	Additional Guidance	Mark
3(c)(ii)	An answer that makes reference to the following point: • rate / r = $k[H_2O_2][I^-]$	Rate equation must be consistent on orders from (i) Allow use of correct names Allow TE from 3(c)(i) Do not award round brackets Do not award omission of rate / r	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(c)(iii)	• calculation of k **(1)** • units of k **(1)**	Example of calculation Calculation must be consistent on rate equation from (ii) k = rate ÷ $[H_2O_2][I^-]$ $3.56 \times 10^{-6} \div (0.200 \times 0.100) = 1.78 \times 10^{-4}$ $dm^3\ mol^{-1}\ s^{-1}$ Allow $dm^3/mol/s$ Allow $dm^3\ mol^-\ s^-$ Allow units in any order Ignore SF except 1 SF Allow TE from incorrect rate equation in 3(c)(ii) Allow calculation based on data from experiments 1 or 2 NOTE – with TE on incorrect order, calculation and units require checking as different experiments give different values	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(d)(i)	An answer that makes reference to the following points: • put glowing splint (into bubbles of gas / presence of gas) **and** splint relights	Ignore 'a splint that has (just) been blown out relights' Do not award 'relights a burnt splint' Do not award squeaky pop	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(d)(ii)	An explanation that makes reference to the following points: • (colour caused by aqueous solution of) iodine **(1)** • (formed as excess hydrogen) peroxide oxidises iodide (ions) / converts iodide (ions) / reacts with iodide (ions) **(1)**	Accept (colour caused by) aqueous (solution of) I_3^- Ignore iodide ions are yellow in solution Do not award iod**ine ions** Allow oxygen oxidises / converts / reacts with the iodide (ions) / iodide reduces (hydrogen) peroxide Allow correct equation $2H^+ + H_2O_2 + 2I^- \rightarrow I_2 + 2H_2O$ Ignore incomplete equations (as considered part of the working out process)	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(e)(i)	• triangle or similar shown on graph to indicate changes in *x* and *y* **(1)** • calculation of gradient **(1)** • units of gradient **(1)**	<u>Example of calculation</u> Allow circling of points / marking of points on line For example –11– - 6 = –5 0.003588 – 0.003038 = 0.00055 –5 ÷ 0.00055 = – 9090.9 Allow gradient in range −8500 to – 9500, consistent with correctly determined y and x values , though gradient must be checked for calculator errors Allow TE on incorrectly determined y and x values from M1 Allow negative gradient even if values used in Δy / Δx would give a positive value Ignore SF Ignore rounding errors in final value of gradient K No TE for units based on inverted axes	**(3)**

Question Number	Answer	Additional Guidance	Mark
3(e)(ii)	• calculation of E_a	Example of calculation $-9090.9 \times 8.31 = -E_a$ E_a = (+) 75.545 (kJ mol^{-1}) Allow (+) 75545 J mol^{-1} Ignore SF except 1 SF Allow TE from (e)(i) Do not award negative activation energies. Note : if answer is in J mol^{-1} units must be given	(1)

Question Number	Answer		Additional Guidance	Mark
3(f)	• expression for, using numbers, or calculation of $e^{-E_a/RT}$ • calculation of A	(1) (1)	Example of calculation $e^{-50200 \div (8.31 \times 370)}$ / 8.1164×10^{-8} $1.60 \times 10^{-3} \div 8.1164 \times 10^{-8} = 1.9713 \times 10^{4}$ Ignore SF Ignore units TE from M1 to M2 Correct answer with no working scores 2 Note – use of rounded values of $e^{-E_a/RT}$ is acceptable and final answer may need checking as it will make a difference to the numerical value M1 can be subsumed in M2	(2)

(Total for Question 3 = 18 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*4</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.

<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</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 five 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 an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).

Comment: Look for the indicative marking points first, then consider the mark for the structure of the Answer and sustained line of reasoning.</td>
<td>(6)</td>
</tr>
</table>

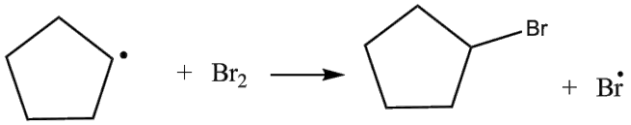
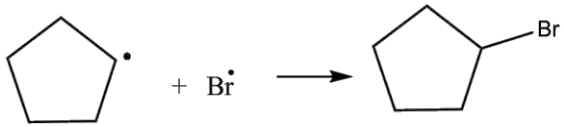
	Indicative content **Treatment of waste polymers** IP1 (waste) polymers can be (sorted and) recycled IP2 (waste) polymers can be incinerated to release energy / generate electricity IP3 (waste) polymers can be cracked / thermally decomposed (to (re)form monomers) **Limiting problems caused by disposal** IP4 (chemists) develop / invent (new) biodegradable polymers IP5 (chemists can help develop techniques to) minimise emission of harmful / toxic / acidic gases from incineration (of waste polymers) IP6 by neutralising HCl / SO_2 / NO_x	Allow re-use / repurpose (objects made from) polymers Allow polymers can be incinerated to release heat / used as a fuel Allow polymers can be used as a feedstock/raw material for cracking Allow polymers can converted into smaller / more useful molecules (to be used as a feedstock) Allow use /develop / invent (new) polymers that decompose Ignore use of alternative non-synthetic materials Ignore biofuels Allow minimise emissions of named pollutants from incineration e.g. HCl / SO_2 / NO_x / CO_2 / CO / dioxins Ignore comments on greenhouse gases / global warming Allow by carbon capture of CO_2 Allow by ensuring complete combustion to minimise CO / by converting CO to CO_2	

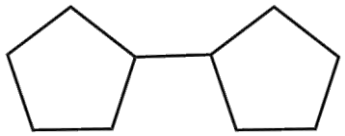
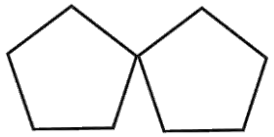
(Total for Question 4 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
5(a)	An answer that makes reference to the following point: • reforming/reformation	 Allow dehydrogenation / cyclisation Ignore oxidation / catalytic Do not award cracking / dehydration	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(b)	• calculate volume of cyclopentane **(1)** • calculate energy density of cyclopentane **(1)** **and** appropriate units	<u>Example of calculation</u> Volume = 30.0 ÷ 0.751 / 39.947 (cm^3) Ignore units in M1 1.41 ÷ (39.947 ÷ 1000) = 35.297 MJ dm^{-3} Ignore SF except 1 SF Allow TE from M1 Allow 3.5297×10^4 kJ dm^{-3} or 3.5297×10^7 J dm^{-3} 3.5297×10^4 J cm^{-3}	**(2)**

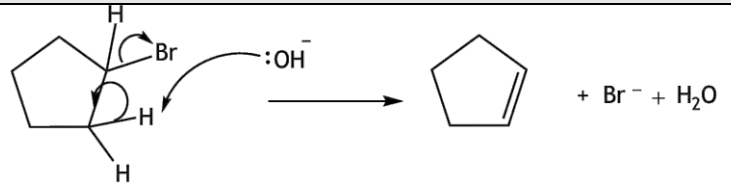
Question Number	Answer	Additional Guidance	Mark
5(c)(i)	An answer that makes reference to the following point: • UV (light) / ultraviolet (light)	 Allow sun(light) / temperature over 250°C Ignore heat under reflux Do not award high pressure	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(c)(ii)	An answer that makes reference to the following points: • Initiation $Br_2 \rightarrow 2Br^{\bullet}$ **(1)** • Propagation  **(1)** • Termination  **(1)**	NOTE – penalise use of hexagons once only in 5(c)(ii) and 5(c)(iii) Penalise omission of unpaired electrons once only Curly-half arrows if shown must be in correct direction Do not award double-headed arrow(s) in M1 Penalise use of chlorine once only Ignore position of bromine relative to dot on free radical	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(c)(iii)	• 	Allow displayed formulae Do not award 	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(d)(i)	An explanation that makes reference to the following points: • to dry the ethanol / solvent **(1)** • as (presence of) water would result in formation of (some) cyclopentanol **(1)**	Allow remove water from the ethanol / solvent Allow to react with the ethanol to remove the water Allow to ensure the reaction conditions are not aqueous Ignore just 'it's a drying agent' Ignore to dry the reactants / removes water that forms in the reaction Do not allow 'to dehydrate' Allow alcohol / hydroxycyclopentane for cyclopentanol Allow as (presence of) water would result in (some) (nucleophilic) substitution (by the hydroxide ion) Ignore hydrolysis	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(d)(ii)	An answer that makes reference to the following point: • elimination	Comment: Allow dehydrohalogenation Do not award nucleophilic / electrophilic / free-radical Ignore oxidation / reduction / basic	**(1)**

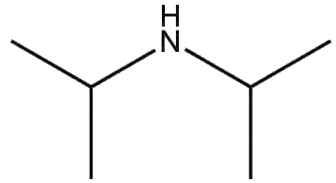
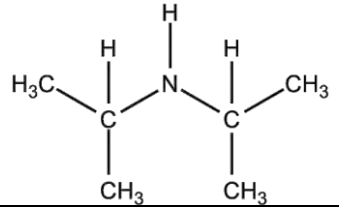
Question Number	Answer	Additional Guidance	Mark
5(d)(iii)	• double-headed arrow from C-H bond to **C-C bond** **and** double-headed arrow from C-Br bond to Br	 Ignore any dipoles, even if incorrect	**(1)**

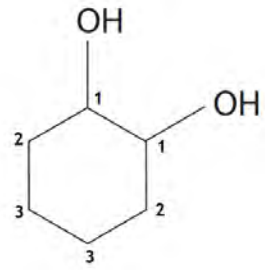
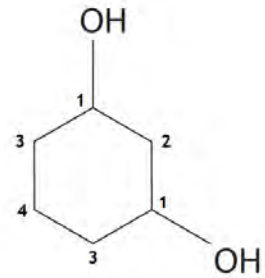
(Total for Question 5 = 12 marks)

Question Number	Answer	Mark
6(a)	**The only correct answer is B** (radio waves) ***A*** *is not correct because IR interacts with bonds* ***C*** *is not correct because UV interacts with electrons* ***D*** *is not correct because X-rays are diffracted by crystals in the solid state*	**(1)**

Question Number	Answer		Additional Guidance	Mark
6(b)	An explanation that makes reference to the following points:			**(2)**
	• TMS acts as a standard / reference (at 0 ppm)	**(1)**	Allow acts as a control / comparison point / baseline / to calibrate / to mark 0 ppm	
	• as it has (12 equivalent) hydrogens that produce a single / strong peak **or** as it has (4 equivalent) carbons that produce a single / strong peak	**(1)**	Ignore just 'has a shift at 0 ppm' Allow produces a peak (well) away from those caused by other hydrogens / carbons Allow (most organic) compounds result in shift values (much) greater than TMS Allow easy to separate from sample (after spectrum is obtained) Allow unreactive (so will not react with sample)	

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	An answer that makes reference to the following point: • the nitrogen (in the amine group) is attached to two carbon atoms / the nitrogen (in the amine group) is attached to two carbons (atoms)	Allow contains an NH group / two alkyl groups attached to the N / two R groups attached to the N / N is adjacent to two carbons Ignore amine group is attached to two carbons	**(1)**

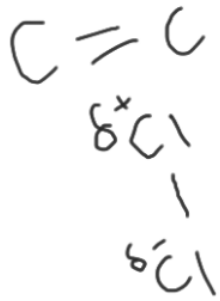
Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	• 	Note – take care to check H is present on N in skeletal formula Allow structural, displayed or hybrid formulae, e.g. 	(1)

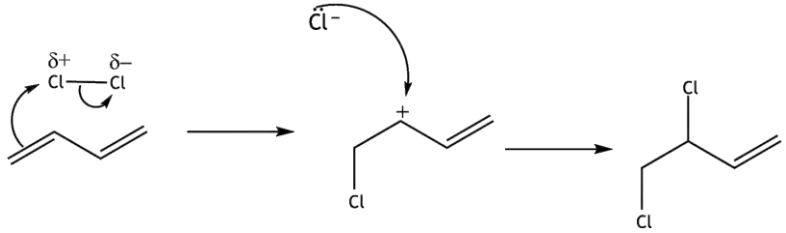
Question Number	Answer	Additional Guidance	Mark
6(d)	An answer that makes reference to the following points: • cyclohexane-1,2-diol has **3 peaks** (in its ^{13}C spectra) **(1)** **and** 3 environments shown on diagram **(1)** • cyclohexane-1,3-diol has **4 peaks** (in its ^{13}C spectra) **and** 4 environments shown on diagram	If no marks scored allow 1 mark for idea that the spectrum of cyclohexane-1,2-diol has fewer peaks / fewer environments than cyclohexane-1,3-diol (even if any numbers quoted are incorrect)   cyclohexane-1,2-diol cyclohexane-1,3-diol Allow alternative labelling systems on diagrams e.g. use of letter Ignore comments related to size of peaks / position of shift values / splitting	(2)

(Total for Question 6 = 7 marks)

Question Number	Answer	Mark
7(a)	**The only correct answer is D** (2-chlorobuta-1,3-diene) ***A*** *is not correct as the position of chlorine is incorrectly numbered* ***B*** *is not correct as the position of double bonds are incorrectly numbered* ***C*** *is not correct as the position of double bonds and chlorine are incorrectly numbered*	**(1)**

Question Number	Answer		Additional Guidance	Mark
7(b)			Example of calculation	(5)
	• calculation of M_r of chloroprene	**(1)**	88.5	
	• calculation of amount of chloroprene in mol	**(1)**	10.0 ÷ 88.5 / = 0.11299 (mol)	
	• conversion of °C to K and kPa to Pa	**(1)**	353 (K) and 205×10^3 / 205000 (Pa) M3 may be subsumed in M4 Allow pressure in kPa if volume is clearly shown as dm^3 in M4	
	• re-arrangement of $pV = nRT$ and calculation of V	**(1)**	$V = (nRT) \div p$ $= (0.11299 \times 8.31 \times 353) \div 205000 = 1.6169 \times 10^{-3}$ (m^3) M4 may be subsumed in M5 Ignore units in M4	
	• conversion to cm^3 and rounding to 2 or 3 SF	**(1)**	1600 / 1620 (cm^3) 1620 with no working scores 5 **Comments** Allow use of correctly rounded values carried forward Take care with awarding 5 for 1600, as it may be the result of an incorrect value from M4, correctly rounded	

Question Number	Answer	Additional Guidance	Mark
7(c)(i)	An explanation that makes reference to the following points: • chlorine (molecule) moves close to (electron rich) double bond / pi bond **(1)** **(1)** • which induces partial positive charge on chlorine (atom) (nearest to double bond / pi bond)	 M1 via diagram e.g Allow C=C bond has a high electron density Accept repulsion between the electrons of chlorine and the pi electrons results in partial positive charge on chlorine (atom) Allow polarises the chlorine forming a δ^+ Cl Note M2 must have idea that the partial charge is induced / brought about / produced so a diagram alone **does not score M2**	**(2)**

Question Number	Answer	Additional Guidance	Mark
7(c)(ii)	An answer that makes reference to the following points: • curly arrow from one double bond to chlorine or just beyond **(1)** • correct dipole on chlorine molecule **(1)** • curly arrow from Cl-Cl bond to Cl **(1)** • carbocation intermediate **(1)** • lone pair on chloride ion **(1)** • curly arrow from chloride ion to carbocation **and** correct final product **(1)** 6 bullet points scores 3 marks, 4/5 bullet points scores 2 marks, 2/3 bullet points scores 1 mark, 0/1 bullet points scores 0 marks	Do not award if arrow shown to partial negative / negative Cl Do not award primary carbocation Do not award Cl / $Cl^{\delta-}$, but allow TE into BP6 If lone pair evident, curly arrow must originate from it  Note – correct dipole discussed in (c)(i) can be awarded as part of M1 if not shown on the diagram	**(3)**

Question Number	Answer	Additional Guidance	Mark
7(c)(iii)	An answer that makes reference to the following point: • addition (polymerisation)	Do not award condensation	**(1)**

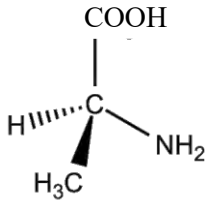
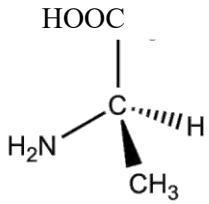
Question Number	Answer	Additional Guidance	Mark
7(d)(i)	An explanation that makes reference to the following points: • both compounds have hydrogen bonds **(1)** • so the intermolecular forces / hydrogen bonds they form together will be similar in strength (to the intermolecular forces / hydrogen bonds they have before mixing) **(1)**	Allow can hydrogen bond to each other Allow H-bond for hydrogen bond Allow correct diagram for M1 Allow 'they break strong H bonds but then form strong H bonds together' Allow the new hydrogen bonds are stronger than the ones between water molecules / ethane-1-2-diol	**(2)**

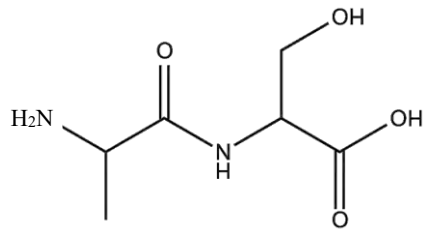
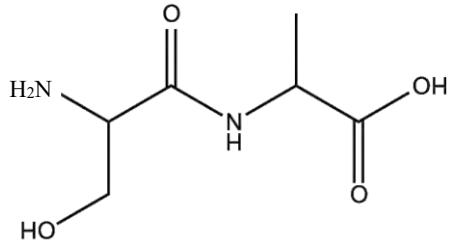
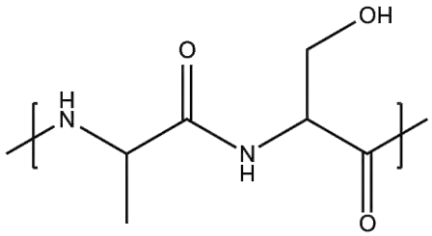
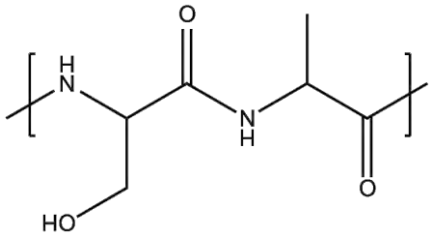
Question Number	Answer	Additional Guidance	Mark
7(d)(ii)	• calculation of mass and moles of polyester **(1)** • calculation of number of molecules of polyester **(1)**	<u>Example of calculation</u> $4.25 \times 10^{-3} \div 8400 = 5.0595 \times 10^{-7}$ (mol) $5.0595 \times 10^{-7} \times 6.02 \times 10^{23} = 3.0458 \times 10^{17}$ (molecules) Ignore SF Allow TE from M1 If incorrect units given in M1 and M2, penalise only once Correct answer with or without working scores 2 marks	**(2)**

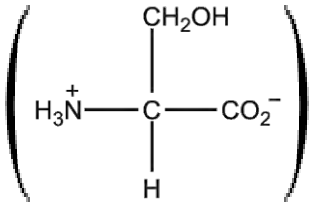
Question Number	Answer	Mark
7(d)(iii)	**The only correct answer is B** (hydrolysis) ***A*** *is not correct as the reaction as dehydration is the removal of water* ***C*** *is not correct as the reaction as neutralisation is a reaction between an acid and a base* ***D*** *is not correct as the reaction as redox is oxidation and reduction*	**(1)**

(Total for Question 7 = 17 marks)

Question Number	Answer	Additional Guidance	Mark
8(a)(i)	An answer that makes reference to the following point: • a carbon atom with four different atoms / groups (of atoms) attached	Allow resulting molecule has non-superimposable mirror images Allow a carbon atom with four different functional groups attached Ignore a carbon atom with four different species attached Do not award 'molecules' for atoms / groups	(1)

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	•  (1)  (1)	Allow 1 mark for 2 tetrahedral mirror images shown with only lines and no wedges / dashed lines Allow 1 mark for 2 tetrahedral mirror images shown with two similar wedges on each structure Accept dashed line for dashed wedges Ignore connectivity	(2)

Question Number	Answer	Additional Guidance	Mark
8(b)	•  **(1)** •  **(1)**	Allow 1 mark for 2 correct structures shown as structural or displayed formulae Ignore displayed NH_2, NH, or OH groups Penalise missing hydrogen atoms on amide group once only Penalise NH group shown as part of chain once only Allow 1 if both dipeptides shown as correct polymer repeat units  **and** 	**(2)**

Question Number	Answer	Mark
8(c)	**The only correct answer is A**  ***B*** *is not correct because the CO_2H group has not lost a proton* ***C*** *is not correct because the NH_2 group has not gained a proton* ***D*** *is not correct because the CH_2OH group has lost a proton*	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(d)(i)	• balanced equation	Examples $C_2H_5OH + Na \rightarrow C_2H_5ONa + ½H_2$ $C_2H_5OH + Na \rightarrow C_2H_5O^-Na^+ + ½H_2$ $C_2H_6O + Na \rightarrow C_2H_5ONa + ½H_2$ $C_2H_6O + Na \rightarrow C_2H_5O^-Na^+ + ½H_2$ Allow multiples Allow displayed / skeletal / molecular formulae Ignore state symbols even if incorrect Do not award $C_2H_5OH + Na \rightarrow C_2H_5O^{\delta-}Na^{\delta+} + ½H_2$	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(d)(ii)	An answer that makes reference to the following point: • ester **(1)** • (*N*-substituted) amide **(1)**	If 3 answers given and 2 are correct, award 1 mark If 4 or more answers given and 2 are correct award 0 marks Ignore structures, even if incorrect	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(d)(iii)	An answer that makes reference to the following points: • hydrochloric acid / HCl(aq) **(1)** • (heat under) reflux **(1)**	Ignore references to concentrated / dilute Allow HCl Allow correct name or formulae of any strong acid e.g. HNO_3, H_2SO_4, Allow phosphoric acid / H_3PO_4 Allow NaOH followed by any identified strong acid Ignore H^+ / H_3O^+ / catalyst Mark independently	**(2)**

Question Number	Answer		Additional Guidance	Mark
8(d)(iv)	• calculation of moles of alanine	**(1)**	Example of calculation 15.0 ÷ 89.0 = 0.16854 (mol)	**(3)**
	• scale to 100 %	**(1)**	0.16854 × (100 ÷ 55) = 0.30644 (mol)	
	• calculation of mass of compound X	**(1)**	0.30644 × 217 = 66.496 = 66.5 g	
	OR			
	• scale mass of alanine to 100%	**(1)**	15.0 × (100 ÷ 55) = 27.273 (g)	
	• calculation of moles of alanine	**(1)**	27.273 ÷ 89.0 = 0.30644 (mol)	
	• calculation of mass of compound X	**(1)**	0.30644 × 217 = 66.496 = 66.5 g	
	OR			
	• calculation of moles of alanine	**(1)**	15.0 ÷ 89.0 = 0.16854 (mol)	
	• calculate mass of X	**(1)**	0.16854 × 217 = 36.573	
	• scale to 100 %	**(1)**	36.573 × (100 ÷ 55) = 66.496 = 66.5 g	
			Correct answer no working scores 3 Ignore SF except 1 SF Allow TE throughout	
			If no mark scored allow 1 mark for 2 correct M_r values, 89 and 217	

Question Number	Answer	Additional Guidance	Mark
8(e)	An explanation that makes reference to the following points: • would move towards the positive electrode / to the left **(1)** **and** as it will form a negative ion • (as basic pH means) the acid groups will **both** lose a proton / has **two** COO^- groups **(1)**	Note The negative charge on the ion and loss of both hydrogen ions from the COOH groups can both be awarded from a correct diagram of the ion Do not award zwitterion Allow the acid groups will **both** lose a hydrogen (ion) M2 can be awarded from diagram / amended structure in question	**(2)**

(Total for Question 8 = 16 marks)

TOTAL FOR PAPER = 90 MARKS

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