Mark Scheme (Results)

October 2019

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

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General Marking Guidance

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

Using the Mark Scheme

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

The mark scheme gives examiners:

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

/ means that the responses are alternatives and either answer should receive full credit.

( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

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

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

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

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A

Question Number	Answer	Mark
1	**The only correct answer is C** (1.20) ***A*** *is incorrect because this is the volume of 1 mol* ***B*** *is incorrect because this is a factor of 10 out* ***D*** *is incorrect because the inverse of the number of mols of lithium carbonate has been divided by 24.0*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is C** (3) ***A*** *is incorrect because different isotopes of chlorine have been ignored* ***B*** *is incorrect because different isotope combinations of chlorine have not been considered* ***D*** *is incorrect because 35Cl/37Cl and 37Cl/35Cl give the same peak*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is D** ($\Delta_f H$ (carbon monoxide) = −110.5 kJ mol^{-1}) ***A*** *is incorrect because there are 2 mol of carbon in the equation and combustion is incomplete* ***B*** *is incorrect because there are 2 mol of carbon monoxide in the equation* ***C*** *is incorrect because the combustion is incomplete*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is D** (London forces) ***A*** *is incorrect because covalent bonds are between atoms not molecules* ***B*** *is incorrect because there are no hydrogen bonds as electronegativity of iodine is low* ***C*** *is incorrect because there are no ions present*	**(1)**

Question Number	Answer	Mark
5(a)	**The only correct answer is C** (Reaction 3) ***A*** *is incorrect because different species are oxidised and reduced* ***B*** *is incorrect because different species are oxidised and reduced* ***D*** *is incorrect because there is no change in oxidation state*	**(1)**

Question Number	Answer	Mark
5(b)	**The only correct answer is D** (Reaction 4) ***A*** *is incorrect because neither reactant is acting as an acid or base* ***B*** *is incorrect because this is a redox reaction* ***C*** *is incorrect because neither reactant is acting as an acid or base and it is a redox reaction*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is C** (barium sulfate is less soluble in water than magnesium sulfate) ***A*** *is incorrect because carbonate thermal stability increases down Group 2* ***B*** *is incorrect because hydroxide solubility increases down Group 2* ***D*** *is incorrect because barium is more reactive than magnesium with water*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is C** (chloride ions are stronger reducing agents than bromide ions) ***A*** *is incorrect because chlorine is more electronegative than bromine* ***B*** *is incorrect because chlorine is more reactive than bromine* ***D*** *is incorrect because chloride ions are stronger reducing agents than fluoride ions*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is A** ($SrBr_2$) ***B*** *is incorrect because sodium produces a yellow flame test* ***C*** *is incorrect because although the flame test would be red the silver halide ppt would be white* ***D*** *is incorrect because the flame test would be green and the silver halide ppt would be yellow and insoluble in concentrated ammonia*	**(1)**

Question Number	Answer	Mark
9(a)	**The only correct answer is B** (0.50) ***A*** *is incorrect because 0.050 is the number of moles produced* ***C*** *is incorrect because the solution concentration is assumed to be the same as the alkali* ***D*** *is incorrect because the solution concentration is assumed to be equal to that of the acid*	**(1)**

Question Number	Answer	Mark
9(b)	**The only correct answer is B** (± 0.20%) ***A*** *is incorrect because both solutions have been considered* ***C*** *is incorrect because the uncertainty has not been doubled* ***D*** *is incorrect because the volume measured has been ignored*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is A** ($NaCl$ and $NaClO$) ***B*** *is incorrect because both products are the result of oxidation* ***C*** *is incorrect because the reaction is not heated and the solution is not concentrated* ***D*** *is incorrect because both products are the result of oxidation*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is D** (SO_3) ***A*** *is incorrect because* H_2S *is a product* ***B*** *is incorrect because* I_2 *is a product* ***C*** *is incorrect because S is a product*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is B** (decreasing the concentration of the hydrochloric acid) ***A*** *is incorrect because an increase in reactant concentration would reduce the time taken* ***C*** *is incorrect because raising the temperature would reduce the time taken* ***D*** *is incorrect because adding a catalyst would reduce the time taken*	**(1)**

Question Number	Answer	Mark
13(a)	**The only correct answer is A** (increase rate, decrease yield) ***B*** *is incorrect because an increase in temperature would increase the rate* ***C*** *is incorrect because the equilibrium would move to the left, i.e. endothermic direction* ***D*** *is incorrect because an increase in temperature would increase the rate and the equilibrium would move to the left, i.e. endothermic direction*	**(1)**

Question Number	Answer	Mark
13(b)	**The only correct answer is C** (increase rate, increase yield) ***A*** *is incorrect because an increase in pressure would increase the yield* ***B*** *is incorrect because an increase in pressure would increase the rate and yield* ***D*** *is incorrect because an increase in pressure would increase the rate*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is B** (2-chloro-2-methylpropane) ***A*** *is incorrect because a primary alcohol would be formed which would be oxidised* ***C*** *is incorrect because a primary alcohol would be formed which would be oxidised* ***D*** *is incorrect because a secondary alcohol would be formed which would be oxidised*	**(1)**

Question Number	Answer	Mark
15(a)	**The only correct answer is B** (oxidising propan-1-ol to propanal) ***A*** *is incorrect because reducing an alcohol would produce an alkane* ***C*** *is incorrect because reducing propanal would produce propan-1-ol* ***D*** *is incorrect because oxidising propan-1-ol would produce propanal or propanoic acid*	**(1)**

Question Number	Answer	Mark
15(b)	**The only correct answer is A** (propan-1-ol) ***B*** *is incorrect because propan-2-ol would not be expected to form a* $^{+}CH_2OH$ *fragment* ***C*** *is incorrect because propanal would not be expected to form a* $^{+}CH_2OH$ *fragment* ***D*** *is incorrect because propanone would not be expected to form a* $^{+}CH_2OH$ *fragment*	**(1)**

Question Number	Answer	Mark
15(c)	**The only correct answer is C** (propanal) ***A*** *is incorrect because propan-1-ol would have a broad absorption at 3750-3200* cm^{-1} *due to –OH* ***B*** *is incorrect because propan-2-ol would have a broad absorption at 3750-3200* cm^{-1} *due to –OH* ***D*** *is incorrect because the absorption due to C=O in propanone would be at 1720-1700* cm^{-1} *and C-H stretching vibrations at 2775-2700* cm^{-1} *would be absent*	**(1)**

(Total for Section A = 20 marks)

Section B

Question Number	Answer	Additional Guidance	Mark
16(a)	• correct balanced equation	Example of equation: $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ or multiples Allow $Ca + H_2O \rightarrow CaO + H_2$ Ignore state symbols even if incorrect	**(1)**

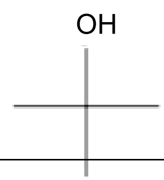
Question Number	Answer	Additional Guidance	Mark
16(b)	An explanation that makes reference to the following points: • concentration of hydroxide ions is greater **(1)** • calcium hydroxide is more soluble than magnesium hydroxide **(1)**	Allow more hydroxide ions are in solution Allow the solubility of the hydroxides increases going down Group 2 reverse argument	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(c)(i)	• correct ionic equation	Example of equation: $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$ Ignore state symbols even if incorrect Do not award H_2CO_3 / $H^+ + HCO_3^-$ as final products	**(1)**

Question Number	Answer	Additional Guidance	Mark
16(c)(ii)	• correct balanced equation **(1)** • state symbols **(1)**	Example of equation: $CO_2(g) + Ca(OH)_2(aq) \rightarrow CaCO_3(s) + H_2O(l)$ M2 depends on M1 Allow equation near miss e.g. $Ca(OH)_2$ +CO_2 -->$CaCO_2$ +H_2O or all correct species being present	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(d)	• calculation of the amount of $Mg(OH)_2$ **(1)** • calculation of M_r $Mg(OH)_2$ **(1)** • calculation of mass $Mg(OH)_2$ **and** answer given to 2 or 3 SF **(1)**	Example of calculation: Amount of $Mg(OH)_2$ = 0.150 ÷ 2 = 0.075 (mol) M_r $Mg(OH)_2$ = 58.3 Mass of $Mg(OH)_2$ = 0.075 x 58.3 = 4.3725 (g) = 4.4 / 4.37 (g) Allow if Mg = 24 then M_r = 58 and mass = 4.4 / 4.35 Correct answer to 2 or 3 SF with no working scores (3)	**(3)**

(Total for Question 16 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
17(a)(i)	• (2)-methylpropan-1-ol and primary **(1)** • butan-2-ol and secondary **(1)** •  **and** tertiary **(1)**	All 6 correct scores 3 4 or 5 correct scores 2 2 or 3 correct scores 1 Ignore bond lengths and bond angles Do not award displayed formula	**(3)**

Question Number	Answer		Additional Guidance	Mark
17(a)(ii)	An explanation that makes reference to the following points:		Accept reverse argument (butan-1-ol has a higher boiling temperature than 2-methylpropan-2-ol because)	(2)
	• Identification of (at least) one of the intermolecular forces and a comparison of its strength in the two molecules	(1)	the instantaneous dipoles-induced dipoles / London forces / dispersion forces / van der Waals forces are stronger between straight chains Allow There are more London forces OR the hydrogen bonding is stronger between straight chain molecules	
	• an explanation for this difference	(1)	the straight chain molecule/ butan-1-ol has greater surface area / more points of contact OR as the -OH group is more exposed / less hindered (so less energy is needed to break the intermolecular forces) If the explanation is in terms of London forces, ignore 'hydrogen bonding is similar / same' Ignore 'references to"longer carbon chain" Do not award Any reference to longer carbon bonds/breaking covalent bonds	

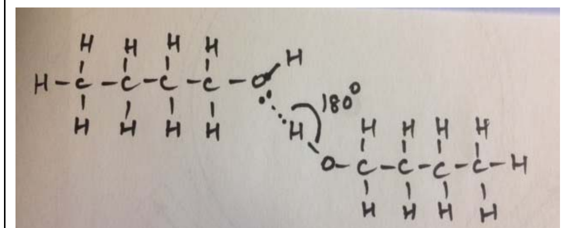
<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>17(a)(iii)</td><td>

- O---H—O **(1)**
- bond O-H-O must be shown as (approximately) linear **(1)**

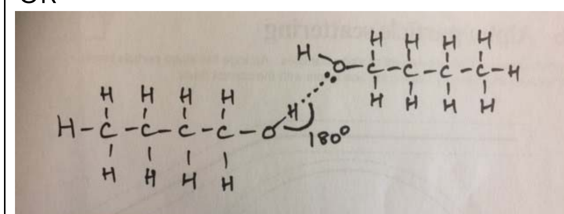
and angle labelled as 180°

</td><td>

Example of diagrams:



OR

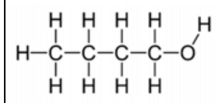


Do not penalise omission of lone pair on the oxygen or errors in the carbon chain e.g. missing Hs

Do not award
hydrogen bond shown as a solid line (M1)
H—O---H bond shown as 180° (M2)
Incorrect -OH attachment to chain (M2)

ignore bond lengths

</td><td>(2)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
17(b)(i)	• balanced equation	 + 6 O=O ⟶ 4 O=C=O + 5 H−O−H	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(b)(ii)	• calculation or working of energy needed to break bonds **(1)** • calculation or working of energy released when bonds are made **(1)** • calculation of energy change and give a sign **(1)**	Here, and throughout the paper do not penalise mol^{-} for mol^{-1} Energy to break all bonds: (3x347) + (9x413) + 358 + 464 + (6x498) = 8568 ($kJ\ mol^{-1}$) Energy released when all bonds made: (10x464) + (8x805) = 11080($kJ\ mol^{-1}$) −11080 + 8568 = −2512 ($kJ\ mol^{-1}$) Do not award incorrect units TE on incorrect balancing of equation and TE at each stage of calculation Ignore SF except 1SF Correct answer no working scores (3) Comment Common error is the use of 6.5 x 498 (forgets about the alcohol oxygen). This gives −2263 $kJ\ mol^{-1}$ scores 2.	**(3)**

Question Number	Answer	Additional Guidance	Mark
17(b)(iii)	An answer that makes reference to the following points: • mean bond enthalpies do not refer to specific compounds such as butan-1-ol/ mean bond enthalpies are averages/mean for different molecules/bonds in different environments/compounds **(1)** • butan-1-ol is a liquid and bond enthalpies refer to gases OR mean bond enthalpy calculations do not include changes of state **(1)**	Ignore just "mean bond enthalpies are an average" Ignore references to standard conditions Just 'different states'	**(2)**

Question Number	**Answer**	**Additional Guidance**	**Mark**
17(c)(i)	• calculation of energy produced per gram **(1)** • calculation of energy produced per cm^3 **(1)** OR • calculation of moles in 1 cm^3 **(1)** • calculation of energy produced per cm^3 **(1)**	Example of calculations: (−)2670 ÷ 74 = (−)36.081/36.1 / 36 ($kJ\ g^{-1}$) 36.1 x 0.81= 29.226/29.2 / 29 ($MJ\ dm^{-3}$) 0.81 / 74 = 0.010946 (moles) 0.010946 x (−)2670 = 29.226/29.2 / 29 ($MJ\ dm^{-3}$) Units, if given, must be correct in $MJ\ dm^{-3}$ Correct answer with no working scores (2) Ignore sign and SF except 1SF	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(c)(ii)	An answer that makes reference to the following points: • biobutanol has a longer hydrocarbon / alkane chain/ more electrons than bioethanol **(1)** • so more/stronger London forces / dispersion forces / Van der Waals forces between biobutanol and petrol (than bioethanol and petrol) **(1)**	Ignore references to polarity, non-polar parts Allow London forces in biobutanol and petrol are similar Do not award just "biobutanol has stronger London forces than bioethanol"	**(2)**

(Total for Question 17 = 17marks)

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	• the arrow pointing to the C=C bond is incorrect **and** the arrow should be pointing away from the bond **(1)** • the partial charge on the C in the intermediate is incorrect **and** it should be a full positive charge **(1)**	Ignore references to lone pairs of electrons Either/both marks could be scored by annotations to the mechanism or using structures in the answer spaces	**(2)**

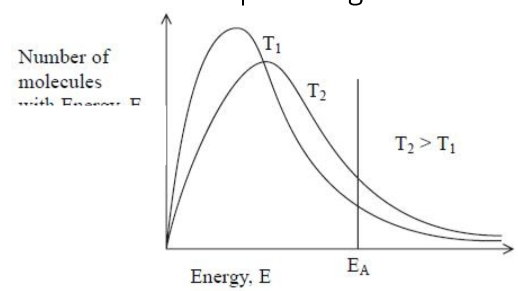
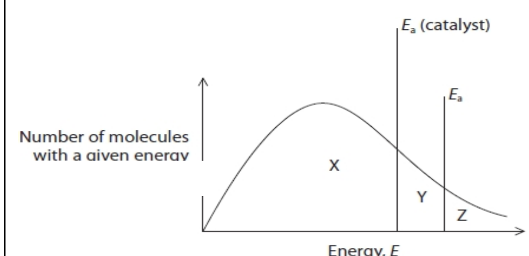
Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	• balanced equation • **(1)** • calculation of mass of chloroethene **and** total mass of reactants / products **(1)** • calculation of % atom economy **(1)**	$C_2H_4 + Cl_2 \rightarrow C_2H_3Cl + HCl$ Ignore state symbols (even if incorrect) Mass of chloroethene = 62.5 Total mass of reactants / products = 99 % Atom economy = $\frac{62.5}{99} \times 100$ = 63.131(%) = 63.1(%) TE on incorrect equation providing the product is chloroethene incorrect molecular masses no TE on incorrect atom economy expression If no other mark is scored correct expression for atom economy scores 1 Ignore SF except 1SF Correct answer with no working scores M3	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(b)	An answer that makes reference to the following points: • Atom economy (of process A is < 100% but) in process B it is 100% **(1)** • in process A HCl(g) is produced which is toxic / corrosive or catalyst for process B / Mercury / Mercury(II) chloride is highly toxic **(1)**	Allow no other product formed in process B Ignore just "process B has a higher atom economy than A" Accept reverse arguments e.g. A does not require a toxic catalyst M2 - Allow **both** processes use non-renewable starting material Do not award Ozone depletion Ignore references to energy involved in either process/ greenhouse gases / acid rain	**(2)**

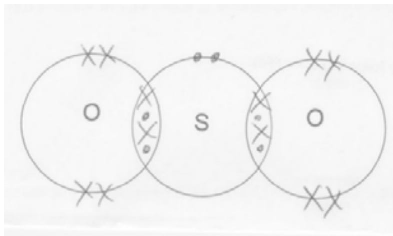
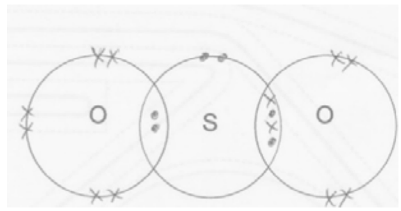
<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*18(c)</td><td>This question assesses a candidate’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.
Marks are awarded for indicative content 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>
<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></td><td>The mark for indicative content should be added to the mark for lines of reasoning. In general it would be expected that 5 or 6 indicative points would score 2 reasoning marks, and 3 or 4 indicative points would score 1 reasoning mark. A total of 2, 1 or 0 indicative points would score 0 marks for reasoning.

Reasoning marks may be subtracted for extra incorrect chemistry.

If there is any incorrect Chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).</td><td>(6)</td></tr>
</table>

Question	Answer	Additional Guidance	Mark
***18(c)**	**Indicative content** The following table shows how the marks should be awarded for structure and lines of reasoning. Indicative content • axes labelled correctly • shape of **two** curves at **two** different temperatures • activation energy with **and** without a catalyst shown • molecules with $E>E_a$/$E=E_a$ can react/ collisions are successful • increasing temperature (increases energy of all molecules so) increases molecules / collisions with $E>E_a$/$E=E_a$ (so rate increases) • adding a catalyst (provides an alternative pathway which) lowers E_a so more molecules / collisions have $E>E_a$/$E=E_a$	Vertical axis labelled fraction / proportion / percentage / number of molecules Horizontal axis labelled *E* / energy Both curves start at 0 and be asymptotic to the horizontal axis. The higher temperature curve must have a lower maximum and be moved to the right Do not award asymptotes which are higher than 30% of their peak height   All the information may be shown on one axis grid and the two different temperatures can be implied unless incorrect.	**(6)**

(Total for Question 18 = 13 marks)
(TOTAL FOR SECTION B = 39 MARKS)

Question Number	Answer	Additional Guidance	Mark
19(a)(i)	  Allow either of the diagrams above • At least one double bond correct **(1)** • All other electrons correct **(1)**	Allow all dots or all crosses Unbonded electron pairs may be at any position on circles or just inside the circles Ignore lines for covalent bonds Electrons do not have to be paired Bonding electrons may be in the intersection space or on the lines bounding this space	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	bond angle 120°	Allow 117° to 123°	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(b)(i)	• two concordant titres had already been obtained	Allow Just 'titres are concordant' The (last two) titres are within 0.2 / 0.1 cm^3 only 10 cm^3 solution left so impossible to pipette a further sample or wtte only a limited/small amount of solution remains Do not award Three titres are concordant The (last two) titres are within ±0.2 /± 0.1 cm^3	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(b)(ii)	• calculation of moles NaOH in mean titre **(1)** • moles sulfuric acid in 10 cm^3 sample (1/2 moles NaOH) **(1)** • moles sulfuric acid in 40 cm^3 (previous answer x 4) **(1)**	Example of calculation: 21.10/1000 x 0.005 = 1.055×10^{-4} / 0.0001055 (mol) 5.275/5.28 x 10^{-5} / 0.00005275 (mol) 2.11 x 10^{-4} / 0.000211 (mol) Ignore SF except 1 SF Correct answer with no working scores 3	**(3)**

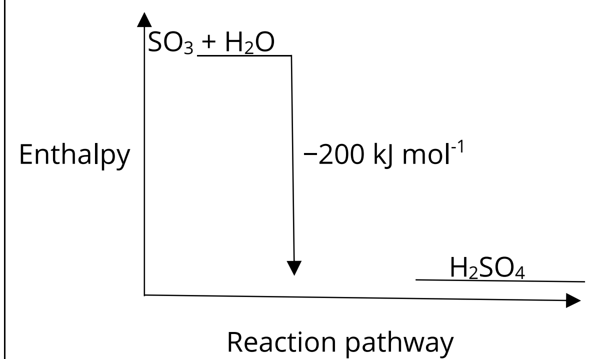
Question Number	Answer	Additional Guidance	Mark
19(b)(iii)	• moles SO_2 in 40 cm^3 same as answer to (ii) **(1)**	2.11×10^{-4} / 0.000211 (mol) TE on 19(b)(ii)	**(1)**

Question	Answer	Additional Guidance	Mark
19(b)(iv)	 • volume of atmospheric sample collected **(1)** • moles of gas in atmosphere **(1)** • concentration SO_2 in atmosphere **(1)** OR • volume SO_2 in atmosphere **(1)** • volume of atmospheric sample collected **(1)** • concentration SO_2 in atmosphere **(1)**	Example of calculation: 10 x 30 = 300 (dm^3) $\frac{300}{24}$ = 12.5 (moles) $\frac{2.11 \times 10^{-4}}{12.5}$ = 1.688×10^{-5} / 1.69×10^{-5} / 0.00001688 = 16.88 / 16.9/ 17 (ppm) $2.11 \times 10^{-4} \times 24 = 5.064 \times 10^{-3}$ (dm^3) 10 x 30 = 300 (dm^3) 5.064×10^{-3} / 300 = 1.688×10^{-5} / 1.69×10^{-5} / 0.00001688 = 16.88 / 16.9 /17 (ppm) Ignore SF except 1SF Correct answer no working scores 3 TE on 19(b)(ii) and (b)(iii) and at each stage in (b)(iv)	**(3)**

Question Number	Answer	Additional Guidance	Mark
19(c)(i)	• correct equation	$2O_3 \rightarrow 3O_2$ Or multiples Do not award equations with uncancelled species Ignore state symbols even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(c)(ii)	An answer which makes reference to **two** of the following: • the chlorine free radical is regenerated • many ozone molecules decompose for each free radical formed • chlorine free radical causes a chain reaction	Ignore the chlorine free radical acts as a catalyst references to increase in skin cancer Do not award references to global warming	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(d)(i)	• S (+)4 → (+)6 (oxidation) **(1)** • O (in O_2) 0 → −2 (reduction) **(1)**	Award 1 mark for sulfur is oxidised and oxygen is reduced	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(d)(ii)	• Reactants energy level higher than that of products **(1)** • Enthalpy change −200 (kJ mol^{-1}) labelled (dependent on correct M1) **(1)**	 Allow Δ*H* for −200 kJ mol^{-1} Do not award just 'reactants & products' Ignore Reactant & product states, even if incorrect Transition state / intermediate hump Comment allow double headed arrows	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(d)(iii)	• carbon dioxide is a greenhouse gas / causes global warming / causes a rise in temperature **(1)** • sulfuric acid (from sulfur dioxide / trioxide) causes global cooling / causes a drop in temperature **(1)** • the effect from sulfur dioxide is greater than that of the carbon dioxide (because the temperatures were lower after the eruption) **(1)**	Ignore references to acid rain/ ozone depletion/radiation Allow sulfur trioxide for sulfuric acid Ignore sulfur dioxide is also a greenhouse gas	**(3)**

(Total for Question 19 = 21 marks)
TOTAL FOR SECTION C =21 MARKS
TOTAL FOR PAPER =80 MARKS

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