National
Qualifications
2023

2023 Chemistry

Advanced Higher

Finalised Marking Instructions

General marking principles for Advanced Higher Chemistry

This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this paper. These principles must be read in conjunction with the detailed marking instructions, which identify the key features required in candidate responses.

(a) Marks for each candidate response must **always** be assigned in line with these general marking principles and the detailed marking instructions for this assessment.

(b) Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.

(c) If a specific candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you must seek guidance from your team leader.

(d) Where a candidate makes an error at an early stage in a multi stage calculation, credit should normally be given for correct follow on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. The same principle should be applied in questions which require several stages of non-mathematical reasoning. The exception to this rule is where the marking instructions for a numerical question assign separate "concept marks" and an "arithmetic mark". In such situations, the marking instructions will give clear guidance on the assignment of partial marks.

(e) In many cases, marks can still be awarded for inaccurate or unconventional spelling or vocabulary as long as the meaning of the word(s) is conveyed. For example, responses that include 'distilling' for 'distillation', or 'it gets hotter' for 'the temperature rises', should be accepted.

(f) If a correct answer and a wrong answer are present, it should be treated as a cancelling error and no marks should be given. For example, in response to the question, 'State the colour seen when blue Fehling's solution is warmed with an aldehyde', the answer 'red green' gains no marks.
However, if a correct answer and additional information, which does not conflict, are present, the additional information should be ignored, whether correct or not. For example, in response to a question concerned with melting point, 'State why the tube should not be made of copper', the response 'Copper has a low melting point and is coloured grey' would **not** be treated as having a cancelling error.

(g) Full marks are usually awarded for the correct answer to a calculation without working and the partial marks shown in the Detailed Marking Instructions are for use when working is given but the final answer is incorrect. An exception is when candidates are asked to 'Find, by calculation', when full marks cannot be awarded for the correct answer without working.

(h) Significant figures.

This marking instruction only applies to correct final answers. If the data in a question is given to three significant figures, the final answer should also have three significant figures. However one fewer significant figure and up to two more significant figures is acceptable.

For example if a correct final answer is 8.16 J then 8.2 J, 8.158 J and 8.1576 J would also be acceptable. Answers out with this range would not be acceptable and one mark would not be awarded.

The use of a recurrence dot, eg $0.\dot{6}$, would imply an infinite number of significant figures and would therefore not be acceptable.

This marking instruction must only be applied a maximum of once per paper and cannot be applied if instruction **(i)** has already been applied in the paper.

(i) Units

This marking instruction only applies to correct final answers. In most questions units are not required. However, if the candidate writes units then they must be correct. The symbols L and l are both acceptable for litres.
An incorrect unit would not be acceptable and one mark would not be awarded.

This marking instruction must only be applied a maximum of once per paper and cannot be applied if instruction **(h)** has already been applied in the paper.

(j) Intermediate rounding.

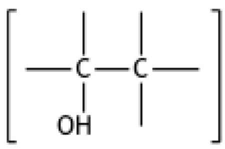
Ideally, calculated intermediate values should not be rounded. However, if the candidate has correctly rounded, the calculated intermediate values can have one significant figure fewer than the data given in the question but no fewer, otherwise full marks may not be awarded and partial marking would apply.
For example, if the data in a question is given to three significant figures, the intermediate value should have no fewer than two significant figures.

(k) If a structural formula is asked for, CH_3 is acceptable as a methyl group, and CH_3CH_2 and C_2H_5 are acceptable as an ethyl group.

If a name is asked for such as 3-methylhexane, then 3, methyl-hexane would be acceptable, ie ignore incorrect use of commas and dashes.

(l) When drawing structural formulae, a mark should only be awarded if the bonds point to the appropriate atoms.

The example below would be incorrect.



Marking instructions for each question

Section 1

Question	Answer	Mark
1.	D	1
2.	C	1
3.	B	1
4.	A	1
5.	D	1
6.	D	1
7.	A	1
8.	B	1
9.	C	1
10.	A	1
11.	A	1
12.	C	1
13.	D	1
14.	A	1
15.	C	1
16.	B	1
17.	A	1
18.	B	1
19.	A	1
20.	D	1
21.	D	1
22.	B	1
23.	C	1
24.	B	1
25.	B	1

Section 2

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	(Excited) electrons fall to lower energy levels. **(1)** The difference in the energy levels corresponds to the (red) light/ energy emitted. **(1)**	**2**	Any mention of the complementary colour emitted/absorbed or HOMO/LUMO/d-d is cancelling for the second mark.
		(ii)	m_s **AND** 1	**1**	s for the quantum number on its own is not sufficient but is not a cancelling error. s must be subscripted in m_s
		(iii) (A)	VII **OR** +7	**1**	
		(iii) (B)	9	**1**	
	(b)	(i) (A)	−1650 (kJ mol^{-1})	**1**	−1600/−1648 Unit not required but must be correct if given.
		(i) (B)	−549 (J K^{-1} mol^{-1})	**1**	−550/−549.4 Unit not required but must be correct if given.
		(i) (C)	3010 (K) **Partial marking** 1 mark may be awarded for one of the following: Use of ΔG = ΔH−TΔS **OR** Use of ΔH/ΔS **OR** Correct substitution of values directly into the above equations. **OR** Reaction is feasible when ΔG = 0	**2**	3005/3005.5 If the candidate has used -1648 and -549.4 then the acceptable answers are 3000/2999.6 If the candidate has used -1648 and -549 then the acceptable answers are 3002/3001.8 Allow follow through from (i)(A) and (i)(B). If this results in a negative value for K then ignore the negative sign. Unit not required but must be correct if given.

Question			Expected response	Max mark	Additional guidance
		(ii)	2700 **OR** 2.70 **(1)** Correct unit for a calculated mass **(1)**	**2**	2698/2.7/2.698 are also acceptable answers. If the candidate uses 25.3 mol then the acceptable answers are 2694/2694.5 (g) 2.694/2.6945 (kg) If the candidate uses 25.33 mol then the acceptable answers are 2698/2697.6 (g) 2.698/2.6976 (kg)

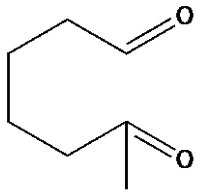
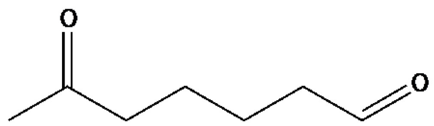
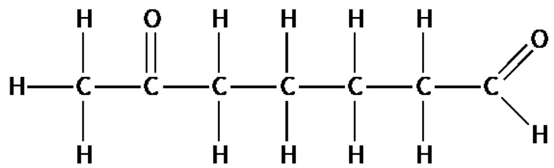
Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	1^{st}/first	**1**	
		(ii)	2^{nd}/second	**1**	
	(b)		Rate = k $[HgCl_2]$ $[C_2O_4^{2-}]^2$	**1**	Mark may be awarded for follow through from part (a). Mark may not be awarded for: - R or r instead of rate. - use of K instead of k - non-square brackets - ( ) or { } - incorrect chemical formulae - omission of ion charge State symbols are not required but must be correct if given.
	(c)	(i)	$2{\cdot}56 \times 10^{-4}$ **(1)** $l^2\ mol^{-2}\ s^{-1}$ **(1)**	**2**	2.6×10^{-4}/2.560×10^{-4}/2.5595×10^{-4} are also acceptable answers. Allow follow through from (b) for both value and unit. Allow units in any order.
		(ii)	0·508 ($mol\ l^{-1}$)	**1**	0·51/0·5075/0·50751 are also acceptable answers. Allow follow through from (b) and (c)(i). Unit not required but must be correct if given.

Question			Expected response	Max mark	Additional guidance
3.	(a)	(i)	Add more/excess calcium chloride (solution)	**1**	Add more reactant is not sufficient for the mark to be awarded.
		(ii)	Dried/heated/put in a desiccator to constant mass	**1**	Must mention constant mass.
	(b)		0.59 (%) **Partial marking** One mark may be awarded for any of the following. 0.053 (g) of oxalic acid **OR** 0.000585 mol of oxalic acid **OR** A correctly calculated percentage from an incorrectly calculated mass of oxalic acid	**2**	0.6/0.587/0.5871 are also acceptable answers. 0.075 ÷ 8.975 = 0.84 % is awarded zero marks.
	(c)		Not all oxalic acid extracted out **OR** Not soaked in water for long enough **OR** Not all precipitated out/not gone to completion **OR** Not enough $CaCl_2$ added **OR** Transfer loss **OR** Natural variation in samples	**1**	Allow follow through from the answer in (b). Other substances present precipitated with Ca^{2+} ions **OR** Sample not dried properly These two answers are only acceptable if the candidate’s answer to (b) is larger than 0.97%.

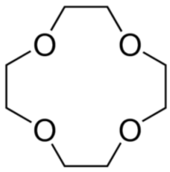
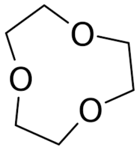
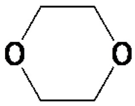
Question			Expected response	Max mark	Additional guidance
4.			This is an open-ended question. **1 mark** The student has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. The student has made some statement(s) that is/are relevant to the situation, showing that at least a little of the chemistry within the context is understood. **2 marks** The student has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. The student makes some statement(s) that is/are relevant to the situation, showing that the context is understood. **3 marks** The maximum available mark would be awarded to a student who has demonstrated, at an appropriate level, a good understanding, of the chemistry involved. The student shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the context. This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.	3	Zero marks should be awarded if the student has demonstrated an understanding of the chemistry that is below the appropriate level. Zero marks should also be awarded if the student merely restates the chemistry given in the question.

Question			Expected response	Max mark	Additional guidance
5.	(a)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ (4s^0)$	**1**	Electron numbers must be superscripted and orbital symbols lower case. Correct orbital box notation is also acceptable as long as the boxes are correctly labelled.
	(b)		hexaamminenickel(II)	**1**	Must be spelled **exactly** as shown.
	(c)	(i)	Bidentate	**1**	
		(ii)	6/six	**1**	Charges are not acceptable.
	(d)	(i)	Electrons move to higher energy d orbitals **(1)** Purple light absorbed/380 – 400 nm light absorbed/red and blue light absorbed/complementary colour (to green) absorbed. **(1)**	**2**	The first mark may not be awarded if the candidate refers to HOMO-LUMO. The second mark may not be awarded if there is any mention of emission.
		(ii)	Ammonia/NH_3 **AND** Absorbs shorter wavelength/higher energy/higher frequency/UV	**1**	Accept inverse reason eg ammonia AND the other/aqua complex absorbs longer wavelengths Accept an answer that states that it is the ligand in $[Ni(NH_3)_6]^{2+}$. If the candidate has stated $[Ni(NH_3)_6]^{2+}$ has the greater ability to split d-orbitals, then this is not an acceptable answer as $[Ni(NH_3)_6]^{2+}$ is not a ligand. Greater absorbance on its own is not sufficient.

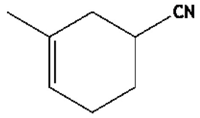
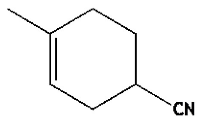
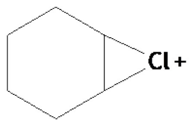
Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	$K = \frac{[HI]^2}{[H_2][I_2]}$	1	Must be capital K and square brackets. State symbols are not required but must be correct if given.
		(ii)	980 **Partial marking** 1 mark may be awarded for $[H_2] = 0.015$ **OR** $[HI] = 0.47$	2	1000/982/981.8 are also acceptable answers. Allow follow through from (a)(i).
		(iii)	207 (kJ mol^{-1}) 1 mark for $E = Lhf$ *and* $c = f\lambda$ **OR** $E = Lhc \div \lambda$ **OR** Correct substitution into the above equations.	2	210/207.2/207.16 If using a frequency of 5.19×10^{14} then the acceptable answers are 210/207/207.1/207.14 Unit not required but must be correct if given.

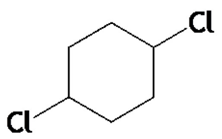
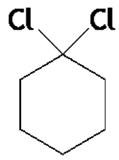
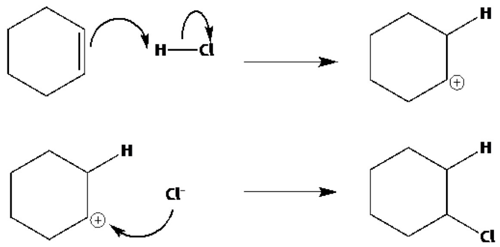
Question			Expected response	Max mark	Additional guidance
	(b)	(i)	Buchner/sintered glass/Hirsch	1	
		(ii)	87.4 (%) **Partial marking** 1 mark may be awarded for Theoretical yield = 287.2 g **OR** Moles of I_2 (1.12) and HI (2.25) **OR** A correctly calculated percentage yield from an incorrectly calculated theoretical yield/moles of I_2 and HI.	2	87/87.38/87.382 are also acceptable answers.
	(c)		 **OR**  **OR**  **OR** Any other correct structural formula	1	

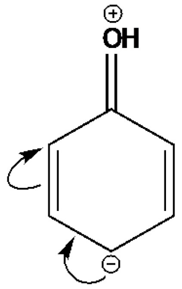
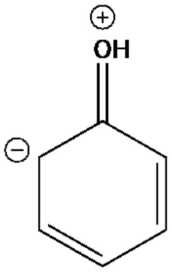
Question			Expected response	Max mark	Additional guidance
7.	(a)		Decrease in CO_2 **AND** Endothermic/backwards/reverse reaction favoured/LHS favoured	1	
	(b)	(i)	(Carbonic acid is a) weaker acid as it has a higher pK_a/lower K_a **OR** Ethanoic acid is a stronger acid as it has a lower pK_a/higher K_a	1	If the candidate states that carbonic acid is weaker/ethanoic acid is stronger but makes no reference to the pK_a or K_a, then this is not sufficient for the mark to be awarded.
		(ii)	Base **OR** Proton/H^+ acceptor	1	
	(c)	(i)	6.3×10^{-9} (mol l^{-1})	1	6×10^{-9}/6.31×10^{-9}/6.310×10^{-9} are also acceptable answers. Unit not required but must be correct if given.
		(ii)	100 (%) **Partial marking** 1 mark may be awarded for correctly subtracting calculated $[H^+]$ values. **OR** correctly calculating a % increase by dividing a calculated change in $[H^+]$ by the value from (c)(i).	2	99.5/99.53 are also acceptable answers. If the candidates uses 6.31×10^{-9} and 1.26×10^{-8} then the acceptable values are 99.7/99.68 Allow follow through from (c)(i).
	(d)	(i)	The following 4 points: - react shells/calcium carbonate with HCl/acid - known quantity/moles/volume **and** concentration of HCl/acid - idea of excess HCl/acid - titrate with NaOH.	2	2 marks awarded for all 4 points. 1 mark awarded for 2 or 3 points. 0 marks awarded for 1 point.
		(ii)	Pure calcium carbonate **OR** Shell/calcium carbonate sample with a known percentage.	1	An answer stating a solution of calcium carbonate is not acceptable.

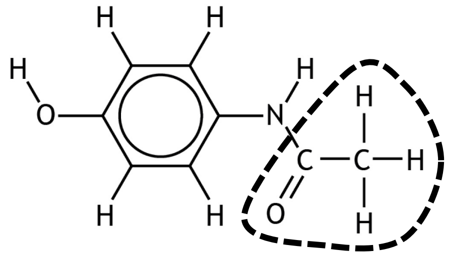
Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	15-crown-5	**1**	Must be written exactly as shown.
		(ii)	 **OR**  **OR** 	**1**	Any correct structure for 12-crown-4 or 9-crown-3 or 6-crown-2.
		(iii)	(Can donate) lone/non-bonding pairs of electrons **OR** Can form dative (covalent) bonds	**1**	It must be clear that a **pair** of electrons is involved.
	(b)	(i)	$C_6H_{14}O_4$	**1**	Any order
		(ii)	Nucleophilic substitution **OR** Condensation	**1**	Substitution on its own is not sufficient.
	(c)		0.0024 (mol l^{-1}) **(2)** **Partial marking** 1 mark may be awarded for Correctly calculating moles of ether/complex (0.00085) **OR** Correctly calculating a concentration from an incorrect number of moles of ether/complex.	**2**	0.002/0.00244/0.002435 are also acceptable answers. If the candidate uses 0.000852 mol of ether then the acceptable answers are 0.002/0.0024/0.00243/0.002434 If the candidate uses 0.00085 mol of ether then the acceptable answers are 0.002/0.0024/0.00243/0.002429 Units not required but must be correct if given.

Question			Expected response	Max mark	Additional guidance
9.			This is an open-ended question **1 mark** The student has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. The student has made some statement(s) that is/are relevant to the situation, showing that at least a little of the chemistry within the context is understood. **2 marks** The student has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. The student makes some statement(s) that is/are relevant to the situation, showing that the context is understood. **3 marks** The maximum available mark would be awarded to a student who has demonstrated, at an appropriate level, a good understanding, of the chemistry involved. The student shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the context. This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.	3	Zero marks should be awarded if the student has demonstrated an understanding of the chemistry that is below the appropriate level. Zero marks should also be awarded if the student merely restates the chemistry given in the question.

Question			Expected response	Max mark	Additional guidance
10.	(a)	(i)	Adjacent (unhybridised) p orbitals that overlap/form a molecular orbital across a system/number of carbon atoms **OR** Electrons delocalised across a number of carbon atoms **OR** Alternating single and double bonds	**1**	
		(ii)	sp^2	**1**	Lower case letters and 2 must be superscripted.
		(iii)	 **OR**  **OR** Any other correct structural formula for the above structures.	**1**	
	(b)	(i)	Repulsion from the pi electrons/ double bond	**1**	
		(ii)	 **OR** Any other correct structural formula	**1**	Dotted/dashed bonds are not acceptable.
		(iii) (A)	Restricted rotation/lack of free rotation (around the single bonds) in the ring	**1**	Mention of double bonds in the ring is a cancelling error.

Question			Expected response	Max mark	Additional guidance
		(iii) (B)	 **OR**  **OR** Any other correct isomer with a five, four or three member ring.	1	
	(c)	(i)	 1 mark for 3 correct curly arrows 1 mark for correct intermediate	2	H does not need to be shown in the intermediate or the final product.
		(ii)	1.08 (D) **(2)** Partial marking 1 mark may be awarded for $\mu = \dfrac{0.178 \times 1.6 \times 10^{-19} \times 0.127 \times 10^{-9}}{3.34 \times 10^{-30}}$ **OR** Correct substitution into the separate equations **OR** μ = 3.62 × 10^{-30} (in Cm) **OR** Correctly calculated value from an incorrect bond length.	2	1.1/1.083/1.0829 are also acceptable answers. Unit not required but must be correct if given.

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	NO_2^+	**1**	Positive charge must be present.
		(ii) (A)		**1**	
		(ii) (B)		**1**	
	(b)		Reduction	**1**	
	(c)		Ethanoic anhydride **OR** Ethanoic acid **OR** Ethanoyl chloride **OR** Correct structure/formula	**1**	
	(d)		The following 4 points in order: • Minimum/small volume (of solvent) • Hot water/solvent • Cool • Filter	**2**	2 marks awarded for all 4 points. 1 mark awarded for 2 or 3 points. 0 marks awarded for 1 point. If there is mention of hot filtering then this must take place before cooling. Filtering must take place after cooling.
	(e)	(i) (A)	C=O, carbonyl	**1**	
		(i) (B)	O-H/N-H overlapping with/present with/in same region as O-H/N-H/C-H	**1**	

Question			Expected response	Max mark	Additional guidance
	(e)	(ii) (A)	 The circled group shows the maximum area that can be circled for the mark to be awarded.	1	Any single hydrogen atom or combination of hydrogen atoms from the circled group is acceptable.
		(ii) (B)	Doublets	1	
		(iii) (A)	Pure **AND** no extra peaks **OR** only 5 (hydrogen) environments/peaks	1	
		(iii) (B)	(mixed) melting point/TLC/ chromatography **(1)** For melting point Narrow range for pure/wide range for impure/compare with literature/compare with pure sample **OR** For TLC One spot if pure/multiple spots if impure/compare with literature/compare R_f values/compare with pure sample **(1)**	2	

[END OF MARKING INSTRUCTIONS]