Mark Scheme (Results)

Summer 2024

Pearson Edexcel International Advanced Subsidiary Level In Chemistry (WCH12) Paper 01 Energetics, Group Chemistry, Halogenoalkanes and Alcohols

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General Marking Guidance

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

Using the Mark Scheme

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

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

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

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

Quality of Written Communication

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

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

Section A

Question Number	Answer	Mark
1	**The only correct answer is A** (arrow A) ***B*** *is incorrect because this is the activation energy for the reaction* ***C*** *is incorrect because this is the difference in energy between the reactants and the intermediate* ***D*** *is incorrect because this is the difference in energy between the products and the intermediate*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is C** (ion-dipole) ***A*** *is incorrect because the ions form no dipole* ***B*** *is incorrect because the ions cannot form hydrogen bonds* ***D*** *is incorrect because the ions do not form significant London forces*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is B** (¼$CCl_4(g)$ → ¼C(g) + Cl(g)) ***A*** *is incorrect because this represents the total energy required to break all four bonds in* CCl_4 ***C*** *is incorrect because this represents the total energy released when forming all four bonds in* CCl_4 ***D*** *is incorrect because this is for bond formation, not bond breaking*	**(1)**

Question Number	Answer	Mark
4(a)	**The only correct answer is A (**  **)** ***B*** *is incorrect because the least branched chain has the highest boiling temperature and this has one methyl branch* ***C*** *is incorrect because the least branched chain has the highest boiling temperature and this has one methyl branch* ***D*** *is incorrect because the least branched chain has the highest boiling temperature and this has two methyl branches*	**(1)**

Question Number	Answer	Mark
4(b)	**The only correct answer is D** (butane-1,4-diol) ***A*** *is incorrect because this compound is held together by London forces only* ***B*** *is incorrect because this compound is held together by London forces only* ***C*** *is incorrect because this compound is held together by hydrogen bonds, but only one per molecule*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is A** ($Mg + H_2O \rightarrow MgO + H_2$) ***B*** *is incorrect because magnesium oxide is formed, not magnesium hydroxide* ***C*** *is incorrect because magnesium oxide is formed, but is MgO not* Mg_2O ***D*** *is incorrect because magnesium oxide is formed, not magnesium hydroxide, which is* $Mg(OH)_2$	**(1)** Choose an item.

Question Number	Answer	Mark
6	**The only correct answer is D** (lithium oxide, nitrogen dioxide and oxygen calcium oxide, nitrogen dioxide and oxygen) ***A*** *is incorrect because both nitrates form an oxide, nitrogen dioxide and oxygen* ***B*** *is incorrect because lithium oxide, nitrogen dioxide and oxygen are formed* ***C*** *is incorrect because calcium oxide, nitrogen dioxide and oxygen are formed*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is A** (gaps between electronic energy levels) ***B*** *is incorrect because the ionic radius plays no part in the colour of the flame test* ***C*** *is incorrect because the electrons move between energy levels and are not lost* ***D*** *is incorrect because it is not the number of electrons but the energy gap between levels which is important*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is D** (strontium chloride) ***A*** *is incorrect because the precipitate would be yellow, not white* ***B*** *is incorrect because the precipitate would be cream coloured, not white* ***C*** *is incorrect because the flame test would be lilac not red*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is D** ($C_6H_{14}O$) ***A*** *is incorrect because this compound requires 8 moles of oxygen* ***B*** *is incorrect because this requires 8.5 moles of oxygen* ***C*** *is incorrect because this requires 9.5 moles of oxygen*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is C** (sodium nitrate solution) ***A*** *is incorrect because a white precipitate of barium sulfate would form* ***B*** *is incorrect because a white precipitate of silver chloride would form* ***D*** *is incorrect because a white precipitate of barium sulfate would form*	**(1)**

Question Number	Answer	Mark
11(a)	**The only correct answer is B** (red to orange) ***A*** *is incorrect because the end-point is orange and the sulfuric acid solution with methyl orange would be red* ***C*** *is incorrect because the end-point is orange and the sulfuric acid solution with methyl orange would be red* ***D*** *is incorrect because the end-point is orange and the sulfuric acid solution with methyl orange would be red*	**(1)**

Question Number	Answer	Mark
11(b)	**The only correct answer is C** (0.29) ***A*** *is incorrect because this is the number of moles of potassium sulfate formed* ***B*** *is incorrect because this is the number of moles of potassium ions in the potassium sulfate formed* ***D*** *is incorrect because this is the concentration of the potassium ions in the final solution*	**(1)**

Question Number	Answer	Mark
11(c)	**The only correct answer is C** (the total percentage uncertainty is 0.8%) ***A*** *is incorrect because the percentage uncertainty is the same for sulfuric acid and potassium hydroxide (0.4%)* ***B*** *is incorrect because the percentage uncertainty for the pipette reading of sulfuric acid has assumed two readings* ***D*** *is incorrect because the percentage uncertainty for the burette reading of potassium hydroxide has assumed one reading*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is D** (number of electrons in the molecule increase) ***A*** *is incorrect because halogen molecules are not polar* ***B*** *is incorrect because the general trend is for a decrease in bond strength and does not affect boiling temperature* ***C*** *is incorrect because electronegativity decreases down the group and is not relevant to bond strength in halogens*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is C** (the first ionisation energy of ^{37}Cl is greater than that of ^{79}Br) ***A*** *is incorrect because the atomic radius of isotopes is the same* ***B*** *is incorrect because the electronegativity of isotopes is the same* ***D*** *is incorrect because the mass spectrum of this molecule would have three molecular ions peaks*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is B** (yellow purple) ***A*** *is incorrect because although the lower layer would be brown if concentrated enough the upper layer is purple* ***C*** *is incorrect because the upper layer should be purple* ***D*** *is incorrect because the colours would be correct in a concentrated enough solution if swapped*	**(1)**

Question Number	Answer	Mark
15(a)	**The only correct answer is C** (E_{mode} and E_{mean} only) ***A*** *is incorrect because* E_a *would not be changed by temperature* ***B*** *is incorrect because* E_{mean} *would also increase* ***D*** *is incorrect because* E_a *would not be changed by temperature*	**(1)**

Question Number	Answer	Mark
15(b)	**The only correct answer is D** (E_a, E_{mode} and E_{mean}) ***A*** *is incorrect because all three would decrease as there are fewer particles in the volume* ***B*** *is incorrect because all three would decrease as there are fewer particles in the volume* ***C*** *is incorrect because all three would decrease as there are fewer particles in the volume*	**(1)**

Question Number	Answer	Mark
15(c)	**The only correct answer is A** (E_a only) ***B*** *is incorrect because the number of particles at* E_{mode} *and the value of* E_{mode} *would stay the same* ***C*** *is incorrect because the number of particles at* E_{mode} *and* E_{mean} *and the value of both would stay the same* ***D*** *is incorrect because* E_{mode} *and* E_{mean} *stay the same, but* E_a *will decrease*	**(1)**

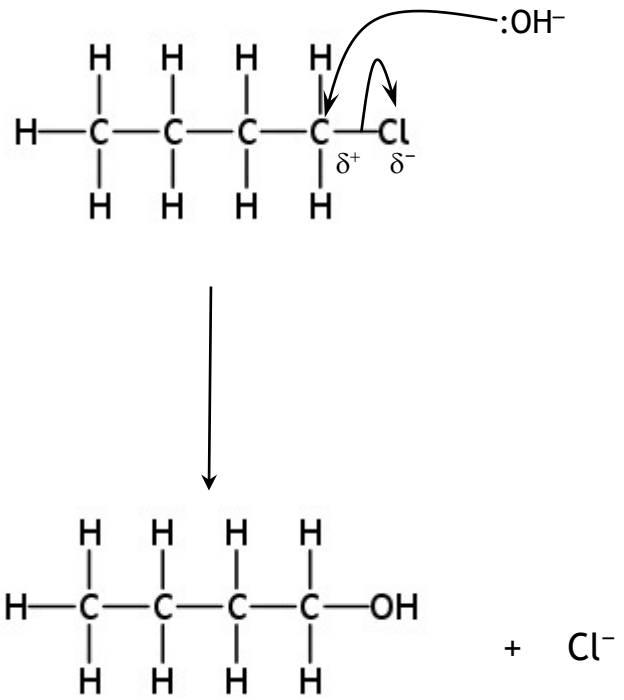
TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Answer	Additional Guidance	Mark
16(a)(i)	An answer that makes reference to the following point: • ethanolic (solution) / ethanol as the solvent / ethanolic KOH / ethanolic potassium hydroxide	Allow alcohol / alcoholic in place of ethanol / ethanolic Allow in ethanol Allow NaOH / sodium hydroxide in place of KOH / potassium hydroxide Allow aqueous ethanol Ignore concentration of potassium hydroxide Ignore heat / temperatures / pressure Ignore heat under reflux Do not award just 'ethanol' or 'alcohol'	**(1)**

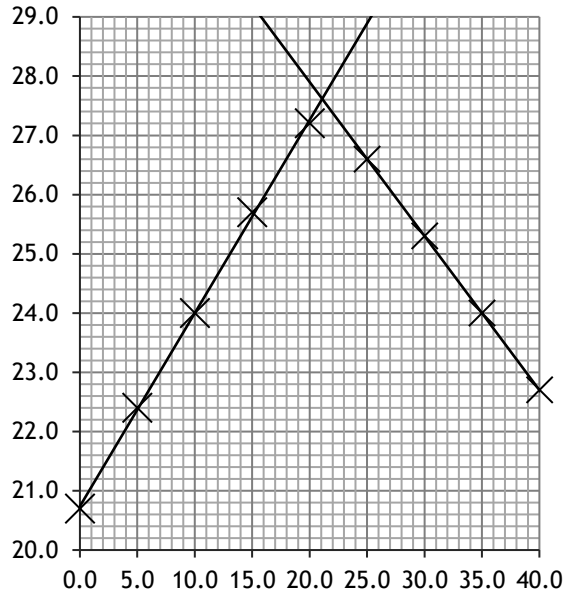
Question Number	Answer	Additional Guidance	Mark
16(a)(ii)	An answer that makes reference to the following point: • elimination (of hydrogen chloride)	Do not award nucleophilic elimination	**(1)**

Question Number	Answer	Additional Guidance	Mark
16(b)(i)	An answer that makes reference to the following point: • aqueous (solution) / solution in water / aqueous KOH / aqueous potassium hydroxide	Accept aqueous condition / condition is aqueous Allow aqueous ethanol Ignore concentration of potassium hydroxide Ignore temperature Ignore heat under reflux Do not award just 'water'	**(1)**

Question Number	Answer	Additional Guidance	Mark
16(b)(ii)	An answer that makes reference to the following points: • lone pair on O of OH^- • dipole on C–Cl bond • curly arrow from lone pair on O to C of C–Cl bond • curly arrow from C–Cl bond to Cl (or just beyond) All four points scores 2, 2 or 3 points scores 1.	 Point 3 can be awarded from an arrow coming from the O if P1 has not been scored Ignore dipoles on the product Ignore presence or absence of lone pair on Cl^- Ignore transition states	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(b)(iii)	An answer that makes reference to the following points: • tertiary halogenoalkanes (like 2-iodo-2-methyl propane) react more quickly than primary halogenoalkanes (like 1-chlorobutane) **(1)** • C−I bond is weaker than C−Cl bond **(1)**	Allow reverse arguments Allow a tertiary structure reacts faster than a primary structure Allow a tertiary carbocation is more stable than a primary carbocation Allow the carbon to halogen bond breaks more readily in a tertiary halogenoalkane than a primary Ignore just 2-iodo-2-methyl propane is a tertiary halogenoalkane but 1-chlorobutane is primary Ignore more branched Do not award tertiary halogenoalkanes react faster as they are more stable than primary Award the C-I bond enthalpy is less (endothermic) / lower than the C-Cl (bond enthalpy) Allow reactivity increases down the group Allow iodoalkanes react more quickly than (equivalent) chloroalkanes	**(2)**

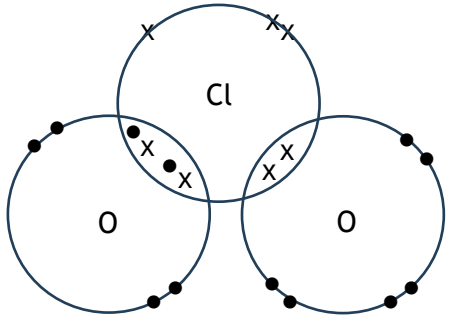
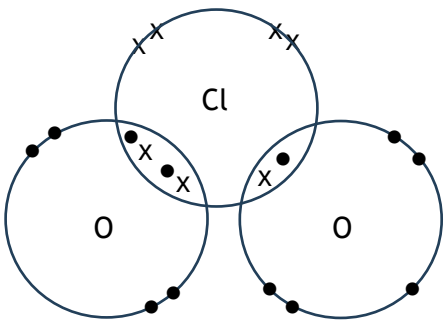
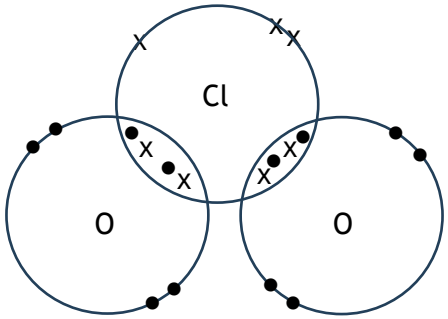
(Total for Question 16 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
17(a)	An answer that makes reference to the following points: **(1)** **(1)** **(1)** Stand alone mark • **two straight** lines of best fit, one passing through the first five points, the other passing through the last four points Dependent on some **straight** lines • end-point volume = 21 (cm^3) ± 0.5 Dependent on some **straight** lines • maximum temperature = 27.6 (ºC) ± 0.1	<u>Example of graph:</u>  If the values given for MP2 and MP3 are not within tolerance then the straight lines do not score if the points are accurately read. Allow 30 + the volume read from the graph for end-point volume Do not award the maximum temperature rise instead of maximum temperature but award its use in (c) Allow TE for MP2 and MP3 providing that two straight lines have been drawn	**(3)**

Question Number	Answer	Additional Guidance	Mark
17(b)	• calculation of moles of ammonia	Example of calculation (1.30 × 21) ÷ 1000 = 0.0273 (mol) Allow TE on end-point volume in (a) or end point volume – 30 if 30 has been added to the volume for the end point from the graph	(1)

Question Number	Answer	Additional Guidance	Mark
17(c)	• calculate mass of water being heated at end-point **(1)** • calculate temperature rise **(1)** • calculation of energy transfer **(1)** • calculation of enthalpy change per mole **(1)** • calculation of final answer to 2 or 3 SF including negative sign **(1)**	Example of calculation 30 + end point volume 30 + 21 = 51 (g) 27.6 – 20.7 = 6.9 (ºC) Energy transfer = 51 × 4.18 × 6.9 = 1470.9 (J) 1470.9 ÷ 0.0273 = 53881 (J / J mol^{-1}) – 53.9 / −54 (kJ mol^{-1}) Allow TE throughout and on (a) and (b)	(5)

(Total for Question 17 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	• two dots and two crosses in one overlap and two crosses in the other overlap **(1)** • all non-bonding electrons correct dependent on M1 **(1)**	 Allow unpaired electrons All dots or all crosses scores 1 mark Allow dots and crosses swapped (dots for crosses, crosses for dots) If no other mark is scored allow (1) for either of the structures below  	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	An answer that makes reference to the following point: • chlorine has non-bonding electrons in its outer shell which repel the bonding pairs (of electrons)	Allow any answer referring to lone or non-bonding electrons, including just a single electron and referring to repulsion or repulsive forces with bonding pairs and/or lone pairs e.g. there are lone pairs of electrons and lone pair repulsion is greater than bond pair repulsion Ignore the lone pairs on oxygen repel Ignore just chlorine dioxide minimises repulsion between electrons Do not award the lone pair of electrons repel the oxygen atoms	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(b)(iii)	An answer that makes reference to the following point: • the Roman numeral is the charge the chlorine would have if the species were fully ionic / is the oxidation number of the chlorine (in the ions) OR the oxidation number of chlorine in chlorate(V) is (+)5 **and** in chlorate(VII) is (+)7	Allow is the oxidation number of chlorine in the compound Ignore just is the charge on the chlorine Do not award is the oxidation number of chlorine in the molecule Allow valency of chlorine in chlorate(V) is (+)5 and in chlorate(VII) is (+)7 Allow chlorine is +5 in chlorate(V) and +7 in chlorate(VII) Do not award the charge on chlorate(V) is +5 and on chlorate(VII) is +7	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(b)(iv)	An answer that makes reference to the following point: • +4 / 4	 Allow (+IV) Do not award −4	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(b)(v)	An answer that makes reference to the following points: • either (+)5 or (+)6 **(1)** • because it must be between (+)4 and (+)7 **(1)**	 Allow must reduce to (+)4 and oxidise to (+)7 Chlorine goes from +5 to +4 and +7 scores M2 Allow TE on answers in (b)(i) and (b)(ii) throughout	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(b)(iv)	• calculation of percentage by mass of oxygen **(1)** • calculation of moles of atoms present **(1)** • calculation of ratio **(1)** • **calculation** of mass of empirical formula (and therefore molecular formula) OR A calculation that shows 84.5 ÷ 84.5 **(1)**	Example of calculation There must be some recognisable working for M2, M3 and M4 % mass of oxygen = 100 – 1.18 – 42.01 = 56.81 H: 1.18 ÷ 1 → 1.18 ÷ 1.18 = 1 Cl: 42.01 ÷ 35.5 → 1.1834 ÷ 1.18 = 1 O: 56.81 ÷ 16 → 3.5506 ÷ 1.18 = 3 mass of $HClO_3$ = 1 + 35.5 + (3 × 16) = 84.5 (÷ 84.5 = 1) Therefore molecular formula is $HClO_3$ Allow atoms in any order Allow TE on M1	**(4)**

Question Number	Answer	Additional Guidance	Mark
18(b)(v)	• equation for Step 1 **(1)** • equation for Step 2 **(1)**	$2KClO_3 + H_2SO_4 \rightarrow 2HClO_3 + K_2SO_4$ OR $KClO_3 + H_2SO_4 \rightarrow HClO_3 + KHSO_4$ $3HClO_3 \rightarrow 2ClO_2 + HClO_4 + H_2O$ Allow two unbalanced equations with all species correct for (1) Allow TE on answer to (b)(v) in place of $HClO_3$ in both equations. Ignore state symbols even if incorrect	**(2)**

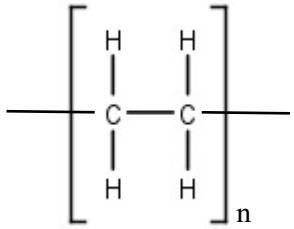
(Total for Question 18 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
19(a)	An answer that makes reference to the following point: • phosphoric((V)) acid / H_3PO_4 / sulfuric((VI)) acid / H_2SO_4	If name and formula are given both must be correct Ignore concentration	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(b)	An answer that makes reference to the following points: • the reaction is cooled so that ethanol (and excess water) condenses / liquefies **(1)** • the unused ethene / starting materials (which is still gaseous) are recycled **(1)**	Mark independently Allow the ethanol is removed from the reaction mixture Ignore just the ethanol condenses / liquifies Ignore comments about temperature change and position of equilibrium, even if incorrect Allow unused reactants are added back to the mixture Allow unused reactants are reused	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(c)(i)	An answer that makes reference to the following points: • the forward reaction is exothermic so is favoured by a lower temperature (giving a higher yield) **(1)** • but the lower temperature results in a rate of reaction that is too slow (to be economically viable) **(1)**	Allow reverse arguments Allow it is an exothermic reaction favoured by a lower temperature Allow the backward reaction is endothermic so at higher temperatures the yield is lower Allow a low temperature decreases the rate of the reaction Allow a higher temperature increases the rate of reaction (making the ethanol faster) Ignore the cost of higher temperatures If no other mark is awarded allow (1) for the temperature used is a compromise between rate and yield	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(c)(ii)	An answer that makes reference to the following points: • the equilibrium shifts giving a greater yield of ethanol **(1)** • (because) there are fewer moles (of gas) on the products side / right hand side (than there are on the reactants side / left hand side **(1)**	Mark independently Ignore direction of shift, even if incorrect Ignore the right hand side is exothermic Do not award incorrect numbers of moles of gaseous reactants and/or products Ignore relative cost of higher pressure and / or higher pressure compared to higher temperature Ignore effect on rate unless linked correctly to higher yield at equilibrium	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(c)(iii)	An answer that makes reference to the following point: • name of poly(ethene) or structural formula of poly(ethene)	Accept polyethene / polythene  If name and formula are given, both must be correct	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(c)(iv)	An answer that makes reference to the following points: • higher pressures require special plant / equipment to withstand the higher pressures (which are expensive)	Allow high pressure results in engineering problems Allow cost linked to either producing high pressure or to special equipment / plant Allow high energy costs Ignore unjustified comments about cost Ignore comments about safety unless linked to cost of special plant Ignore more equipment Ignore energy linked to global warming	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(c)(v)	An answer that makes reference to the following points: • (an advantage is that) it pushes equilibrium to the right increasing the yield (of ethanol) **(1)** • (a disadvantage is) that there is more water condensed with the ethanol (to separate) OR **(1)** the catalyst is washed from the support / is diluted by the water / dissolves in the condensed water and is removed from the reaction vessel	Allow the rate of the forward reaction will increase (lowering the concentration of water) and increase the yield of ethanol Ignore just the rate of the (forward) reaction increases Ignore just the yield of ethanol increases Allow the final mixture is more impure Allow the ethanol produced / final mixture will be diluted Ignore cost of heating more water Ignore the reaction mixture will be diluted Ignore comments about rate of reaction Ignore corrosion	**(2)**

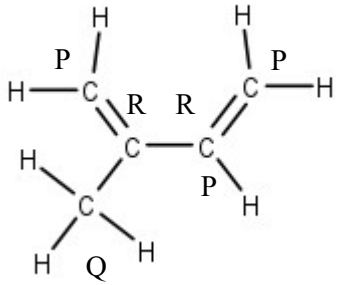
(Total for Question 19 = 11 marks)

TOTAL FOR SECTION B = 40 MARKS

Section C

Question Number	Answer	Additional Guidance	Mark
20(a)(i)	An answer that makes reference to the following point: • (2-)methylbuta-1,3-diene	 Allow (2-)methylbut-1,3-diene Allow (2-)methylbutan-1,3-diene Allow (2-)methyl-1,3-butadiene Do not award (2-)methylbuta-1,3-ene / (2-)methyldibut-1,3-ene Ignore missing or incorrect hyphens or commas	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(a)(ii)	An answer that makes reference to the following points: • m/z = 68 is $(CH_2{=}C(CH_3){-}CH{=}CH_2)^+$ **(1)** • m/z = 53 is $(CH_2{=}C{-}CH{=}CH_2)^+$ **(1)**	Penalise molecular formulae once only Penalise lack of positive charges or presence of negative charges once only Allow displayed or skeletal formulae, with or without brackets around the outside Ignore absence of double bonds Award $(CH_3{-}C(=CH_2){-}CH{=}CH_2)^+$ Award $(CH_2{=}CH{-}C(CH_3){=}CH_2)^+$ Award $(CH_2{=}CH{-}C(=CH_2){-}CH_3)^+$ Award $(CH_2{=}CH{-}C{=}CH_2)^+$	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(a)(iii)	An answer that makes reference to the following points:	Accept a diagram with labels showing one or more of each of the bonds e.g.  	**(3)**
	• P is due to C-H (stretching vibrations) in an alkene **(1)**	Do not award C-H (stretching) in an arene	
	• Q is due to C-H (stretching vibrations) in an alkane **(1)**	Do not award C-H (stretching) in an arene If M1 and M2 are not scored allow P and Q are due to C-H (stretching vibrations) for (1) but do not award this if either C-H is attributed to an arene	
	• R is due to C=C (stretching vibrations in an alkene) **(1)**	Do not award C=C (stretching) in an arene	

Question Number	Answer	Additional Guidance	Mark
20(b)(i)	An answer that makes reference to the following points: • molecular formula of either myrcene, limonene or both is $C_{10}H_{16}$ and the molecular / empirical formula of isoprene is C_5H_8 **(1)** • so the molecular formula of myrcene **and** limonene is twice isoprene (so they are terpenes) **(1)** OR • molecular formula of either myrcene, limonene or both is $C_{10}H_{16}$ and the molecular / empirical formula of isoprene is C_5H_8 **(1)** • so the empirical formula of myrcene **and** limonene is the same as isoprene (so they are terpenes) **(1)**	Allow TE on incorrect molecular formulae Allow TE on incorrect molecular formulae	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(b)(ii)	An answer that makes reference to the following point: • heat **and** nickel / Ni (catalyst)	Allow nickle Allow any quoted temperature or range of temperatures above room temperature Allow Pt, Pd, Ir, Rh, Ru	**(1)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>20(b)(iii)</td><td>Stand alone first mark
• calculation of M_r of terpene and moles of terpene (1)

Method 1
• either value for number of moles of H_2 (1)
• either volume of H_2 (1)
• second volume of H_2 with unit (1)

Method 2
• either value for one H_2 per terpene (1)
• either volume of H_2 (1)
• second volume of H_2 with unit (1)</td><td><u>Example of calculation:</u>

5 ÷ 136 = 0.036765

<table><tr><th></th><th>Myrcene</th><th>Limonene</th></tr><tr><td>numbers of moles of hydrogen required</td><td>0.036765 × 3
= 0.11030</td><td>0.036765 × 2
= 0.07353</td></tr><tr><td>volume of hydrogen required</td><td>0.11030 × 24000
= 2647.2 cm^3 / 2.6472 dm^3</td><td>0.07353 × 24000
= 1764.7 cm^3 / 1.7647 dm^3</td></tr></table>
<table><tr><th></th><th>Myrcene</th><th>Limonene</th></tr><tr><td>one hydrogen per terpene</td><td>0.036765 × 24000
= 882.36</td><td>0.036765 × 24000
= 882.36</td></tr><tr><td>total volume of hydrogen required</td><td>882.36 × 3
= 2647.1 cm^3 / 2.6471 dm^3</td><td>882.36 × 2
= 1764.7 cm^3 / 1.7647 dm^3</td></tr></table>
Final answers can be found by use of ratios of 2:3 or 3:2 so not all values will necessarily be seen
Ignore rounding errors in all steps except the final answer
Both final volumes attributed to the correct terpene with some working scores (4)
Allow TE throughout
Ignore SF</td><td>(4)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
20(b)(iv)	An answer that makes reference to the following point: • 2,6-dimethyloctane	Ignore any structures drawn as working	**(1)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*20(c)</td>
<td>
This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

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

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>

The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</td>
<td>
Guidance on how the mark scheme should be applied.

The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

In general it would be expected that
5 or 6 indicative points would get 2 reasoning marks
3 or 4 indicative points would get 1 reasoning mark
0, 1 or 2 indicative points would get zero reasoning marks

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).

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

	Indicative content (potassium dichromate(VI) is not a good choice because) **IP1** potassium dichromate(VI) would go from **orange to green** (with menthol and citronellol but would stay the same / would not go green with linalool) **IP2** menthol and citronellol are oxidised / react but linalool is a tertiary alcohol which is not oxidised by / does not react with potassium dichromate (so does not identify this –OH group) (potassium manganate(VII) is not a good choice because) **IP3** potassium manganate(VII) would go from **purple to colourless** (with all three alcohols) **IP4** (but would not identify the presence of the –OH group) as it also reacts with the C=C / reacts to produce a diol with linalool and citronellol / two of the alcohols Phosphorus(V) chloride is the best choice because) **IP5** phosphorus(V) chloride will produce **misty fumes** (with all) **IP6** (and identifies the presence of the –OH group in each as it) reacts with primary secondary and tertiary alcohols / reacts with all three alcohols	IP1, 3 and 5 are for the general results of the test IP2, 4 and 6 are for results for each and explanation linked to structure around -OH group Ignore additional tests throughout Allow blue instead of green Observation is not needed for linalool to score in IP1 but do not award for an incorrect linalool observation Allow primary or secondary alcohols instead of citronellol and menthol Do not award pink to colourless Allow steamy fumes Allow white fumes	

(Total for Question 20 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

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