Mark Scheme (Results)

January 2024

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

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General Marking Guidance

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

Using the mark scheme

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

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

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is essential to the answer. ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

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

Quality of Written Communication

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

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

Section A

Question Number	Answer	Mark
1	The only correct answer is A (HF) *B is not correct because tellurium and hydrogen have the same electronegativity* *C is not correct because arsenic is less electronegative than hydrogen* *D is not correct because tin is less electronegative than hydrogen*	(1)

Question Number	Answer	Mark
2	The only correct answer is B ($H_2O(l) \rightarrow H_2O(g)$) *A is not correct because a covalent bond is being broken* *C is not correct because only London forces are being broken* *D is not correct because covalent bonds are being broken and formed*	(1)

Question Number	Answer	Mark
3	The only correct answer is C (PH_3) *A is not correct because NO has polar bonds* *B is not correct because $BeCl_2$ has polar bonds* *D is not correct because CI_4 is symmetrical and has only London forces between its molecules*	(1)

Question Number	Answer	Mark
4	The only correct answer is D ($CH_3(CH_2)_7CH_3$) *A is not correct because $(CH_3)_4C$ has fewer electrons and a branched carbon chain* *B is not correct because $CH_3CH_2CH_2CH_2CH_3$ has fewer electrons* *C is not correct because $(C_2H_5)_4C$ has a branched carbon chain*	(1)

Question Number	Answer	Mark
5	The only correct answer is B (cyclohexane) *A is not correct because ammonia is a polar solvent* *C is not correct because methanol is a polar solvent* *D is not correct because water is a polar solvent*	(1)

Question Number	Answer	Mark
6	The only correct answer is D (CH_4) *A is not correct because the oxidation state of F is –1 in HF* *B is not correct because the oxidation state of H is –1 in NaH* *C is not correct because the oxidation state of O is –1 in H_2O_2*	(1)

Question Number	Answer	Mark
7	The only correct answer is A ($Br_2 + F_2 \rightarrow 2BrF$) *B is not correct because chlorine is reduced and fluorine does not change oxidation state* *C is not correct because fluorine is reduced only* *D is not correct because this is not a redox reaction*	(1)

Question Number	Answer	Mark
8	The only correct answer is B ($BaCl_2$ and Ag_2SO_4) *A is not correct because in B $BaSO_4(s)$ is formed as well as $AgCl(s)$* *C is not correct because no solid would form* *D is not correct because in B $AgCl(s)$ is formed as well as $BaSO_4(s)$*	(1)

Question Number	Answer	Mark
9	The only correct answer is C (nitric acid) *A is not correct because sodium carbonate is used to identify carboxylic acids* *B is not correct because sodium hydroxide is used to identify ammonium ions* *D is not correct because ammonia is used to distinguish silver halide precipitates*	(1)

Question Number	Answer	Mark
10	The only correct answer is D (40) *A is not correct because a mole ratio of 2:1 instead of 1:2 has been used and the volume is in dm^3* *B is not correct because this is the correct volume in dm^3* *C is not correct because a mole ratio of 2:1 instead of 1:2 has been used*	(1)

Question Number	Answer	Mark
11	The only correct answer is C (2.8 g) *A is not correct because this is the percentage by mass of nitrogen in ammonium nitrate* *B is not correct because this is the mass of ammonium nitrate* *D is not correct because only one nitrogen atom has been taken into account*	(1)

Question Number	Answer	Mark
12	The only correct answer is A (increases, decreases, decreases) *B is not correct because the boiling temperature increases, the electronegativity decreases and the reactivity as an oxidising agent decreases down the group* *C is not correct because the reactivity as an oxidising agent decreases down the group* *D is not correct because the boiling temperature increases and the electronegativity decreases down the group*	(1)

Question Number	Answer	Mark
13	The only correct answer is D (the frequency of collisions with $E \geq E_a$ increases) *A is not correct because the activation energy remains the same* *B is not correct because there is no reference to the frequency or energy of collisions* *C is not correct because the particles must collide in order to react*	(1)

Question Number	Answer	Mark
14	The only correct answer is A (the position of equilibrium is affected by temperature, by pressure and by catalysts) *B is not correct because the concentration of the reactants remain constant* *C is not correct because the rate of the forward reaction is equal to the rate of the backward reaction* *D is not correct because equilibrium can be reached from either direction*	(1)

Question Number	Answer	Mark
15	The only correct answer is D (1-iodobutane) *A is not correct because the carbon-halogen bond enthalpy decreases down the group* *B is not correct because the carbon-halogen bond enthalpy decreases down the group* *C is not correct because the carbon-halogen bond enthalpy decreases down the group*	(1)

Question Number	Answer	Mark
16	The only correct answer is C (4) *A is not correct because there are 4 cyclic alcohol structural isomers with molecular formula C_4H_8O* *B is not correct because there are 4 cyclic alcohol structural isomers with molecular formula C_4H_8O* *D is not correct because there are 4 cyclic alcohol structural isomers with molecular formula C_4H_8O*	(1)

Question Number	Answer	Mark
17	The only correct answer is C ($CH_3CH_2CH_2CH_2OH + 4O_2 \rightarrow 4CO + 5H_2O$) *A is not correct because this equation shows complete combustion* *B is not correct because this equation shows complete combustion and the oxygen is not balanced* *D is not correct because the oxygen is not balanced*	(1)

Question Number	Answer	Mark
18	The only correct answer is A (1, 2 and 3) *B is not correct because tertiary alcohols react with concentrated HCl to produce chloroalkanes* *C is not correct because alcohols react with PCl_5 to produce chloroalkanes* *D is not correct because concentrated H_2SO_4 and KCl produce HCl which reacts with the tertiary alcohol*	(1)

Question Number	Answer	Mark
19	The only correct answer is D (5) *A is not correct because each primary alcohol group needs 2 mol of [O] and the secondary alcohol group needs 1 mol of [O]* *B is not correct because each primary alcohol group needs 2 mol of [O] and the secondary alcohol group needs 1 mol of [O]* *C is not correct because each primary alcohol group needs 2 mol of [O] and the secondary alcohol group needs 1 mol of [O]*	(1)

Question Number	Answer	Mark
20	The only correct answer is B (CH_3COCH_3) *A is not correct because the molecular ion peak would be at m/z = 60 and there would be a fragment ion peak at m/z = 45* *C is not correct because there would be a fragment ion peak at m/z = 29* *D is not correct because there would be a fragment ion peak at m/z = 29*	(1)

(Total for Section A = 20 marks)

Section B

Question Number	Answer	Additional Guidance	Mark
21(a)	An answer that makes reference to the following point: • $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$	Accept correct electrons-in-boxes notation Accept expansion of p-subshell(s), eg $2p_x^2 2p_y^2 2p_z^2$ for $2p^6$ Allow non-superscript numbers for electrons Ignore use of commas and spaces Ignore 2,8,8,2 Ignore [Ar] for $1s^2 2s^2 2p^6 3s^2 3p^6$ Do not award incorrect order of subshells	(1)

Question Number	Answer	Additional Guidance	Mark
21(b)(i)	An explanation that makes reference to the following points: • calcium/Ca oxidised and from 0 (in Ca) to (+)2 (in $CaCl_2$) (1) • chlorine/Cl_2/Cl reduced and from 0 (in Cl_2) to –1 (in $CaCl_2$) (1)	Ignore explanations in terms of electron loss/gain Oxidation numbers may be shown in the equation Allow calcium/Ca is a reducing agent Ignore just oxidation number of Ca increases Allow chlorine/Cl_2/Cl is an oxidising agent Ignore just oxidation number of Cl decreases If no other mark awarded: Calcium/Ca changes from 0 to +2 and chlorine/Cl_2/Cl changes from 0 to –1 scores (1) OR Calcium/Ca oxidised/reducing agent and chlorine/Cl_2/Cl reduced/oxidising agent scores (1) provided no contradiction in terms of increase/decrease in oxidation number	(2)

Question Number	Answer	Additional Guidance	Mark
21(b)(ii)	An answer that makes reference to the following points: • any two or three correct scores (1) • any four or five correct scores (2) • all six correct scores (3)	<u>Example of completed table</u>:	(3)

Species	Bonding	Structure
(Ca(s))	metallic	giant / lattice
Cl_2((g))	(covalent)	simple / molecular
$CaCl_2$((s))	ionic	(giant)

Question Number	Answer	Additional Guidance	Mark
21(b)(iii)	An answer that makes reference to the following point: • orange-red	Accept brick-red Allow red Allow orange Allow yellow-red Allow yellow-orange Ignore just yellow Do not award crimson red Do not award scarlet red Do not award magenta red	(1)

Question Number	Answer	Additional Guidance	Mark
21(c)(i)	An answer that makes reference to any two of the following points: • P1: brown gas (produced) (1) • P2: bubbles (through water) (1) • P3: (water/indicator) turns red (1) • P4: solid melts (1)	Penalise incorrect gas, including other nitrogen oxides (eg NO), in P1/P2 once only Allow fumes for gas Ignore red Do not award any other colour Ignore nitrogen dioxide/NO_2 Ignore oxygen/O_2 Ignore any reference to relighting of a glowing splint Ignore effervescence/fizzing Ignore nitrogen dioxide/NO_2/oxygen/O_2 Ignore air/nitrogen/N_2 Allow turns pink Ignore turns orange Ignore turns yellow Do not award any other colour Do not award water turns milky / white ppt formed If stated, initial colour must be green/yellow Allow colourless liquid formed Ignore solid glows Ignore white solid/ppt produced (in heated tube) Do not award solid dissolves Do not award black solid produced	(2)

Question Number	Answer	Additional Guidance	Mark
21(c)(ii)	An explanation that makes reference to the following points: • magnesium (nitrate) is less (thermally) stable (1) • magnesium ion/Mg^{2+} is smaller OR magnesium ion/Mg^{2+} has higher charge density and is more polarising (1) • less energy needed to break N–O (1)	Accept reverse arguments throughout Allow (thermal) stability increases down the group Allow decomposition/reaction is less endothermic with magnesium (nitrate) Allow decomposition/reaction occurs at a lower temperature with magnesium (nitrate) Allow magnesium (nitrate) decomposes faster / more easily Ignore just magnesium (nitrate) reacts faster / more easily Ignore magnesium ion for magnesium (nitrate) Allow magnesium/Mg has smaller ionic radius Allow magnesium ion/Mg^{2+} has fewer shells Ignore any reference to just magnesium/Mg (atoms) Allow distorts/weakens nitrate/anion more Allow less energy needed to break bond(s) in nitrate/anion Allow easier to break N–O / bond(s) in nitrate/anion Ignore just weaker N–O / bond(s) in nitrate/anion Do not award less energy needed to break (ionic) bond(s) between Mg^{2+}/cations and NO_3^-/anions	(3)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*21(d)</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 lines of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning 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. 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).

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>

	Indicative points: • IP1: $Ca((s)) + 2H_2O((l)) \rightarrow Ca(OH)_2((aq)) + H_2((g))$ • IP2: effervescence • IP3: (indicator) turns blue • IP4: faster / more vigourous reaction with calcium and linked to an observation OR no (observable) reaction with magnesium • IP5: Ca has lower ionisation energy OR Ca has more shielding / more shells / larger atoms • IP6: darker blue / more alkaline / higher pH with Ca and linked to greater solubility of $Ca(OH)_2$	Ignore any reference to Ca / Mg dissolving Allow multiples Ignore state symbols Ignore equations involving magnesium Allow fizzing/bubbling Allow turns purple If stated, initial colour must be green/yellow Ignore forms solution with pH > 7 Accept reverse arguments eg reaction with calcium: • has faster bubbling • changes colour faster • forms (white) ppt faster • gets hotter (Ignore more exothermic) • (solid) disappears faster Ignore (indicator) remains green with Mg Ignore no (white) ppt with Mg Accept reverse arguments Allow Ca has less attraction on (outer) $e^{(-)}$ Allow Ca loses electron(s) more easily Ignore calcium ions/Ca^{2+} for calcium/Ca Accept reverse arguments Ignore less (white) ppt with Ca Allow hydroxide solubility increases down group Allow $Mg(OH)_2$ insoluble Ignore explanations of solubility	

(Total for Question 21 = 18 marks)

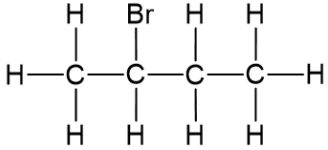
Question Number	Answer	Additional Guidance	Mark
22(a)	An explanation that makes reference to the following points: • 1 mol of substance / compound / MgO (1) • formed from element(s) in standard state(s) (1)	Allow 1 mol of product Ignore Mg(s) and O_2(g) / reactant(s) for element(s) Ignore normal/natural etc for standard Ignore any reference to standard conditions	(2)

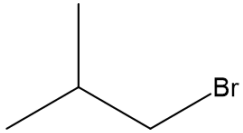
Question Number	Answer	Additional Guidance	Mark
22(b)		Here and throughout the paper: • penalise incorrect rounding once only and only if the final answer is incorrect • do not penalise correct premature rounding • penalise incorrect units once only • Allow mol^{-} for mol^{-1} <u>Example of calculation</u>: Correct answer to 3SF or 2SF with some working scores (4) Ignore SF except 1SF and penalise use of 1SF once only Ignore sign in M1 and M3	(4)
	• calculation of energy transferred (1)	energy = 25.0 × 4.18 × (28.0 – 21.5) = 679.25 (J) Allow 0.67925 (kJ)	
	• calculation of amount of MgO (1)	amount = 0.189 ÷ 40.3 = 0.0046898 / 4.6898×10^{-3} (mol) Allow 0.004725 / 4.725×10^{-3} (mol) from M_r = 40	
	• calculation of $\Delta_r H_2$ (1)	$\Delta_r H_2$ = 679.25 ÷ 0.0046898 = 144830 ($J\ mol^{-1}$) Accept 144.83 ($kJ\ mol^{-1}$) Allow 143760 ($J\ mol^{-1}$) / 143.76 ($kJ\ mol^{-1}$) from M_r = 40 TE on M1 and M2	
	• negative sign and answer to 3SF or 2SF (1)	–145 / –140 ($kJ\ mol^{-1}$) Allow –145000 / –140000 $J\ mol^{-1}$ Allow –144 ($kJ\ mol^{-1}$) / –144000 $J\ mol^{-1}$ from M_r = 40 TE on M3	

Question Number	Answer	Additional Guidance	Mark
22(c)	• correct expression for $\Delta_r H_1$ (1) • calculation of $\Delta_r H_1$ (1)	Example of calculation: Correct answer with some working scores (2) $\Delta_r H_1$ = –462 + (–286) – answer to (b) $\Delta_r H_1$ = –462 + (–286) – (–145) = –603 (kJ mol^{-1}) Ignore SF TE on answer to (b) No TE on incorrect expression from M1 Allow –604 (kJ mol^{-1}) from M_r = 40 in (b) If using –100 (kJ mol^{-1}) for answer to (b) $\Delta_r H_1$ = –462 + (–286) – (–100) = –648 (kJ mol^{-1})	(2)

(Total for Question 22 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
23(a)(i)	An answer that makes reference to the following point: • 2-bromo-2-methylpropane	Ignore omission of hyphens or use of commas Allow 2-methyl-2-bromopropane Do not award 2,2-bromomethylpropane	(1)

Question Number	Answer	Additional Guidance	Mark
23(a)(ii)	An answer that makes reference to the following point: • displayed formula of 2-bromobutane	<u>Example of displayed formula</u>:  Ignore any other type of formula Ignore bond lengths and bond angles Ignore any name even if incorrect Do not award non-displayed CH_3 groups Do not award any missing hydrogens / bonds	(1)

Question Number	Answer	Additional Guidance	Mark
23(a)(iii)	An answer that makes reference to the following point: • skeletal formula of 1-bromo-2-methylpropane	<u>Example of skeletal formula</u>:  Ignore any other type of formula Ignore bond lengths and bond angles Ignore any name even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
23(b)	An answer that makes reference to the following point: • structure of $(CH_3)_3CBr$	Allow skeletal, structural or displayed formulae, or any combination of these If more than one type of formula used, all must be correct Ignore CH_3-C connectivity Ignore name even if incorrect	(1)

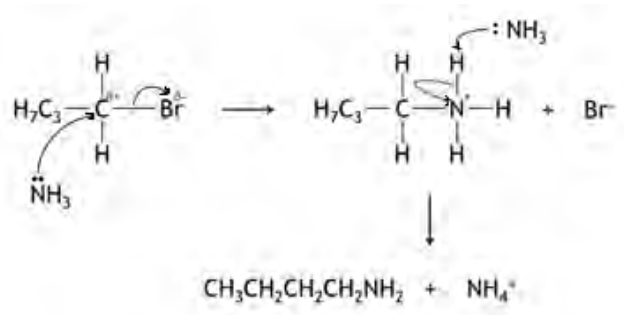
<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>23(c)(i)</td>
<td>An answer that makes reference to the following points:

• any two or three correct scores (1)
• any four or five correct scores (2)
• any six or seven correct scores (3)
• all eight correct scores (4)</td>
<td><u>Example of completed table</u>:

Allow indication of conditions in reagent box, eg NaOH(aq) indicates aqueous conditions

Penalise ions for reagents and/or names for formulae once only

<table>
<tr><th>Reaction</th><th>Name of mechanism</th><th>Formula of Reagent</th><th>Condition(s)</th></tr>
<tr><td>R1</td><td>(nucleophilic substitution)</td><td>KOH
Allow NaOH
Ignore H_2O</td><td>aqueous and heat
Allow aqueous ethanol for aqueous
Allow warm/reflux for heat</td></tr>
<tr><td>R2</td><td>elimination</td><td>KOH
Allow NaOH</td><td>(heat in ethanol)</td></tr>
<tr><td>R3</td><td>nucleophilic substitution</td><td>(NH_3)</td><td>alcohol/ethanol and heat/warm and under pressure/sealed</td></tr>
<tr><td>R4</td><td>nucleophilic substitution</td><td>KCN
Allow NaCN
Ignore HCN</td><td>(heat in ethanol)</td></tr>
</table>
</td>
<td>(4)</td>
</tr>
</table>

Question Number	Answer	Additional Guidance	Mark
23(c)(ii)	An answer that makes reference to the following points: • any two or three correct scores (1) • any four or five correct scores (2) • any six or seven correct scores (3) • all eight correct scores (4) P1: lone pair on N of left hand NH_3 P2: curly arrow from NH_3 lone pair to $C^{(\delta+)}$ P3: correct dipole on $C^{\delta+}$–$Br^{\delta-}$ bond P4: curly arrow from C–Br bond to $Br^{\delta-}$ P5: positive charge on N of ammonium salt P6: lone pair on N of right hand NH_3 P7: curly arrow from NH_3 lone pair to H of N–H P8: curly arrow from N–H bond to $N^{(+)}$	Example of completed mechanism:  Do not award incorrect positioning of lone pair in P1/P6 but penalise once only Do not award negative charge on NH_3 in P1/P6 but penalise once only Do not award use of half-headed arrows in P2/P4/P7/P8 but penalise once only Ignore any dipole on N–H bond in P7/P8 Do not award arrow from incorrect N–H bond in P8 Ignore H^+ ion / HBr / NH_4Br by-product	(4)

Question Number	Answer	Additional Guidance	Mark
23(c)(iii)	A description that makes reference to the following points: • (absorptions at) 2260-2215 (cm^{-1}) (1) • (due to) C≡N (1)	Ignore any reference to 2962-2853 (cm^{-1}) / 1485-1365 (cm^{-1}) / C–H / C–C M1 and M2 are standalone marks Allow any range or number within 2260-2215 Do not award 2260-2100 Do not award any other wavenumbers Ignore just CN Ignore name of any functional group, even if incorrect Do not award C–N / C=N Do not award C≡C Do not award any other bond	(2)

(Total for Question 23 = 14 marks)

Section C

Question Number	Answer	Additional Guidance	Mark
24(a)(i)	An answer that makes reference to the following points: • calculation of total reactant bond enthalpies (1) • calculation of total product bond enthalpies (1) • calculation of S–F bond enthalpy (1)	<u>Example of calculation</u>: Correct answer with some working scores (3) 8 × 268 + 24 × 151 = 2144 + 3624 (= 5768 kJ mol^{-1}) 5768 – (–9672) = 5768 + 9672 (= 15440 kJ mol^{-1}) TE on M1 (M1 value + 9672) 15440 ÷ (8 × 6) = 321.67 = 322 (kJ mol^{-1}) Ignore SF except 1SF TE dependent on use of both M1 value and 9672 Do not award just division of any number by 48	(3)

Question Number	Answer	Additional Guidance	Mark
24(a)(ii)	An answer that makes reference to the following points: • bond enthalpy data is for the gas phase and sulfur/S_8 is a solid (1) • bond enthalpy is not accurate for S–S/S_8/sulfur OR bond enthalpy is an average/mean for many compounds (1)	Ignore any reference to standard conditions Ignore any reference to enthalpy measurements Ignore any reference to heat loss Allow sulfur/S_8 is not a gas Do not award any reference to SF_6 and/or F_2 as solid/liquid/not a gas Allow bond enthalpy is an average/mean for S–S/S_8/sulfur Ignore just bond enthalpy is an average/mean Ignore any reference to F–F / S-F bond enthalpy Allow different for many Allow molecules/bonds for compounds If no other mark awarded: bond enthalpy data is for gas(es) and bond enthalpy is an average/mean scores (1)	(2)

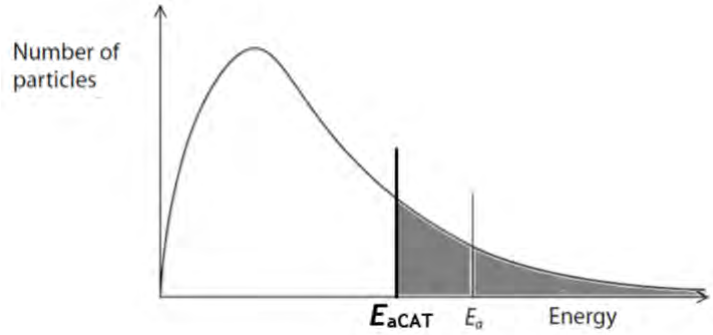
Question Number	Answer	Additional Guidance	Mark
24(a)(iii)	An answer that makes reference to the following points: • calculation of amount of SF_6 (1) • calculation of amount of CO_2 (1) • calculation of n(CO_2) : n(SF_6) (1)	<u>Example of calculation</u>: Ignore correct use of Avogadro constant throughout amount = 1.00 ÷ 146.1 (= 0.0068446 / 6.8446 × 10^{-3}) Allow use of 146 for M_r (giving 0.0068493 / 6.8493 × 10^{-3}) amount = 23900 ÷ 44.0 (= 543.18) 543.18 ÷ 0.006845 = 79359 (molecules of CO_2) TE on M1 and M2 Ignore SF Do not award 0.006845 ÷ 543.18 = 1.2601 × 10^{-5}	(3)

Question Number	Answer	Additional Guidance	Mark
24(b)(i)	An answer that makes reference to the following point: • ClO^-	Allow OCl^- Ignore NaClO Do not award HClO / any other answer	(1)

Question Number	Answer	Additional Guidance	Mark
24(b)(ii)	An answer that makes reference to the following points: • equilibrium 1 shifts left (to make HClO) (1) • equilibrium 2 shifts to the right (to make chlorine solution) (1) • chlorine gas (produced) and (which is) toxic (1)	Marks can be awarded in any order Allow any unambiguous indication of equilibrium 1 shifting left, eg H^+ reacts with ClO^- forming HClO Allow any unambiguous indication of equilibrium 2 shifting right, eg HClO reacts with HCl forming Cl_2 (and H_2O) Accept $Cl_2(g)$ for chlorine gas Allow poisonous for toxic Ignore harmful for toxic If no other mark awarded neutralisation / reaction of acid and alkali is (highly) exothermic scores (1)	(3)

Question Number	Answer	Additional Guidance	Mark
24(b)(iii)	An answer that makes reference to the following points: • formula of sodium chlorate(V) product (1) • rest of equation correct (1)	$NaClO_3$ Allow ClO_3^- Do not award any other chlorate product $3NaClO \rightarrow 2NaCl + NaClO_3$ Allow multiples Ignore state symbols, even if incorrect $3ClO^- \rightarrow 2Cl^- + ClO_3^-$ scores (2)	(2)

Question Number	Answer	Additional Guidance	Mark
24(c)	• calculation of molar mass of $C_{12}H_{18}Br_6$ fire retardant (1) • calculation of % by mass of Br to 3SF or 2SF (1)	<u>Example of calculation</u>: 12 × 12(.0) + 18 (× 1.0) + 6 × 79.9 OR 641.4 (g mol^{-1}) Allow use of A_r(Br) = 80 giving 642 (g mol^{-1}) 479.4 ÷ 641.4 × 100 = 74.7 / 75(%) TE on M1 Do not award TE if % by mass > 100(%) Allow 74.8(%) from A_r(Br) = 80	(2)

Question Number	Answer	Additional Guidance	Mark
24(d)	An explanation that makes reference to the following points:	<u>Example of labelled Maxwell-Boltzmann distribution</u>:  All marks are standalone	(4)
	• y-axis label and x-axis label (1)	Allow fraction / amount for number Allow molecules / atoms for particles Accept kinetic energy	
	• single distribution starting at the origin and approaching but not touching the x-axis (1)	Do not award two or more distributions	
	• catalyst provides (alternative route with) lower activation energy / E_a (1)	Allow labelled activation energies with and without catalyst on diagram	
	• more particles/collisions have $E \geq E_a$ with catalyst (1)	Allow annotated shaded areas on diagram Allow more particles/collisions have sufficient energy to react Ignore any reference to successful collisions	

(Total for Question 24 = 20 marks)

(Total for Section C = 20 marks)

(Total for Paper = 80 marks)

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