GradeMax



Mark Scheme (Results)

October 2021

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

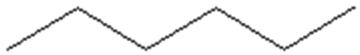
Question Number	Answer	Mark
1	**The only correct answer is B** (hexane) ***A*** *is not correct because the spectrum does not have a peak for the C=O* ***C*** *is not correct because the spectrum does not have a peak for the C=O and O-H* ***D*** *is not correct because the spectrum does not have a peak for the O-H*	(1)

Question Number	Answer	Mark
2	**The only correct answer is D** (CH_3COCH_3) ***A*** *is not correct because it is a primary alcohol so will react* ***B*** *is not correct because it is a secondary alcohol so will react* ***C*** *is not correct because it is an aldehyde so will react*	**(1)**

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

Question Number	Answer	Mark
4	**The only correct answer is D** (highest mass/charge ratio) ***A*** *is not correct because the molecular ion does not always have the greatest abundance* ***B*** *is not correct because the molecular ion does not always have the greatest stability* ***C*** *is not correct because the molecular ion cannot have a higher charge than the other ions*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is C** (43) ***A*** *is not correct because both would be expected to have this peak due to* CH_3^+ ***B*** *is not correct because both would be expected to have this peak due to* $C_2H_5^+$ ***D*** *is not correct because both would be expected to have this peak due to* $C_4H_9^+$	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is A**  ***B*** *is not correct because the molecule is branched so has weaker London Forces* ***C*** *is not correct because the molecule is branched so has weaker London Forces* ***D*** *is not correct because the molecule is branched so has weaker London Forces*	**(1)**

Question Number	Answer	Mark
7(a)	**The only correct answer is A** (addition) ***B*** *is not correct because it is not an oxidation reaction* ***C*** *is not correct because it is not a polymerisation reaction* ***D*** *is not correct because it is not a substitution reaction*	**(1)**

Question Number	Answer	Mark
7(b)	**The only correct answer is B** (oxidation) ***A*** *is not correct because it is not an addition reaction* ***C*** *is not correct because it is not a reduction reaction* ***D*** *is not correct because it is not a substitution reaction*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is D** (Z ionic radius 0.149, ionic charge +1) ***A*** *is not correct because the ion is smaller and more highly charged* ***B*** *is not correct because the ion is smaller* ***C*** *is not correct because the ion is smaller and more highly charged*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is D** (0.264 g) ***A*** *is not correct because the ratio used is 3:1 not 1:3* ***B*** *is not correct because the ratio used is 1:1 not 1:3* ***C*** *is not correct because the atomic numbers have been used to calculate the molar mass of carbon dioxide*	**(1)**

Question Number	Answer	Mark
10(a)	**The only correct answer is C** (5:3:8) ***A*** *is not correct because y is wrong* ***B*** *is not correct because x and z are wrong* ***D*** *is not correct because x, y and z are wrong*	**(1)**

Question Number	Answer	Mark
10(b)	**The only correct answer is B** ($C_2O_4^{2-}$) ***A*** *is not correct because the oxidation number of H has not changed* ***C*** *is not correct because it is the oxidising agent* ***D*** *is not correct because the oxidation numbers of S and O have not changed*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is C** (+5) ***A*** *is not correct because this is the charge on the ion* ***B*** *is not correct because, although this is a common oxidation number of phosphorus, it is incorrect here* ***D*** *is not correct because this hbecause been obtained using the oxidation number of oxygen because –1*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is B** ($2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$) ***A*** *is not correct because it is a redox reaction* ***C*** *is not correct because it is a redox reaction* ***D*** *is not correct because it is a redox reaction*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is C** (475 cm^3) ***A*** *is not correct because this would only halve the concentration to 0.5 mol* dm^{-3} ***B*** *is not correct as this would be the total volume to produce a concentration of 0.5 mol* dm^{-3} ***D*** *is not correct because this is the total volume*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is B** (reactivity increases down the group) ***A*** *is not correct because boiling temperature does increase down the group* ***C*** *is not correct because first ionisation energy does decrease down the group* ***D*** *is not correct because electronegativity does decrease down the group*	**(1)**

Question Number	Answer	Mark
15	**The only correct answer is A** (purple) ***B*** *is not correct because this is the colour of bromine in water* ***C*** *is not correct because the solution is not colourless* ***D*** *is not correct because the solution is not brown*	**(1)**

Question Number	Answer	Mark
16	**The only correct answer is C** (HCl, HBr, HI, HF) ***A*** *is not correct because HF is the highest* ***B*** *is not correct because HI is not the lowest* ***D*** *is not correct because HF is the highest and the rest of the order is wrong*	**(1)**

Question Number	Answer	Mark
17	**The only correct answer is C** (hydrogen sulfide) ***A*** *is not correct because bromine is formed* ***B*** *is not correct because hydrogen bromide is formed* ***D*** *is not correct because sulfur dioxide is formed*	**(1)**

Question Number	Answer	Mark
18	**The only correct answer is B** (4.89 g) ***A*** *is not correct because this is the mass of water lost using the atomic numbers of water* ***C*** *is not correct because this is the mass of water lost* ***D*** *is not correct because they have used the atomic numbers to calculate the molar mass of water*	**(1)**

(Total for Section A = 20 Marks)

Section B

Question Number	Answer	Additional Guidance	Mark
19(a)(i)	• calculation of moles of ethanol	Example of calculation: 1.19/46 = 0.025870/ 2.5870 x 10^{-2} (mol) Ignore SF except 1 SF	(1)

Question Number	Answer		Additional Guidance	Mark
19(a)(ii)	• calculation of temperature change • calculation of energy required	(1) (1)	Example of calculation: (63.9-21.6) = 42.3(°C) 42.3 x 4.18 x 100= 17681.4 (J) / 17.6814 (kJ) Units are not required in (a)(ii) but if given they must be correct. If values converted to kJ units must be given. Ignore signs Ignore SF except 1 SF Correct answer with no working scores 2	(2)

Question Number	Answer		Additional Guidance	Mark
19(a)(iii)			Example of calculation:	(3)
	• calculation of the energy per mole	(1)	17681 ÷ 0.025870 = 683480 (J mol^{-1}) / 683.48 (kJ mol^{-1})	
	• (calculation of the enthalpy change per mole) **and** sign **and** units	 (1)	− 683480 J mol^{-1} / −683.48 kJ mol^{-1}	
	• answer to 2 or 3 SF	(1)	680000 / 683000 / 680 / 683 TE from 19(a)(i) and 19(a)(ii)	

Question Number	Answer		Additional Guidance	Mark
19(a)(iv)	An explanation that makes reference to the following points:			(2)
	• incomplete combustion	(1)	Allow formation of soot / carbon / carbon monoxide Allow insufficient oxygen Ignore incomplete reaction/experiment Ignore not all the ethanol burned/reacted	
	• evaporation of the ethanol/alcohol/fuel	(1)	Ignore evaporation of the water/product Ignore non-standard conditions / heat loss / specific heat capacity of water / hotspots / systematic errors	

Question Number	Answer	Additional Guidance	Mark
19(b)(i)	An answer that makes reference to the following points: • energy required to break **one mole** of a (specific) bond **(1)** • in the **gaseous** phase/state **and** averaged over a number of compounds/ different molecules/different compounds/different molecules **(1)**	Allow enthalpy/enthalpy change/ Energy/ energy change Ignore just mean Ignore any equations even if incorrect Ignore any mention of conditions Do not award if there is any indication that it is averaged over a number of different types of bonds. If neither M1 or M2 is scored 'The energy required to break a particular bond averaged out over a number of compounds' (1)	**(2)**

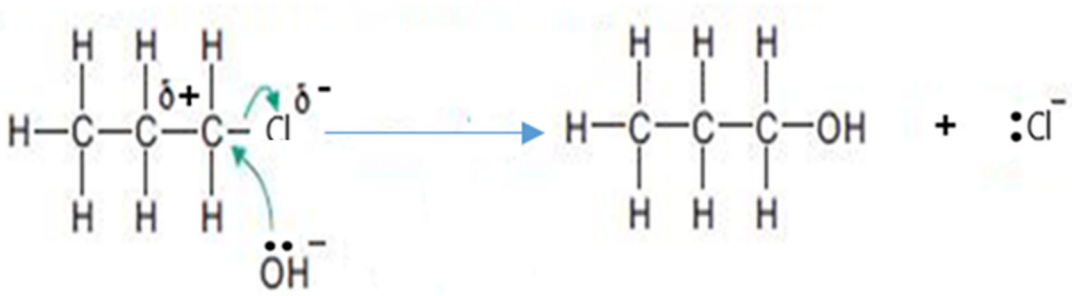
Question Number	Answer		Additional Guidance	Mark
19(b)(ii)			<u>Example of calculation</u>	**(3)**
	• **M1** Calculation of the energy change to break the bonds	**(1)**	Breaking 3 × C-H, 1 × C-O, 1× O-H, 1½ × O=O, (3 × 413) + (1× 358) +(1 × 464) +(1½ × 498) = (+) 2808(kJ mol^{-1})	
	• **M2** Calculation of the energy change to make the bonds	**(1)**	Making 2 x C=O, 4 x O-H (2 x 805) + (4 x 464) = (–) 3466(kJ mol^{-1})	
	• **M3** Calculation of the enthalpy change of the reaction	**(1)**	= 2808(kJ mol^{-1}) −3466(kJ mol^{-1}) −658 (kJ mol^{-1}) Ignore SF except 1SF Ignore units even if wrong M3 TE on M1 and M2 +658 (kJ mol^{-1}) scores (**2**) If the TE answer is + we do not need to see the sign. Correct answer with or without working scores **(3)**	

Question Number	Answer	Additional Guidance	Mark
19(c)	• correct Hess cycle with arrow on the RHS going down and correct balanced products in the box. **(1)** • calculation of left-hand side **(1)** • Correct **Answer** and **sign** **(1)**	Example of calculation $2C\ (s,graphite) + 2H_2(g) + \frac{1}{2}O_2(g) \rightarrow CH_3CHO(g)$ $(+2\ \frac{1}{2}O_2)$ $(+2\ \frac{1}{2}O_2)$ $2CO_2\ (g) + 2H_2O\ (l)$ Ignore state symbols even if incorrect No TE on incorrect cycle $(2 \times -286) + (2 \times -394) = -1360\ (kJ\ mol^{-1})$ An expression giving $-1360\ (kJ\ mol^{-1})$ is sufficient $(-1360\ (kJ\ mol^{-1}) + 1167\ (kJ\ mol^{-1}))$ $= -193\ (kJ\ mol^{-1})$ If units are given they must be correct Allow $kJ\ mol^{-}$ for $kJ\ mol^{-1}$ Correct answer with or without working scores M2 and M3 $+193\ (kJ\ mol^{-1})$ scores M2 TE on LHS	**(3)**

(Total for Question 19 = 16 Marks)

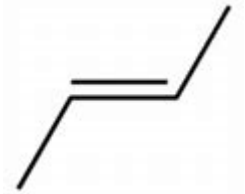
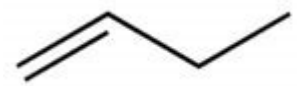
Question Number	Answer	Additional Guidance	Mark
20(a)(i)	• time taken for the (first appearance of the)precipitate (of silver halide) to form	Allow ppt / ppte for precipitate / cloudy/ silver halide Allow how fast / how quickly / rate for time	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(a)(ii)	An explanation that makes reference to the following points: • 1-iodopropane **(1)** • **C−I** bond weakest/lowest bond enthalpy **(1)**	Allow any correct formula Do not award for simply saying the iodine /1-iodopropane bond is weakest M2 depends on M1 Ignore reference to bond length Ignore any references to reactivity, electronegativity/size	**(2)**

Question Number	Answer	Additional Guidance	Mark
20 (b)	A mechanism that shows: • dipole on C-Cl bond and curly arrow from bond to Cl or just beyond **(1)** • curly arrow from lone pair on OH^- ion to δ+ carbon **(1)** 	Ignore S_N2 transition state Do not award curly arrow from negative charge on OH Do not award M2 if a metal hydroxide e.g. KOH has a covalent bond Ignore products Penalise use of half arrows once only in M1 and M2 If S_N1 mechanism M1 as above and then M2 awarded for curly arrow from lone pair on OH^- ion to C+ of carbocation	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(c)	An answer that makes reference to the following points: • London forces (and (permanent) dipole-(permanent) dipole forces) **(1)** • iodine atoms are more polarisable (than chlorine or bromine)/ 1-iodopropane has more electrons (than 1-chloropropane and 1-bromopropane) **(1)** • (resulting in) stronger / more London Forces (so more energy required to overcome these forces) **(1)** • (despite) 1-iodopropane having the weakest (permanent) dipole / (permanent) dipole forces **(1)**	Accept dispersion forces / instantaneous dipole-(induced) dipole Allow van der Waals' Allow iodine has more electrons than chlorine/ bromine Ignore it is a larger molecule / larger molar mass Do not award iodine has stronger/more London forces. Allow van der Waals / dispersion forces Ignore just stronger intermolecular forces Do not award M3 if any indication that covalent bonds are being broken. Allow 1-chloropropane has the strongest (permanent) dipole / (permanent) dipole forces Ignore abbreviations such as id-id and pd-pd	**(4)**

Question Number	Answer	Additional Guidance	Mark
20 (d)			**(3)**

Skeletal formula	Name
	*Z*-but-2-ene
	*E* -but-2-ene
	but-1-ene

Allow any order

Allow *cis*

Allow *trans*
If only one but-2-ene isomer is given the *E/Z* does not have to be identified

Penalise displayed formulae only once

All 6 correct scores **(3)**
4-5 correct scores **(2)**
2-3 correct scores **(1)**

No TE of names of incorrect formulae

(Total for Question 20 = 12 Marks)

Question Number	Answer	Additional Guidance	Mark
21(a)(i)	• correct equation **(1)** • correct state symbols **(1)**	Examples of equations $2K(s) + 2H_2O(l) \longrightarrow 2KOH(aq) + H_2(g)$ OR $K(s) + H_2O(l) \longrightarrow KOH(aq) + ½H_2(g)$ Allow multiples M2 dependent on M1 or correct species and an unbalanced equation	**(2)**

Question Number	Answer	Additional Guidance	Mark
21 (a)(ii)	An answer that makes reference to the following points: • K / potassium from 0 to +1 **and** oxidation **(1)** • H / hydrogen from +1 to 0 **and** reduction **(1)**	If oxidation numbers are wrong or omitted one mark is scored for K oxidised **and** H reduced. or one mark is scored for K changes from 0 to +1 **and** H changes from +1 to 0.	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(a)(iii)	• lilac	Allow purple or lilac-purple Do not award any other colour	(1)

Question Number	Answer		Additional Guidance	Mark
21(b)(i)	• from (pale) pink • to colourless	(1) (1)	Do not award red/purple Award (1) mark for correct colours in reverse order	(2)

Question Number	Answer	Additional Guidance	Mark
21(b)(ii)	• moles of HCl in titre **(1)** • moles of MOH in the flask (= mol M) **(1)** • molar mass of M **(1)** • identification of M **(1)**	Example of calculation $12.8 \times 0.400 \div 1000 = 5.12 \times 10^{-3}$ / 0.00512 (mol) 5.12×10^{-3} / $0.00512 \times 10 = 5.12 \times 10^{-2}$ / 0.0512 $0.37 \div 5.12 \times 10^{-2} = 7.23$ (g mol^{-1}) Ignore SF Li TE for each stage but for M4, **M** must be a Group 1 metal and is dependent on a calculation of a molar mass.	**(4)**

Question Number	Answer	Additional Guidance	Mark
21(c)	A description that makes reference to the following points: • (some) oil weighed with M/ the mass of M is lower than the mass of material weighed/ **(1)** • relative atomic mass of M will be greater **(1)**	Ignore mass increased/decreased/mass different Allow fewer moles of HCl (required in the titration)/lower titration value	**(2)**

(Total for Question 21 = 13 Marks)

(Total for Section B = 41 Marks)

Section C

Question Number	Answer	Additional Guidance	Mark
22(a)	A description that makes reference to the following points: • advantage: (it is produced from) renewable / sustainable (resources) **or** it produces fewer emissions (of CO_2 / greenhouse gases) **(1)** • disadvantage: it uses up land (that could be used for food production)/uses a food crop that could be eaten **or** it produces less energy (per mole / g) **(1)**	Do not award no greenhouse gases Ignore cleaner fuel/ more efficient combustion Ignore reference to engine modifications/carbon neutrality/using less oil/good for the environment Ignore just ' it uses lots of crops' Ignore references to time to grow crops/time to carry out fermentation/cost Ignore produces CO_2 Do not award any references to ozone depletion	**(2)**

Question Number	Answer	Additional Guidance	Mark
22(b)	• **ethanol** can be oxidised	Allow **ethanol** can react with oxygen Allow possible (organic) products of oxidation e.g. carboxylic acid / ethanoic acid / aldehyde / ethanal Ignore just 'oxidation takes place' or 'it can be oxidised' Allow to ensure only anaerobic respiration takes place. Allow aerobic respiration would take place (in the air) (producing water and carbon dioxide) Do not award yeast reacts with oxygen Do not award to prevent combustion/ethanol would burn	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(c)	• (fractional) distillation	Allow distil the mixture	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(d)(i)	• ethanol forms hydrogen bonds (with water)	Ignore both are polar/ they are miscible Ignore comments about solubility/like dissolves like	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(d)(ii)	An answer that makes reference to one of the following points: • (water can cause) corrosion / rusting • reduce the energy efficiency of the engine/fuel/ethanol • causes phase separation of the fuel	 Ignore damages the engine Allow water does not burn/ fewer km per l / miles per gallon Allow just 'reduced efficiency' Ignore references to ethanol being diluted	**(1)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*22(e)(i)</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>
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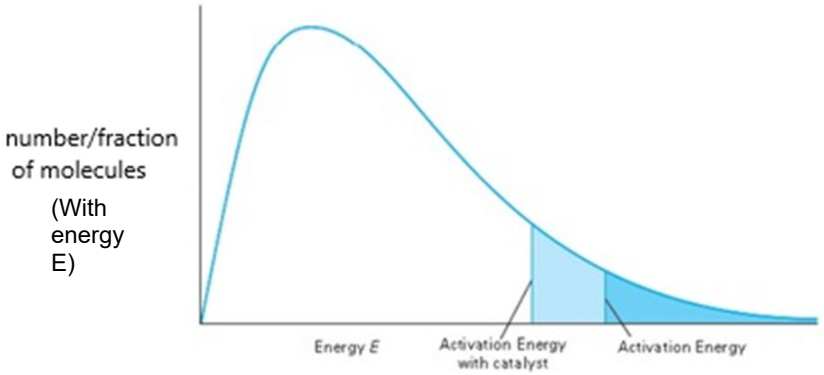
The following table shows how the Marks should be awarded for structure and lines of reasoning.

<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>
</table>
</td>
<td>Guidance on how the Mark scheme should be applied.
The Mark for indicative content should be added to the Mark for lines of reasoning. For example, a response with five indicative Marking points that is partially structured with some linkages and lines of reasoning scores 4 Marks (3 Marks for indicative content and 1 Mark for partial structure and some linkages and lines of reasoning).

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

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

	Answer is partially structured with some linkages and lines of reasoning	1		
	Answer has no linkages between points and is unstructured	0		
	Indicative content **IP1** if temperature increases, **rate** increases (because more particles have energy greater than E_a) **IP2** if temperature increases, yield decreases (because forward reaction is exothermic/ reaction moves in the endothermic direction) **IP3** if pressure increases, rate increases (because particles are more crowded and) collision frequency increases) **IP4** if pressure increases, yield increases(as there are fewer particles on the RHS of the equation) **IP5** the catalyst allows the use of lower temperature/less energy (for the same rate) **IP6** high pressure (and temperature) are very expensive		Allow reaction shifts to the left as an alternative to decreases yield Allow reaction shifts to the right as an alternative to increase yield Ignore fewer atoms on the RHS Ignore any reference to how the catalyst works and the effect of catalyst on rate and yield Allow conditions used are compromise between yield **and** cost / rate **and** cost Allow reverse argument for all points	

Question Number	Answer	Additional Guidance	Mark
22 (e)(ii)	An explanation that makes reference to the following points: • correct labelling of both axes. **(1)** • activation energy labelled **(1)** • activation energy with a catalyst shown to the left of the uncatalysed activation energy. **(1)** • more particles have energy greater than the activation energy with the catalyst / more particles to the right of the activation energy / greater area to the right of the activation energy **(1)**	 M1, M2 and M3 shown on the diagram Both Ea and the catalysed Ea must be to the right of the peak and on the same curve if another temp curve is drawn M4 can be shown on the diagram with labelled shading Allow more particles have activation energy Do not award catalyst increases yield / particles have more energy/ particles move faster/ greater collision frequency Ignore more frequent successful collisions	**(4)**

Question Number	Answer	Additional Guidance	Mark
22(f)(i)	• large(r) surface area (so faster rate of reaction)	Accept more (active) sites Allow more / greater surface Ignore greater area / area of contact	(1)

Question Number	Answer	Additional Guidance	Mark
22(f)(ii)	A description that makes reference to the following points: • remove the ethanol **(1)** • recycle the (unused) reactants **(1)**	Accept condense the ethanol Allow remove the ethanol to shift the eqm to the right scores (2) Ignore any reference to temperature, pressure or catalyst Ignore any reference to adding more reactants	(2)

(Total for Question 22 = 19 Marks)
(Total for Section C = 19 Marks)
TOTAL FOR PAPER = 80 MARKS

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