Mark Scheme (Results)

November 2021

Pearson Edexcel GCE
In Chemistry (8CH0)
Paper 2: 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.

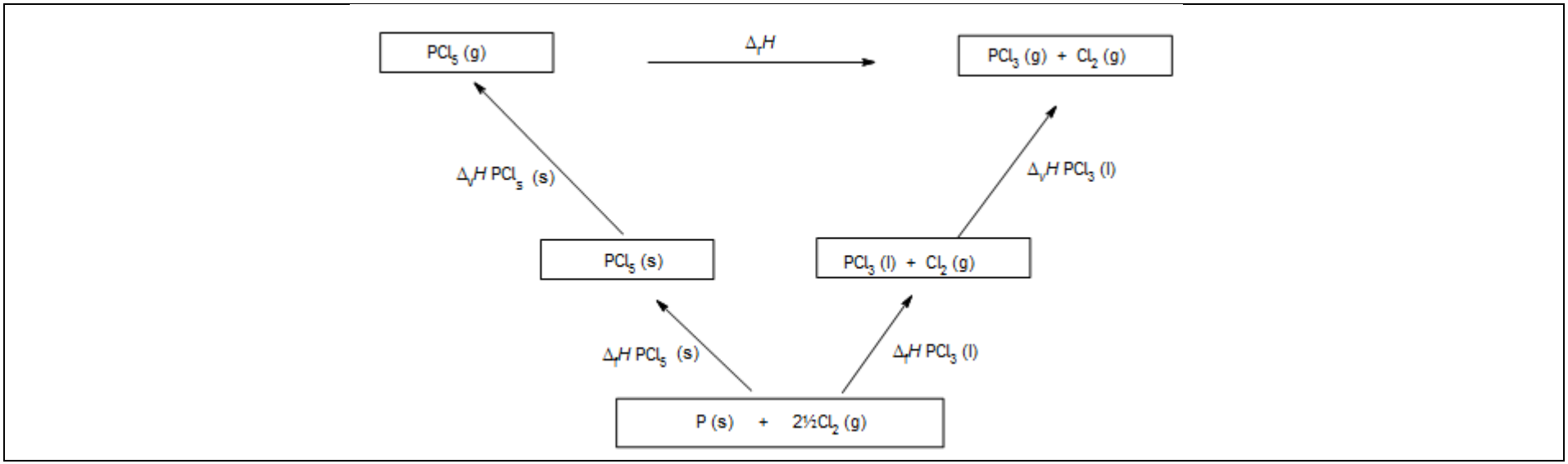
Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex 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	**The only correct answer is C** (*E/Z*) **A** *is not correct because there are no differences in the carbon chain* **B** *is not correct because the functional group (C=C) is in the same position in both molecules* **D** *is not correct because cis/trans isomerism does not assign groups in order of priority*	**(1)**

(Total for Question 1 = 1 mark)

Question Number	Answer	Additional Guidance	Mark
2(a)(i)	An answer that makes reference to the following points: • correct elements in the lower box (P(s), $Cl_2(g)$) **(1)** • correct moles of each element, P(s) **and** $2½Cl_2(g)$ **(1)** • arrows correctly labelled ($\Delta_f H$ [PCl_5], $\Delta_f H$ [PCl_3]) **(1)**	Penalise missing states only once (M1) States are required Allow $P_4(s)$ Ignore balancing numbers for M1 Allow $¼P_4(s)$ Ignore state symbols (if given) Ignore state symbols (if given) on arrows	**(3)**
Example of cycle			

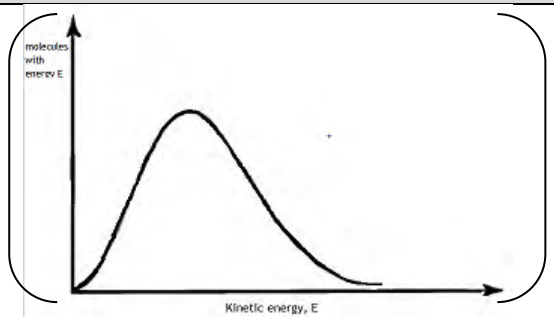


Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	• use of ∑(Δ$_f$*H*[products] - ∑(Δ$_f$*H*[reactants] **(1)** • correct answer with sign and units **(1)**	Example of calculation (-319.7 + 30.5) - (-443.5 + 64.9) Allow correct sums (−289.2 and −378.6) but must be negative = +89.4 kJ mol^{-1} Sign and units must be shown Allow TE from M1(for omission of Δ$_v$*H* data (+123.8 kJ mol^{-1}) Correct answer with no working scores (2)	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(b)	An explanation that makes reference to the following points:		**(2)**

	• (increasing the temperature) will move the equilibrium position to the right/ in forward direction **(1)** • because the (forward) reaction is endothermic **(1)**	Allow more products will form M2 conditional on M1	

(Total for Question 2 = 7 marks)

Question Number	Answer	Mark
3	**The only correct answer is A**  **B** *is not correct because a catalyst does not affect the Maxwell-Boltzmann distribution of molecular energies at the same T and P. This curve would be expected from a decrease in temperature.* **C** *is not correct because a catalyst does not affect the Maxwell-Boltzmann distribution of molecular energies at the same T and P. This curve would be expected from an increase in temperature.*	**(1)**

	D *is not correct because the area under the curve has increased, so the number of molecules has increased.*	

(Total for Question 3 = 1 mark)

Question Number	Answer	Additional Guidance	Mark
4(a)	• correct equation	Example of equation $2CaSO_4 \cdot 2H_2O(s) \rightarrow 2CaSO_4 \cdot \frac{1}{2}H_2O(s) + 3H_2O(l)$ **OR** $CaSO_4 \cdot 2H_2O(s) \rightarrow CaSO_4 \cdot \frac{1}{2}H_2O(s) + 1\frac{1}{2}H_2O(l)$ Allow multiples Allow $H_2O(l)$ or $H_2O(g)$	**(1)**

Question Number	Answer	Mark
4(b)	**The only correct answer is D** (endothermic, dehydration) **A** *is not correct because hydration involves adding water*	**(1)**

	B *is not correct because a reaction that requires heat is unlikely to be exothermic and hydration involves adding water* **C** *is not correct because a reaction that requires heat is unlikely to be exothermic*	

Question Number	**Answer**	**Additional Guidance**	**Mark**
4(c)(i)	• calculation of moles of $CaSO_4 \cdot \frac{1}{2}H_2O$ **(1)** • calculation of volume (or mass) of water required **(1)**	<u>Example of calculation</u> 10.00 g $CaSO_4 \cdot \frac{1}{2}H_2O$ = 10.00 ÷ 145.2 mol = 0.06887 mol Allow 0.069 (moles of water required = 0.06887 x 1.5 = 0.1033 mol) volume of water required = 0.1033 x 18 ÷ 1.00 = 1.86 cm^3 Allow 1.86 g Ignore SF except 1 SF Correct answer with no working scores (2)	**(2)**

		Allow calculation using multiples of these moles (still gets same final answer scores 2) Allow alternative correct calculations: e.g. comparison of moles of $CaSO_4 \cdot ½H_2O$ with moles of water in 10.00 g.	

Question Number	Answer	Additional Guidance	Mark
4(c)(ii)	• calculation of ΔT **(1)** • use of $mc\Delta T$ to find Q **(1)** • calculation of $\Delta_r H$ **(1)** • correct final answer, with sign and 2 or 3 SF **(1)**	<u>Example of calculation</u> $\Delta T = 2.8\ ^oC$ $m = 10.00$ g, $c = 4.18$ J g^{-1} $^oC^{-1}$ $Q = mc\Delta T = 117.04$ J / 0.11704 kJ Allow M1 and M2 if figure of 117.04 J is seen Ignore units unless converted to kJ $117.04 \div 0.06887 = -1699.4$ (J mol^{-1}) -1.70 / -1.7 (kJ mol^{-1})	**(4)**

		Correct answer with no working scores (4) Allow TE throughout and from 4ci (for moles $CaSO_4 \cdot \frac{1}{2}H_2O$)	

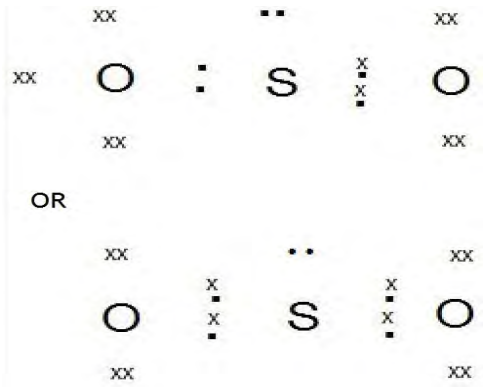
Question Number	Answer	Additional Guidance	Mark
4(c)(iii)	• selection of thermometer **(1)** • calculation of percentage uncertainty **(1)**	Example of calculation $\frac{2 \times 0.5 \times 100}{2.8} = 35.7 / 36 / 40$ (%) Allow selection of measuring cylinder **and** percentage uncertainty is 5%, scores (1) mark Do not award selection of balance Ignore SF	**(2)**

(Total for Question 4 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
5(a)	• correct species **(1)** • balancing **(1)**	Example of equation $2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$ Allow multiples of correct equation Ignore states (if shown)	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	An explanation that makes reference to the following points: • because sulfur compounds/impurities in fuel **and** react with oxygen (from air) **(1)** • because nitrogen in the air **and** reacts with oxygen (from air) **(1)**	Penalise omission of oxygen (from air) once only Allow nitrogen compounds in the fuel	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation that makes reference to the following points: • (because although sulfur dioxide is removed) carbon dioxide is produced. **(1)** • carbon dioxide is a greenhouse gas (and must therefore be removed/stored) **(1)**	Do not award more energy/fossil fuel burned to heat the reaction Allow carbon dioxide adds to/causes global warming	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(c)	• correct dot-and-cross diagram	<u>Example of dot-and-cross diagrams</u>  Allow all dots or crosses Do not allow 3 electron S-O bonds Ignore lines shown as bonds Ignore inner electrons if shown, provided outer electrons are clear	**(1)**

(Total for Question 5 = 7 marks)

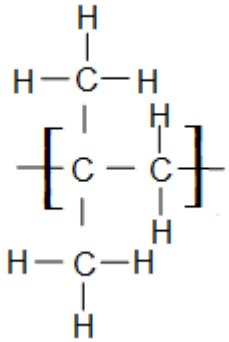
Question Number	Answer	Additional Guidance	Mark
6(a)	• tangent drawn on graph at 50 s **(1)** • calculation of rate **(1)** • units **(1)**	 <u>Example of calculation</u> vertical axis 0.055 mol dm^{-3} horizontal axis 110 s rate = 0.055 ÷ 110 = (-)5.0 x 10^{-4} Allow answers in the range (-)4.0 – (-)6.0 x 10^{-4} Ignore missing negative sign mol dm^{-3} s^{-1} mol dm^{-3} /s mol dm^{-3} per s	**(3)**

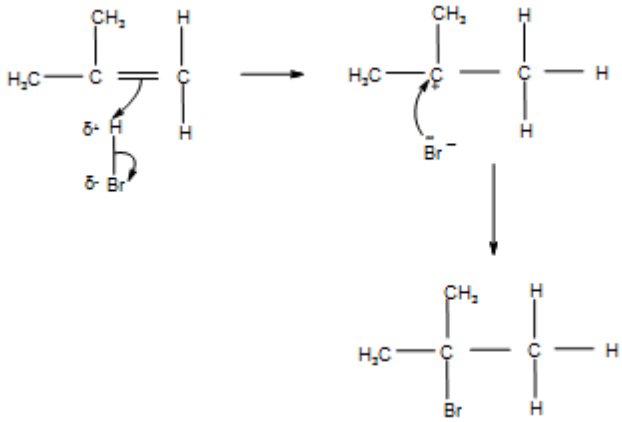
Question Number	Answer	Mark
6(b)	**The only correct answer is D** (nucleophilic substitution) **A** *is not correct because there is more than one product* **B** *is not correct because substitution occurs, not elimination* **C** *is not correct because free radicals are not involved in this reaction*	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	an answer that makes reference to the following points: • cream precipitate/precipitation **(1)** • AgBr **(1)**	 Allow off-white / very pale yellow for cream Do not allow just yellow Allow ppt / ppte / solid / crystals for precipitate Ignore silver bromide Ignore state (if shown)	**(2)**

Question Number	Answer	Mark
6(c)(ii)	**The only correct answer is C** (Z, Y, X) **A** *is not correct because hydrolysis of primary halogenoalkane (**X**) is the slowest* **B** *is not correct because hydrolysis of primary halogenoalkane (**X**) is the slowest* **D** *is not correct because hydrolysis of primary halogenoalkane (**X**) is the slowest*	**(1)**

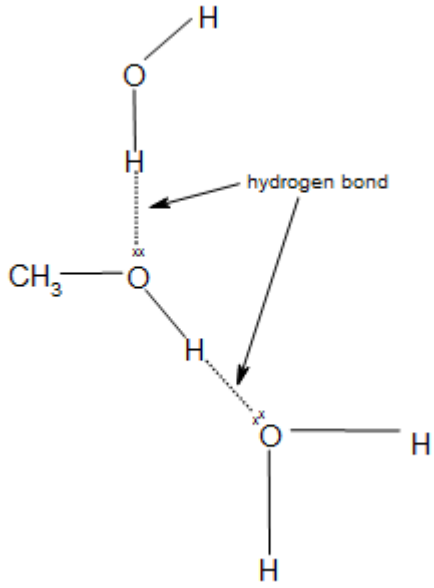
Question Number	Answer	Additional Guidance	Mark
6(d)(i)	An answer that makes reference to the following points: • potassium hydroxide / KOH **(1)** • alcohol / ethanol **and** reflux **(1)**	Mark independently Allow sodium hydroxide / NaOH Allow just 'heat' in place of reflux Do not award aqueous ethanol	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	• repeat unit	Example of repeat unit  Allow non-displayed methyl groups ($-CH_3$) Ignore connectivity of the methyl group Allow n outside brackets Ignore missing brackets / round brackets	**(1)**

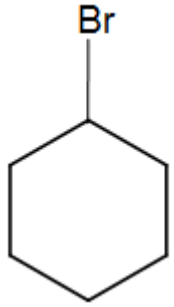
Question Number	Answer	Additional Guidance	Mark
6(d)(iii)	• curly arrow from double bond to H of HBr **and** correct structure of 2-methylpropene **(1)** • curly arrow from H-Br bond to Br atom **and** correct dipole on HBr molecule **(1)** • intermediate with + on correct Carbon **and** Br^- **(1)** • lone pair on Br^- **and** curly arrow from lone pair to C^+ **(1)**	Example of mechanism  incorrect structure of 2-methylpropene loses M1 only + on incorrect carbon loses M3 only	**(4)**

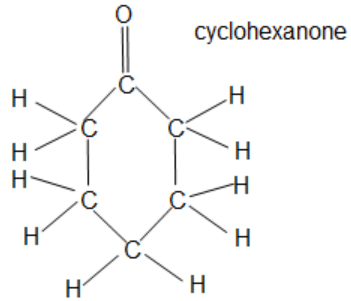
(Total for Question 6 = 14 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)	An answer that makes reference to the following point: • (a series of compounds each containing the) same functional group / same chemical properties **and** the same general formula	Allow one differs from the next by one CH_2 unit	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(b)	An answer that makes reference to the following points: • methanol hydrogen bonds to water **(1)** • at least one lone pair on an oxygen atom and an approximate 180° OHO bond angle **(1)** • strength of (all) intermolecular forces between methanol and water is approximately the same as those in water and methanol **or** strength/extent of H-bonding between methanol and water is same/> that between water/methanol molecules **(1)**	<u>Example of diagram</u>  Accept one labelled hydrogen bond (min) between the O or H of methanol and a correct atom in water. Minimum of one lone pair must be shown on the relevant O atom Ignore reference to the methyl group Allow any mention of H-bond between methanol and water for M11720 – 1700 cm^{-1}	**(3)**

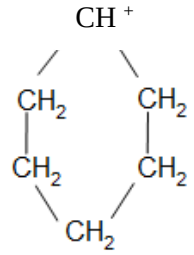
(Total for Question 7 = 4 marks)

Question Number	Answer	Additional Guidance	Mark
8(a)	• skeletal formula	Example of skeletal formula  Bond from ring to Br must be shown but the length is not important.	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	An answer that makes reference to the following points: • name **(1)** • displayed formula **(1)**	Example of displayed formula  Allow CH_2 groups Allow skeletal formula Do not award molecular formula	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An answer that makes reference to the following points: • O-H bond (stretching) 3750 – 3200 cm^{-1} in cyclohexanol is not present in cyclohexanone /disappears (when cyclohexanol reacts). **(1)** • C=O bond (stretching) 1720 – 1700 cm^{-1} appears in cyclohexanone **(1)**	Allow a range within the specified range Allow 1725 – 1700 cm^{-1} Do not allow 1740 – 1720 cm^{-1} (aldehyde)	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	• highest $m/z = M_r = 98$	Check, answer may be shown on mass spectrum Do not accept just '98' with no supporting evidence Allow peak furthest to the right / molecular ion peak is 98	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)(iv)	• fragment **(1)** • charge **(1)**	Examples of fragment structure  $C_6H_{11}^+$ Allow charge anywhere on fragment, including outside brackets around the fragment Allow straight chain fragment provided it has the correct number of C and H atoms	**(2)**

Question Number	Answer	Mark
8(c)(i)	**The only correct answer is B** (elimination) **A** *is not correct because the reaction involves only one reacting molecule (cyclohexanol)* **C** *is not correct because there is no change in the oxidation numbers of any of the elements involved* **D** *is not correct because nothing has been substituted.*	**(1)**

Question Number	Answer		Additional Guidance	Mark
8(c)(ii)	• calculation of mass and mol of cyclohexanol	**(1)**	Example of calculation Mass cyclohexanol = 10.0 × 0.962 = 9.62 (g) and Mol of cyclohexanol = 9.62 ÷ 100 = 0.0962 (mol)	**(4)**
	• calculation of mol of cyclohexene	**(1)**	Mol of cyclohexene = 0.63 × 0.0962 = 0.060606 (mol)	
	• calculation of mass of cyclohexene	**(1)**	Mass of cyclohexene = 0.060606 × 82.0 = 4.9697 (g)	
	• calculation of volume of cyclohexene	**(1)**	Volume of cyclohexene = 4.9697 ÷ 0.811 = 6.1279 = 6 / 6.1 / 6.13 (cm^3) / 6.1 x 10^{-3} dm^3 Ignore SF in final answer Allow TE at each stage Correct answer with no working scores 4	

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*8(c)(iii)</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.
<table>
<tr><th></th><th>Number of marks awarded for structure and sustained lines of reasoning</th></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>
</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 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 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).

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).
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>

	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** separate cyclohexene from water using separating funnel • **IP2** remove the lower aqueous layer because it has a higher density • **IP3** suitable drying agent • **IP4** separate the cyclohexene from the drying agent • **IP5** redistil product • **IP6** collect the distillate boiling over between 80 and 86 ^{o}C to collect the pure cyclohexene	Mark independently Suitable specified drying agents: (anhydrous) $CaCl_2$, Na_2SO_4, $CaSO_4$, $MgSO_4$ By filtering or decanting	

(Total for Question 8 = 19 marks)

Question Number	Answer	Additional Guidance	Mark
9(a)(i)	• sum of bond energies of all reactants **(1)** • sum of bond energies of all products **(1)** • calculation of $\Delta_r H$ **(1)**	Example of calculation $945 + (3 \times 436) = (+)2253$ (kJ mol^{-1}) $6(N{-}H) = 6 \times 391 = (-)2346$ (kJ mol^{-1}) $-2346 + 2253 = -93$ (kJ mol^{-1}) TE from either/both M1 and M2 Correct answer with no working scores 3	**(3)**

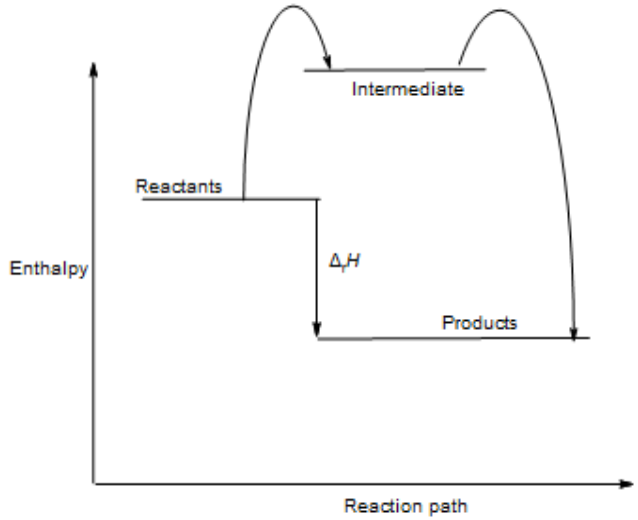
Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	An answer that makes reference to the following points: • the equation in 9(a)(i) is for the formation of two moles of ammonia **(1)** • the bond energies in the table are mean / not specific to ammonia **(1)**	Ignore any references to differing conditions for the Haber process Ignore heat losses	**(2)**

Question Number	Answer	Mark
9(a)(iii)	**The only correct answer is D** (100 %) **A** *is not correct because this is the percentage of hydrogen* **B** *is not correct because this is half the atom economy for making ammonia* **C** *is not correct because this is the percentage of nitrogen*	**(1)**

Question Number	Answer	Mark
9(a)(iv)	**The only correct answer is C** $K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$ **A** *is not correct because this expression shows molar quantities, not powers and is inverted* **B** *is not correct because this expression shows molar quantities, not powers* **D** *is not correct because this expression is for the reverse equation*	**(1)**

Question Number	Answer	Additional Guidance	Mark
9(b)	An answer that makes reference to any **three** of the following points: • the equilibrium position will shift to the right OR this will favour forward reaction **(1)** • (in an equilibrium) removal of product decreases rate of back reaction / rate of formation of reactant(s) **(1)** • time to attain / reach equilibrium may be too long **(1)** • unreacted reactants can be recycled **(1)**		**(3)**

Question Number	Answer	Additional Guidance	Mark
9(c)(i)	An answer that makes reference to the following points: • provide / overcome the activation energy or (is slow at room temperature but) accelerates as temperature rises **(1)** • (sufficiently / very) exothermic enough to melt the copper / break bonds in copper **(1)**	Do not allow 'to lower the activation energy' Allow answers that link rise in temperature to rising rate	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(c)(ii)	 • intermediate energy level/transition state **(1)** • product line below level of reactant line **and** $\Delta_r H$ / ΔH shown on down/ vertical arrow **(1)**	Allow transition state for intermediate Ignore type of arrows to and from intermediate Allow any diagram with a hump shown, with / without intermediate / transition state label Do not penalise missing 'Products' label Allow use of $\Delta_r H$ / -905.2 (kJ mol^{-1})	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(c)(iii)	An answer that makes reference to any **three** of the following points: • reactants **adsorb** onto catalyst / surface **(1)** • (there are) active sites on catalyst (surface) **(1)** • bonds in reactants weakened / broken **or** reaction takes place **(1)** • products **desorb** from the catalyst/active site **(1)**	Do not allow absorb	**(3)**

(Total for Question 9 = 17 marks)

Total for paper = 80 marks

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