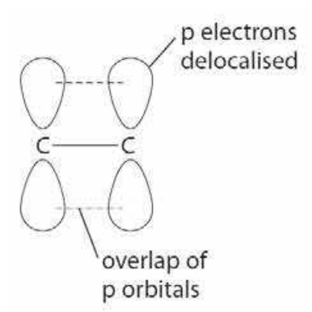
CHEMISTRY A LEVEL PAPER 2 MARK SCHEME

Question Number	Answer	Additional Guidance	Mark
1(a)(i)	A		1
1(a)(ii)	D		1
1(b)	A description that makes reference to: • (head on) overlap between orbitals from neighbouring carbon atoms to form a sigma bond (1) • (the remaining) p orbitals overlap sideways (1) • and so electrons delocalise (around the ring) (1) Example of a possible diagram scoring 2 marks (marking points 2 and 3)  	Allow sp^2 hybrid orbitals overlap to form a sigma bond	3

(Total Question 1 = 5 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)	A		**1**
2(b)	C		**1**
2(c)	D		**1**

(Total Question 2 = 3 marks)

Question Number	Answer	Additional Guidance	Mark
3(a)	reacts with acids to form a salt/proton acceptor (1)	Allow electron pair donor	**1**
3(b)	B		**1**
3(c)	Any **two** of the following points: • the nucleophile does not have an unpaired electron, it has a lone pair of electrons (1) • the slightly positive carbon is not attached to an electropositive chlorine atom, it is attached to an electronegative chlorine atom (1) • the product is not an amide, it is a (secondary) amine (1)		**2**

(Total Question 3 = 4 marks)

Question Number	Answer	Additional Guidance	Mark
4(a)	C		**1**
4(b)	• Prediction: 7/neutral (1) • Justification: Amino group accepts one proton released from acid / **B** exists as a zwitterion (so it is not acidic or alkaline) (1)	Allow 6.5 to 7.5 Allow proton from acid accepted by amine	**2**
4(c)	An answer that makes reference to the following points: • pentane has the lowest melting temperature because it only has London forces (1) • butan-1-ol and glycine have (similar) London forces (due to similar number of electrons) (1) • butan-1-ol has higher / less negative melting temperature than pentane as it has hydrogen bonds (1) • glycine has the highest melting temperature as it is an ionic solid (lattice) / consists of zwitterions (1)	Accept van der Waals as alternative to London If marking points 2 and 3 are not scored then allow 1 mark for the idea that butan-1-ol has higher melting temperature (than pentane) due to stronger intermolecular forces	**4**

(Total Question 4 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
5(a)(i)	C		**1**
5(a)(ii)	C		**1**
5(b)(i)	• amount of sodium thiosulfate (1) • amount of liberated iodine (1)	<u>Example of calculation</u> Amount of sodium thiosulfate = 21.2/1000 x 0.500 = 0.0106 (mol) Amount of liberated iodine = 0.0106/2 = 5.3×10^{-3} /0.0053 (mol) Allow ecf from 1st to 2nd mark Correct answer with no working scores 2 marks	**2**
5(b)(ii)	• initial amount of ICl (1) • amount of ICl that reacted with oil (1) • mass of iodine in ICl (1) • expression for iodine value (1) • final iodine value (1)	Allow ecf from (b)(i) If no subtraction allow 3 max (1st, 4th and 5th marks) <u>Example of calculation</u> Initial amount of ICl = 11.0 /162.4 = 0.067734 (mol) Amount of ICl that reacted with oil = 0.067734 - 5.3×10^{-3} = 0.062434 (mol) Mass of iodine in ICl = 0.062434 x 126.9 =7.9229s g (with 6.4 g oil) Iodine value = 7.9229 x 100/6.4 = 123.79 / 124 Correct answer with no working scores 5 marks	**5**
5(c)	A		**1**

(Total Question 5 = 10 marks)

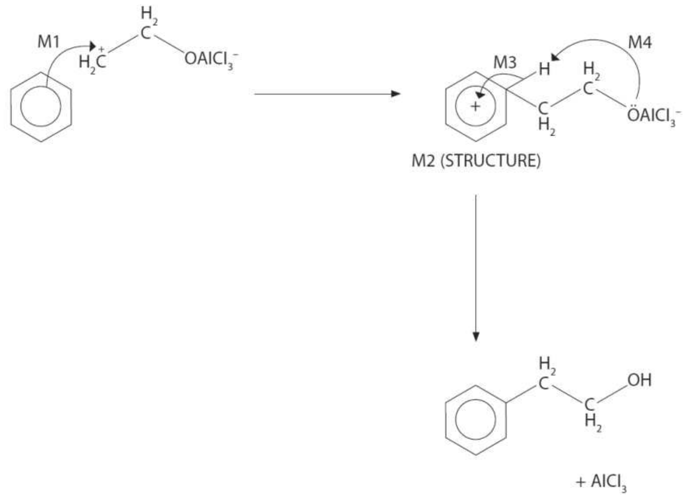
Question Number	Answer	Additional Guidance	Mark
6(a)	C		**1**
6(b)(i)	• Comparison of runs 1 and 2 to determine order wrt A = 1 (1) • Comparison of runs 1 and 3 to determine order wrt B = 2 (1)	Allow comparisons of other relevant pairs of runs	**2**
6(b)(ii)	(When comparing runs 2 and 4) • [A] constant so no effect but [B] x 4 so increases rate by 16 / to 0.0768 (1) • [C] x 3 and rate increases by 0.23 ÷ 0.0768 (= 2.99 i.e. 3), so first order with respect to C (1)	Allow comparisons of other relevant pairs of runs, e.g. runs 3 and 4	**2**
6(b)(iii)	• rate = $k[A][B]^2[C]$ (1)		**1**
6(b)(iv)	• rearrangement of rate expression (1) • evaluation of value for *k* to 2.s.f (1) • units $dm^9\ mol^{-3}\ s^{-1}$ (1)	<u>Example of calculation</u> k = rate / $[A][B]^2[C]$ = 7.324…. = 7.3 $dm^9\ mol^{-3}\ s^{-1}$ Allow ecf from b (iii) Allow units in any order Correct answer with no working and units to 2 sf scores 3 marks	**3**

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	• 2^{nd} order (1)		**1**
6(c)(ii)	An explanation that makes reference to the following points: • rate increases because increased concentration of propanone means more propanone molecules in a given volume (1) • so more frequent collisions / greater rate of collisions / more collisions per second (1)		**2**
6(d)(i)	An explanation that makes reference to the following points: • increases the rate of reaction because it lowers the activation energy (1) • by providing alternative reaction mechanism /pathway (1) • so greater proportion of particles collide with sufficient energy (1)	Responses in terms of heterogeneous catalysis can score a maximum of 2 marks • Reactants bond onto catalyst surface (adsorption) • Increases concentration of reactant (at surface) • Products break away from catalyst surface (desorption) All 3 points scores 2 marks A combination of any 2 points scores 1 Any single point only scores 0 marks	**3**

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	• one Maxwell-Boltzmann distribution shown drawn with appropriate shape (1) • second distribution shown with maximum lower and to right of that shown by first curve, with larger area below curve beyond E_a (1) (to score 2nd mark there must be a clear indication that the second distribution is at a higher temperature)	Curves should not cross *x*- axis	**2**

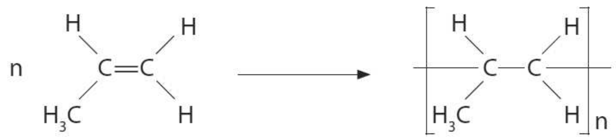
(Total Question 6 = 17 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)	• calculation of mass of C from CO_2 (1) • calculation of mass of H from H_2O (1) • subtraction to find mass of O, and evaluation of number of moles of C, H and O (1) • confirm whole number ratio (1)	<u>Example of calculation</u> Mass of C = 4.26 x 12/44 = 1.1618 g Mass of H = 1.1 x 2/18 = 0.12222 g So mass O = 1.56 − (1.1618 + 0.1222) = 0.27598 g Moles C = 1.1618/12 = 0.096817 Moles H = 0.12222/1 = 0.12222 Moles O = 0.27598/16 = 0.017249 Ratio = 5.6 : 7.1 : 1 = 11 : 14 : 2 Allow alternative correct methods	**4**
7(b)	• 4 (additional) peaks drawn (1) • Splitting marks (ignore chemical shift at this point) (2) - **p**, **q** and **s** are triplets and **r** is quartet scores 2 marks - two or three splitting patterns correctly shown scores 1 mark • area under curve (1) - total shown by candidate = (2+2+2+3) = 9 • chemical shifts (2) - Peak at 0-2 ppm due to protons on **s** - Peak at 2-3 ppm due to protons on **r** - Peak at 3-4 ppm due to protons on **q** - Peak at 1.6-2.8 ppm due to protons on **p**	Peaks can be shown as separate lines Ignore whether values are linked to correct peak All peaks at correct chemical shift score 2 marks Two or three at correct chemical shift peaks score 1 mark	**6**

Question Number	Answer	Additional Guidance	Mark
7(c)(i)	A		**1**
7(c)(ii)	 • electron pair movement from ring to electrophile (1) • formula of intermediate ion (1) • movement of bond pair to reinstate delocalised ring (1) • movement of lone pair from oxygen to hydrogen (1)	Can show H^+ ion forming and reacting with lone pair from oxygen Can show O-Al bond breaking	**4**
7(c)(iii)	B		**1**
7(c)(iv)	• (concentrated) sulfuric acid / H_2SO_4 **or** (concentrated) hydrochloric acid/HCl (1)	Do not award dilute sulfuric acid	**1**

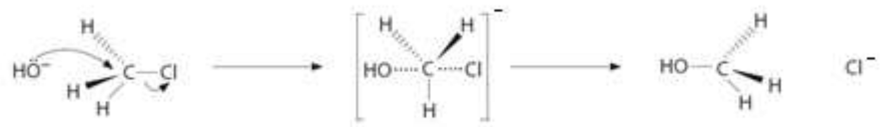
(Total Question 7 = 17 marks)

Question Number	Answer	Additional Guidance	Mark
8(a)	Any **one** from: • $C_3H_6 + C_7H_{16}$ (1) • $2C_3H_6 + C_4H_{10}$ (1) • $3C_3H_6 + CH_4$ (1)		**1**
8(b)(i)	• **X** is propan-1-ol (1) Step 2 • reaction with aqueous NaOH (and heat) (1) Step 3 • oxidation to acid using acidified $K_2Cr_2O_7$ (1) • with excess oxidising agent / heated under reflux (1)	Allow 'H^+ and $Cr_2O_7^{2-}$'	**4**
8(b)(ii)	An explanation that makes reference to **two** of the following points: • main product from reaction with HBr will be 2-bromopropane (1) • as secondary carbocation (formed in mechanism) is more stable (than primary) (1)	Allow reverse argument e.g. • 1-bromopropane is the minor product • as primary carbocation (formed in mechanism) is less stable (than secondary)	**2**

Question Number	Answer	Additional Guidance	Mark
8(c)(i)	 • formulae (1) • balancing and brackets (1)	Ignore type of brackets 2nd mark dependent on correct formulae	**2**
8(c)(ii)	A description that makes reference to: • nylon is formed by a condensation reaction / releases HCl when polymers forms (1) • nylon is formed from two different monomers (1) **OR** • poly(propene) is formed by an addition reaction / forms only one product (1) • poly(propene) is formed from only one type of monomer (1)		**2**

Question Number	Answer	Additional Guidance	Mark
8(c)(iii)	An answer that makes reference to **two** of the following points: • reprocessing of polymers into simpler compounds for use as feedstock in the chemical industry (1) • capture and use of energy from incineration (1) • sorting (Using IR) **and** recycling of polymers (1) • removal of harmful/toxic/corrosive products formed during incineration (1)		**2**

(Total Question 8 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
9(a)	 • attack by hydroxide ion on positive carbon (1) • breaking of C-Cl bond (1) • formula of transition state with correct charge (1) • 'partial' bonds to OH and Cl shown in transition state (1)	Arrow must start from O and go to C; lone pair not required Arrow from bond to Cl Ignore brackets	**4**
9(b)(i)	3-bromo-3-methylhexane (1)	Allow 3-methyl-3-bromohexane	**1**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*9(b)(ii)</td><td>This question assesses a 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><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></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></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, an answer with five indicative marking points which 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 are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td>6</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
***9(b)(ii) cont.**	The following table shows how the marks should be awarded for structure and lines of reasoning. | | Number of marks awarded for structure of answer and sustained line of reasoning | |---|---| | Answer shows a coherent and 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 | **Indicative content** • Reaction 2 forms optically active product as only one enantiomer formed (S_N2) • as hydroxide ion can only attack on opposite side to leaving group • which causes inversion (of configuration) of the chiral centre • Reaction 3 product mixture shows no significant optical activity as a racemic mixture forms (S_N1) • as intermediate is a planar carbocation, • so can be attacked (by hydroxide ion) from either side	Could use labelled diagrams to illustrate attack of hydroxide ions in either mechanism	

Question Number	Answer	Additional Guidance	Mark
***9(b)(ii) cont.**	**Or** • mechanism of reaction 2 is S_N2 • because single enantiomer is formed as product and is optically active • as hydroxide ion can only attack on opposite side to leaving group • reaction 3 produces a racemic mixture as product is not significantly optically active • so reaction 3 is S_N1 • as the two products rotate the plane of plane-polarised light in opposite directions		
9(c)(i)	• two correct structures (1)		**1**
9(c)(ii)	An explanation that makes reference to the following points: • in alkenes this occurs due to non-rotation of C=C bond (1) • because π-bond prevents it / π-bond above and below σ - bond (1)	Allow no free rotation around the carbon-carbon double bond	**2**

(Total Question 9 = 14 marks)