

Mark Scheme (Results)

October 2022

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.

Section A

Question	Answer	Mark
1	The only correct answer is B (463.5)	1
		•
	A is not correct because 242 has been subtracted not added	
	C is not correct because 498 has not been divided by 2	
	$m{D}$ is not correct because the final answer has not been divided by 2	

Question	Answer	Mark
Number		
2	The only correct answer is A (Na(s) + $\frac{1}{2}Cl_2(g) \rightarrow NaCl(s)$)	1
	B is not correct because the enthalpy change of formation refers to only one mole of a compound C is not correct because the Na should be solid and the Cl should be ¹ / ₂ Cl ₂ D is not correct because ions are not involved in the enthalpy change of formation	

Question	Answer	Mark
Number		
3	The only correct answer is D (-193 kJ mol ⁻¹)	1
	A is not correct because $4 \times H_2$ has been used, not 2 and the sign is incorrect	
	B is not correct because $4 \times H_2$ has been used, not 2	
	C is not correct because the sign is incorrect	

Question Number	Answer	Mark
4	The only correct answer is C (0.72 g)	1
	A is not correct because a 2:1 ratio has been used, not 1:2 B is not correct because a 1:1 ratio has been used, not 1:2 D is not correct because a 1:3 ratio has been used, not 1:2	

Question	Answer	Mark
Number		
5	The only correct answer is C (solubility of the sulfates)	1
	 A is not correct because the reactivity of the elements increases down the group B is not correct because the solubility of the hydroxides increases down the group D is not correct because the thermal stability of the carbonates increases down the group 	

Question	Answer	Mark
Number		
6	The only correct answer is C (4)	1
	A is not correct because there are 4 isomers	
	B is not correct because there are 4 isomers	
	D is not correct because there are 4 isomers	

Question Number	Answer	Mark
7	The only correct answer is D (nucleophilic substitution) <i>A</i> is not correct because the CN^- ion is a nucleophile and the reaction is a substitution <i>B</i> is not correct because the reaction is a substitution <i>C</i> is not correct because the CN^- ion is a nucleophile	1

Question Number	Answer	Mark
8	The only correct answer is D (energy emitted, from excited state to ground state)	1
	 A is not correct because the flame colour is not caused by the absorption of energy B is not correct because electrons do not emit energy on promotion C is not correct because electrons do not absorb energy on returning to the ground state 	

Question	Answer	Mark
Number		
9	The only correct answer is A (hydrogen iodide has stronger London forces than hydrogen bromide)	1
	B is not correct because hydrogen iodide has a smaller permanent dipole than hydrogen bromide C is not correct because neither HBr or HI can form hydrogen bonds D is not correct because the H–I bond is weaker than the H–Br bond	

Question Number	Answer	Mark
10	The only correct answer is B (NaNO ₃) A is not correct because both oxygen and nitrogen dioxide would be produced C is not correct because both oxygen and nitrogen dioxide would be produced D is not correct because both oxygen and nitrogen dioxide would be produced	1

Question	Answer	Mark
Number		
11	The only correct answer is B (1

Question Number	Answer	Mark
12	 The only correct answer is A (HCl) B is not correct because hydrogen bonds form between molecules of H2O C is not correct because hydrogen bonds form between molecules of HF D is not correct because hydrogen bonds form between molecules of NH3 	1

Question Number	Answer	Mark
13	The only correct answer is C (+5)	1
	A is not correct because the oxidation number is $+5$ in BrO_3^- B is not correct because the oxidation number is $+5$ in BrO_3^- D is not correct because the oxidation number is $+5$ in BrO_3^-	

Question Number	Answer	Mark
14	The only correct answer is D $(Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s))$ <i>A is not correct because Cl has undergone disproportionation</i> <i>B is not correct because O has undergone disproportionation</i> <i>C is not correct because Cl has undergone disproportionation</i>	1

Question	Answer	Mark
Number 15	The only connect engineer is D (recetivity of the elements in encode)	1
15	The only correct answer is D (reactivity of the elements increases)	1
	A is not correct because atomic radius increases down the group	
	B is not correct because the boiling temperature increases down the group	
	<i>C</i> is not correct because electronegativity decreases down the group	
	<u> </u>	

Question	Answer	Mark
Number		
16	The only correct answer is A (0.75)	1
	B is not correct because this is the reciprocal of the correct answer	
	C is not correct because this is the total volume at 40 seconds divided by 40	
	D is not correct because this is the initial rate	

Question Number	Answer	Mark
17(a)	 The only correct answer is C (the area under the curve to the right of the activation energy, <i>E_a</i> represents the number of particles with enough energy to react) A is not correct because this is the mode energy of the particles B is not correct because the activation energy is the minimum energy required for a reaction to take place D is not correct because a patchet meril domain the particles area to the left. 	1

Question	Answer	Mark
Number		
17(b)	The only correct answer is D (shifts to the left, higher)	1
	$m{A}$ is not correct because the curve would shift to the left and the peak would be higher	
	B is not correct because the curve would shift to the left	
	C is not correct because the peak would be higher	

Question	Answer	Mark
Number		
18	The only correct answer is C (arrow 3)	1
	A is not correct because the arrow 1 is correctly used	
	B is not correct because the arrow 2 is correctly used	
	D is not correct because the arrow 4 is correctly used	

Question Number	Answer	Mark
19	 The only correct answer is B (yellow to orange and pink to colourless) A is not correct because the phenolphthalein colour change is reversed and the methyl orange colour change is for acid to neutral C is not correct because the methyl orange colour change is for acid to neutral D is not correct because the phenolphthalein colour change is reversed 	1

Total for Section A = 20 Marks

Section B

Question Number	Answer		Additional Guidance	Mark
20(a)			Example of calculation:	4
	• M1 moles of CuSO4.5H2O	(1)	$10.68 \div 249.6 = 0.042788/89 \div 2080$	
	• M2 energy change	(1)	$2.5 \times 55 \times 3.70 = 508.75$ (J) = 0.50875 (kJ)	
	• M3 enthalpy change per mole	(1)	$\begin{array}{l} 508.75 \div 0.042788 = 11890 \; (J \; mol^{-1}) \\ Or \\ 0.50875 \div 0.042788 = 11.890 \; (kJ \; mol^{-1}) \end{array}$	
	• M4 correct sign and units and 2 or 3 SF	(1)	(+)11900 J mol ⁻¹ / (+)11.9 kJ mol ⁻¹ / (+)12000 J mol ⁻¹ / (+)12 kJ mol ⁻¹	
	Note M4 is not a stand-alone mark it depends on a sensible calculation by dividing joules by a number of moles.		TE throughout	
			Correct answer with sign and units and 2-3 SF score (4)	

Question Number	Answer	Additional Guidance	Mark
20(b)(i)		Example of diagram	2
	A diagram which shows		
	• both arrows pointing down (1)	$CuSO_4(s) + 5H_2O(l) \qquad \qquad$	
	• correct product in box (1)		
		CuSO ₄ (aq)	
		Ignore any extra water in the box e.g. + 5H ₂ O	
		Ignore any numbers on the arrows Allow ions separated $Cu^{2+}(aq)$ and $SO_4^{2-}(aq)$ Allow $CuSO_4 + (aq)$	

Question Number	Answer		Additional Guidance	Mark
20(b)(ii)			Example of calculation:	2
	• correct use of data (1))	$(+) - 67.4 \text{ (kJ mol}^{-1}) (-) + 11.9 \text{ (kJ mol}^{-1})$	
	• correct sign and answer (1))	-79.3 / -79 (kJ mol ⁻¹) Ignore units unless wrong but not award mixed	
	Note the only TE is using their value from (a).		units	
			Allow $-79.16(kJ mol^{-1})$ for rounding moles to 0.43 Allow TE on value from (a).	
			No TE on incorrect cycle Ignore SF	

Total for Question 20 = 8 Marks

Question	Answer		Additional Guidance	Mark
Number				
21(a)(i)	An answer that makes reference to the following points:			
	• both have London forces (only)	(1)	Accept dispersion forces Accept instantaneous dipole-induced dipoles Allow van der Waals' forces Note any mention of other intermolecular forces	
	 S molecules have more electrons / S is a larger molecule (than oxygen) / S electrons are more easily polarised 	(1)	being present e.g. dipole-dipole negates M1 Allow S ₈ , rather than O ₂ Allow just S has more electrons Allow just S is larger Allow reverse argument Ignore electron density	
	Independent marks		Do not award a S atom has more electrons than an oxygen molecule	

Question Number	Answer	Additional Guidance	Mark
21(a)(ii)	An answer that makes reference to the following points:		4
	Increasing temperature		
	• equilibrium shifts to the LHS/backwards (1)	Ignore any reference to yield	
	• in the endothermic direction (in order to reduce the temperature) (1)	Allow reaction is exothermic Allow favours endothermic direction	
	 Increasing pressure equilibrium shifts to the RHS/forward (1) 	Allow favours RHS/forward direction	
	 to the side with fewer (gaseous) molecules/moles (in order to reduce the pressure) (1) Independent marks 	Allow 3 moles (of gas) on the LHS (forms) 2 moles(of gas) on the RHS. If numbers of moles are quoted they must be correct. Allow reverse argument Ignore any reference to rate	

Question Number	Answer		Additional Guidance	Mark
21(a)(iii)	 reactants/(2)SO₂ + O₂ higher than products/(2)SO₃ non-catalysed activation energy correctly labelled and arrow going up catalysed activation energy correctly labelled and arrow going up enthalpy change labelled and arrow going down 	 (1) (1) (1) (1) 	Energy Reactants Enthalpy change Products	4
	If just one curve is drawn max (3) MB distribution scores (0) If endothermic reaction TE available for M2, M3 and M4 Double-headed arrows or no arrow heads penalise once		Progress of reaction Allow energy for enthalpy Allow E_a and E_{cat} Allow intermediates in the activation energy curves Ignore sign and units of energy even if incorrect	

Question	Answer		Additional Guidance	Mark
Number				
21(a)(iv)	An explanation that makes reference to the following points:			2
	• (operates at) a lower temperature	(1)	Allow lower temperature	
	 less energy required (for the reaction to proceed at an acceptable rate) or less burning of fossil fuels / less greenhouse gas evolved / less CO₂ evolved 	(1)	Allow less energy costs Ignore just cheaper Ignore less time/faster rate Allow less pollution	

Question	Answer		Additional Guidance	Mark
Number				
*21(b)	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.		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	0
	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).	
	6 5-4 3-2 1 0	4 3 2 1 0	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).	
	The following table shows how the structure and lines of reasoning Answer shows a coherent logical	marks should be awarded for Number of marks awarded for structure of answer and sustained lines of reasoning 2	In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning and 0, 1 or 2 indicative points would score zero marks for reasoning. If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not	
	structure with linkages and fully sustained lines of reasoning demonstrated throughout		deduct mark(s). Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer	
	Inswer is partially structured with linkages and lines of reasoning Answer has no linkages between points and is unstructured		and sustained line of reasoning	

Indicative content		
Potassium chloride		
IP1 (misty/steamy fumes of) HCl/hydrogen chloride	Note observation is not required for IP	
Potassium iodide	This can be seen in an equation	
IP2 purple vapour/black solid and I2/iodine	Ignore any reference to hydrogen iodide/HI/misty	
IP3 bad eggs and H ₂ S/ hydrogen sulfide	Tunies	
OR III III III		
yellow solid and S/ sulfur		
Choking gas and SO ₂ /sulfur dioxide		
IP4 KCl is not a redox reaction and KI is a redox reaction / KCl cannot reduce sulfuric acid but KI can	The two parts of this answer may often be seen in different places.	
IP5 iodide stronger reducing agent than chloride	Allow hydrogen iodide or potassium iodide is a stronger reducing agent than hydrogen chloride or potassium chloride. Allow reducing ability (of the halides) increases down the group Or reverse argument	
	Do not award iodine/I is a stronger reducing agent than chlorine/Cl	

IP6 (because) S is reduced from $+6$ to -2 in H ₂ S OR S is reduced from $+6$ to 0 in S OR S is reduced from $+6$ to $+4$ in SO ₂	Allow just correct stated product and oxidation number $eg - 2$ in H_2S or 0 in S or $+ 4$ in SO_2	
OR Any balanced equation making H ₂ S, SO ₂ , or S showing electrons eg $8H^+ + H_2SO_4 + 8e^- \longrightarrow H_2S + 4H_2O$ $2H^+ + H_2SO_4 + 2e^- \longrightarrow SO_2 + 2H_2O$ $6H^+ + H_2SO_4 + 6e^- \longrightarrow S + 4H_2O$	Ignore I ₂ oxidation number = 0	

Question	Answer		Additional Guidance	Mark
Number				2
21(0)			Example of calculation	2
		(1)	1.5	
	• number of moles of sulfuric acid in 40.5 cm ³	1)	$1.5 \times 500 \div 1000 = 0.75 \text{ (mol)}$	
	• concentration of the concentrated sulfuric acid	(1)	$0.75 \times 1000 \div 40.5 = 18.519 \pmod{\text{dm}^{-3}}$	
			Allow IE on incorrect moles	
			Units not required but if given they must be correct	
			1 2 2	
			Correct answer with or without working scores (2)	
			Ignore SE except 1 SE	
			Total for Ouestion 21 -	20 marks

Question	Answer		Additional Guidance	Mark
Number				
22(a)	An explanation that makes reference to the following points:			2
	• contains the OH group/OH is the alcohol group	(1)	Accept a hydrocarbon in which one H atom has been replaced by an OH group Allow contains O-H bond Allow contains a C-OH bond Ignore hydroxyl Do not award hydroxide/ OH ⁻	
	 primary means the C bonded to the OH (group) is attached to 1 (or 0) alkyl group / carbon atom/ R group 	(1)	Allow the OH group is attached to a carbon atom bonded to 2 (or 3) H atoms Do not award the OH is attached to a single R/alkyl/carbon group	

Question	Answer					Additional	Mark
Number						Guidance	
22(b)		1			1		5
	Name	butan-1-ol		(2-)methylpropan-2-ol	(2)	One mark for	
	Displayed formula		$\begin{array}{cccccccccccccccccccccccccccccccccccc$	H H H H H C H H H H H H H H H H H H H H	(2)	One mark for each correct displayed formula	
	Nature of	nnimony	coondowy	О Н			
	alcohol	primary	secondary		(1)	One mark for both alcohol	
						types	
						Allow CH ₃ and OH undisplayed	
						Penalise missing Hs only once.	

Question Number	Answer		Additional Guidance	Mark
22(c)(i)	An answer that makes reference to the following points:			2
	 potassium dichromate((VI)) / K₂Cr₂O₇ 	(1)	Allow sodium dichromate((VI)) / Na ₂ Cr ₂ O ₇ If oxidation state is given it must be correct Do not award potassium manganate(VII) / potassium permanganate	
	 sulfuric acid / H₂SO₄ Note M2 depends on M1 or a near miss such as potassium permanganate or potassium dichromate with the wrong oxidation number 	(1)	Do not award hydrochloric acid Ignore just 'acidified' Ignore concentration of sulfuric acid Ignore heat If no other mark is scored acidified dichromate / H^+ and Cr_2O7^{2-} score (1)	

Question	Answer	Additional Guidance	Mark
Number			
22(c)(ii)		Allow	1
	• $(CH_3)_2CHCH_2OH + [O] \rightarrow (CH_3)_2CHCHO + H_2O$	$C_4H_{10}O + [O] \longrightarrow C_4H_8O + H_2O$	
		The [O] may be above the arrow	
		Allow displayed/molecular/skeletal	

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Question Number	Answer	Additional Guidance	Mark
22(c)(iii)	An answer that makes reference to two of the		
	following points:	Ignore any reference to the size/width of the peaks due to stretching etc	
	 (resulting mixture) would give a peak due to O-H bond in alcohols at 3750-3200 (cm⁻¹) (1) 	Allow (resulting mixture) would give a peak due to OH (in alcohols) at 3750-3200 (cm ⁻¹) Do not award -OH	
	 would give a peak due to C=O bond in aldehydes at 1740-1720 (cm⁻¹) or 	Do not award 1720-1700 (cm ⁻¹) for C=O in ketones	
	would give a peak due to C–H bond in CHO at (1) 2900-2820 and/ or 2775-2700 (cm ⁻¹)	Allow any range within the range. Do not award single numbers but penalise once only	
		If no other marks have been scored a correct wave number range for both the O-H and C=O score (1) 3750-3200 (cm ⁻¹) 1740-1720 (cm ⁻¹)	

(Total for Question 22 = 12 Marks)

Section C

Question Number	Answer	Additional Guidance	Mark
23(a)(i)	$TiO_2 + 2Cl_2 + 2C \rightarrow TiCl_4 + 2CO$	Ignore state symbols even if incorrect Allow multiples	1

Question Number	Answer		Additional Guidance	Mark
23(a)(ii)				2
	• Ti is reduced and from +4 to 0	(1)	Four correct oxidation numbers with no or incorrect mention of reduced or oxidised scores (1)	
	• Mg is oxidised and from 0 to +2	(1)	Ti is reduced as it gains electrons and Mg is oxidised as it loses electrons with no or incorrect oxidation numbers scores (1)	

Question Number	Answer		Additional Guidance	Mark
23(b)	 hydrolysis titanium((IV)) oxide/TiO₂ 	(1) (1)	Do not award hydration Ignore hydrogen chloride/HCl Allow titanium((IV))hydroxide/Ti(OH)4 If both name and formula/oxidation number	2
			are given they must all be correct	

Question	Answer		Additional Guidance	Mark
Number				
23(c)	H CH ₃ H CH ₃ -C -C -	(1) (1)	Allow adjacent pairs of methyl groups Ignore square brackets and subscript n/2	2
	Note M2 depends on M1 or near miss eg missing a H		Ignore connectivity of CH ₃	

Question	Answer		Additional Guidance	Mark
Number				
23(d)(i)	An answer that makes reference to the following points:			2
	• reagent: potassium hydroxide / KOH	(1)	Allow sodium hydroxide / NaOH	
	• conditions: aqueous/water	(1)	Ignore any reference to concentration or heat Allow dilute	
	M2 dependent on M1or near miss e.g. OH ⁻ will not score M1 but will allow access to M2.			

Question Number	Answer	Additional Guidance	Mark
23(d)(ii)	An answer that makes reference to the following points:		2
	 reagent: (concentrated) phosphoric((V)) acid / H₃PO₄ (1) 	Allow (concentrated) sulfuric acid Ignore heat Do not award H ₃ PO ₃ Allow passing vapour over porous pot / alumina or any surface catalyst and heat	
	• reaction type: elimination/dehydration (1)		
	Independent marks		

Question	Answer		Additional Guidance	Mark
Number				
23(d)(iii)	An answer that makes reference to the following points:			2
	 reagent: phosphorus(V) chloride/ phosphorus pentachloride/PCl₅ 	(1)	Allow thionyl chloride / SOCl ₂ Allow phosphorus (III) chloride / phosphorus trichloride / PCl ₃	
	• equation: $C_4H_9OH + PCl_5 \rightarrow C_4H_9Cl + HCl + POCl_3$	(1)	Allow $C_{4}H_{9}OH + SOCl_{2} \rightarrow C_{4}H_{9}Cl + HCl + SO_{2}$ $3C_{4}H_{9}OH + PCl_{3} \rightarrow 3C_{4}H_{9}Cl + H_{3}PO_{3}$ Allow skeletal, structural, displayed or molecular formulae	

Question	Answer		Additional Guidance	Mark
Number				
23(d)(iv)	An answer that makes reference to the following			2
	points:			
	• conditions: alcoholic (1	1)	Allow ethanol/ethanolic Ignore heat and concentration	
	• role of the hydroxide ions: base (1	1)	Allow proton acceptor/reacts with H ⁺	
	Note answers may be given on either line			

Question Number	Answer	Additional Guidance	Mark
23(e)	An answer that makes reference to the following points:	Examples of calculation	5
	• moles of carbon dioxide (1)	$16 \div 44 = 0.36364 \text{ (mol)} / 4 \div 11 \text{ (mol)}$	
	• conversion of cm^3 to m^3 (1)	$20 \div 1000000 = 2 \times 10^{-5} / 0.00002 \text{ (m}^3)$	
	• conversion of °C to K (1)	273 + 25 = 298 (K)	
	• rearrangement of the ideal gas equation (1)	$p = \frac{nRT}{V}$	
	• calculation of pressure and correct units (1) given	$\frac{0.3636 \times 8.31 \times 298}{2 \times 10^{-5}} = \frac{45025000 \text{ Pa} / 45025 \text{ kPa}}{4.5 \text{ x } 10^7 \text{ Pa} / 45\text{MPa}}$	
		Ignore SF except 1	
		Allow TE for answers to M1, M2 and M3 But no TE on wrong rearrangement of gas equation	
		Correct answer, including units with or without working scores (5)	

Total for Question 23 = 20 Marks Total for Section C = 20 Marks TOTAL FOR PAPER = 80 MARKS

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