PEARSON EDEXCEL A-LEVEL CHEMISTRY · 9CH0

CHEMISTRY



MARK SCHEME

TOPIC 6: ORGANIC CHEMISTRY I

SCORE	PERCENTAGE
/443	%

STEMUP

These questions belong to Pearson Edexcel, not to us.

The examination questions and mark schemes in this pack were written and published by Pearson Edexcel. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with Pearson Edexcel and does not own, and makes no claim to own, any of the question or mark scheme material in this pack. Pearson has not endorsed, approved or been involved in the production of it. Pearson, Edexcel and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

Pearson publishes its past papers and mark schemes free of charge. Always check the current specification at qualifications.pearson.com before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

This question is about hydrocarbons and chloroalkanes.

(i) Which could be the molecular formula of a cycloalkane?

(1)

☒ **A** C_5H_{12}

☒ **B** C_6H_{14}

☒ **C** C_7H_{14}

☒ **D** C_7H_{16}

(ii) Which could be the molecular formula of an alkene with two double bonds?

(1)

☒ **A** C_6H_{12}

☒ **B** C_6H_{14}

☒ **C** C_7H_{12}

☒ **D** C_7H_{14}

Mark Scheme

Q1.

Question number	Answer	Mark
	The only correct answer is D (16σ bonds and 1π bond) ***A*** *is incorrect because there are 10 σ C-H bonds, 6 C-C σ bonds and 1 C-C π bond* ***B*** *is incorrect because there are 10 σ C-H bonds, 6 C-C σ bonds and 1 C-C π bond* ***C*** *is incorrect because there are 10 σ C-H bonds, 6 C-C σ bonds and 1 C-C π bond*	**(1)**

Q2.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	• 3-methylbutan-2-ol / secondary alcohols cannot be oxidised to a carboxylic acid OR • 3-methylbutanone / the product / ketones cannot be (further) oxidised	Allow only primary alcohols can be oxidised to carboxylic acids	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	• H_2SO_4	Ignore 'sulfuric acid'	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(iii)	• all formulae correct **(1)** • all state symbols correct **(1)**	<u>Example of equation:</u> $Na_2CO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$ OR $Na_2CO_3(s) + 2H^+(aq) \rightarrow 2Na^+(aq) + H_2O(l) + CO_2(g)$ OR $Na_2CO_3(s) + 2H_2SO_4(aq) \rightarrow 2NaHSO_4(aq) + H_2O(l) + CO_2(g)$ Use of $NaCO_3$ or H_2CO_3 scores zero Allow any acid. M2 consequential on M1 being awarded, or a 'near-miss'	(2)

Q3.

Question Number	Acceptable Answer	Mark
	The only correct answer is **B** ***A*** *is incorrect because not a systematic name* ***C*** *is incorrect because it has five carbons* ***D*** *is incorrect because it has only three carbons*	(1)

Q4.

Question Number	Answer	Mark
(i)	**The only correct answer is C (homolytic bond fission to form free radicals)** *A is incorrect because such bond fission would produce ions* *B is incorrect because the first step of the reaction produces free radicals by homolytic fission* *D is incorrect because the first step of the reaction produces free radicals*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	122.9 æ(122.9 + 80.9) x 100 **or** 122.9 æ(44.0 + (2 x 79.9)) x 100 **or** (122.9æ203.8) x 100 (1) = 60.304% (1)	Allow 123 æ (123+81) = 60.29% Award M1 only if final answer given as decimal 0.603 rather than % Allow TE for M2 for only one incorrect A_r value Ignore SF Correct answer with or without working scores (2)	**(2)**

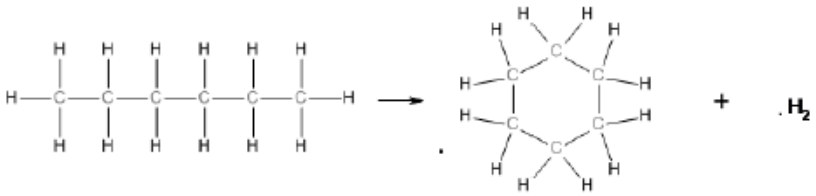
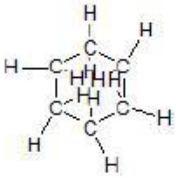
Question Number	Answer	Mark
(iii)	**The only correct answer is D** (the reaction produces a mixture of organic products) *A is incorrect because bromine is very reactive* *B is incorrect because gaseous reactants do not necessarily give a poor yield* *C is incorrect because the kinetics of the reaction do not affect the yield*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iv)	Amount of 1-bromopropane (1) So moles of propane required (1) So volume of propane required to 2 or 3 SF (1) **Alternative route** Target mass of 1-bromopropane required to produce 14.7 g (with a 31.0% yield) (1) Moles of propane required to produce the required mass of 1-bromopropane (1) So volume of propane required to 2 or 3 SF (1)	14.7/122.9 = 0.11961 (mol) (0.11961/31) x 100 = 0.38584 (mol) = 0.38584 x 24.0 = 9.2601 (dm^3) = 9.3 / 9.26 (dm^3) Allow 14.7/123 = 0.11951 (mol) (0.11951/31) x 100 = 0.38552 (mol) = 0.38552 x 24.0 = 9.2526 (dm^3) = 9.3 / 9.25 (dm^3) 14.7 x $\frac{100}{31.0}$ = 47.4 g $\frac{47.4}{122.9}$ = 0.3857 (mol) 0.3857 x 24.0 = 9.3 / 9.26 (dm^3) Award (2) for a final answer of 0.890 / 0.89 (dm^3) (incorrect use of 31.0%) Answer assuming 100% yield scores (2) for final answer of 2.87 / 2.9 (dm^3) Penalise incorrect units in M3 Do not award M3 if Ideal Gas Eqtn used for propane volume Penalise incorrect rounding once only **Correct answer to 2 or 3 SF with or without working scores (3)**	**(3)**

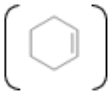
Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following points: • different alkanes have different boiling temperatures/points **(1)** • because of (different) chain length/molar mass /strength of intermolecular forces/ number of electrons **(1)**	Allow Volatility for boiling temperature Allow Different alkanes condense at different temperatures Ignore melting temperatures if given with boiling temperatures Ignore densities Accept London /dispersion /van der Waals forces Allow reference to size A comparison such as 'longer alkanes have higher boiling points' scores 2 Ignore any reference to surface area Do not award references to cracking Do not award reference to just weight/mass Do not award incorrect trend	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	Correct equation	<u>Example of equation:</u> $C_8H_{18} \rightarrow C_2H_4 + C_6H_{14}$ OR $C_8H_{18} \rightarrow 2C_2H_4 + C_4H_{10}$ OR $C_8H_{18} \rightarrow 3C_2H_4 + C_2H_6$ Allow $CH_2=CH_2$ for C_2H_4 Products can be given in either order Do not award equations forming H_2	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iii)	Correct equation	Example of equation:  Accept bonds to hydrogen atoms inside the ring, e.g.  Allow skeletal or structural formulae for hexane  or $CH_3(CH_2)_4CH_3$ and for cyclohexane  or $(CH_2)_6$ Ignore $C_6H_{14} \rightarrow C_6H_{12} + H_2$	(1)

Q6.

Question number	Answer	Mark
	The only correct answer is C  *A is incorrect because this has molecular formula C_6H_{12}* *B is incorrect because this has molecular formula C_6H_8* *D is incorrect because this has molecular formula C_6H_8*	(1)

Q7.

Question number	Answer	Mark
	The only correct answer is C (2,3-dimethylbut-1-ene) *A is incorrect because the longest chain has 4 carbon atoms* *B is incorrect because the longest chain has 4 carbon atoms* *D is incorrect because the C=C should have the lowest number*	(1)

Q8.

Question Number	Answer	Mark
	The only correct answer is D $CH_3CH_2CH(OH)CH_2CH_3$ only **A** *is not correct because it will not form pent-2-ene* **B** *is not correct because it will only form pent-1-ene* **C** *is not correct because* $CH_3CH(OH)CH_2CH_2CH_3$ *will also form pent-1-ene*	**(1)**

Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	• mass of carbon in both substances **(1)** • molar masses of both substances **(1)** • calculation of percentages by mass of carbon **(1)**	Example of calculation (12 x 7 =) 84 Phenylmethanol 108 and Benzoic acid 122 Phenylmethanol (84 ÷ 108) x100 = 78%/ 77.8%/ 77.78% / 77.7 % Benzoic acid (84 ÷ 122) x 100 = 68.85%/ 68.9%/69% Ignore sf except 1 Allow TE on incorrect M_r values Allow (2) for 11.1% and 9.8% calculated using 12 not 84 Allow 'rescue' (1) for one substance completely correct	**(3)**

Question Number	Answer	Additional Guidance	Mark
(ii)	A description that makes reference to: • black smoke	Allow Black fumes/soot/(yellow) smoky flame / grey smoke Ignore carbon particulates Do not award carbon monoxide/yellow flame	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to • Alkenes	Allow Cycloalkenes/cycloalkanes/alkynes/ carbon-carbon double bonds Ignore Ethene/named alkenes/named alkynes Do not award benzene/arenes	(1)

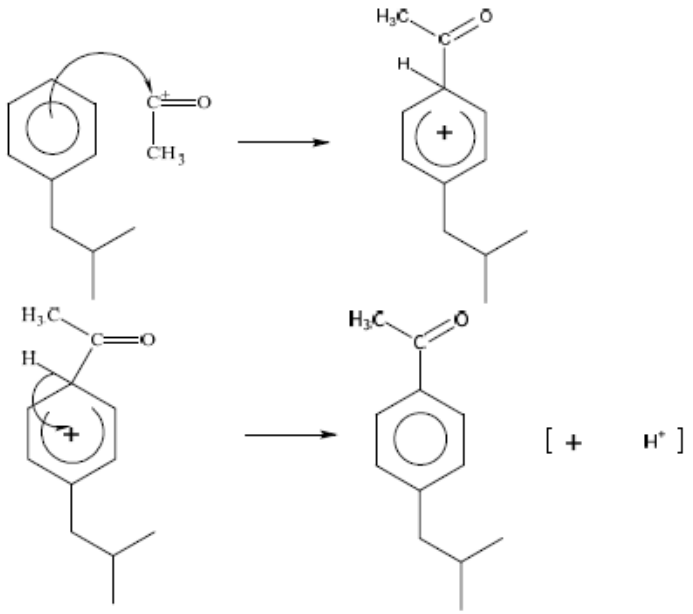
Question Number	Answer	Additional Guidance	Mark
(iv)	An explanation that makes reference to • (window) above the safety line means the exhaust system is not strong enough to draw in the fumes **(1)** • so the toxic fumes will escape (into the laboratory) **(1)**	Allow reverse argument Allow reference to exhaust/fan not able to prevent gas escaping Allow poisonous/harmful/irritant/ carbon monoxide/soot for 'toxic fumes' Ignore reference to protection from splashing etc	(2)

Q10.

Question Number	Acceptable Answers	Reject	Mark
(a)(i)	Overall **yield** higher OR Reduces use of solvents (ALLOW chemicals / reactants) OR Less loss of chemicals OR Less waste products IGNORE References to Energy / fuel / CO_2 References to atom economy More efficient conversion Fewer side products		**1**

Question Number	Acceptable Answers	Reject	Mark
(a)(ii)	Lowers (operating) temperature / energy (requirements) OR Less fuel needed IGNORE References to catalyst properties such as 'lowers E_a', 'can be re-used' Atom economy		**1**

Question Number	Acceptable Answers	Reject	Mark
(b)(i)	$CH_3COCl + AlCl_3 \rightarrow CH_3CO^+ + AlCl_4^-$ Structural formulae not required Positive charge may be anywhere on the electrophile. IGNORE Curly arrows even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
(b)(ii)	 TE on incorrect electrophile in (b)(i) If benzene used instead of substituted benzene OR If final product is not 1,4 only MP 1 and 2 can be scored Curly arrow from on or within the circle to positively charged carbon		**3**
	ALLOW Curly arrow from anywhere within the hexagon Arrow to **any** part of the electrophile including to the + charge (which can be anywhere on the electrophile) **(1)** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** with some part of the positive charge within the horseshoe ALLOW dotted horseshoe **(1)** Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure of a stable molecule **(1)** Correct Kekulé structures score full marks Ignore any involvement of $AlCl_4^-$ in the final step	Curly arrow on or outside the hexagon Partial bonds to H and CH_3 unless part of a 3D with a wedge bond	

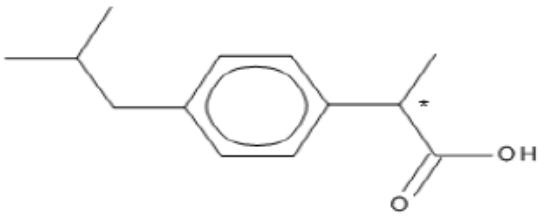
Question Number	Acceptable Answers	Reject	Mark
(b)(iii)	No HCl formed (as a by-product) OR Ethanoic acid easier to recover ALLOW Reverse arguments IGNORE Chlorine containing product References to ozone layer, acid rain, global warming Atom economy	Chlorine	**1**

Question Number	Acceptable Answers	Reject	Mark
(c)(i)	Catalyst (more) easily recovered / separated OR can be filtered OR Facilitates the use of flow (rather than batch) systems IGNORE references to properties of catalysts		**1**

Question Number	Acceptable Answers	Reject	Mark
(c)(ii)	**Reaction 1** (red) phosphorus / P / P_4 and iodine / I_2 ALLOW PI_3 / HI **(1)** **Reaction 3** Hydrochloric acid / HCl(aq) or sulfuric acid / H_2SO_4 (aq) **(1)** **and** reflux / heat **(1)** Award second mark for Acid / H^+ / H_3O^+ **and** reflux OR NaOH(aq) / KOH(aq) **(1)** (reflux) **then** acidify with HCl(aq) or H_2SO_4 (aq) **(1)** IGNORE Omission of states throughout	NaI + H_2SO_4 PI_5 Just H^+ / H_3O^+ reflux / heat without acid or with warm or <50°C	

Question Number	Acceptable Answers	Reject	Mark
(c)(iii)	C=O / carbonyl group (only) in carboxylic acid / ibuprofen **(1)** Absorption / peak at 1725 - 1700 (cm^{-1}) **(1)** If no other mark has been awarded, then ALLOW (for 1 mark) OH in both but in alcohol 3750 - 3200 (cm^{-1}) but in carboxylic acids 3300 to 2500 (cm^{-1})	ketone 1700 - 1680 (cm^{-1}) Single values rather than ranges	**2**

Question Number	Acceptable Answers	Reject	Mark
(d)(i)	(A chiral molecule is) non-superimposable on its mirror image. ALLOW Asymmetric (tetrahedral) carbon atom / has a carbon atom bonded to **four** different groups / atoms IGNORE Has two enantiomers Functional (as in functional groups) Reference to rotation of plane polarized light	molecules / species (for groups)	**1**

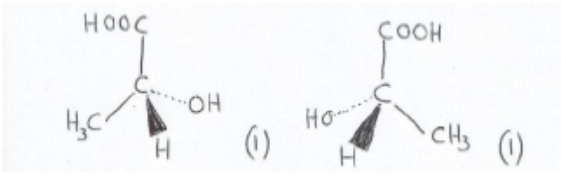
Question Number	Acceptable Answers	Reject	Mark
(d)(ii)	 ALLOW any clear indication of chiral carbon		**1**

Question Number	Acceptable Answers	Reject	Mark
(d)(iii)	(A racemic mixture is) an equimolar mixture of the two enantiomers / (optical) isomers ALLOW (for equimolar mixture) equal amounts / concentrations / volumes / proportions OR 50:50 mixture	Just 'no effect on plane polarised light'	**1**

Q11.

Question Number	Acceptable Answer	Additional guidance	Mark
	• Balanced equation **(1)** • Appropriate colours **(1)**	Example of equation: $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ Allow multiples Orange colourless green colourless Allow 'No colour' for colourless Do not award 'blue' for 'green' Do not award 'clear' for colourless Do not award if any spaces left blank Ignore any colour given for electrons Ignore any shades of colour	**(2)**

Q12.

Question Number	Answer	Additional Guidance	Mark
(i)	Allow  	Diagram must be 3-dimensional with either wedges or dashes to score 2 marks Ignore orientation of group at the top Ignore vertical bond to H of OH group	**(2)**

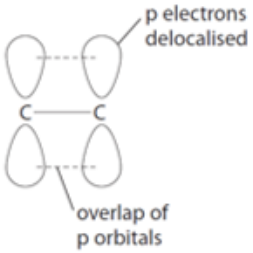
Question Number	Answer	Additional Guidance	Mark
(ii)	• They **rotate** the plane of plane-polarised light (equally) and in opposite/different directions OR Determine in which direction they **rotate** the plane of plane-polarised light	Allow one plane	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iii)	• Does not accumulate in the environment/does not occupy landfill	Accept answers that outline the benefit of avoiding other means of disposal such as incineration, use of toxic chemicals Ignore just less harm to environment/less harm to animal life/less pollution/less of an "eyesore"/less energy to break it down	**(1)**

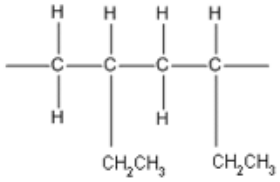
Q13.

Question Number	Acceptable Answer	Mark
	The only correct answer is **A** ***B*** *is incorrect because oxides of nitrogen are not black solids* ***C*** *is incorrect because oxides of sulfur are not black* ***D*** *is incorrect because unburnt hydrocarbons are not black solids*	**(1)**

Q14.

Question Number	Answer	Additional Guidance	Mark
	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**

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	• 2 repeat units with extension bonds	Example of two repeat units  The extension bonds can be solid / dotted / dashed Allow C_2H_5 for the side chains Allow ethyl groups on carbon atoms: 1 and 3, 2 and 4, 1 and 4 or 2 and 3 Allow skeletal formula / any combination of structural or displayed formulae Ignore brackets / n Ignore connectivity of vertical CH_2CH_3 groups	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation of moles of but-1-ene **(1)** • calculation of number of molecules of but-1-ene **(1)**	Example of calculation moles of but-1-ene = $\frac{70.0}{56.0}$ = 1.25 (mol) molecules of but-1-ene = 1.25 x 6.02 x10^{23} = 7.525 x 10^{23} TE on moles but-1-ene Ignore SF except 1 SF Do not award M2 for mass x 6.02 x10^{23} Correct answer with no working scores (2)	(2)

Q16.

Question Number	Answer	Additional Guidance	Mark
	A		1

Q17.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td></td>
<td>A description that makes reference to two of the following points:

• reagent (1)

• corresponding observation (1)</td>
<td>Examples of reagents and observations

<table>
<tr><th>Reagent</th><th>Observation</th></tr>
<tr><td>bromine water
Allow bromine (in an organic solvent)</td><td>orange / yellow / brown solution goes colourless
Allow bromine water is decolourised</td></tr>
<tr><td>carboxylic acid and (concentrated) H_2SO_4 / HCl / H^+</td><td>characteristic smell (of an ester)</td></tr>
<tr><td>acidified potassium manganate(VII) / permanganate</td><td>purple to colourless / decolourised</td></tr>
<tr><td>alkaline potassium manganate(VII)</td><td>purple to green</td></tr>
<tr><td>(neutral) potassium manganate(VII)</td><td>purple to brown ppt</td></tr>
<tr><td>acidified (potassium) dichromate((VI)) (ions)</td><td>orange to green</td></tr>
</table>

Allow names or formulae for reagents but if both are given, both must be correct

Ignore conditions e.g. heat

Do not award PCl_5 / Na

If more than one test is given, penalise any incorrect tests</td>
<td>(2)</td>
</tr>
</table>

Q18.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to the following points: (1) • reagent (1) • observation	Examples of reagents and observations Reagent / Observation any carbonate / $NaHCO_3$ / $KHCO_3$ (added to aqueous acid) / effervescence / fizzing / bubbles / gas evolved that turns limewater milky magnesium (added to aqueous acid) / effervescence / fizzing / bubbles / gas evolved that gives a pop with a lighted splint alcohol **and** (concentrated) H_2SO_4 / HCl / H^+ / characteristic smell (of an ester) Allow names or formulae for reagents but if both are given, both must be correct Ignore conditions e.g. heat Do not award PCl_5 / Na If more than one test is given, penalise any incorrect tests	(2)

Q19.

Question Number	Answer	Mark
(i)	**The only correct answer is A** (50 cm^3) ***B*** *is incorrect because this is the increase in volume from 200 cm^3 of ethane* ***C*** *is incorrect because this is the volume of CO_2 formed* ***D*** *is incorrect because this is the total volume of CO_2 and H_2O formed*	(1)

Question number	Answer	Additional Guidance	Mark
(ii)	• calculation of x **(1)** • calculation of y **(1)** • structure of cyclopentene **(1)**	Example of calculation (volume of CO_2 = 125 (cm^3) so x = 125/25) = 5 (25 + 25(5 + (y/4)) − 75 = 125) y = 8  Allow the skeletal formula of any cyclic C_5H_8 compound with C=C e.g. a methylcyclobutene TE on x and y for a cyclic hydrocarbon	(3)

Q20.

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	• **Raw materials** (1) – wood is renewable <u>and</u> polystyrene uses slightly more petroleum fractions • **Energy use** (1) – paper cup uses nearly 4x as much energy • **Water use** (1) – paper cup uses nearly 50x as much water • **Air emissions** (1) – paper cup produces chlorine and more sulfur dioxide both of which are toxic / acidic <u>and</u> polystyrene cup produces a lot of hydrocarbons		
	• **Justification** (2) – Selection of either cup with two valid reasons	For example: polystyrene is more sustainable, as although it uses up non-renewable raw materials, its production requires much less energy which is likely to save on fossil fuel use **or** paper is more sustainable, as no hydrocarbons are emitted into the atmosphere and the raw materials are renewable and use less petroleum fractions	**6**

Q21.

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>* (a)</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><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, 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></td>
</tr>
</table>

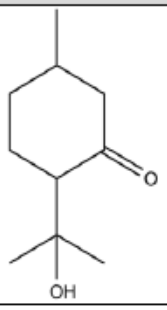
	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages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

Indicative Content:

- technique A allows heating for a longer time period / technique B is suitable for a shorter time period
- technique A ensures oxidation / technique B may result in loss of reactant before oxidation
- technique A minimises release of flammable **or** harmful vapours / technique B allows release of flammable **or** harmful vapours, unless carried out in fume cupboard
- technique A involves more expensive equipment **or** is more complex to set up / technique B is simpler to set up **or** uses less expensive equipment
- as complete oxidation is not necessary to qualitatively show it is an alcohol that can be oxidised
- technique B is most appropriate as simpler / technique A is most appropriate as oxidation is guaranteed

6

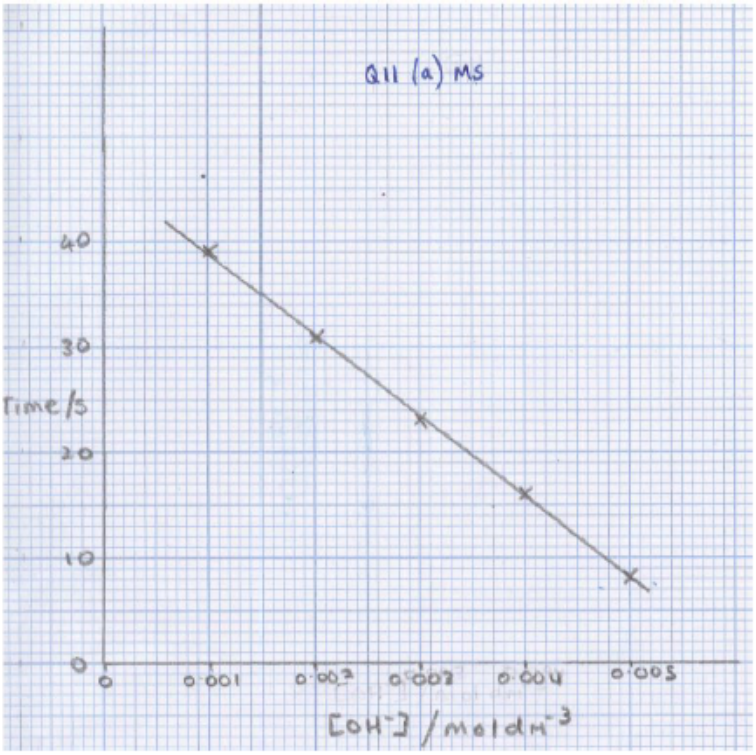
Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to the following pairs: **either** • no, as chloride ions could be oxidised by dichromate(VI) ions (reducing amount of oxidant / producing toxic chlorine) (1) • $E^{\ominus}$ values for dichromate(VI) and chloride ions being oxidised to chlorine are sufficiently close (even though $E^{\ominus}$ is negative = -0.03 V) for chlorine to be formed (1) **or** • yes, as reaction is dependent on H^+ ions (not anions) (1) • $E^{\ominus}$ value is negative (-0.03 V) (1)		**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)			**1**

Q22.

Question Number	Acceptable Answer	Additional guidance	Mark
	An answer that gives reference to the following • **(M1)** use of ethanol (as a solvent) **(1)** • **(M2)** use of silver nitrate (solution) **(1)** • **(M3)** equal amounts used of each halogenoalkane **(1)** • **(M4)** measure the time taken for precipitate to form **(1)** • **(M5)** use a water bath (to control a raised temperature) **(1)**	Allow "alcohol" Do not award ammoniacal silver nitrate Ignore use of nitric acid Allow equal volumes/equal stated volumes Allow "time for cross to disappear" Do not award for a colour to form. M4 dependent on M2 or near miss. If hydroxide (ions) used for hydrolysis then measuring the reaction is too quick, so no M4. The solution would need to be acidified before the addition of silver nitrate if M2 is to be awarded. If hydrochloric acid is used, then only M1, M3 and M5 can be scored	**(5)**

Q23.

Question Number	Answer	Additional Guidance	Mark
(a)	• **M1** axes labelled with units on axes, suitable uniform scale with points covering at least half the available space in both directions **(1)** • **M2** all points plotted correctly with straight line of best fit **(1)**	Example of graph  Allow variables on either axis	**(2)**

Question Number	Answer	Additional Guidance	Mark
(b)	An answer that makes reference to the following points • zero order with respect to hydroxide ions **(1)** • The graph is a straight line so the rate of reaction is independent of the concentration of the hydroxide ions **(1)**	M2 dependent on M1	**(2)**

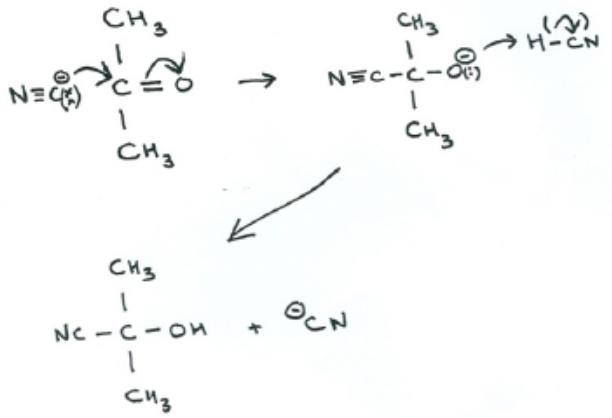
Question Number	Answer	Additional Guidance	Mark
(c)	An answer that makes reference to the following points • S_N1 **(1)** • as there is only one reactant in the rate determining step / as the hydroxide ions do not affect the rate **(1)**	Mark consequentially on order Allow TE from (b) e.g. if first order in (b) allow S_N2	**(2)**

Question Number	Answer	Additional Guidance	Mark
(d)	• the chloroalkane is tertiary	Allow TE from first order in (b) and/or S_N2 in (c) e.g. if S_N2 in (c) allow primary NOTE if first order wrt hydroxide ions in (b) but S_N1 given in (c) can score 1 mark in (d) for tertiary	(1)

Q24.

Question Number	Correct Answer	Reject	Mark
(a)(i)	Sodium/potassium dichromate ((VI)) **and** (Dilute/concentrated) sulfuric acid OR correct formulae / H^+ **and** $Cr_2O_7^{2-}$ ALLOW H^+ **and** $Cr_2O_7^{2-}$/acidified dichromate((VI)) **(1)** Reflux/distil Ignore 'heat', 'warm', and 'boil' alone. ALLOW Just 'under reflux' Just 'under distillation' **(1)** Second mark depends on mention of dichromate/$Cr_2O_7^{2-}$ in first part OR $KMnO_4$ and acid with heat **(1)**	Hydrochloric acid	2

Question Number	Correct Answer	Reject	Mark
(a)(ii)	Carbonyl group – addition of 2,4-dinitrophenylhydrazine / 2,4-DNP(H) / Brady's reagent **(1)** to give yellow/orange/red precipitate/ppt/ppte/solid/crystals ALLOW recognisable spelling e.g., percepitate **(1)** $CH_3C{=}O$ reaction with iodine in alkali/NaOH/KOH/OH^- ALLOW Iodoform/tri-iodomethane/haloform AND reaction/test **(1)** to form (pale) yellow / cloudy precipitate/solid/crystals **(1)** Ignore references to smell Ignore heat in either part	2-DNP/4DNP Just DNP Brick red ppt	4
	Note • In both cases result mark depends on test being recognisably correct even if it did not score a mark Examples: DNP gives yellow ppt Iodine test gives yellow ppt Tests for aldehydes with correct results, no marks		

Question Number	Correct Answer	Reject	Mark
(b)(i)			3
	Arrow (from carbon) of CN^- to carbon of C=O	CN without negative charge	
	AND		
	Arrow from part of C=O double bond to oxygen		
	ALLOW		
	Two steps via a charged canonical form **(1)**		
	Intermediate anion with C-CN bond. **(1)**		
	Arrow from resulting O^- to hydrogen of $HCN/H^+/H_2O$ **(1)**		
	Note	…C-NC bond	
	Arrow directions must be correct to score each mark		
	Penalise half-headed arrows each time in both parts		
	ALLOW skeletal formulae.		

Question Number	Correct Answer	Reject	Mark
(c)(i)	(Acid) hydrolysis OR Alkaline hydrolysis followed by acidification	Hydration	1

Question Number	Correct Answer	Reject	Mark
(b)(ii)	At low pH very few CN^- ions ALLOW No CN^- ions OR No KCN/ only HCN present **(1)** At high pH very few H^+ / HCN ALLOW No H^+ / HCN OR Hydroxide reacts with H^+ / HCN/ acid **(1)**		1

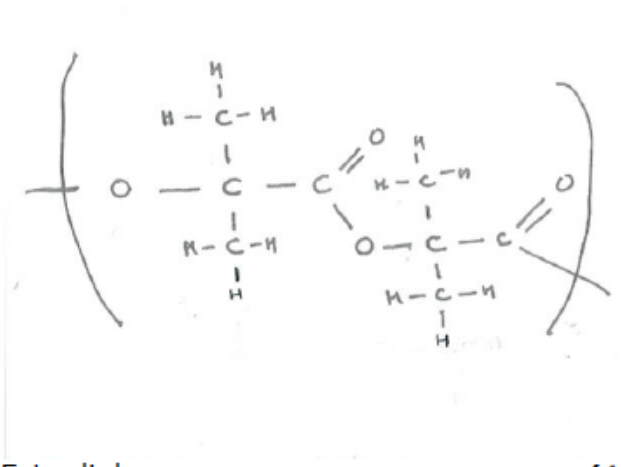
Question Number	Correct Answer	Reject	Mark
(c)(ii)	The O-H absorptions for alcohol and carboxylic acid overlap. OR OH absorption for an acid is very broad OR Quote data booklet values which must show some overlap, to include 3300 to 3200. ALLOW OH absorptions similar/the same.	Just 'both have OH groups' Just 'two OH groups present'	1

Question Number	Correct Answer	Reject	Mark
(c)(iii)	(Chemical shift □) 2.0 - 4.0 (ppm) / any value within this range e.g 3.1/ 3.12/3 ALLOW Correct number followed by□□, eg 3δ		1

Question Number	Correct Answer	Reject	Mark
(c)(iv)	3 (peaks) / three		1

Question Number	Correct Answer	Reject	Mark
(c)(v)	There is no hydrogen atom/proton on the adjacent/neighbouring carbon atom ALLOW No adjacent/neighbouring hydrogens/protons		1

Question Number	Correct Answer	Reject	Mark
(c)(vi)	(No) 2-hydroxy-2-methylpropanoic acid does not have a chiral centre OR It is not chiral OR It does not have a mirror image which is non-superimposable OR Does not have a carbon atom attached to four different groups	Yes...	1

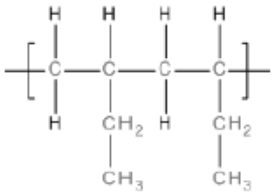
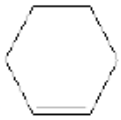
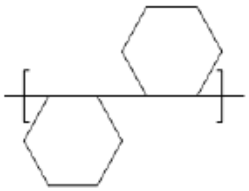
Question Number	Correct Answer	Reject	Mark
(d)(i)	 Ester linkage **(1)** Rest of molecule **(1)** ALLOW Attached chains as structural formulae Ignore n or other numbers outside bracket **COMMENT** Check formulae carefully – different carbon frameworks appear.		1

Question Number	Correct Answer	Reject	Mark
(d)(ii)	Ester		1

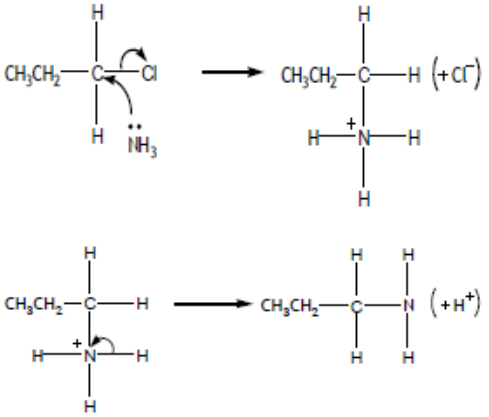
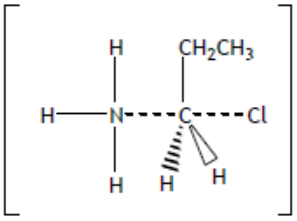
Q25.

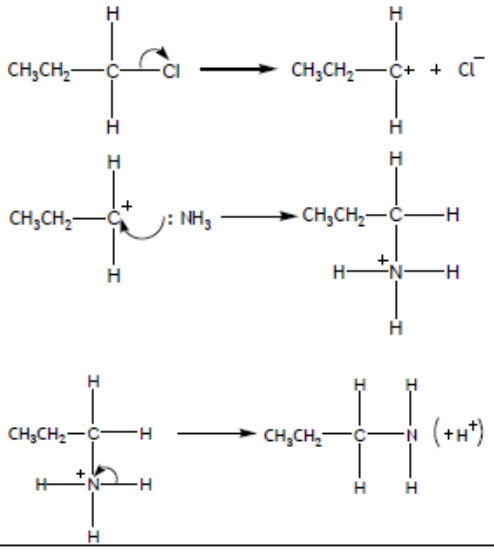
Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following: An advantage • release of energy/avoids landfill **(1)** A disadvantage • release of toxic fumes (of polycyclic aromatics) **(1)**	 Allow used to generate electricity Allow Release of benzene/carbon monoxide Release of carbon dioxide because of global warming / it's a greenhouse gas/ reduces recycling Release of carbon particulates increases respiratory problems Do not award damages the ozone layer Do not award references to acid rain Ignore just 'harmful' fumes	**(2)**

Q26.

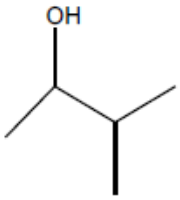
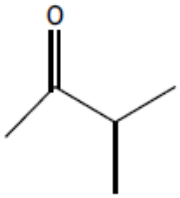
Question Number	Answer	Additional Guidance	Mark
	($CH_2=CHCH_2CH_3\rightarrow$)  **(1)** (→)  **(1)**	Accept skeletal, structural or displayed formulae or combination of which is clear, e.g. $-C_2H_5$ Brackets are not essential Ignore 'n' Ignore orientation of side chains Ignore bond length Ignore where bond goes to for the ethyl groups Penalise lack of 'end-bonds' once only Award 1 mark max if only one repeat unit given for each polymer Ignore more than 2 repeat units	**(2)**

Q27.

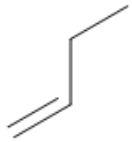
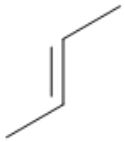
Question Number	Acceptable Answers	Additional Guidance	Mark
	• first two curly arrows and lone pair shown on the nitrogen **(1)** • structure of intermediate including positive charge **(1)** • third curly arrow and formation of final organic product **(1)**	Ignore correct dipoles Allow non-displayed NH_3^+ for MP2 Ignore involvement of Cl^- / NH_3 or wrong inorganic products for MP3 EITHER  Ignore depiction of transition state e.g. 	**(3)**

	OR • fission of C-Cl bond curly arrow **and** curly arrow from nitrogen in NH_3 with lone pair shown on N atom to correct carbocation **(1)** • structure of resulting nitrogen-containing intermediate including positive charge **(1)** • curly arrow resulting in breaking of an N-H bond and structure of the final organic product **(1)**	OR AWARD S_N1 mechanism 	

Q28.

Question Number	Acceptable Answers	Additional Guidance	Mark
	 **(1)**  **(1)**	Do not penalise 'connectivity' to OH unless O-H-C Allow O-H for OH Penalise non-skeletal formulae once only	**(2)**

Q29.

Question Number	Answer			Additional Guidance	Mark
	 **(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 If more than 3 skeletal formulae drawn then deduct one mark for each additional formula 2-methylpropene negates a correct formula only if four formulae given View any formulae given with skeletal formula as working and ignore Ignore names even if incorrect Penalise any other alkenes such as pentenes, once only	**(3)**

STEMUP.CO.UK

Q30.

Question Number	Acceptable Answer	Additional guidance	Mark
	An explanation that makes reference to the following • ethanol would be oxidised to ethanal **(1)** • because ethanal has a low boiling temperature **or** ethanal will distil before ethanoic acid can be formed **(1)**	Allow aldehyde for ethanal Allow ethanal will be formed Allow ethanal is (more) volatile Accept reverse argument in terms of reflux condensing ethanal for oxidation to ethanoic acid	**(2)**

Q31.

Question Number	Answer	Additional Guidance	Mark
(a)	**B** (hydrolysis of butanenitrile with dilute hydrochloric acid)		**1**

Question Number	Answer	Additional Guidance	Mark
(b)	**D** (CH_3COCl and $CH_3CH_2CH_2OH$)		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(i)	An answer that makes reference to the following points: • to separate (the esters)		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(ii)	An answer that makes reference to the following points: • to identify (the esters) (by determining the M_r / measuring the molecular ion's *m/z* to 4 dp / by fragmentation)		**1**

Q32.

Question Number	Acceptable Answers	Additional Guidance	Mark
	A synthetic pathway that includes: **Conversion to alcohol** • (aqueous ethanolic) potassium / sodium hydroxide **(1)** • name or structure of propan-1-ol **(1)** **EITHER ROUTE 1** **Conversion to carboxylic acid** • (oxidise some of the propan-1-ol using) potassium dichromate((VI)) **and** (dilute) sulfuric acid **(1)** • name or structure of propanoic acid **(1)** **Formation of ester** • react propan-1-ol and propanoic acid together **and** using (concentrated) sulfuric acid (catalyst) **(1)** **PTO for ROUTE 2**	Allow names or formulae for reagents but if both are given, both must be correct Allow correct species in unbalanced equations Allow any combination of structural, displayed or skeletal formulae for the intermediates Penalise missing H once only Ignore conditions e.g. heat / reflux Allow hydroxide ions / OH^- Ignore concentration Do not award just ethanol / ethanolic Stand alone mark e.g. $CH_3CH_2CH_2OH$ Allow propanol if correct structure shown somewhere Allow acidified potassium dichromate((VI)) / $Cr_2O_7^{2-}$ **and** H^+ Allow acidified manganate((VII)) Ignore concentration of acid / formation of aldehyde Do not award hydrochloric acid / HCl Stand alone mark e.g. CH_3CH_2COOH Stand alone mark for C_3 compounds Allow (concentrated hydrochloric) acid / H^+ / H_3O^+ instead of sulfuric acid Ignore concentration of acid Ignore incorrect structure of ester e.g. with H or O missing	**(5)**

	OR ROUTE 2 **Conversion to acyl chloride** • (oxidise some of the propan-1-ol using) potassium dichromate((VI)) **and** (dilute) sulfuric acid **and** add phosphorus(V) chloride to propanoic acid **(1)** • name or structure of propanoyl chloride **(1)** **Formation of ester** • react propan-1-ol and propanoyl chloride together **(1)**	Allow acidified potassium dichromate((VI)) / $Cr_2O_7^{2-}$ **and** H^+ Allow acidified manganate((VII)) Ignore concentration of acid / formation of aldehyde Do not award hydrochloric acid / HCl Stand alone mark e.g. CH_3CH_2COCl Stand alone mark for C_3 compounds Ignore incorrect structure of ester e.g. with H or O missing	

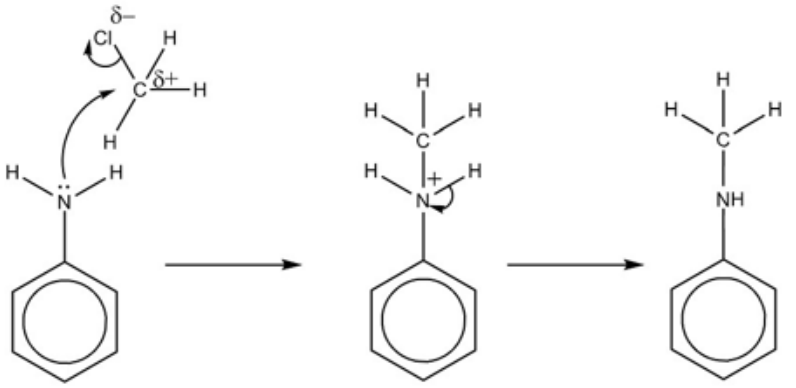
Q33.

Question Number	Answer	Mark
(i)	**The only correct answer is C** (fractional distillation) *A is incorrect because the process is used to produce smaller hydrocarbons* *B is incorrect because the process is used to produce branched and cyclic hydrocarbons* *D is incorrect because the process is used to heat reaction mixtures*	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to one of the following pairs of points Either • the OH groups (in compound **X**) can form hydrogen bonds **(1)** • so more energy is needed to vaporise compound **X** / break intermolecular forces in compound X **(1)** Or • hydrocarbons have only London forces, but compound **X** has hydrogen bonds (as well) **(1)** • hydrogen bonds are stronger (than London forces) **(1)**	Ignore references to dipole-dipole interactions Allow 'the oxygen (in compound X) can form hydrogen bonds') Allow 'more energy is needed to break bonds in compound **X**' if H bonds discussed Any reference to the breaking of **covalent** bonds loses M2 only	**(2)**

Q34.

Question Number	Answer	Mark
(i)	**The only correct answer is D** (nucleophilic substitution) **A** *is not correct because it is not electrophilic or addition* **B** *is not correct because it is not electrophilic* **C** *is not correct because it is not addition*	**(1)**

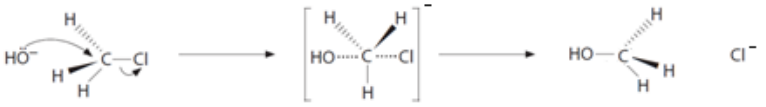
Question Number	Answer	Additional Guidance	Mark
(ii)	• **M1** arrow from lone pair on nitrogen atom to carbon atom (1) • **M2** dipole shown **and** arrow from C–Cl bond to Cl or just beyond (1) • **M3** formula of including intermediate the + charge on the N atom (1) • **M4** arrow from N-H bond to N^+ and formula of organic product (1)	Example of mechanism  (+ H^+ / HCl) **Comment** M2 is a stand alone mark Allow access to full marks for correct use of other halogenomethanes Ignore any SN2 transition states Ignore use of a second molecule of phenylamine behaving as a base	(4)

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following points: • **M1** dissolve (impure product) in a **minimum** volume of **hot** solvent (1) • **M2** cool (in ice) **or** leave to recrystallise (1) • **M3** filter using vacuum filtration / Buchner filtration / filter under suction (1) • **M4** dry solid in desiccator / between filter papers (1)	Allow any named solvent Ignore hot filtration after M1 Allow dry in a **warm** oven Ignore references to rinsing Do not award M4 if drying agent added to the crystals / solution	(4)

Q35.

Question Number	Answer	Mark
	The only correct answer is B (propan-1-ol) **A** *is not correct because it does not give hydrogen chloride when PCl_5 is added* **C** *is not correct because it does not give hydrogen chloride when PCl_5 is added* **D** *is not correct because it does not give hydrogen chloride when PCl_5 is added*	(1)

Q36.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>(a)</td><td>
• 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)</td><td>Arrow must start from O and go to C; lone pair not required

Arrow from bond to Cl

Ignore brackets</td><td>4</td></tr>
<tr><td>(b)(i)</td><td>3-bromo-3-methylhexane</td><td>3-methyl-3-bromohexane</td><td>1</td></tr>
<tr><td>*(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><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>
</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>

***(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

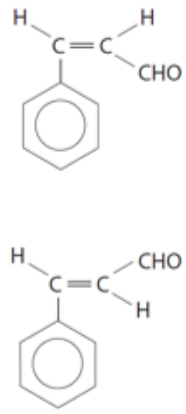
Could use labelled diagrams to illustrate attack of hydroxide ions in either mechanism

***(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

Q37.

Question Number	Answer	Additional guidance	Mark
(b)(i)	• contains C=C/alkene		1
(b)(ii)	• contains carbonyl group/ aldehyde or ketone	C=O alone	1
(b)(iii)	• aldehyde/ -CHO		1
(c)(i)	• 77 $C_6H_5^+$ (1) • 103 $C_8H_7^+$ (1)	Must show a charge but only penalise omission once Allow structural, displayed or skeletal formulae	2
(c)(ii)	 	Allow non-displayed benzene C-Hs	2
(c)(iii)	• The peak is due to the presence of an atom of a (^{13}C) isotope	Allow reference to other named isotope of H or O	1

Q38.

Question Number	Acceptable Answers	Additional Guidance	Mark
	An answer that makes reference to the following points: • (First change) Adjust so that the flow of water goes in at the bottom of the condenser and out at the top of the condenser **(1)** • (Reason) Keeps condenser full of water / water removes (any) air in the condenser / allows more efficient / better cooling / prevents 'air-lock' **(1)** • (Second change) (Replace funnel and) seal with a thermometer or a stopper **(1)** • (Reason) Prevents vapour / gas / product / reactants escaping **(1)**	First and second change can be in either order Ignore prior refluxing Ignore water bath Allow just "water should enter the condenser at the bottom" OR Just "water should leave at the top" OR Just "swap the tubes around" Allow replacing the funnel with a tap / dropping funnel Ignore thermometers used to measure boiling temperatures	**(4)**

Q39.

Question Number	Answer	Mark
	The only correct answer is B (4-ethyl-3-methylheptane) ***A*** *is not correct because the longest consecutive carbon chain involves the seven carbon atoms from the top left of the molecular drawing down to the bottom right which means that the stem of the name is not pentane but heptane, with the consequential effect on the numbering and length of side chains* ***C*** *is not correct because the longest consecutive carbon chain involves the seven carbon atoms from the top left of the molecular drawing down to the bottom right which means that the stem of the name is not hexane but heptane, with the consequential effect on the numbering and length of side chains* ***D*** *is not correct because the longest consecutive carbon chain involves the seven carbon atoms from the top left of the molecular drawing down to the bottom right which means that the stem of the name is not hexane but heptane, with the consequential effect on the numbering and length of side chains*	**(1)**

Q40.

Question Number	Answer	Mark
	The only correct answer is D (free radical substitution) ***A*** *is not correct because electrophilic addition would be the reaction mechanism between alkenes, such as ethene, and chlorine but the substance in the question is the alkane, ethane* ***B*** *is not correct because electrophilic substitution involves the reactions of aromatic systems but this question refers to the reaction of the alkane, ethane* ***C*** *is not correct because the mechanism of reaction between an alkane such as ethane and chlorine involves substitution and not addition*	**(1)**

Q41.

Question number	Answer	Mark
	The only correct answer is D (C_6H_{14}) ***A*** *is incorrect because this has general formula* C_nH_n *and non-cyclic, saturated hydrocarbons have the general formula* C_nH_{2n+2} ***B*** *is incorrect because this has general formula* C_nH_{2n-2} *and non-cyclic, saturated hydrocarbons have the general formula* C_nH_{2n+2} ***C*** *is incorrect because this has general formula* C_nH_{2n} *and non-cyclic, saturated hydrocarbons have the general formula* C_nH_{2n+2}	**(1)**

Q42.

Question Number	Correct Answer	Reject	Mark
	A		**1**

Q43.

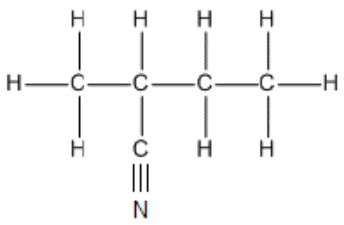
Question Number	Correct Answer	Reject	Mark
	C		1

Q44.

Question Number	Answer	Mark
	The only correct answer is A (4-ethyloctane) *B is incorrect because the position of the ethyl group should be shown by counting in the direction that gives the lowest possible number* *C is incorrect because the longest carbon chain has 8 carbons* *D is incorrect because the longest carbon chain has 8 carbons and because the position of the alkyl group should be shown by counting in the direction that gives the lowest possible number*	**(1)**

Q45.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(i)	NH_3	Do not allow just the name ammonia	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(ii)		Do not award skeletal/structural formulae or a combination of these	**1**

Question Number	Answer	Additional Guidance	Mark
(b)	**A** (the C-Cl bond has a higher bond enthalpy than the C-Br bond)		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(i)	An answer that makes reference to the following points: • hydroxide ions are nucleophiles as they donate a (lone) pair of electrons (to form a covalent bond) (1) • substitution because OH replaces the halogen atom (in the molecule) (1)		**2**

Question Number	Answer	Additional Guidance	Mark
(c)(ii)	**D** (2-bromo-2-methylpropane, 2-bromobutane, 1-bromobutane)		**1**

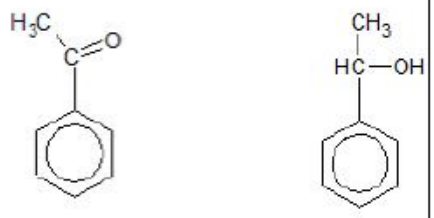
Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(iii)	An answer that makes reference to the following points: • rate = k[$(CH_3)_3CBr$] / rate = k[$(CH_3)_3CBr$]^1 (1) • only the reactants/$(CH_3)_3CBr$ in the slow/rate determining step appear in the rate equation (1)		**2**

Q46.

Question Number	Answer	Additional Guidance	Mark
	• calculation of moles of Br_2 **(1)** • calculation of moles of limonene **(1)** • calculation of mass of limonene **(1)** • calculation of percentage of limonene **and** answer given to 2 or 3 SF **(1)**	Example of calculation moles of Br_2 = $\frac{30.6 \times 0.200}{1000}$ = 0.00612 / 6.12×10^{-3} moles of limonene = $\frac{0.00612}{2}$ = 0.00306 / 3.06×10^{-3} TE on moles of Br_2 molar mass of limonene = 136 (g mol^{-1}) **and** mass of limonene in oil = 0.00306 x 136 = 0.41616 (g) TE on moles of Br_2 percentage of limonene = $\frac{0.41616}{0.500} \times 100$ (= 83.232(%)) = 83/83.2(%) TE on mass of limonene provided answer is less than 100% with 0.500 as denominator Correct answer with no working scores (4)	**(4)**

Q47.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following: synthetic pathway that consists of: (Step 1) • (acylation of benzene) using ethanoyl chloride **(1)** • use of aluminium chloride (and heat) **(1)** (Step 2) • (reduction of) **A** with $LiAlH_4$ in ether (dry) **(1)** (Step 3) • (dehydration of) **B** with (conc.) phosphoric acid/H_3PO_4 **(1)** (Intermediates) • identification of **A** as phenylethanone and **B** as (1-)phenylethanol	The compounds used can be stated or given within equations. Only award if part of a Friedel-Crafts reaction Only award if given to reduce an aromatic carbonyl or carboxylic acid Allow (conc.) sulfuric acid/ H_2SO_4 Only award if given to dehydrate an aromatic alcohol Accept formulae for names, but if both given, then both must be correct This also applies to reagents	**(5)**

	 **(1)**	Do not award use of other reagents not in the table.	

Q48.

Question Number	Answer	Additional Guidance	Mark
(i)	**C** (homolytic fission)		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	• $CH_3CH_2CH_3 + Cl\cdot \rightarrow CH_3CH\cdot CH_3 + HCl$ (1)	Allow 1 mark for two correct equations forming 1-chloropropane	
	• $CH_3CH\cdot CH_3 + Cl_2 \rightarrow CH_3CHClCH_3 + Cl\cdot$ (1)	Allow one mark for two correct equations using molecular formula of propane forming C_3H_7Cl	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following points: • the chlorine radical can remove a hydrogen from anywhere in the propane molecule (1) • so a mixture of products is formed (1)	e.g. 1-chloropropane / 1,2-dichloropropane	**2**

Q49.

Question Number	Answer	Additional Guidance	Mark
(i)	C		**1**
(ii)	C		**1**

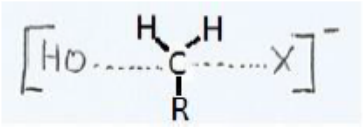
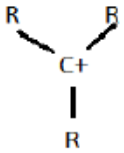
Q50.

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td></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 an overall score of 3 marks (3 marks for indicative content and zero marks for linkages).</td>
<td>(6)</td>
</tr>
</table>

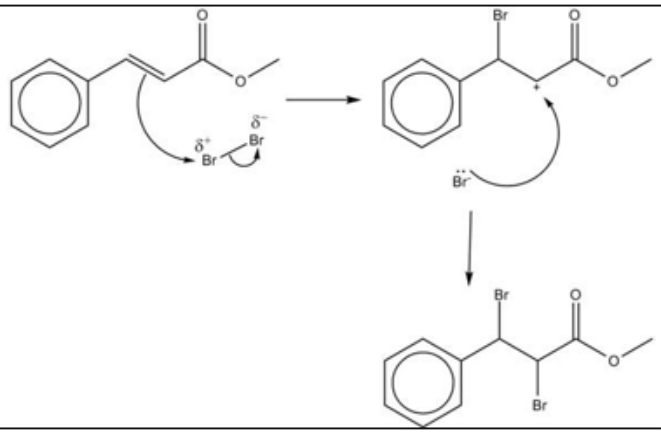
		Number of marks awarded for structure of answer and sustained lines of reasoning	In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning. If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s). More than one indicative marking point may be made within the same comment or explanation	
	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		
	Indicative content • (similarity)(both) are nucleophilic substitution **(1)** • Hydrolysis mechanism for RCH_2X/primary is S_N2 via a transition state **and** R_3CX/tertiary is S_N1 via a carbocation/intermediate **(1)**		Words needed at least once provided S_N1 and S_N2 are given	

	• RCH_2X and OH^- in the RDS **(1)** • R_3CX only in the RDS **(1)** • (RCH_2X forms a transition state with OH^-) diagram, including dotted lines and charge **(1)** • (R_3CX forms a carbocation / intermediate) diagram, including charge **(1)**	Allow "both/two species in the RDS" Allow correct rate equations for IP3 and IP4  Allow "-" either on the "OH" or the "X" Ignore point of attachment of OH Ignore dipoles within structure  Ignore shape Ignore references to comparative rates of reaction between 1° and 3° even if incorrect Ignore references to optical activity.	

Q51.

Question Number	Answer	Additional Guidance	Mark
(i)	• **M1** arrow from double bond to (δ+)Br in Br_2 (1) • **M2** arrow from bond in Br_2 to $Br^{\delta-}$ (1) • **M3** structure of carbocation (1) • **M4** arrow from **lone pair** on Br^- to C^+ in carbocation **and** final product (1)	Example of mechanism **See below** Penalise lack of dipole only once in M1 and M2 Award C^+ in intermediate on either C from the double bond Do not award M3 if four bonds are shown on carbocation Br atoms can be shown either upwards or downwards in final product Award (0) if just electrophilic substitution mechanism given. If **both** electrophilic substitution and addition shown allow 2 max Penalise errors in structure of methyl cinnamate once only in either M3 or M4	(4)

Example of mechanism



Question Number	Answer	Mark
(ii)	**The only correct answer is C (4)** **A** *is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms* **B** *is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms* **D** *is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms*	(1)

Question Number	Answer	Mark
(iii)	**The only correct answer is D** (rotated) **A** *is not correct because diffracted is the wrong term* **B** *is not correct because reflected is the wrong term* **C** *is not correct because refracted is the wrong term*	**(1)**

Q52.

Question Number	Acceptable Answer	Mark
	The only correct answer is **C** ***A*** *is incorrect because* there are not 22 hydrogen atoms ***B*** *is incorrect because* there are not 20 hydrogen atoms ***D*** *is incorrect because* there are not 16 hydrogen atoms	**(1)**

Q53.

Question Number	Answer	Additional Guidance	Mark
(i)	**C** (C_7H_{14})		**1**

Question Number	Answer	Additional Guidance	Mark
(ii)	**C** (C_7H_{12})		**1**

Mark Scheme

Q1.

Question Number	Correct Answer	Reject	Mark
	D		1

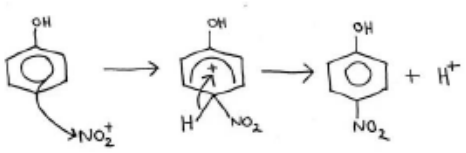
Q2.

Question Number	Answer	Additional Guidance	Mark
	• Name of the three functional groups **(2)**	Alcohol / diol, ester and alkene Allow hydroxy / hydroxyl (group) for alcohol Ignore primary Do not award incorrect structures of functional groups in conjunction with correct name Do not award secondary or tertiary alcohol Three correct functional groups scores (2) Two correct functional groups scores (1) One or zero correct functional groups (0) Four groups named with three correct scores (1)	**(2)**

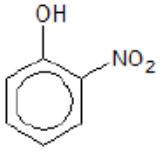
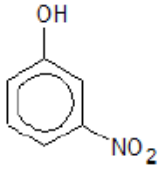
Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	A		**1**
(ii)	D		**1**

Q4.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An answer that makes reference to • Electron pair movement from ring to electrophile **(1)** • Formula of intermediate ion **(1)** • Curly arrow from C-H bond to reform delocalised ring and correct final structure with H^+ also formed **(1)**	Allow arrow that starts from anywhere within the hexagon but it must go to the nitrogen of the ion 'Horseshoe' to cover at least three carbon atoms, facing the tetrahedral carbon and part of the + sign to be inside the 'horseshoe' Do not award '+' charge on the tetrahedral carbon Do not award dotted bonds unless part of a 3D structure Curly arrow to go from the bond to anywhere inside the ring Accept the drawing of HSO_4^- to remove the H from the ring as long as H_2SO_4 is given as the product instead of H^+ Exemplar mechanism  Do not penalise attachment of OH/NO_2 to benzene ring Penalise incorrect product: 1 mark	(3)

Question Number	Acceptable Answer	Mark
(ii)	The only correct answer is **B** ***A*** *is incorrect because this is 15% of the mass of the starting material* ***C*** *is incorrect because this is the percentage of the starting mass over the max mass of product* ***D*** *is incorrect because this is 100% yield and not 15%*	(1)

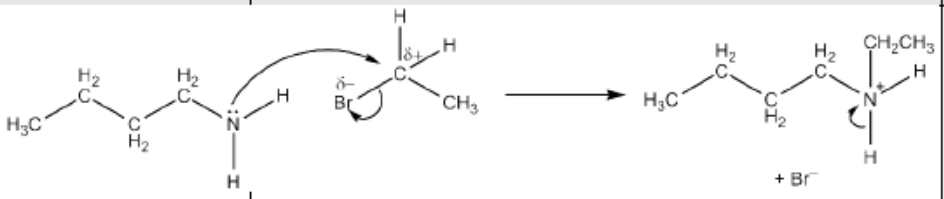
Question Number		Additional Guidance	Mark
(iii)	 **and** 	Ignore connectivity of OH/NO_2	(1)

Q5.

Question Number	Answer	Mark
	The only correct answer is A (*E*-2-methylbut-2-enoic acid) ***B*** *is incorrect because the two high priority groups are on opposite sides* ***C*** *is incorrect because the methyl group is on carbon 2* ***D*** *is incorrect because the two high priority groups are on opposite sides and the methyl group is on carbon 2*	**(1)**

Q6.

Question Number	Answer	Mark
(i)	**The only correct answer is D** (nucleophilic substitution) ***A*** *is incorrect because the reaction is not an addition or electrophilic* ***B*** *is incorrect because the attacking species is not an electrophile* ***C*** *is incorrect because the reaction is not an addition*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	 • arrow from lone pair on nitrogen atom to carbon atom (1) • dipole shown **and** arrow from C-Br bond to Br or just beyond (1) • formula of intermediate including + charge on the N atom and Br^- (1) • arrow from N-H bond to N^+ (1)	Ignore transition state Ignore arrow from Br^- ion to H in intermediate	(4)

Q7.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following point: • (hydroxide ions in ethanol would give an) elimination reaction	Allow an alkene would form Ignore references to solubility in ethanol / ethanol is a (co-)solvent Ignore just 'causes another reaction'	(1)

Q8.

(a)	B		**1**

Question Number	Correct Answer	Reject	Mark
(b)	C		**1**

Question Number	Correct Answer	Reject	Mark
(c)	D		**1**

Question Number	Correct Answer	Reject	Mark
(d)	A		**1**

Q9.

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

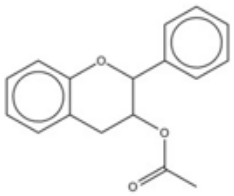
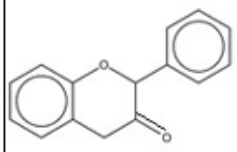
Typically

Number of IPs Reasoning mark

6 or 5 scores 2

4 or 3 scores 1

2 or 1 or 0 scores 0</td>
<td>(6)</td>
</tr>
</table>

	Indicative content • **IP1** any mention of **oxidation** of ethanol **or oxidation** of flavan-3-ol (by oxygen in the air) • **IP2** for formation of **either** ethanoic acid **or** ethanal (from ethanol) • **IP3** for formation of ethyl ethanoate (from the reaction between ethanol and ethanoic acid) • **IP4** for structure / name of flavan-3-one • **IP5** for (-OH group on) flavan-3-ol forms an ester with ethanoic acid • **IP6** correct structure of the ester formed between flavan-3-ol and ethanoic acid  **This is the structure of the ester formed between flavan-3-ol and ethanoic acid**	Allow names or formulae **but** if both are given **both** must be correct  **Comment** For correct structure of the ester formed between flavan-3-ol and ethanoic acid award both **IP5** and **IP6** Do not award IP4 if the product is described as an aldehyde	

Q10.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	$C_5H_{12}O + [O] \rightarrow C_5H_{10}O + H_2O$ • left-hand side of equation correct **(1)** • right-hand side of equation correct **(1)**	**Molecular** formulae must be used throughout Allow [O] above the arrow Do not award for $C_5H_{11}OH$ as the alcohol Ignore state symbols if incorrect or conditions mentioned	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	• calculation of moles of both of $C_5H_{10}O$ and $C_5H_{12}O$ **(1)** • calculation of mass of $C_5H_{12}O$ **(1)** OR • calculation of theoretical mass of $C_5H_{10}O$ **and** moles of $C_5H_{10}O$ **(1)** • calculation of mass of $C_5H_{12}O$ **(1)**	Example of calculation Moles $C_5H_{10}O = \frac{2.15}{86.0} = 0.025(0)$ (mol) **and** moles $C_5H_{12}O = \frac{0.025(0)}{62.5} \times 100 = 0.04(00)$ (So) mass of $C_5H_{12}O = 0.04(00) \times 88 = 3.52$ g Theoretical mass $C_5H_{10}O = \frac{2.15}{62.5} \times 100 = 3.44$ g **and** moles $C_5H_{10}O = \frac{3.44}{86.0} = 0.04(00) =$ mol $C_5H_{12}O$ (So) mass of $C_5H_{12}O = 0.04(00) \times 88 = 3.52$ g Correct answer with no working scores (2) Allow TE from MP1 Award 1 mark for 3.36 g, 1.375 g or 2.2 g	**(2)**

Q11.

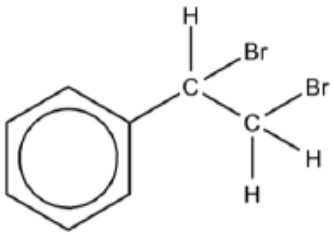
Question Number	Answer	Additional Guidance	Mark
(i)	• $C_8H_9NO_2$	Allow the symbols, with subscripts, in any order e.g. $C_8H_9O_2N$ Allow large numbers but not superscripts Ignore any other formulae as working	(1)

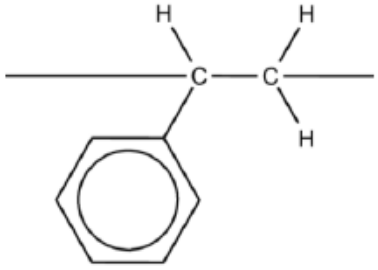
Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation of amount of Ce^{4+} (1) • calculation of amount of paracetamol in 25.0 cm^3 (1) • calculation of amount of paracetamol in 100.0 cm^3 (1) • calculation of molar mass of paracetamol **and** mass of paracetamol in 1 tablet (1) • calculation of percentage of paracetamol in 1 tablet **and** conclusion	Example of calculation amount Ce^{4+} used = $\frac{16.5 \times 0.100}{1000}$ = 0.00165 / 1.65 x 10^{-3} (mol) amount paracetamol in 25.0 cm^3 = $\frac{0.00165}{2}$ = 0.000825 / 8.25 x 10^{-4} (mol) TE on M1 amount paracetamol in 100.0 cm^3 = 4 x 0.000825 = 0.00330 / 3.30 x 10^{-3} (mol) TE on M2 molar mass of paracetamol, $C_8H_9NO_2$ = (8 x 12) + (9 x 1) + 14 + (2 x 16) = 151 **and** mass of paracetamol in 1 tablet = 0.00330 x 151 = 0.4983 g TE on M3 and (d)(i) percentage of paracetamol = $\frac{0.4983}{0.500}$ x 100 = 99.66 (%) **and** the tablet was from Brand **R** TE on M4 provided M4 < 0.500 g Ignore SF except 1 SF	(5)

Q12.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• orange to colourless	Allow brown / yellow to colourless	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	A explanation that makes reference to the following points: • becomes polar / forms temporary dipole (1) • as electron density in C=C bond repels bond pair (of electrons in bromine) (1)	Polar bromine can be shown by using a diagram e.g. $\overset{\delta+}{Br}—\overset{\delta-}{Br}$	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	• addition (1) • structure (1)	Example of structure: 	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iv)		Ignore addition of square brackets and n	**1**

Q13.

Question Number	Answer	Additional guidance	Mark
	$nC_6H_5CH{=}CH_2 \rightarrow \{CH(C_6H_5){-}CH_2\}_n$ • correct product formula (1) • balanced equation (1)		2

Q14.

Question Number	Answer	Additional Guidance	Mark
*	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. Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points 6 / 4 5-4 / 3 3-2 / 2 1 / 1 0 / 0 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 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	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 an overall score of 3 marks (3 marks for indicative content and zero marks for linkages).	(6)

STEMUP.CO.UK

	Indicative content • **IP1** in both cases many monomers join (by covalent bonds to form polymers) • **IP2** cyclohexene forms an addition polymer / the polymer is formed by an addition reaction • **IP3** 4-hydroxycyclohexanecarboxylic acid forms a condensation polymer / the polymer is formed by a condensation reaction • **IP4** no additional products from when cyclohexene polymerises, but water is also formed when 4-hydroxycyclohexanecarboxylic acid polymerises • **IP5** • **IP6**  	Allow both polymerisations require a catalyst Allow both polymers are formed from a single type of monomer Allow unsaturated monomer forms saturated polymer Allow 'only 1 product in addition but two products in condensation' Allow only one functional group is needed for addition polymerisation but two different functional groups are needed for condensation polymerisation Allow cyclohexene polymerisation has 100% atom economy, 4-hydroxycyclohexanecarboxylic polymerisation has less than 100% atom economy Ignore omitted or misplaced n in **IP5** and **IP6** Allow 1 IP for IP5 and IP6 if both correct repeat units shown Allow 2 oxygen atoms on RHS and none on LHS for IP6 repeat unit	

Q15.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following points • recycling (1) • incineration to release energy / generate electricity (1) • use as a feedstock (for cracking) (1)	Allow re-use Allow 'use as a fuel' Allow 'break down into monomers' / 'hydrolyse to form monomers' / 'break down to form small(er) molecules' Ignore 'remove toxic waste gases from incineration' / developing biodegradable polymers	(3)

Q16.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	An answer that makes reference to the following points: • cool the mixture because the reaction (with concentrated sulfuric acid / H_2SO_4) is (very) exothermic / releases (a lot of) heat **(1)** • anti-bumping granules are added to prevent violent / sudden / localised boiling **or** to prevent superheating / large bubbles forming **or** to promote smooth / even / controlled boiling **or** to promote the formation of small bubbles **or** to provide nucleation centres / (rough) surface for bubble formation **(1)** • heating under reflux is used to prevent the loss of any volatile substances / volatile reactants / volatile products / organic compound / named organic compound **or** to make sure the vapour / gas condenses **or** to prevent vapour escaping **(1)**	Ignore reaction is violent / to prevent splashing / to slow down the reaction / to stop reactants evaporating Do not award to quench the reaction / reference to explosion Ignore to stop bumping / spitting / explosion / liquid splashing out / vigorous reaction / loss of reactants / to distribute heat more evenly / any reference to rate / to promote smooth heating Allow so that the reaction goes to completion Ignore just 'to prevent gas escaping' / just 'to prevent loss of reactants / products' / just 'reactants / products are volatile' / 'because 1-bromobutane / butan-1-ol is flammable' / to increase yield / reference to safety Do not award for reference to oxidation or reduction	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	An answer that makes reference to the following points: • there is a gap between the condenser and the flask / seal the joint between the flask and condenser **and** so vapour / gas / reactants / products will escape **(1)** • the water is flowing the wrong way through the condenser / the water should go in at the bottom (and out at the top) **and** so it doesn't fill with water / is only part filled /there is an airlock **(1)** • there is a stopper on the condenser / there should not be a stopper on the condenser **and** so there will be a build-up of pressure (if the gap between condenser and flask is closed) **(1)**	Allow answers shown on annotated diagram e.g. gap circled Ignore any additional errors Ignore additional suggested modifications even if incorrect Do not award just 'the apparatus is not sealed' unless it is clear it means between the condenser and flask Allow so this will lower the yield of product / 1-bromobutane Ignore condenser is fitted the wrong way up Allow so there will be inefficient condensation / cooling Allow so the stopper will blow off / there will be an explosion / it will be dangerous	(3)

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(iii)	An explanation that makes reference to the following points: • (brown vapour / it) is bromine / Br_2 **(1)** • bromide ions / Br^- / HBr oxidised (by concentrated sulfuric acid) **(1)**	Stand alone mark Do not award just 'Br' Do not award any other brown gas in addition to bromine Allow bromide ions / Br^- / HBr reduce sulfuric acid / act as a reducing agent Ignore sodium bromide / NaBr is oxidised Ignore just 'redox reaction' Do not award bromine is oxidised Do not award oxidation by anything other than sulfuric acid	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(i)	An answer that makes reference to the following: • aqueous layer is on the top **and** because water / it has a lower density than 1-bromobutane	Allow 'it' for aqueous layer Allow because 1-bromobutane has a higher density than water Ignore reference to butanol unless in a third layer Do not award water is 'lighter' Do not award reference to three layers	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(ii)	An answer that makes reference to the following points: Step **8** • (aqueous sodium hydrogencarbonate / $NaHCO_3$) reacts with / neutralises / removes the (hydrochloric) acid / H^+ (ions) in the mixture **(1)** Step **9** • (the tap is opened) to release the carbon dioxide / gas (formed) **or** to allow the carbon dioxide / gas to escape **or** to prevent the build-up of pressure **(1)** Step **10** • (anhydrous sodium sulfate is added) to remove / absorb water **(1)**	Do not award reacts with incorrect acid e.g. H_2SO_4 / HBr / ethanoic acid Ignore removes water Do not award an incorrect gas e.g. hydrogen Allow (anhydrous) sodium sulfate is a drying agent / added to dry the product Do not award dehydration / reacts with water	(3)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(iii)	• starting temperature 99 or 100 or 101 (°C) **and** final temperature 103 or 104 or 105 (°C)	Do not award just one value / 102 (°C) Do not award 102 (°C) with another temperature	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(iv)	• calculation of mol of 1- bromobutane **(1)** • calculation of number of molecules **and** answer to 2/3 SF **(1)**	Example of calculation mol of 1-bromobutane = $\frac{12.0 \times 1.27}{136.9}$ = 0.11132 (mol) Do not award 0.1 number of molecules = $0.11132 \times 6.02 \times 10^{23}$ = 6.7×10^{22} / 6.70×10^{22} TE on a calculated mol 1-bromobutane using M_r Correct answer to 2 or 3 SF with no working scores (2)	**(2)**

Q17.

Question Number	Answer	Mark
	The only correct answer is A (red phosphorus) **B** *is not correct because it will not form iodoalkanes with iodine and alcohols* **C** *is not correct because it will not form iodoalkanes with iodine and alcohols* **D** *is not correct because it will not form iodoalkanes with iodine and alcohols*	**(1)**

Q18.

Question Number	Answer	Mark
	The only correct answer is D (cracking) *A is incorrect because substitution would exchange atoms/groups in the reactant for other atoms/groups* *B is incorrect because reforming would produce branched/cyclic alkanes* *C is incorrect because fractional distillation would separate a mixture of alkanes*	**(1)**

Q19.

Question Number	Acceptable Answer	Mark
	The only correct answer is **B** ***A*** *is incorrect because this is an oxidising agent for alcohols not alkenes* ***C*** *is incorrect because this would not react* ***D*** *is incorrect because this would only produce an alcohol*	**(1)**

Q20.

Question Number	Correct Answer	Reject	Mark
(a)	B		**1**

Question Number	Correct Answer	Reject	Mark
(b)	C		**1**

Question Number	Correct Answer	Reject	Mark
(c)	A		**1**

Question Number	Correct Answer	Reject	Mark
(d)	D		**1**

Q21.

Question Number	Correct Answer	Reject	Mark
(a)	B		1

Question number	Correct Answer	Rejecct	Mark
(b)	D		1

Question Number	Correct Answer	Reject	Mark
(c)	D		1

Question Number	Correct Answer	Reject	Mark
(d)	A		1

Q22.

Question Number	Answer	Additional Guidance	Mark
(i)	**B** (alcohol **Q**)		**1**

Question Number	Answer	Additional Guidance	Mark
(ii)	**C** (alcohols **P, R** and **S** only)		**1**

Question Number	Answer	Additional Guidance	Mark
(iii)	**C** (alcohol **R**)		**1**

Q23.

Question Number	Correct Answer	Reject	Mark
(a)	D		1

Question Number	Correct Answer	Reject	Mark
(b)	C		1

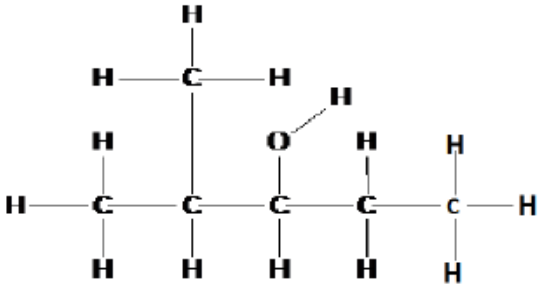
Question Number	Correct Answer	Reject	Mark
(c)	A		1

Question Number	Correct Answer	Reject	Mark
(d)	C		1

Question Number	Correct Answer	Reject	Mark
(e)	B		1

Q24.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)	C atom of C–Mg bond labelled as δ– **and** Mg labelled as δ+	Do not award full + or – charge Ignore δ- on Br	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(i)		Ignore other structures Allow non-displayed formula	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(ii)	• 2-methylpentan-3-ol	Allow 2-methyl-3-pentanol No TE on incorrect formula from 5(b)(i)	(1)

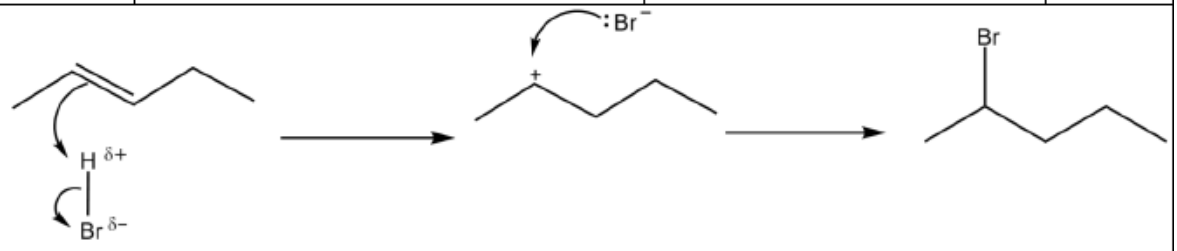
Question Number	Acceptable Answers	Additional Guidance	Mark
(c)	• ✓ next to nucleophile **(1)** • ✓ next to reducing agent **(1)**	If more than two boxes ticked scores (0)	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)	• propane / C_3H_8	Accept name or formula or structural / skeletal / displayed formula Ignore additional inorganic products Do not award just 'alkane' If name and formula given then they both must be correct	(1)

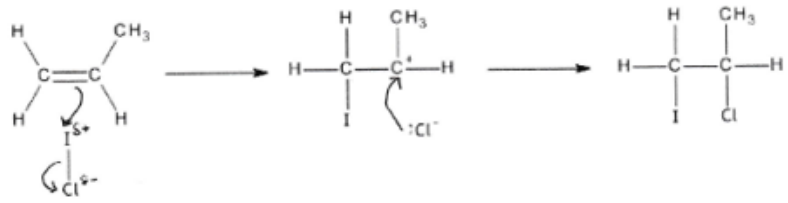
Q25.

Question Number	Correct Answer	Reject	Mark
	A		**1**

Q26.

Question Number	Answer	Additional Guidance	Mark
	• arrow from double bond to ∂+ H in HBr (1) • arrow from bond in HBr to $Br^{\partial-}$ (1) • structure of carbocation (1) • arrow from lone pair on Br^- to C^+ in carbocation and final products (1)	Penalise lack of dipole only once in M1 or M2 Do not award M1 if arrow from C=C to C also shown Formation of 3-bromopropane can potentially score M1, M2 and M4 as a TE	(4)
			

Q27.

Question Number	Answer	Additional Guidance	Mark
	• dipole on I-Cl **and** correct major product **(1)** • curly arrow from C=C to I **and** curly arrow from I-Cl to, or just beyond, Cl **(1)** • intermediate **(1)** • lone pair on Cl^- **and** curly arrow from **lone pair** to C^+ **(1)**	Example of mechanism  Do not award $C^{\delta+}$ on intermediate Allow curly arrow from lone pair to $C^{\delta+}$ if penalised in M3 **Notes** If minor product formed, M2, M3 (with I on other carbon atom) and M4 can score If dipole shows $Cl^{\delta+}$ or no dipole shown and Cl joining first, M2 can score for curly arrow from C=C to Cl **and** curly arrow from Cl-I to, or just beyond, I and M4 can score for lone pair on I^- **and** curly arrow from lone pair to C^+	**(4)**

Q28.

Question Number	Acceptable Answer	Mark
	The only correct answer is **D** ***A*** *is incorrect because it is not an addition reaction* ***B*** *is incorrect because no multiple bond is formed* ***C*** *is incorrect because initiation is only the first stage in the mechanism of the reaction*	**(1)**

Q29.

Question Number	Acceptable Answer	Mark
	The only correct answer is **D** ***A*** *is incorrect because no alkenes are produced* ***B*** *is incorrect because hydrogen is formed* ***C*** *is incorrect because the molecular formulae of the organic compounds are not the same*	**(1)**

Q30.

Question Number	Answer	Additional Guidance	Mark
(i)	Correct equation	$2NO + 2CO \rightarrow N_2 + 2CO_2$ Accept multiples Ignore catalysts and conditions if stated	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	A description that makes reference to the following points:	Absence of reference to the catalytic surface results in a deduction of one mark	**(3)**
	• **adsorption** of gases to catalytic surface **(1)**	Do not award absorption or "stick"	
	• weakening of bonds (and chemical reaction) on catalytic surface **(1)**	Allow bonds break (and reaction occurs) on catalytic surface Ignore the type of interaction referred to between the reactants and the catalytic surface	
	• desorption of products from catalytic surface **(1)**	Allow 'release' of products from catalytic surface Allow de-adsorbed	

Q31.

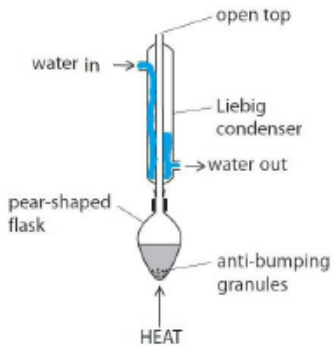
Question Number	Answer	Mark
(i)	**The only correct answer is B** (2-methylpentan-2-ol) **A** *is not correct because it is a secondary alcohol* **C** *is not correct because it is a secondary alcohol* **D** *is not correct because it is a secondary alcohol*	**(1)**

Question Number	Answer	Mark
(ii)	**The only correct answer is A** (hexan-2-ol) **B** *is not correct because it is a tertiary alcohol* **C** *is not correct because it does not contain a CH_3CHOH group* **D** *is not correct because it does not contain a CH_3CHOH group*	**(1)**

Q32.

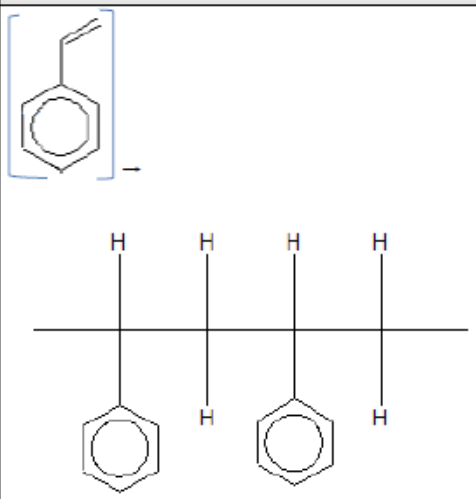
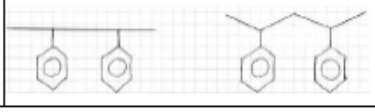
Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • reactivity increases down Group (7) **(1)** • because (C—X) bond enthalpy decreases / because (C—X) bond gets weaker down Group 7 **(1)**	Accept reverse argument References to halogen reactivity scores (0) Do not award references to ions/halides Do not award explanation in terms of just electronegativity or C—X dipoles Ignore references to atom size, shielding etc and references to intermolecular forces No TE on incorrect reactivity trend	**(2)**

Q33.

Question Number	Acceptable Answer	Additional guidance	Mark
(i)	A diagram with any shading that is not 100%	An example of a suitable diagram:  Allow shaded area to show 'air pockets'	(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following prevention of uncontrolled boiling by: • distributing the heat more evenly **or** • providing a surface for bubbles to form/allow smaller bubbles to form/provides nucleation sites for bubbles	 Do not award provide surface area for reaction Ignore reference to mixing the reagents/provide smooth boiling	(1)

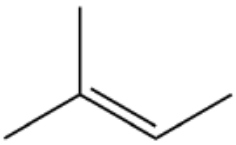
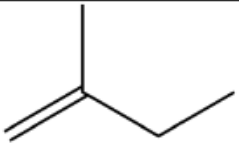
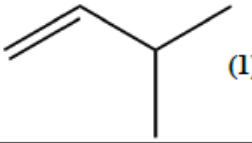
Q34.

Question Number	Acceptable Answer	Additional Guidance	Mark
		Accept skeletal, structural or displayed formulae Accept any orientation of benzene ring Ignore brackets Ignore 'n' / '2n' / '$^{n}/_{2}$' Allow syndiotactic and atactic forms Allow more than two units, as long as all correct. Neither of these diagrams scores Both have missing CH_2 	(1)

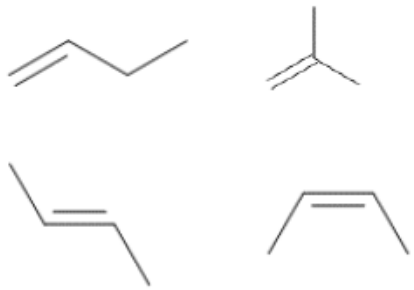
Q35.

Question Number	Answer	Additional Guidance	Mark
	A		1

Q36.

Question Number	Answer	Additional Guidance	Mark
	 (1)  (1)  (1)	Allow (2) for three correct displayed or structural formulae Allow (1) for any two correct displayed or structural formulae	(3)

Q37.

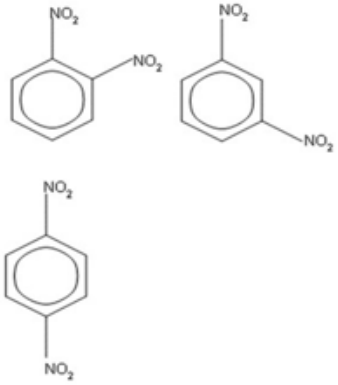
Question Number	Acceptable Answer	Additional Guidance	Mark
	 • all 4 correct (3) • any 3 correct (2) • any 2 correct (1)	Allow 2 marks for four correct structures that are not skeletal Do not award cycloalkanes	3

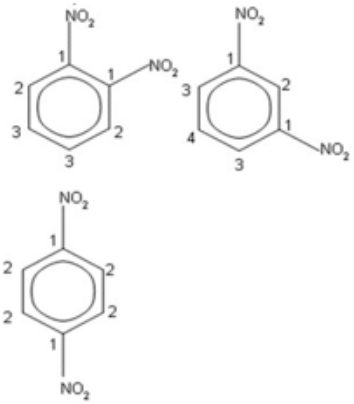
Q38.

Question Number	Answer	Additional Guidance	Mark
(i)	• two correct structures (1)		1
(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

Q39.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	$C_6H_4^+$	Allow $H_4C_6^+$ Do not award just C_6H_4	(1)

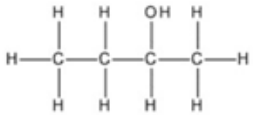
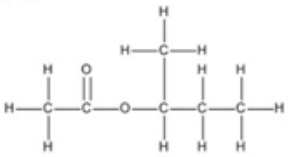
Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	• 3 correct formulae **(2)**	Examples of formulae  Allow (1) for any 2 correct formulae Allow (2) for three disubstituted benzenes with incorrect substituents / (1) for any two disubstituted benzenes with incorrect substituents Allow incorrectly displayed formulae of NO_2 groups **In (c)(ii) and (iii):** Allow Kekule structures Allow hydrogen atoms shown on benzene Ignore connectivity of NO_2 groups Penalise missing circle in benzene once only	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(iii)	• **D** identified as 1,3-dinitrobenzene **and** 4 different carbon environments labelled **(1)** • 3 different carbon environments labelled on 1,2-dinitrobenzene **(1)** • 2 different carbon environments labelled on 1,4-dinitrobenzene **(1)**	 Examples of identification These labels may be shown on the structures in (c)(ii) The identification of **D** can be assumed if it is the only structure with 4 carbon environments labelled Allow any form of identification of the carbon environments e.g. numbers, letters, equivalent carbon environments circled TE on disubstituted benzene substituents in (ii) Penalise only half the carbon environments labelled once only	**(3)**

Q40.

Question number	Answer	Mark
	The only correct answer is B (3) ***A*** *is incorrect because the structural isomers of C_5H_{12} are pentane, 2-methylbutane and 2,2-dimethylpropane* ***C*** *is incorrect because the structural isomers of C_5H_{12} are pentane, 2-methylbutane and 2,2-dimethylpropane* ***D*** *is incorrect because the structural isomers of C_5H_{12} are pentane, 2-methylbutane and 2,2-dimethylpropane*	**(1)**

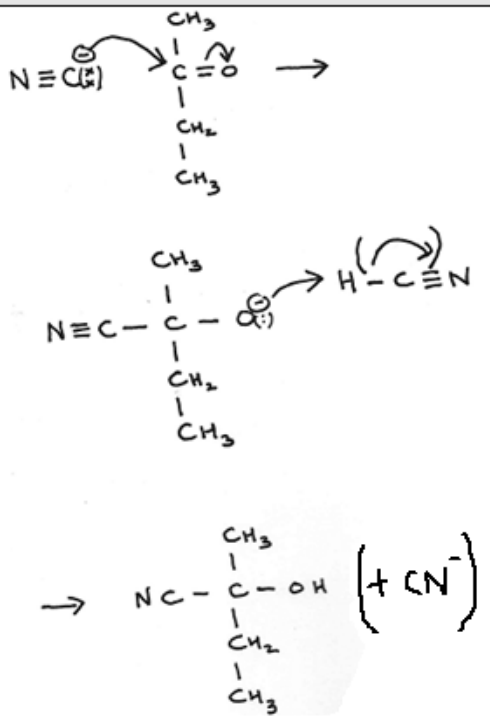
Q41.

Question Number	Acceptable Answers	Additional Guidance	Mark
	Identifications • structure of alcohol **B** **(1)** • structure of ester **A** **(1)** **Justification** • butan-2-ol / $CH_3CH_2CHOHCH_3$ is the **only** alcohol (with formula $C_4H_{10}O$) that (undergoes elimination and) produces (but-1-ene and) but-2-ene **(1)**	Allow any combination of structural, displayed or skeletal formulae / correct species in unbalanced equations Allow structures not labelled **A** and **B** Penalise missing H once only Examples of identification **(B)**  Ignore connectivity of the OH group unless horizontal **(A)**  Ignore incorrect name for **A** TE on incorrect alcohol Allow butan-2-ol can form a double bond either side of the C with OH / between the 1st and 2nd carbon atoms and the 2nd and 3rd carbon atoms – this can be shown on diagram / equation Allow OH must be on the 2nd carbon atom / secondary alcohol to form but-1-ene and but-2-ene Allow butan-1-ol gives but-1-ene **and** 2- methylpropan-1-ol / 2-methylpropan-2-ol gives (2-)methylpropene Allow the other alcohols (with formula $C_4H_{10}O$) do not give but-2-ene	**(3)**

Q42.

Question Number	Correct Answer	Reject	Mark
(a)(i)	Sodium/potassium dichromate ((VI)) **and** (Dilute/concentrated) sulfuric acid OR correct formulae / H^+ **and** $Cr_2O_7^{2-}$ ALLOW H^+ **and** $Cr_2O_7^{2-}$/acidified dichromate((VI)) **(1)** Reflux/distil Ignore 'heat', 'warm', and 'boil' alone. ALLOW Just 'under reflux' Just 'under distillation' **(1)** Second mark depends on mention of dichromate/$Cr_2O_7^{2-}$ in first part OR $KMnO_4$ and acid with heat **(1)**	Hydrochloric acid	**2**

Question Number	Correct Answer	Reject	Mark
(a)(ii)	Carbonyl group – addition of 2,4-dinitrophenylhydrazine / 2,4-DNP(H) / Brady's reagent **(1)** to give yellow/orange/red precipitate/ppt/ppte/solid/crystals ALLOW recognisable spelling e.g., percepitate **(1)** $CH_3C{=}O$ reaction with iodine in alkali/NaOH/KOH/OH^- ALLOW Iodoform/tri-iodomethane/haloform AND reaction/test **(1)** to form (pale) yellow / cloudy precipitate/solid/crystals **(1)**	2-DNP/4DNP Just DNP Brick red ppt	**4**
	Ignore references to smell Ignore heat in either part **Note** • In both cases result mark depends on test being recognisably correct even if it did not score a mark Examples: DNP gives yellow ppt Iodine test gives yellow ppt • Tests for aldehydes with correct results, no marks		

Question Number	Correct Answer	Reject	Mark
(b)(i)	 Arrow (from carbon) of CN^- to carbon of C=O AND Arrow from part of C=O double bond to oxygen ALLOW	CN without negative charge	**3**
	Two steps via a charged canonical form **(1)** Intermediate anion with C-CN bond. **(1)** Arrow from resulting O^- to hydrogen of $HCN/H^+/H_2O$ **(1)** **Note** Arrow directions must be correct to score each mark Penalise half-headed arrows each time in both parts ALLOW skeletal formulae.	...C-NC bond	

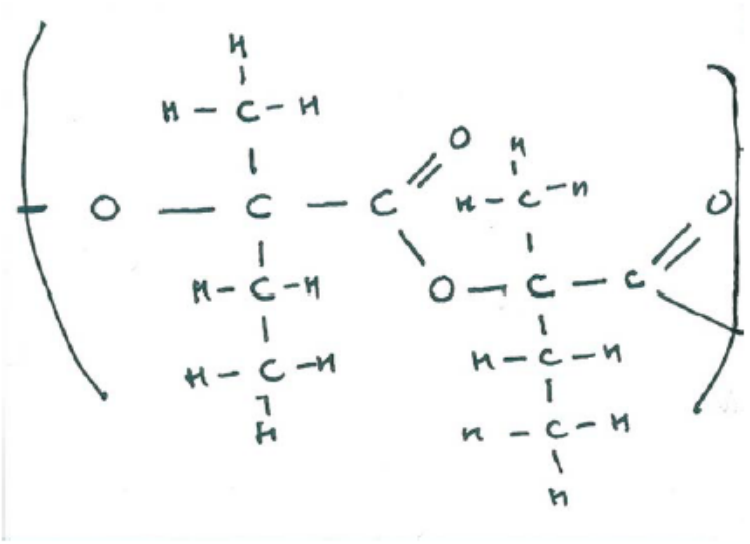
Question Number	Correct Answer	Reject	Mark
(b)(ii)	Forms a racemic mixture **(1)** Because bonds around C=O are planar OR Carbonyl group/reaction site is (trigonal) planar OR Bonds around carbonyl carbon are planar **(1)** Cyanide can attack from either side / above or below **(1)**	Butanone/molecule/it is planar C=O is planar Carbonyl bond is planar Intermediate is planar	**3**

Question Number	Correct Answer	Reject	Mark
(c)(i)	(Acid) hydrolysis OR Alkaline hydrolysis followed by acidification	Hydration	**1**

Question Number	Correct Answer	Reject	Mark
(c)(ii)	The O-H absorptions for alcohol and carboxylic acid overlap. OR OH absorption for an acid is very broad OR Quote data booklet values which must show some overlap, to include 3300 to 3200. ALLOW OH absorptions similar/the same.	Just 'both have OH groups' Just 'two OH groups present'	**1**

Question Number	Correct Answer	Reject	Mark
(c)(iii)	(Chemical shift δ) 2.0 - 4.0 (ppm) / any value within this range ALLOW Correct number followed by δ, eg 3δ		**1**

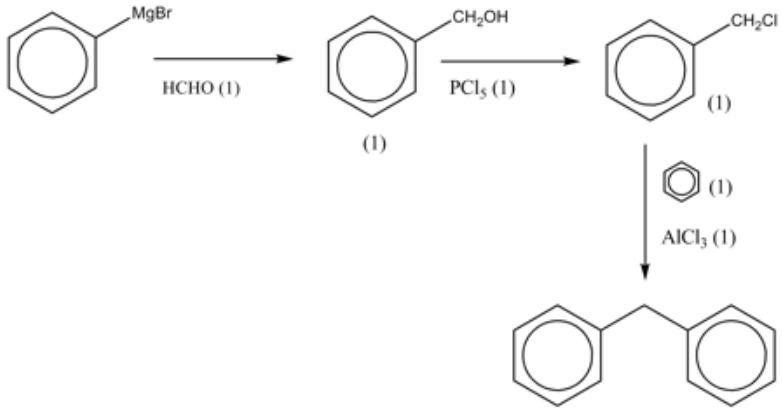
Question Number	Correct Answer	Reject	Mark
(c)(iv)	There is no hydrogen atom/proton on the adjacent/neighbouring carbon atom ALLOW No adjacent/neighbouring hydrogens/protons		**1**

Question Number	Correct Answer	Reject	Mark
(d)	 Ester linkage **(1)** Rest of molecule **(1)** ALLOW Attached chains as structural formulae Ignore n or other numbers outside bracket		**2**

Q43.

Question Number	Answer	Additional Guidance	Mark
	• 2-bromo-2-methylbutane reacts with Mg **(1)** • Dry ether **(1)** • $CH_3CH_2C(MgBr)(CH_3)CH_3$ **(1)** • react Grignard reagent with HCHO **(1)** • $CH_3CH_2C(CH_3)_2CH_2OMgBr$ **(1)** • (hydrolyse) with (dilute) acid **(1)** OR • 2-bromo-2-methylbutane reacts with KCN **(1)** • ethanol (as solvent) **(1)** • $CH_3CH_2C(CN)(CH_3)CH_3$ **(1)** • nitrile (hydrolysed) with (dilute) acid **(1)** • $CH_3CH_2C(COOH)(CH_3)CH_3$ **(1)** • carboxylic acid (reduced) with $LiAlH_4$ (in dry ether) **(1)**	Note – award of reagent or solvent marks must be in context of attempt to carry out an appropriate reaction e.g. use of **ethanolic** KCN to react with a ketone would not score OR M2 do not award HCOH Allow with water / H^+ Ignore HCN Allow methanol Allow H^+	(6)

Q44.

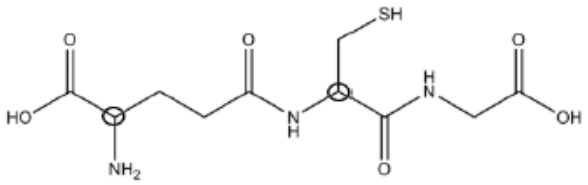
Question Number	Answer	Additional guidance	Mark
(i)	Iron / iron(III) bromide	Allow aluminium / aluminium bromide Allow correct formulae	1
(ii)	• reagent for step 1 (1) • product of step 1 (1) • reagent for step 2 (1) • product of step 2 (1) • reagent for step 3 (1) • catalyst for step 3 (1) Example of synthesis:  		6

Q45.

Question Number	Answer	Additional guidance	Mark
(i)	• evaluation of number of moles of 2-hydroxybenzoic acid used (1) • calculation of mass of aspirin at 100% yield (1) • calculation of mass of aspirin at 65% yield (1)	Example of calculation 2 / 138 = 0.0145 mol 0.0145 x 180 = 2.61 g 2.61/100 x 65 = 1.70 g Correct answer with no working scores 3 marks	3
(ii)	The mark for each reason must be linked with the correct improvement. • Improvement: swap the water inflow and outflow in the condenser (1) • Reason: to improve efficiency of condensing process (1) • Improvement: add anti-bumping granules to flask (1) • Reason: to promote smooth boiling/to prevent material escaping from top of condenser (1) • Improvement: insert condenser into neck of flask (1) • Reason: to prevent escape of reagents (1)		6

Q46.

Question Number	Answer	Mark
(i)	**The only correct answer is C** (oxidation) ***A** is incorrect as there is no evidence the species have added to the benzene ring* ***B** is incorrect as there is no evidence of chemical breakdown due to reaction with water* ***D** is incorrect as the -NH group and -OH group have lost hydrogen atoms*	**(1)**

Question Number	Answer	Additional guidance	Mark
(ii)	• both carbon atoms circled	 Allow any other labelling e.g. asterisk / arrow Do not award additional incorrect carbon atoms	(1)

Question Number	Answer	Mark
(iii)	**The only correct answer is B** (glutamic acid and cysteine) *A is incorrect as aspartic acid has only 4 carbon atoms* *C is incorrect as the sulfur atom in methionine has a methyl group attached* *D is incorrect as the sulfur atom in methionine has a methyl group attached and aspartic acid has only 4 carbon atoms*	(1)

Q47.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following point: • the hydride ion will not attack / will be repelled by regions of high electron density	Allow the reduction by $LiAlH_4$ is a nucleophilic addition / alkenes do not undergo nucleophilic reactions / H^- is a nucleophile Allow alkenes react with H^+ / $H^{\delta+}$ / H• Allow the hydride ion will not attack a pi-bond / C=C Allow like charges repel Ignore hydride ions cannot reduce alkenes Ignore hydride ions can only reduce carbonyl compounds	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • hydrogen / H_2 **(1)** • nickel / Ni **or** platinum / Pt / palladium / Pd **(1)**	Mark independently Ignore reference to temperature	**(2)**

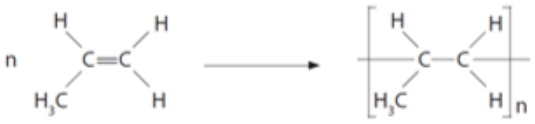
Question Number	Answer	Additional Guidance	Mark
(iii)	• 1-bromobutane / $CH_3CH_2CH_2CH_2Br$	If name and formula are given, both must be correct Allow Cl or I instead of Br Allow skeletal or displayed formulae	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iv)	• hydrochloric acid / HCl / H^+	Allow any (dilute) strong acid Ignore concentration of acid Do not award any weak acid	**(1)**

Q48.

Question Number	Answer	Additional Guidance	Mark
(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**
(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**
(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 (1) • as primary carbocation (formed in mechanism) is less stable (than secondary)	**2**

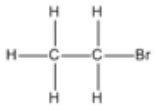
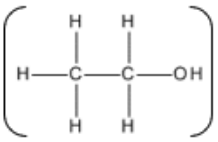
Q49.

Question Number	Answer	Additional Guidance	Mark
(i)	 • formulae (1) • balancing and brackets (1) (2nd mark dependent on use of correct formulae)	Ignore type of brackets	2
(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
(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

Q50.

Question Number	Acceptable Answer	Additional guidance	Mark
	An explanation that makes reference to the following • the reaction rate is in the order 1-chlorobutane<1-bromobutane<1-iodobutane **(1)** • because the C-Cl bond is stronger than the C-Br bond which is stronger than the C-I bond **(1)**	Accept reverse arguments Incorrect trend scores (0) Allow 'the C-Cl bond is the strongest' Ignore any reasoning given Do not award if reference is made to the bonding of the halide (ion)	**(2)**

Q51.

Question Number	Answer	Additional Guidance	Mark
	• product in Reaction **1** **(1)** • reagent in Reaction **2** **(1)** • condition in Reaction **2** **(1)**	Example of table Reaction 1: Reagent and condition: (HBr at room temperature); Product:  Reaction 2: Reagent and condition: steam / $H_2O(g)$ and acid / H^+; Product:  Allow structural / skeletal / molecular formula / name for (1-)bromoethane Allow water / H_2O **and** heat instead of steam Allow specific acid e.g. (concentrated) phosphoric acid / sulfuric acid Ignore any specific temperature and pressure Do not award acid if mention of any reagent other than steam / water e.g. acidified dichromate	**(3)**

Q52.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	An answer that makes reference to the following points: • 3300 — 2500 (cm^{-1}) **and** O-H (bond) **(1)** • 1725 — 1700 (cm^{-1}) **and** C=O (bond) **(1)**	Allow any value(s) within the range 3300 — 2500 (cm^{-1}) Allow -OH Allow any value(s) within the range 1725 — 1700 (cm^{-1}) Allow 1320 – 1210 (cm^{-1}) **and** C-O	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	An answer that makes reference to the following points: • structures 1 and 2 will have an absorption at Either C=C at 1669 — 1645 (cm^{-1}) **or** C—H in an alkene at 3095 — 3010 (cm^{-1}) **(1)** • only structure 2 will have an absorption due to the presence of an alcohol / O—H at 3750 —3200 (cm^{-1}) **(1)** • structure 3 will have none of these absorptions / will not show C=C absorption / C-H absorption for an alkene **(1)**	Reject C=C at 3010 (cm^{-1})	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	• calculation of moles of NaOH **(1)** • calculation of mass of NaOH **(1)**	Example of calculation: (moles NaOH = 0.140 x 250) 1000 = 0.035(0) (mol) = 40(.0) x 0.035(0) = 1.4(0) (g) Correct answer with or without working scores 2 marks Allow TE for M2 on moles of NaOH Alternative route, allow M1 for conversion of concentration to 5.6 g dm^{-3} Ignore SF	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(i)	An explanation that makes reference to the following points: • (because the) sodium hydroxide has been diluted **(1)** • (the titre will be) smaller **(1)**	Allow Fewer moles of sodium hydroxide present / some sodium hydroxide will have been removed M2 dependent on M1	**(2)**

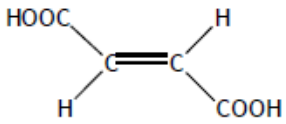
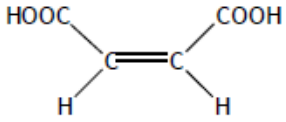
Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(ii)	An explanation that makes reference to the following points: M1 no effect (on the titre) **(1)** M2 because the (number of) moles of sodium hydroxide is unaffected **(1)**	 M2 depends on M1 Allow base / alkali / hydroxide (ions) Allow amount / mass of sodium hydroxide is unaffected	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(iii)	• calculation of percentage uncertainty in burette volume **(1)** • calculation of percentage uncertainty in volumetric flask volume **and** in pipette volume **(1)** • identification of volume with the lowest percentage uncertainty **(1)**	Example of calculation: 2 x (±)0.05 x 100% = (±)0.980392156% 10.20 (±)0.30 x 100% = (±)0.12% 250.0 **and** (±)0.040 x 100% = (±)0.4% 10.0 Volumetric flask has the lowest uncertainty Allow TE for identification in M3 Allow ANY number of SF in answer, from 1 SF up to calculator value	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(i)	• left-hand side of equation correct **(1)** • right-hand side of equation correct **(1)**	Example of equation $HOOCCH=CHCOOH + 2NaOH \rightarrow NaOOCCH=CHCOONa + 2H_2O$ ALLOW use of molecular formulae or ionic equation: $C_4H_4O_4 + 2NaOH \rightarrow Na_2C_4H_2O_4 + 2H_2O$ $HOOCCH=CHCOOH + 2OH^- (+ 2Na^+) \rightarrow {}^-OOCCH=CHCOO^- + 2H_2O (+ 2Na^+)$ ALLOW Multiples Correct charges Do not award if O–Na covalent bond drawn IGNORE State symbols, even if incorrect	**(2)**

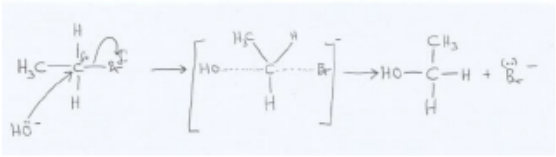
Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(ii)	An answer that makes reference to the following points: • (New mean titre) = 20.4(0) (cm^3) / double (the original value) **(1)** • For structure 2, mole ratio / reacting ratio is 1:1 (with NaOH) **(1)**	Mark M1 and M2 independently Allow structure 2 has 1 COOH / 1 acid group	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)	<table><tr><th>Structure</th><th>Test with Br_2 water</th><th>Test with acidified $K_2Cr_2O_7$</th></tr><tr><td>HOOCCH=CHCOOH</td><td>✓</td><td>x</td></tr><tr><td>$HOCH_2CH=CHCH_2COOH$</td><td>✓</td><td>✓</td></tr><tr><td>$CH_3CH_2CH_2CH_2CH_2COOH$</td><td>x</td><td>x</td></tr></table> Left hand column correct **(1)** Right hand column correct **(1)**	3 correct ticks with no crosses scores 1 Ignore descriptions of result in terms of colour (changes) / reactions occurring	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(f)(i)	• *E*-isomer:  **(1)** • *Z*-isomer:  **(1)**	ALLOW skeletal or displayed structures ALLOW $-CO_2H$ IGNORE Connectivity to the –COOH group IGNORE bond angles Award one mark if correct structures are drawn, but *E*- and *Z*-isomers labelled the wrong way round Award 1 mark if incorrect molecule used but *E* - and *Z*- isomers are correct	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(f)(ii)	An answer that makes reference to the following points: • restricted / limited rotation (about the C=C double bond) **(1)** • each carbon atom in the double bond is attached to (two) different atoms / different groups (of atoms) / to a H (atom) and a COOH group **(1)**	Allow "no rotation" Do not award the carbons are attached to 2 "different molecules" Mark points M1 and M2 independently	**(2)**

Q53.

Question Number	Answer	Additional Guidance	Mark
(i)	• dipole on C—Br bond **and** curly arrow from C-Br bond to Br or just beyond **(1)** • curly arrow from **lone pair** on oxygen of hydroxide ion to carbon bonded to Br **(1)** • formula of transition state with correct charge, partial bonding **(1)** • correct final products **(1)**	 Dipole and curly arrow may be shown on transition state Allow curly arrow to C^+ of carbocation Do not award if carbocation formed as intermediate Square brackets are not essential Allow charge on Br or OH of transition state Allow longer bonds for partial bonding Ignore geometry of transition state Allow NaBr product if mechanism starts with NaOH Only penalise horizontal bond from the H of OH to C in the product e.g. $OH-CH_2CH_3$ Use of incorrect halogenoalkane loses this mark One mark max deducted for omission of charge on ions, including transition state S_N1 mechanism can score M1, M2 and M4 but not M3. M2 can be awarded for curly arrow from the lone pair on the oxygen of the hydroxide ion to the C+ of the carbocation intermediate	(4)

Question Number	Answer	Additional Guidance	Mark
(ii)	Reagents: nitric acid / HNO_3 **and** silver nitrate (solution) /$AgNO_3$ **(1)** (Result) cream/off-white precipitate **(1)**	Use of hydrochloric acid/HCl OR sulfuric acid/H_2SO_4 scores **(0)** Do not award acidified silver nitrate If name and formula given then both must be correct Allow (very) **pale** yellow Do not award just white or just yellow Ignore subsequent additions of ammonia even if incorrect Result mark dependent on reagents mark or 'near miss' such as omitting to add nitric acid, using ethanolic silver nitrate, incorrect formulae	(2)