Mark Scheme (Results)

Summer 2022

Pearson Edexcel GCE
In Chemistry (8CH0)
Paper 02 Core Organic and Physical Chemistry

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General Marking Guidance

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

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate.

Using the Mark Scheme

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

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

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

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

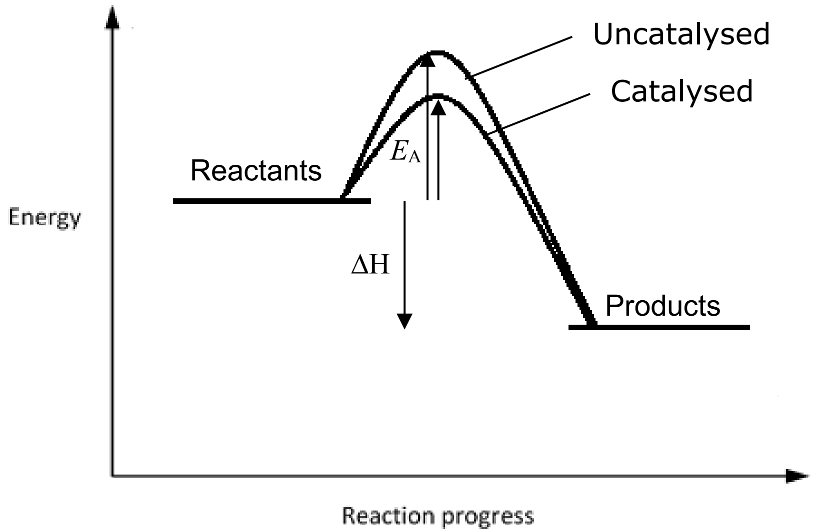
Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex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

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

Question Number	Answer	Mark
1(a)(i)	The only correct answer is **A** (The minimum energy required for a reaction to take place when reactant molecules collide) ***B*** *is not correct because very little energy is required for molecules to collide, but they just bounce off one another* ***C*** *is not correct because not all collisions result in a reaction under most conditions, the particles bounce off one another* ***D*** *is not correct because particles can collide with the appropriate orientation with very little energy so will bounce off one another unless there is enough energy in the collision*	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(a)(ii)	An answer that makes reference to the following points: • (at higher temperature) the peak shifts to the right and is lower **(1)** • because at higher temperatures there are more particles with higher energy **(1)**	Allow reverse arguments for lower temperatures Allow at higher temperatures the particles are distributed over a wider range (of energies) Allow fewer particles are present at the modal / average temperature If no other mark is scored allow at higher temperature / T_2 (on average) the particles have greater (kinetic) energy Ignore comments about the area under the curves Ignore comparisons of activation energy or particles which have the activation energy Ignore discussion of collisions and/or rate of reaction	**(2)**

Question Number	Answer	Mark
1(a)(iii)	The only correct answer is **D** (there are more collisions, all of which are successful, at a higher temperature) ***A*** *is not correct because the number of particles under the curve are those which can react in a collision and there are more at a higher temperature* ***B*** *is not correct because on average particles have more energy so a larger percentage of collisions are successful at a higher temperature* ***C*** *is not correct because more collisions result in more successful collisions giving a faster rate of reaction*	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)(i)	• position of reactants and products with labels **(1)** • two curves with at least one correctly labelled as catalysed or uncatalysed **(1)** • approximately vertical arrow from approximately the reactant line to nearly the height of the top of one or both of the curves labelled E_a / activation energy **(1)** • approximately vertical arrow from reactant line to products line labelled energy change / enthalpy change / ΔH **(1)**	 Allow any suitable equivalent labels Ignore any transition states, labelled or not Do not award straight lines for curves Penalise double headed arrow once only Do not award the arrow in the wrong direction Do not award –ΔH instead of ΔH For an endothermic reaction do not award M1	**(4)**

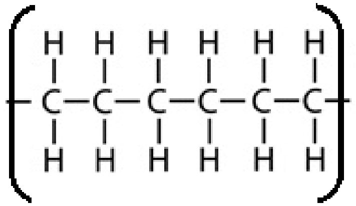
Question Number	Answer	Additional Guidance	Mark
1(b)(ii)	An answer that makes reference to the following points: • a catalyst lowers the activation energy (for the reaction without being used up by it)	Ignore just 'provides an alternative pathway' Do not award lowers the activation energy without taking part in the reaction	**(1)**

Question Number	Answer	Mark
1(c)	The only correct answer is **D** (is often a porous material, so increasing the surface area) ***A** is not correct because though it increases the rate it does take part in, but is not used up by, the reaction* ***B** is not correct because the yield at equilibrium is not affected by the catalyst* ***C** is not correct because a heterogenous catalyst is in a different phase, while a homogeneous catalyst is in the same phase*	**(1)**

(Total for Question 1 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)	An answer that makes reference to two of the following points: • recycling **(1)** • incineration to release energy **(1)** • as a feedstock for cracking **(1)**	Allow remoulding Allow made into other items / description of recycling Allow for burning as a fuel Ignore just 'for incineration' Ignore just 'as a feedstock'	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(b)	An answer that makes reference to the following point: • Vinyl chloride is the **monomer** from which (the polymer) polyvinyl chloride is made Or the **polymer** polyvinyl chloride is made from the (monomer) vinyl chloride	Correct answers will include monomer, polymer or words describing bonding / joining / linking of the vinyl chloride Allow pvc for polyvinyl chloride throughout Allow many vinyl chloride molecules joined / bonded together to make polyvinyl chloride Allow vinyl chloride is the repeat unit in polyvinyl chloride	**(1)**

Question Number	Answer	Mark
2(c)	The only correct answer is **C** ( ***A*** *is not correct because this is the structure of the polymer and does not show three repeat units* ***B*** *is not correct because it is one and a half repeat units* ***D*** *is not correct because this is three polymer molecules joined together due to the n after the brackets*	(1)

(Total for Question 2 = 4 marks)

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	• calculation of energy associated with bond breaking **(1)** • calculation of energy associated with bond formation **(1)** • calculation of the enthalpy change of combustion by subtraction and a negative sign **(1)**	Example of calculation = (22 x 413) + (9 x 347) + (15.5 x 498) = 19928 (kJ) (ans 1) = (20 x 805) + (22 x 464) = 26308 (kJ) (ans 2) Ignore minus sign = (ans 1) – (ans 2) = 19928 – 26308 = –6380 (kJ mol^{-1}) Ignore units even if incorrect Allow TE throughout but for M3 do not award positive values Ignore SF except 1 SF Correct answer with no working scores (3) (+)6380 (kJ mol^{-1}) with no working scores (2)	**(3)**

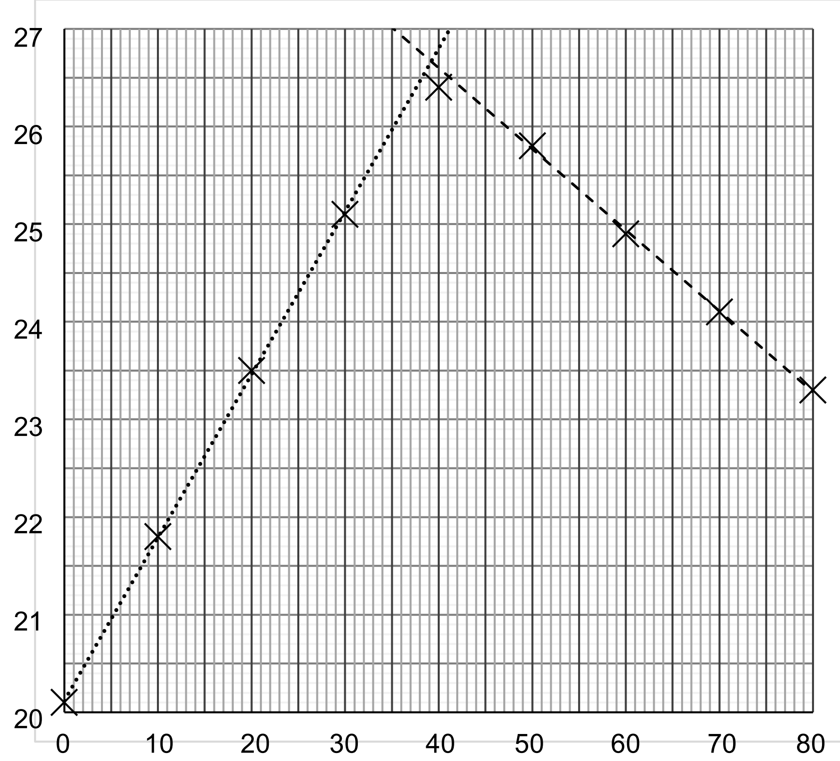
Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	An answer that makes reference to the following points: • use of mean bond enthalpy values rather than actual values for the molecules involved **(1)** • substances in the wrong state for bond energy calculations **(1)**	Ignore just 'mean bond enthalpies are not accurate' without qualification Allow water / decane is a liquid / not a gas	**(2)**

Question Number	Answer	Mark
3(b)(i)	The only correct answer is **C** (NO● is a species with an unpaired electron) ***A** is not correct because nitrogen dioxide, NO_2, is formed during this reaction* ***B** is not correct because this would be NO^-. NO● has 15 protons, 15 neutrons and 15 electrons* ***D** is not correct because radicals such as this are made by homolytic fission*	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	• correct substances **(1)** • correct balancing **(1)**	Example of equation $2C_{10}H_{22} + 62NO \rightarrow 20CO_2 + 22H_2O + 31N_2$ Ignore a dot on NO ALLOW multiples	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(b)(iii)	An answer that makes reference to the following point: • oxygen is present and so $C_{10}H_{22}$ / intermediate compounds might react with oxygen Or NO might react with CO	Allow there is (enough) oxygen for complete combustion Allow the reaction must occur in a series of steps as there are too many particles reacting in the equation Allow it is unlikely for the reactants to be in the correct ratio Allow it is unlikely there will be enough NO / decane Allow reactants can react in other ways giving formation of other named products (such as CO, C, NO_x) Allow NO may react with other substances / air / oxygen to form NO_x / oxides of nitrogen / other nitrogen containing products	**(1)**

(Total for Question 3 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	An answer that makes reference to the following points: • points plotted correctly **(1)** • two suitable straight lines of best fit drawn **(1)**	 Do not award dot to dot lines	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	• temperature rise read from graph	26.7 – 20.1 = 6.6 (°C) Allow maximum temperature shown by graph – 20.1 or temperature from line of best fit at 0 cm^3 added when these are not the same BUT do not award temperature rises which include subtraction of 20.0 unless the lines of best fit indicate this. Ignore SF except 1SF	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(a)(iii)	• gives correct volume added at end-point from the graph (accurate to half a square) **(1)** • finds moles of acid added **(1)**	Example of calculation = 39 cm^3 Do not award 40 cm^3 unless the lines of best fit indicate this value $= \frac{39}{1000} \times 1.10 = 0.0429 / 4.29 \times 10^{-2}$ (mol) Ignore units, even if incorrect Allow TE on first volume given, e.g. Use of 80cm^3 as volume giving 0.088 moles scores (1)	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(a)(iv)	• use of energy change = m x c x ΔT **(1)** • calculation of energy change per mole **(1)** • final answer with correct sign and units **(1)**	Example of calculation (30 + 39) x 4.18 x 6.6 = 1 903.6 / 1.9036 x 10^3 (J) $= \frac{1\ 903.6}{0.0429} = 44\ 372$ (J mol^{-1}) – 44 372 J mol^{-1} / – 44 400 J mol^{-1} / – 44.372 kJ mol^{-1} / – 44.4 kJ mol^{-1} Allow TE throughout from the graph in (a)(i) and calculations in (a)(ii) and (a)(iii) Ignore SF except 1 SF	**(3)**

Question Number	Answer	Mark
4(b)(i)	The only correct answer is **C** (exothermic so energy is absorbed by the water) ***A*** *is not correct because the reaction is exothermic not endothermic* ***B*** *is not correct because the reaction is exothermic not endothermic and energy is absorbed not released by the water* ***D*** *is not correct because energy is absorbed not released by the water*	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	An answer that makes reference to the following point: • (no further release of energy so colder) solution being added cools the reaction mixture OR Added ethanoic acid is at a lower temperature than the reaction mixture	Allow the heat energy is shared over a larger volume Ignore the reaction has stopped so no more energy is released Ignore heat loss	**(1)**

(Total for Question 4 = 10 marks)

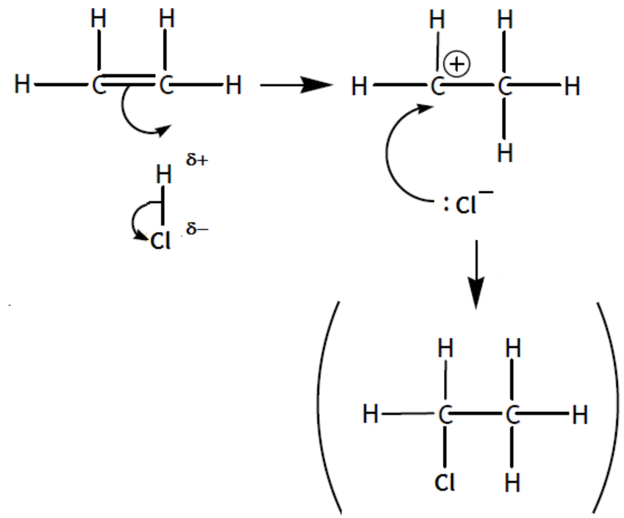
Question Number	Answer	Additional Guidance	Mark
5(a)(i)	An answer that makes reference to the following point: • HCl((g)) / hydrogen chloride (gas)	Do not award hydrochloric acid / HCl(aq) / chlorine / Cl_2 / Cl If name and formula are both given, both must be correct	**(1)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>5(a)(ii)</td>
<td>An answer that makes reference to the following points:

• dipole present on hydrogen chloride (1)

• arrow from C=C bond to H or to where bond will be and arrow from H–Cl bond to, or just beyond, Cl (1)

• correct carbocation intermediate (1)

• arrow from lone pair on chloride ion to positive carbon in carbocation (to give correct product) (1)</td>
<td>

Allow TE for use of Cl_2 in (a)(i), but max (3) if chloroethane is formed as the product
Use of the wrong alkene (e.g. propene) or the wrong hydrogen halide (e.g. HBr) cannot score M4</td>
<td>(4)</td>
</tr>
</table>

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	An answer that makes reference to the following points: • chlorine / Cl_2 **and** ultraviolet / uv (light)	Allow sunlight Ignore chlorine radicals Ignore temperatures Do not award presence of an additional catalyst Do not award hydrogen chloride / HCl / hydrochloric acid / HCl(aq)	**(1)**

Question Number	Answer	Mark
5(b)(ii)	The only correct answer is **C** (free radical substitution) ***A*** *is not correct because as ethane is saturated the reaction is a substitution* ***B*** *is not correct because as ethane is saturated the reaction is a substitution* ***D*** *is not correct because as ethane has no bonds with significant polarity the reaction is not nucleophilic*	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(b)(iii)		Allow radical dots anywhere on the radical species throughout	(3)
	• chloroethane reacts with a chlorine radical OR both correct structure formulae of the products **including** identification of which is which **(1)**	CH_3CH_2Cl + $Cl•$ → $•CH_2CH_2Cl$ + HCl or CH_3CH_2Cl + $Cl•$ → $CH_3CHCl•$ + HCl Allow C_2H_5Cl + $Cl•$ → $C_2H_4Cl•$ + HCl CH_3CHCl_2 1,1-dichloroethane CH_2ClCH_2Cl 1,2-dichloroethane	
	• formation of 1,1-dichloroethane via radical mechanism OR overall equation for the formation of 1,1-dichloroethane **(1)**	$CH_3CHCl•$ + $Cl•$ → CH_3CHCl_2 or $CH_3CHCl•$ + Cl_2 → CH_3CHCl_2 + $Cl•$ Ignore reactions of $C_2H_4Cl•$ CH_3CH_2Cl + Cl_2 → $CH_3CH_2Cl_2$ + HCl	
	• formation of 1,2-dichloroethane via radical mechanism OR	$•CH_2CH_2Cl$ + $Cl•$ → CH_2ClCH_2Cl or $•CH_2CH_2Cl$ + Cl_2 → CH_2ClCH_2Cl + $Cl•$ Ignore reactions of $C_2H_4Cl•$	

	equation for the formation of 1,2-dichloroethane **(1)**	$CH_3CH_2Cl + Cl_2 \rightarrow CH_3CHCl_2 + HCl$ If M2 and M3 are not scored allow (1) for a balanced equation for the reaction of $C_2H_4Cl\bullet$ with $Cl\bullet$ or Cl_2 to form $C_2H_4Cl_2$ (examples shown) $C_2H_4Cl\bullet + Cl\bullet \rightarrow C_2H_4Cl_2$ or $C_2H_4Cl\bullet + Cl_2 \rightarrow C_2H_4Cl_2 + Cl\bullet$	

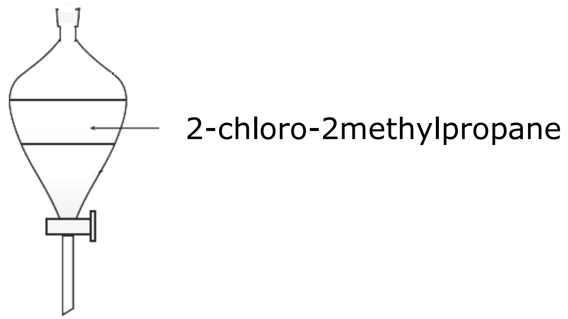
Question Number	Answer	Additional Guidance	Mark
5(b)(iv)	An answer that makes reference to the following points: • 98 peak is due to $C_2H_4{}^{35}Cl_2^+$ **and** 102 peak is due to $C_2H_4{}^{37}Cl_2^+$ **(1)** • 100 peak is due to $C_2H_4{}^{35}Cl^{37}Cl^+$ **(1)**	Allow $C_2H_4{}^{35}Cl^{35}Cl^+$ Allow $C_2H_4{}^{37}Cl^{37}Cl^+$ Allow structural formulae of the molecular ions of either 1,1- or 1,2-dichloroethane or both Allow structures with the positive charge anywhere including outside of brackets of any type. Penalise omission of + once only	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(v)	An answer that makes reference to the following point • ^{35}Cl and ^{37}Cl atoms are in a 3:1 ratio	Answer must refer to the isotopes of chlorine. Ignore comments about isotopes of carbon or hydrogen or just isotopes Allow a larger proportion of chlorine atoms are chlorine-35 than chlorine-37 Allow the ratio of the peak heights to be 9:6:1 Allow the abundance of chlorine-35 and chlorine-37 are different Allow there are two isotopes of chlorine	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(b)(vi)	An answer that makes reference to the following points: Either • the peaks are formed by fragments containing both chlorine atoms attached to one carbon atom or the fragments are $CH^{35}Cl^{37}Cl^{+}$, $CH^{35}Cl_2^{+}$ and $CH^{37}Cl_2^{+}$ **(1)** • this fragmentation / configuration is only possible from 1,1-dichloroethane / is not possible from 1,2-dichloroethane **(1)** Or • the peaks at 83, 85 and 87 represent the loss of a CH_3 group **(1)** • only 1,1-dichloroethane has a methyl group **(1)**	Allow a diagram showing the fragmentation of 1,1- dichloromethane to form a fragment containing one carbon and two chlorine atoms Allow the use of molecule instead of fragment Do not award fragments where the number of hydrogens on the carbon changes Allow just $CHCl_2^{+}$ Do not penalise the absence of the positive charge Do not award fragments where the number of hydrogens changes to allow for the different masses Allow only 1,1-dichloroethane has two chlorines on the same carbon / 1,2-dichlorethane does not have two chlorines on the same carbon Allow the peaks are 15 below the molecular ion values so they represent the loss of a CH_3 group	**(2)**

(Total for Question 5 = 15 marks)

Question Number	Answer	Additional Guidance	Mark
6(a)	An answer that makes reference to the following point: • PCl_5 / phosphorus(V) chloride / phosphorus pentachloride	Allow thionyl chloride / $SOCl_2$ Allow phosphorus(III) chloride / PCl_3 / phosphorus trichloride Ignore phosphorus chloride If name and formula are given both must be correct	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)	An answer that makes reference to the following points: • a separating funnel (with or without a stopper or bung) **(1)** • a two layer system with the top layer labelled as the organic layer / 2-chloro-2-methylpropane **(1)**	Allow any shape separating funnel with a tap at the bottom (no label required) with a bung, stopper or appropriate joint / gap at the top. Allow anything labelled as a tap Do not award a sealed apparatus if stopper / bung is unclear  Do not award a three layer system	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	An answer that makes reference to the following point: • carbon dioxide / CO_2	 Ignore references to limewater turning cloudy	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	An answer that makes reference to the following point: • H^+ / H_3O^+	 Ignore 'hydrogen ion' Ignore numbers before e.g. $2H^+$	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(c)(iii)	An answer that makes reference to the following points: • mixed with an appropriate named drying agent, e.g. (anhydrous) calcium chloride / $CaCl_2$ / (anhydrous) magnesium sulfate / $MgSO_4$ / (anhydrous) sodium sulfate / Na_2SO_4 / silica gel **(1)** • leave until the solution becomes clear / left until added drying agent remains powdered / left until added drying agent does not clump together **or** decant the liquid / filter the solid (to separate from the drying agent **(1)**	M2 is dependent on a drying agent being added in M1 Do not award sodium hydroxide, potassium hydroxide, anhydrous copper sulfate, anhydrous cobalt chloride, calcium sulfate, calcium carbonate, potassium sulfate	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	An answer that makes reference to the following point: • 50-52 (ºC)	Allow 48-54 (ºC) Allow a range within these limits to include 51 (ºC) Do not award just 51 (ºC)	**(1)**

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*6(d)(ii)</td><td>This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

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

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table></td><td>Guidance on how the mark scheme should be applied:

The mark for indicative content should be added to the mark for lines of reasoning.

For example, an answer with five indicative marking points, which is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td>(6)</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*6(d)(ii) contd</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and 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>

Indicative content:
IP1 add anti-bumping granules</td><td>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.

Reasoning marks may be reduced for extra incorrect chemistry

Ignore stated errors which are not present</td><td></td></tr>
</table>

	• IP2 to prevent the formation of large bubbles / rapid heating / transfer of reaction mixture to collecting vessel (leading to impure product) • IP3 the thermometer should be opposite the entrance of the condenser • IP4 collecting over the wrong temperature range (therefore impure or the wrong product) • IP5 add more ice-water mixture • IP6 ensure you collect as much product as possible	Allow to prevent uneven boiling / ensure smooth boiling Ignore prevents bumping Do not award so reaction does not explode / shatter glassware / damage apparatus Allow thermometer should be measuring the vapour temperature not the liquid temperature Allow collecting impure product but must be linked to wrong position of thermometer Do not award just the temperature is inaccurate without mention of vapour Allow collection flask should be further in the ice-water mixture Allow to ensure greater / quicker condensation	

Question Number	Answer	Additional Guidance	Mark
6(e)	Method 1 • calculation of the mass of 2-chloro-2-methylpropane collected **(1)** • calculation of the moles of 2-chloro-2-methylpropane collected **(1)** • calculation of the maximum moles of 2-chloro-2-methylpropane possible **(1)** • calculation of the percentage yield **(1)** Method 2 • calculation of the moles of 2-methylpropan-2-ol **(1)** • calculation of maximum mass of 2-chloro-2-methylpropane possible **(1)** • calculation of maximum volume of 2-chloro-2-methylpropane **(1)** • calculation of the percentage yield **(1)**	Example of calculation: = 11.6 x 0.84 = 9.744 (g) $= \frac{9.744}{92.5} = 0.10534$ / 0.105 (mol) $= \frac{12.00}{74} = 0.16216$ / 0.162 (mol) $= \frac{0.10534}{0.16216} \times 100 = 64.961$ / 65.0 (%) $= \frac{12.00}{74} = 0.16216$ / 0.162 (mol) = 0.16216 x 92.5 = 14.998 / 15.0 (g) $= \frac{14.998}{0.84}$ = 17.855 (cm^3) $= \frac{11.6}{17.855} \times 100 = 64.968$ / 65.0 (%)	**(4)**

	Method 3 • calculation of the mass of 2-chloro-2-methylpropane collected • calculation of the moles of 2-chloro-2-methylpropane collected • calculation of mass of methylpropan-2-ol if yield were 100% • calculation of percentage yield	$= 11.6 \times 0.84 = 9.744$ (g) $= \frac{9.744}{92.5} = 0.10534 / 0.105$ (mol) $= 0.10534 \times 74 = 7.7952$ (g) $= \frac{7.7952}{12.0} \times 100 = 64.960 / 65.0$ (%) Other variations on these methods are possible. Final answer which rounds to 65.0 % with some relevant working scores (4) ALLOW TE throughout but do not award M4 for yields over 100% Ignore SF except 1 SF	

Question Number	Answer	Additional Guidance	Mark
6(f)(i)	An answer that makes reference to the following points: • look for the absence of peaks in the infrared spectrum corresponding to the O-H (stretching absorption in alcohols) / in the range 3750 – 3200 / 3200 – 3750 (cm^{-1})	Ignore references to incorrect spectrometers, e.g. mass spectrometer Do not award for –O–H where it is unclear which bond is stretching	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(f)(ii)	An answer that makes reference to the following points: • an advantage is the cost associated with the chemical test is small Or result is very rapid Or chemicals are readily available **(1)** • a disadvantage is the chemical test is not so sensitive Or Uses some of the sample which cannot easily be recovered **(1)**	Allow reverse arguments for infrared spectroscopy Ignore comments about quantities used Allow can be in schools / anywhere Allow infrared spectroscopes not available in schools / require special laboratories Allow easy to access the chemicals Ignore test is less accurate Allow produces hazardous /corrosive HCl (from PCl_5) Allow produces hazardous / flammable H_2 (from Na) Ignore comments about identification of compounds using spectroscopy	**(2)**

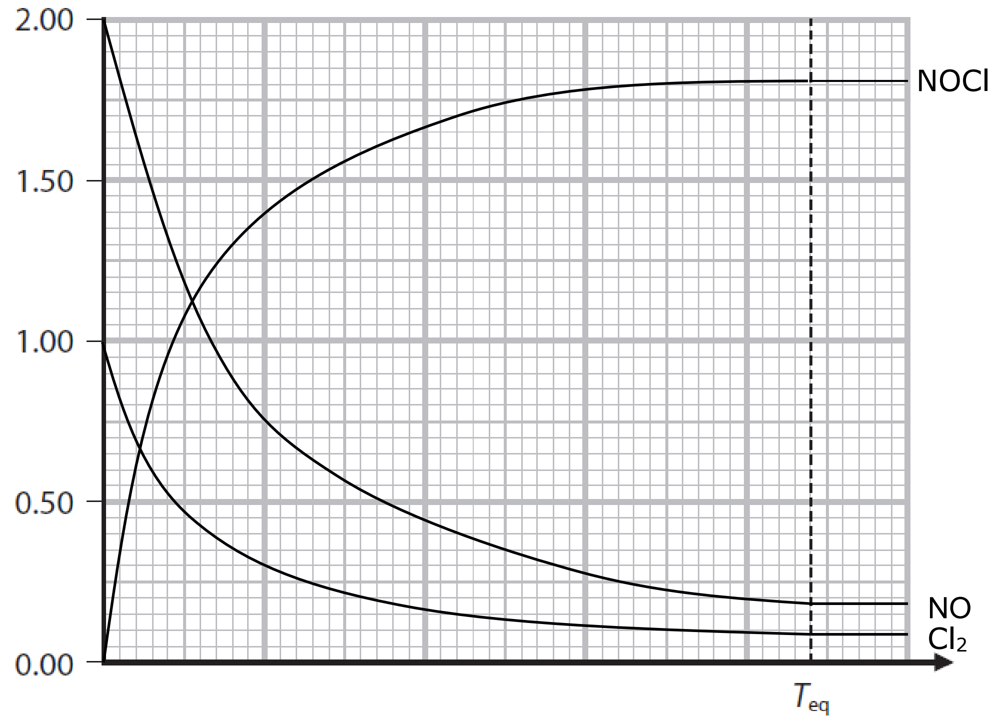
(Total for Question 6 = 21 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)(i)	• calculation of the moles of NO present at equilibrium **(1)** • calculation of the moles of Cl_2 present at equilibrium **(1)**	Example of calculation $2 - 1.82 = 0.18$ (mol) $1 - \frac{1.82}{2} = 0.09$ (mol) Allow TE	**(2)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>7(a)(ii)</td>
<td>

- line starting at 2.00 and ending at 0.18 **(1)**
- line starting at 1.00 and ending at 0.09 **(1)**
- line starting at 0.00 and ending at 1.82 **(1)**

</td>
<td>



Ignore lack of labels
Allow any reasonable curves, curving in the direction shown, with no maximum or minimum
Do not award straight lines
If no marks awarded, allow (1) for 3 correct starting points and / or (1) for 3 correct finishing points

</td>
<td>(3)</td>
</tr>
</table>

		Ignore lines going past T_{eq} unless they are clearly far from horizontal (allow the line to go up or down by 1 square from value at T_{eq} Allow TE on answers to (a)(i)	

Question Number	Answer	Mark
7(a)(iii)	The only correct answer is **B** ($K_c = \dfrac{[NOCl]^2}{[NO]^2[Cl_2]}$) ***A*** *is not correct because this is multiplying [NOCl] and [NO] by 2 rather than squaring* ***C*** *is not correct because this is multiplying by 2 and is upside down* ***D*** *is not correct because this is upside down*	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(a)(iv)	An answer that makes reference to the following points: • equilibrium shifts to favour the endothermic direction (which is the backward reaction)	Answer must make reference to either exo- or endothermic or to significance of negative ΔH Allow the backward reaction is endothermic (so yield decreases) Allow the forward reaction is exothermic so reaction shifts to the left Ignore just forward reaction is exothermic Do not award 'the rate of the forward reaction decreases'	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	• correct species with state symbols in bottom box **(1)** • arrows in correct direction **(1)**	Example of Hess cycle $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$ $N_2(g) + O_2(g) + Cl_2(g)$	**(2)**

Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	• multiplies enthalpy change of formation of NO, $\Delta_f H^{\ominus}_{298}$(NO) by 2 or divides $\Delta_r H^{\ominus}_{298}$ by 2 **(1)** • calculates enthalpy of formation of NOCl **(1)**	Example of calculation (2 x + 90.3) = 180.6 / 181 (kJ) or $-\frac{75.6}{2} = -37.8$ (kJ) $2\Delta_f H^{\ominus}_{298}$NOCl = $\frac{180.6-75.6}{2}$ = 52.5 (kJ mol^{-1}) or $\Delta_f H^{\ominus}_{298}$NOCl = 90.3 – 37.8 = 52.5 (kJ mol^{-1}) Unit, if given, must be correct. Correct answer with no working scores (2) –52.5 (kJ mol^{-1}) scores (1) 14.7 (kJ mol^{-1}) scores (1) +7.35 (kJ mol^{-1}) scores (1) –14.7 (kJ mol^{-1}) scores (0) Ignore presence of absence of 298 Ignore SF except 1 SF M2 no TE other than the answers above No TE on an incorrect cycle	**(2)**

(Total for Question 7 = 11 marks)

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