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Pearson Edexcel

Mark Scheme (Final)

Summer 2023

Pearson Edexcel International Advanced Subsidiary Level In Chemistry (WCH12)
Paper 01
Unit 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohol

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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.

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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.

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Section A (Multiple Choice)

Question number	Answer	Mark
1	**The only correct answer is C** ($2Cl(g) \rightarrow Cl_2(g)$) ***A*** *is incorrect because the diagram represents an exothermic reaction and atomisation is always endothermic* ***B*** *is incorrect because the diagram represents an exothermic reaction and ionisation is always endothermic* ***D*** *is incorrect because the diagram represents an exothermic reaction and dissolving NH_4NO_3 is endothermic*	**(1)**

Question number	Answer	Mark
2(a)	**The only correct answer is C** (14.7 %) ***A*** *is incorrect because ±7.37 is an uncertainty based on halving the difference between the experimental and data book values and taking this as a percentage of the data book value* ***B*** *is incorrect because ±8.65 is an uncertainty based on halving the difference between the experimental and data book values and taking this as a percentage of the experimental value* ***D*** *is incorrect because 17.3 compares the difference in values to the experimental rather than the data book value*	**(1)**

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Question number	Answer	Mark
2(b)	**The only correct answer is B** (lowers the error in the final value obtained) ***A*** *is incorrect because increasing the specific heat capacity increases the magnitude of the final value which will then be closer to the data book value* ***C*** *is incorrect because the difference is 8.6% which is significant* ***D*** *is incorrect because 8.6% is large compared with the measurement uncertainties*	**(1)**

Question number	Answer	Mark
3	**The only correct answer is A**(+491 kJ mol^{-1}) **B** *is incorrect because the* $\Delta_r H^{\ominus}$ *value for the formation of carbon monoxide has not been tripled* **C** *is incorrect because* $-491kJ\ mol^{-1}$ *is the enthalpy change for the reverse reaction* **D** *is incorrect because* $-713kJ\ mol^{-1}$ *is a calculation for the reverse reaction in which the* $\Delta_r H^{\ominus}$ *value for the formation of carbon monoxide has not been tripled*	**(1)**

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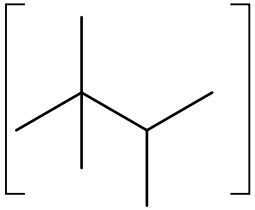
Question number	Answer	Mark
4	**The only correct answer is D**  **A** *is incorrect because the alkane with the most carbon atoms will always have the highest boiling temperature* **B** *is incorrect because the alkane with the most carbon atoms will always have the highest boiling temperature* **C** *is incorrect because the alkane with the most carbon atoms will always have the highest boiling temperature*	**(1)**

Question number	Answer	Mark
5	**The only correct answer is C** (cyclohexane molecules have a larger area of contact) ***A*** *is incorrect because the cyclohexane molecules have fewer electrons than hexane molecules* ***B*** *is incorrect because these molecules have negligible permanent dipole-permanent dipole forces* ***D*** *is incorrect because neither molecule forms hydrogen bonds*	**(1)**

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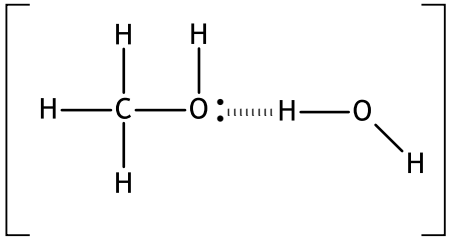
Question number	Answer	Mark
6	**The only correct answer is B** (propanal molecules have strong permanent dipole-permanent dipole forces) ***A*** *is incorrect because butane molecules have more electrons than propanal molecules* ***C*** *is incorrect because the areas of contact between the molecules will be similar and any difference is too small to account for such a large difference in boiling temperature* ***D*** *is incorrect because neither molecule forms hydrogen bonds in the pure liquid*	**(1)**

Question number	Answer	Mark
7	**The only correct answer is A**  **B** *is incorrect because the O-----H─O bond angle should be 180°* **C** *is incorrect because the hydrogen atoms bonded to carbon atoms cannot form hydrogen bonds* **D** *is incorrect because the hydrogen atoms bonded to carbon atoms cannot form hydrogen bonds*	**(1)**

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Question number	Answer	Mark
8	**The only correct answer is B** (chromium in $K_2Cr_2O_7$ and K_2CrO_4) ***A*** *is incorrect because chlorine is in oxidation state +7 in* Cl_2O_7 *and +5 in* $Ca(ClO_3)_2$ ***C*** *is incorrect because* manganese *is in oxidation state +6 in* K_2MnO_4 *and +7 in* Mn_2O_7 ***D*** *is incorrect because oxygen is in oxidation state −2 in* K_2O *and −1 in* K_2O_2	**(1)**

Question number	Answer	Mark
9	**The only correct answer is D** ($BaFeO_4$) ***A*** *is incorrect because* Ba_2FeO_3 *is consistent with the oxidation number of Ba being +1 and of Fe being +4* ***B*** *is incorrect because* $BaFeO_3$*is consistent with the oxidation number of Fe being +4* ***C*** *is incorrect because*Ba_2FeO_4*is consistent with the oxidation number of Ba being +1*	**(1)**

Question number	Answer	Mark
10	**The only correct answer is C** (the sodium ion has a larger ionic radius than the lithium ion) ***A*** *is incorrect because the greater reactivity of sodium does not lead to the formation of a peroxide* ***B*** *is incorrect because the lower first ionisation energy of sodium does not affect the oxide formed* ***D*** *is incorrect because thelithium ion has a higher charge density than the sodium ion*	**(1)**

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Question number	Answer	Mark
11	**The only correct answer is D** (0.200 mol dm^{-3}) ***A*** *is incorrect because 0.025 is obtained by omitting to scale from 0.25 dm^3 to 1 dm^3 and halving the amount of NaOH formed* ***B*** *is incorrect because 0.050 is obtained by omitting to scale from 0.25 dm^3 to 1 dm^3* ***C*** *is incorrect because 0.100 is obtained by halving the amount of NaOH formed*	**(1)**

Question number	Answer	Mark
12	**The only correct answer is B** (2.97 g) ***A*** *is incorrect because 1.48 g does not take into account that 2 mol $Mg(NO_3)_2$ decompose* ***C*** *is incorrect because 7.42 g does not take into account that 2 mol $Mg(NO_3)_2$ decompose or that 5 mol of gas form* ***D*** *is incorrect because 14.8 g does not take into account that 5 mol of gas form*	**(1)**

Question number	Answer	Mark
13	**The only correct answer is A** (electrons being excited to higher energy levels and emitting yellow light on returning to the ground state) ***B*** *is incorrect because blue-violet is the complementary colour to yellow* ***C*** *is incorrect because this describes the formation of a blue-violet colour by the reflection of a beam of white light* ***D*** *is incorrect because this describes the formation of a yellow colour by the reflection of a beam of white light*	**(1)**

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Question number	Answer	Mark
14	**The only correct answer is A** (copper(II)) ***B*** *is incorrect because the presence of lead(II) slows the reaction down* ***C*** *is incorrect because sodium nitrate has no significant effect on the rate* ***D*** *is incorrect because zinc sulfate has no significant effect on the rate*	**(1)**

Question number	Answer	Mark
15	**The only correct answer is A**($1.3\ cm^3\ min^{-1}$) ***B*** *is incorrect because 2.5 $cm^3\ min^{-1}$ is final total volume (20 cm^3) divided by the total reaction time (8 min)* ***C*** *is incorrect because 4.4 $cm^3\ min^{-1}$ is the average rate in reaching point X* ***D*** *is incorrect because 25 $cm^3\ min^{-1}$ is the initial rate of formation of oxygen (taking a tangent at t = 0 to t =1)*	**(1)**

Question number	Answer	Mark
16	**The only correct answer is C** (**R** only) ***A*** *is incorrect because **P** is a secondary halogenoalkane* ***B*** *is incorrect because **Q** is a primary halogenoalkane* ***D*** *is incorrect because **Q** is a primary halogenoalkane*	**(1)**

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Question number	Answer	Mark
17	**The only correct answer is D** (water) ***A*** *is incorrect because ethanol is a co-solvent* ***B*** *is incorrect because nitrate ions are not effective nucleophiles* ***C*** *is incorrect because the silver ion is positively charged and cannot be a nucleophile*	**(1)**

Question number	Answer	Mark
18(a)	**The only correct answer is C** (phosphoric(V) acid) ***A*** *is incorrect because 50% sulfuric acid is not concentrated enough to effect dehydration* ***B*** *is incorrect because ethanolic potassium hydroxide cannot effect elimination of alcohols, only of halogenoalkanes* ***D*** *is incorrect because red phosphorus is used with iodine to bring about a substitution reaction*	**(1)**

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Question number	Answer	Mark
18(b)	**The only correct answer is A**(elimination) ***B*** *is incorrect because water is a product not a reactant* ***C*** *is incorrect because both hydrogen and oxygen are lost* ***D*** *is incorrect because no atom or group is replaced*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

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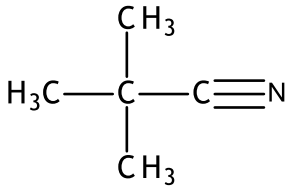
Section B

Question number	Answer	Additional guidance	Mark
19(a)	An answer that makes reference to the following • nucleophilic substitution	Allow substitution nucleophilic	**(1)**

Question number	Answer	Additional guidance	Mark
19(b)	An answer that makes reference to the following • IUPAC name (1) • structure (1)	2,2-dimethylpropanenitrile Ignore punctuation errors e.g. spaces. omission of commas or hyphen or 'e' in propane Allow 2,2-dimethylpropanonitrile / 2,2-dimethylpropanitrile Accept displayed, skeletal or structural formula or any combination of these. e.g.  Accept CN for C≡N Ignore connectivity errors on alkyl group e.g. CH_3─C Do not award C=N / C─N / NC Standalone marks. No TE	**(2)**

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Question number	Answer	Additional guidance	Mark
19(c)	An answer that makes reference to the following • ammonia / NH_3 (1) • (heat) under pressure **and** in alcoholic solution (1)	Standalone marks Accept concentrated ammonia Allow concentrated aqueous ammonia Allow ammonia solution Ignore gas Do not award just aqueous ammonia Do not award dilute ammonia (solution) Allow heat **and** in a sealed tube / container (in alcohol) Accept alcohol or ethanolic or ethanol for alcoholic Do not award heat under reflux	**(2)**

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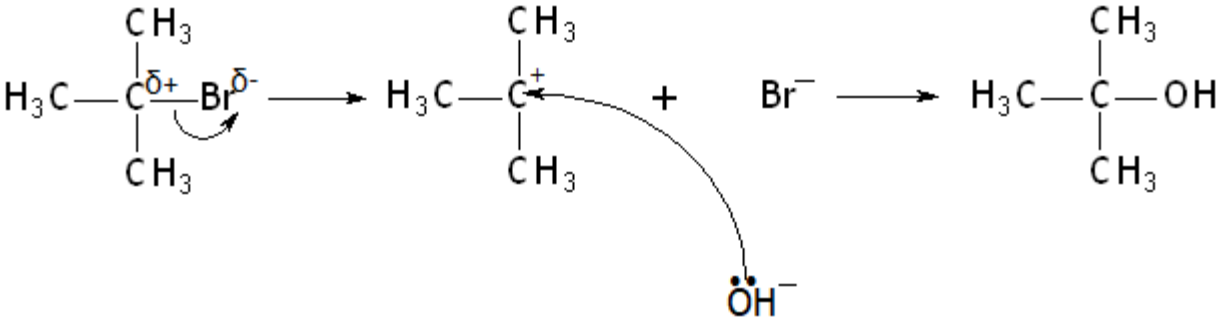
Question number	Answer	Additional guidance	Mark
19(d)(i)	An answer that shows the following • dipole on C─Br • curly arrow from C─Br bond to Br atom or just beyond • lone pair on oxygen of OH^- • curly arrow from oxygen to positively charged carbon atom	All four points correct scores (2) Any two or three points correct scores (1) Do not award second curly arrow from negative charge Penalise use of half-arrows once only Ignore an extra OH^- attacking the 2-bromo-2-methylpropane molecule. Ignore lone pair on this extra species Ignore extra curly arrows and lone pairs	(2)

Example of mechanism



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Question number	Answer	Additional guidance	Mark
19(d)(ii)	An answer that makes reference to the following • heterolytic (bond) fission occurs (1) • the (pair of) electrons in the C─Br bond are transferred to the bromine atom (1)	Standalone marks Allow heterolytic (bond) breaking Allow heterolysis Do not award heterolytic fission of any other bond. Ignore heterolytic reaction Allow 'the **bonding** electron **pair** is transferred to the bromine (atom)' Allow 'C─Br bond is broken **and** both electrons are transferred to the bromine (atom)' There must be an indication of **two** electrons (pair / both)	**(2)**

Question number	Answer	Additional guidance	Mark
19(d)(iii)	An answer that makes reference to the following • (shape is) trigonal planar (1) • three bond pairs (and no lone pairs) **and** arranged to minimise repulsion (1)	Allow triangular planar Ignore just 'trigonal' Ignore bond angles Allow regions of electrons Do not award lone pairs / atoms for bond pairs Allow for maximum separation No TE on incorrect numbers of valence electron pairs	**(2)**

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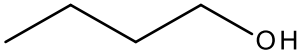
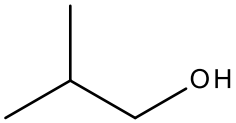
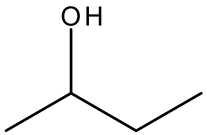
Question number	Answer	Additional guidance	Mark
19(d)(iv)	An answer that makes reference to the following • two structures of isomeric alcohols $C_4H_{10}O$ (1) • third structure of isomeric alcohol $C_4H_{10}O$ (1)	All three correct scores (2) Any two correct scores (1) Allow displayed, structural or skeletal formulae or any combination of these Allow C_2H_5 for CH_3CH_2 M2 depends on M1 being scored Penalise connectivity errors only with horizontal OH and once only Penalise omission of H atoms in displayed structures once only Using C_3H_7OH scores zero	**(2)**

Examples of structures

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Question number	Answer	Additional guidance	Mark
19(e)(i)	An answer that makes reference to the following • all species correct (1) • equation balanced (1)	$Ag_2O + H_2O \rightarrow 2Ag^+ + 2OH^-$ Non-ionic equation scores (1) $Ag_2O + H_2O \rightarrow 2AgOH$ Allow reversible arrow Ignore state symbols even if incorrect	(2)

Question number	Answer	Additional guidance	Mark
19(e)(ii)	An answer that makes reference to the following • (because silver(I) oxide is insoluble) it can easily be separated from the reaction mixture (when reaction is complete)	Allow (because silver(I) oxide is insoluble) it can be reused Allow NaOH / KOH are caustic / corrosive (due to high concentration of hydroxide ions) Allow Ag_2O is less corrosive (than NaOH) Ignore reference to reactivity of NaOH and KOH Ignore reference to reactivity of Na and K Ignore reference to other silver compounds	(1)

(Total for Question 19 = 16 marks)

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Question number	Answer	Additional guidance	Mark
20(a)(i)	• identification and number of bonds broken **and** the values needed (1) • evaluation of energy required (1) • identification of bonds formed **and** the values needed **and** evaluation of energy produced (1) • evaluation of enthalpy change of combustion (1)	Here and throughout the paper Do not penalise correct premature rounding Penalise incorrect rounding only in their final answer Example of calculation Bonds broken: 7 × C─C + 18 × C─H + 12.5 × O=O *E* (bond breaking) = 7 × 347 + 18 × 413 + 12.5 × 498 = (+)16088 (kJ mol^{-1}) TE only if at least 2 bonds used Bonds formed: *E* (bond forming) = 16 × C=O + 18 × O─H = 16 × 805 + 18 × 464 = (−)21232 (kJ mol^{-1}) $\Delta_c H$ = 16088 – 21232 = −5144 (kJ mol^{-1}) TE at each stage (even if final value is positive) Ignore SF except 1 SF Units are not required but if given must be correct for the **final** value Correct answer with some working scores (4)	**(4)**

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Question number	Answer	Additional guidance	Mark
20(a)(ii)	An answer that makes reference to the following • the bond enthalpies are averaged over a (large) number of compounds (1) • bond enthalpies always refer to substances in the gas phase **and** octane and water are liquids when the value of $\Delta_c H^{\ominus}$ is obtained (1)	Allow just bond enthalpies are average values Allow just octane is a liquid or water is a liquid Allow calculations using mean bond enthalpies do not include changes of state Ignore non-standard conditions Do not award explanations for experimental error such as heat loss, or incomplete combustion	**(2)**

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Question number	Answer	Additional guidance	Mark
20(a)(iii)	• calculation of molar mass of octane (1) • conversion of kJ mol^{-1} to MJ kg^{-1} **and** calculation of percentage efficiency (1)	Example of calculation M = 8 × 12 + 18 = 114 g mol^{-1} Allow mol octane = 1000÷(8x12 + 18x1) = 8.772 Ignore just (8x12 + 18x1) 1000 × 5470 ÷ 114 = 47982 kJ kg^{-1}= 47.982 MJkg^{-1} Efficiency = 100 x 11 ÷ 47.982 = 22.925 /22.9 / 23% Allow conversion of MJ kg^{-1} to kJ mol^{-1} = 114 x 11 x 1000 ÷ 1000 = 1254 (kJ mol^{-1}) and Efficiency = 100 x 1254 ÷ 5470 = 22.925 /22.9 / 23% Ignore SF except 1 SF TE unless % efficiency > 100 Correct answer with no working scores (2) Allow calculation using $\Delta_c H^{\ominus}$ from mean bond enthalpy data (−5144 kJ mol^{-1}): Efficiency =24.378% Allow calculation using stated incorrect $\Delta_c H^{\ominus}$ from mean bond enthalpy data unless % efficiency > 100	**(2)**

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Question number	Answer	Additional guidance	Mark
20(a)(iv)	An answer that makes reference to **two** of the following • heat loss to the surroundings (1) • energy is used to bring the engine to operating temperature (1) • incomplete combustion (of the fuel) (1)	Accept specific examples such as Heat loss due to friction in the engine Heat loss via hot exhaust Allow just 'converted to heat' Allow energy loss to the surroundings Ignore just 'friction' Allow energy is used to warm up the engine Allow energy is used to start the engine Allow energy is used for aircon / electronic devices Allow combustion is not smooth Ignore inefficient combustion Ignore references to standard conditions Ignore fuel evaporates Ignore petrol not 100% octane Ignore the idea that some other force is moving the car e.g. car is going downhill	**(2)**

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<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr>
<td>*20(b)</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 0 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>

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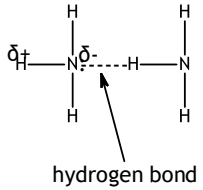
Question	Answer	Additional guidance	Mark
***20(b) cont**	Indicative points Similarities • **IP1**both hydrogen and ammonia form London / dispersion forces • **IP2** a temporary dipole forms in a molecule and induces a dipole in an adjacent molecule • **IP3** the attraction (between the temporary dipoles) is small(er) in hydrogen because the H_2 electron cloud is not easily polarised Differences • **IP4** ammonia forms hydrogen bonds (because nitrogen is very electronegative)  • **IP5** Accept hydrogen bond forms between the nitrogen lone pair and the (δ+) hydrogen (of a different molecule) • **IP6** ammonia liquefies more easily than hydrogen because hydrogen bonds are stronger than London forces	Allow van der Waals forces Ignore permanent dipole-dipole forces in ammonia Do not award H_2 forms hydrogen bonds / permanent dipole-dipole forces Accept fluctuating electron clouds result in differences in electron density within the molecule Allow instantaneous dipole-dipole attractions between molecules Allow because H_2 has only two / few electrons Allow attraction is greater in ammonia because it has more electrons Do not award ammonia forms hydrogen bonds with water IP4 and IP5 may be scored by a diagram showing dipole and lone pair and with H bond labelled Allow N----H─N bond angle not equal to 180 Allow hydrogen bond forms between the δ− nitrogen and the δ+ hydrogen (of a different molecule) Allow permanent dipole-dipole forces for H bonds here Ignore just ‘H-bonding is the strongest IMF’ Ignore reference to boiling temperatures Do not award hydrogen liquefies to form water Do not award energy is required to liquefy a gas	**6**

(Total for Question 20 = 16 marks)

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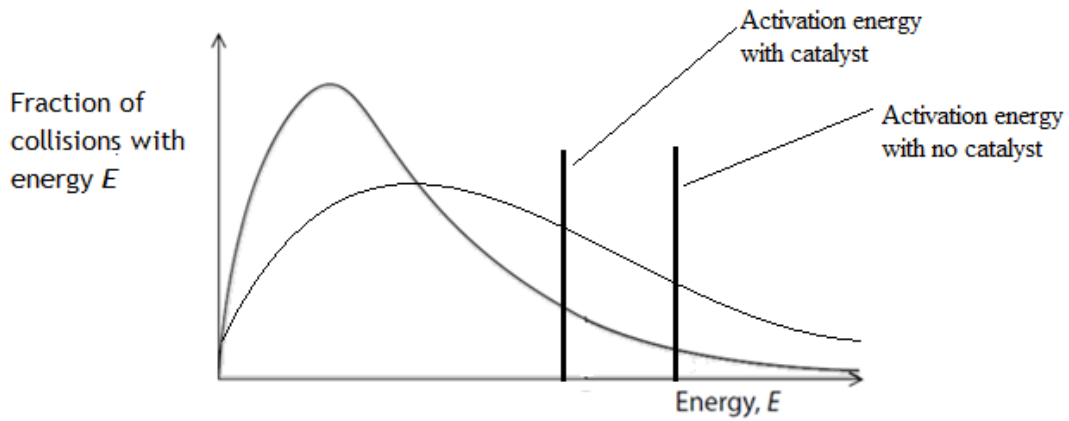
Question number	Answer	Additional guidance	Mark
21(a)(i)	A diagram showing the following • new line starting at the origin **and** lower maximum **and** peak moved to the right **and** asymptotic line above the original	 Do not award if any part of the curve to the right of the peak is below the 300°C line Do not award if asymptote finishes higher than 25% the height of the new peak	**(1)** **clip with (a)(ii)**

Example of Maxwell-Boltzmann distribution



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Question number	Answer	Additional guidance	Mark
21(a)(ii)	An answer that makes reference to the following EITHER • Increasing the temperature increases the (average kinetic) energy of collisions **and** so more collisions have energy greater than the activation energy (1) • adding a catalyst lowers the activation energy **and** so more collisions have energy greater than the activation energy (1) OR • (rate increases when) more collisions have an energy greater than (or equal to) the activation energy (1) • the area under the curve beyond E_a is increased when the temperature is increased **and** when E_a becomes E_{cat} (1)	Allow particles / molecules / atoms for collisions throughout Allow just 'increasing the temperature increases the number of collisions with energy greater than E_a' Standalone mark Allow particles / molecules / atoms for collisions In no other mark is scored increasing the temperature increases the (average kinetic) energy of collisions **and** adding a catalyst lowers the activation energy scores (1) M2 may be scored by clear labelling of the relevant areas under the curves	**(2)** **clip with (a)(i)**

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Question number	Answer	Additional guidance	Mark
21(b)	An answer that makes reference to the following • Advantage: hydrogen is a useful by-product (1) • Disadvantage: higher temperature means higher energy costs (1)	Allow higher atom economy Ignore higher temperature gives higher rate Ignore oxygen not needed Allow higher temperature is more expensive Allow the energy required is more expensive Allow higher temperature needs more expensive equipment Allow more energy is required Ignore just 'more expensive' Ignore reference to yield Do not award the hazards of hydrogen	**(2)**

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Question number	Answer	Additional guidance	Mark
21(c)	An answer that makes reference to the following • (methanol) O─H stretch wavenumber range 3750-3200 (cm^{-1})(1) • (methanal) C=O stretch wavenumber range 1740-1720 (cm^{-1}) or (methanal) C─H stretch wavenumber range 2900-2820 (cm^{-1}) or (methanal) C─H stretch wavenumber range 2775-2700 (cm^{-1}) (1)	Allow OH or CO Ignore ROH / CH_3OH / HCHO Both wavenumber ranges without bonds scores (1) Specific wavenumbers within the ranges or wavenumber ranges within the Data Booklet ranges scores max (1) If more than one wavenumber is given for methanal all must be correct Ignore alkyl C─H stretch wavenumber ranges	**(2)**

(Total for Question 21 = 7 marks)

TOTAL FOR SECTION B = 39 MARKS

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Section C

Question number	Answer	Additional guidance	Mark
22(a)	An answer that makes reference to the following • (safety) glasses / goggles / spectacles	 Allow gloves Ignore laboratory coat / apron Ignore mask Ignore open window Ignore all explanations for the selected safety precaution Do not award use in a cupboard / fume cupboard	**(1)**

Question number	Answer	Additional guidance	Mark
22(b)(i)	An answer that makes reference to the following • ionic equation for acid-carbonate reaction	Example of equation $2H^+ + CaCO_3 \rightarrow Ca^{2+} + H_2O + CO_2$ Allow $2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$ Allow multiples Ignore state symbols even if incorrect Do not award inclusion of spectator ions	**(1)**

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Question number	Answer	Additional guidance	Mark
22(b)(ii)	• calculation of mass of HCl in 50 cm^3 (1) • calculation of M_r of HCl **and** calculation of moles of HCl in 50 cm^3 (1) • calculation of moles of $CaCO_3$ (1) • calculation of M_r of $CaCO_3$ **and** calculation of mass of $CaCO_3$ (1) If moles of HCl in 750 cm^3 are calculated first = 85÷36.5 = 2.3288 (mol). This scores M2	Example of calculation mass of HCl = 85.0 × 50 ÷ 750 = 5.6667 (g) HCl M_r = 36.5 mol HCl = 5.6667 ÷ 36.5 = 0.15525 (mol) mol $CaCO_3$ = 0.15525 ÷ 2 = 0.077626 / 7.7626 × 10^{-2} (mol) $CaCO_3$ M_r = 100.1 0.077626 × 100.1 = 7.7703 / 7.77 / 7.8 (g) TE at each stage Allow $CaCO_3$ *M*r = 100 giving 7.7626 (g) Correct answer with some working scores (4) Ignore SF except 1 SF If all the HCl is used, mass $CaCO_3$ = 116.55 g scores (3) If the reacting ratio is used the wrong way round the mass $CaCO_3$ = 31.08 g	**(4)**

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Question number	Answer	Additional guidance	Mark
22(c)(i)	An answer that makes reference to the following • disproportionation (reaction) (1) • chlorine oxidised from zero (in Cl_2) to +1 in HClO / ClO^- (1) • chlorine reduced from zero (in Cl_2) to −1 in HCl / Cl^- (1)	Example of equation standalone mark Ignore ‘redox’ Ignore just ‘chlorine both oxidised and reduced’ For M2 and M3 allow oxidation numbers of the species shown in the equation If M2 and M3 not scored just ‘chlorine oxidised from zero (in Cl_2) to +1 and reduced from zero (in Cl_2) to −1’ scores (1) If M2 and M3 not scored the three oxidation numbers of chlorine scores (1). This may be shown on the equation Do not award M2 / M3 if changes of oxidation numbers of H and O given	**(3)**

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Question number	Answer	Additional guidance	Mark
22(c)(ii)	• calculation of moles of oxygen (1) • deduction of moles of NaOCl(1) • calculation of M_r (NaOCl) & mass of NaOCl in 5 cm^3(1) • calculation of mass of of NaOCl in 1 dm^3 **and** answer given to 2 SF (1)	Example of calculation mol O_2 = 113 ÷ 24000 = 4.7083×10^{-3} / 0.0047083 (mol) mol NaOCl = mol O_2 = 4.7083×10^{-3} / 0.0047083 (mol) M_r (NaOCl) = 74.5 mass of NaOCl in 5 cm^3 = $74.5 \times 4.7083 \times 10^{-3}$ = 0.35077 (g) $0.35077 \times 200 = 70.154 = 70$ (g dm^{-3}) TE at each stage Correct answer with some working scores (4) The conversion from moles to mass omitted and the answer given to 2 SF as 0.94 (mol dm^{-3}) scores (3)	**(4)**

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Question number	Answer	Additional guidance	Mark
22(c)(iii)	An answer that makes reference to the following • propane-1,2,3-triol forms **three** hydrogen bonds per molecule (1) • so the molecules are strongly attracted to each other (and to surfaces) (1)	Standalone marks Allow propane-1,2,3-triol has three OH groups **and** forms hydrogen bonds Allow 'propane-1,2,3-triol forms three hydrogen bonds' Do not award propane-1,2,3-triol has / forms OH^- ions Allow so the intermolecular forces are (very) strong Allow so molecules do not move past each other (easily) Allow the intermolecular forces need a lot of energy to overcome Ignore just 'hydrogen bonding is the strongest intermolecular force'	**(2)**

Question number	Answer	Additional guidance	Mark
22(d)	An answer that makes reference to the following • toxic chlorine would be produced (1) • (because) the chlorine disinfectant equilibrium would move to the left (because the concentration of H^+ would increase (1)	Ignore just 'forms chlorine' Allow $NaClO + 2HCl \rightarrow NaCl + H_2O + Cl_2$ Allow $HClO + HCl \rightarrow H_2O + Cl_2$ Do not award $NaClO + HCl \rightarrow NaOH + Cl_2$	**(2)**

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<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr>
<td>22(e)</td>
<td>
• calculation of mol of each element (1)

• calculation of ratio
and
calculation of simplest whole number ratio (1)

• deduction of moles of water of crystallisation (1)

• deduction of formula (1)
</td>
<td>
Example of calculation
<table>
<tr><td></td><td>H</td><td>B</td><td>O</td><td>Na</td></tr>
<tr><td>%</td><td>5.2</td><td>11.3</td><td>71.4</td><td>12.1</td></tr>
<tr><td>mol</td><td>5.2/1
=5.2</td><td>11.3/10.8
=1.05</td><td>71.4/16
= 4.46</td><td>12.1/23
= 0.526</td></tr>
<tr><td>÷ 0.526</td><td>9.89</td><td>2.00</td><td>8.48</td><td>1</td></tr>
<tr><td>ratio</td><td>20</td><td>4</td><td>17</td><td>2</td></tr>
</table>
TE for only 3 elements
Hydrogen is only in water so 10 H_2O

$Na_2B_4O_7.10H_2O$
TE at each stage for formulae with H_2O
Correct answer with some working scores (4)
Ignore SF except 1 SF
Incorrect rounding leads to formulae such as $NaB_2H_{10}O_8$ which scores (1)
Processing this to $NaB_2O_3.5H_2O$ scores (3)
</td>
<td>(4)</td>
</tr>
</table>

(Total for Question 22 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FORPAPER = 80 MARKS

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