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Edexcel

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.

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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

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)**

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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)**

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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)**

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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)**

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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)**

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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)**

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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)

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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	

	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)

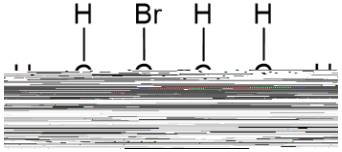
Question Number	Answer	Additional Guidance	Mark
22(a)	An explanation that makes reference to the following points: • 1 mol of substance / compound / MgO **(1)** • formed from element(s) in standard state(s) **(1)**	Allow 1 mol of product Ignore Mg(s) and $O_2(g)$ / reactant(s) for element(s) Ignore normal/natural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

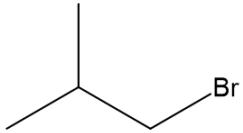
Question Number	Answer		Additional Guidance	Mark
22(b)			Here and throughout the paper: • penalise incorrect rounding once only and only if the final answer is incorrect • do not penalise correct premature rounding • penalise incorrect units once only • Allow mol^{-} for mol^{-1} Example of calculation: 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 = $25.0 \times 4.18 \times (28.0 - 21.5)$ = 679.25 (J) Allow 0.67925 (kJ)	
	• calculation of amount of MgO	**(1)**	amount = $0.189 \div 40.3$ = $0.0046898 / 4.6898 \times 10^{-3}$ (mol) Allow $0.004725 / 4.725 \times 10^{-3}$ (mol) from $M_r = 40$	
	• calculation of $\Delta_r H_2$	**(1)**	$\Delta_r H_2$ = $679.25 \div 0.0046898$ = 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)**	<u>Example of calculation</u>: 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(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)**

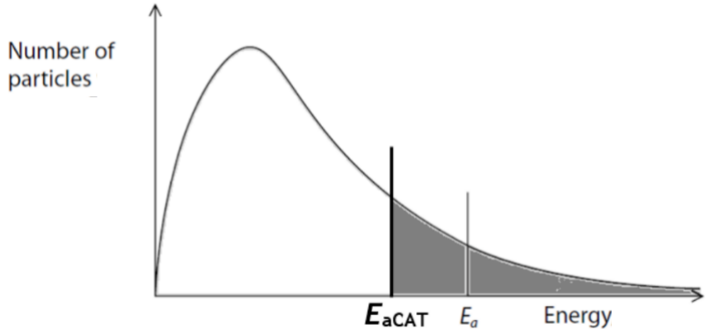
Question Number	Answer	Additional Guidance	Mark
24(a)(iii)	An answer that makes reference to the following points: • calculation of amount of SF_6 **(1)** • calculation of amount of CO_2 **(1)** • calculation of n(CO_2) : n(SF_6) **(1)**	<u>Example of calculation</u>: Ignore correct use of Avogadro constant 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)**	Example of calculation: 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})	**(2)**
	• calculation of % by mass of Br to 3SF or 2SF	**(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	

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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