National
Qualifications
2022

2022 Chemistry

Advanced Higher

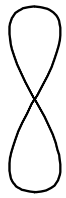
Finalised Marking Instructions

Marking instructions for each question

Section 1

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

Section 2

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>1.</td><td>(a)</td><td>(i)</td><td></td><td>1</td><td>Any orientation acceptable.

Ignore any axes or labels given.</td></tr>
<tr><td></td><td></td><td>(ii)</td><td><table><tr><th>Quantum number</th><th>Value</th></tr><tr><td>n</td><td>2</td></tr><tr><td>l</td><td>1</td></tr><tr><td>m_l</td><td>(+)1 / 0 / −1</td></tr><tr><td>m_s</td><td>$+\frac{1}{2} / -\frac{1}{2}$</td></tr></table></td><td>1</td><td>All correct
There must be only one value for each of the quantum numbers.

There must be a + or – sign in front of the ½.</td></tr>
<tr><td></td><td>(b)</td><td></td><td>Oxygen has a less stable electronic structure/configuration because it does not have a half-filled p subshell.

OR

Special stability associated with half-filled p subshell in nitrogen.

OR

Special stability associated with all p orbitals having one electron/being half-filled in nitrogen.</td><td>1</td><td>A correct diagram is an acceptable way of showing the electronic structure.

Half-filled orbital rather than orbitals is not acceptable.

This mark is not awarded for answers that do not imply stability due to a half-filled p subshell.

For example,

Oxygen has a less stable electronic configuration</td></tr>
<tr><td></td><td>(c)</td><td></td><td>1.05×10^{-16} (J)</td><td>1</td><td>1×10^{-16}/1.0×10^{-16} / 1.046×10^{-16} /1.0464×10^{-16} are also acceptable values.

Unit not required but must be correct if given.</td></tr>
</table>

Question			Expected response	Max mark	Additional guidance
2.	(a)		(+) 86.6 (kJ mol^{-1}) **AND** not feasible/ no **OR** (+) 86600 (J mol^{-1}) **AND** not feasible/ no Partial marking Up to 2 marks may be awarded for any two of the following: The expression $\Delta G = \Delta H - T\Delta S$ or substituted values **OR** $\Delta H =$ 90.3 (kJ mol^{-1}) / 90300 (J mol^{-1}) **AND** $\Delta S =$ 12.5 (J K^{-1} mol^{-1}) / 0.0125 (kJ K^{-1} mol^{-1}) **OR** Correctly predicted feasibility from a correctly calculated value for ΔG from incorrect values for ΔH and/or ΔS. The units for ΔH and ΔS must correspond.	**3**	87 / 86.58 / 86.575 are also acceptable values. 2 marks may be awarded for calculating the temperature at which the reaction becomes feasible (7224 K). 3 marks may only be awarded if the candidate has explained the range of values for T at which ΔG is less than zero. Unit not required but must be correct if given.
	(b)		0.6 g/ 600 mg **(2)** Partial marking 1 mark may be awarded for the following: 0.6/600 **(1)** **OR** Correct unit for a calculated final mass. **(1)**	**2**	
	(c)		+4 +3	**1**	Both answers must be correct, as shown.

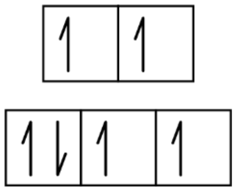
Question			Expected response	Max mark	Additional guidance
2	(d)	(i) (A)	Rate = $k[NO(g)]^2[H_2(g)]$	**1**	State symbols are not required but any that are given must be correct. r is not an acceptable symbol for rate. k must be lower case. Must have square brackets.
		(i) (B)	0.0099 (mol l^{-1})	**1**	0.01/0.00994/0.009938 are also acceptable answers. Allow follow through from (d)(i)(A). Unit not required but must be correct if given.
		(ii)	$2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$	**1**	Multiples are acceptable State symbols are not required but any that are given must be correct.

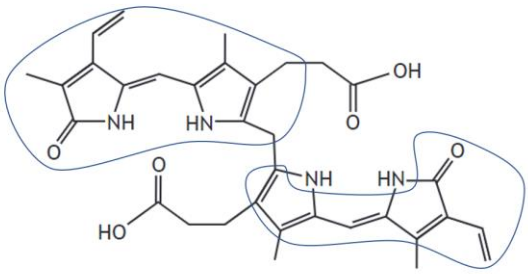
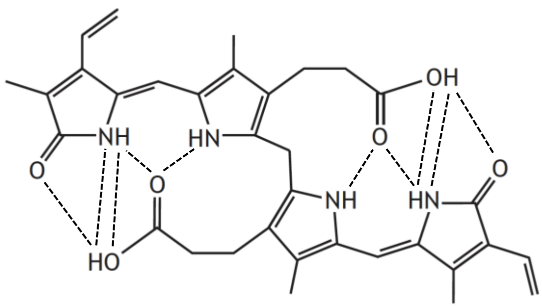
Question			Expected response	Max mark	Additional guidance
3.	(a)		Partially dissociated into ions in aqueous solution.	**1**	
	(b)	(i)	1.31 **(2)** Partial marking 1 mark may be awarded for the following: $pH = \frac{1}{2}pKa - \frac{1}{2}\log c$ **OR** correct substitution **OR** $[H^+] = \sqrt{(K_a c)}$	**2**	If the candidate has used the pKa value from the data booklet (3.20) the range of acceptable answers is 1.3/1.313/1.3130 If the candidate has used the Ka value from the data booklet (6.3×10^{-4}) the range of acceptable answers is 1/1.3/1.31/1.313.
		(ii)	7.50 (%) **(2)** Partial marking 1 mark may be awarded for the following: Mass of 75 (g in 1 l) **OR** A mass divided by 1000 and multiplied by 100.	**2**	7.5 is also acceptable.
		(iii)	Tetrahedral	**1**	A diagram is not acceptable.

Question			Expected response	Max mark	Additional guidance
4.	(a)	(i) (A)	Heating under reflux/refluxing	**1**	
		(i) (B)	Anti-bumping granules	**1**	Accept appropriate equivalent for anti-bumping granules. 'Bumping' granules is not acceptable.
		(ii)	Hydrogen ions react/bond with the conjugate base (of the acid) (to form undissociated weak acid molecules.) **OR** Hydrogen ions react/bond with the negative ion of the salt.	**1**	Mention of buffer is a cancelling error. Hydrogen ions react/bond with the salt/conjugate base of the salt is not acceptable.
		(iii) (A)	Vacuum (filtration) **OR** Acceptable labelled diagram	**1**	Mark not awarded for "with Buchner funnel/flask" on its own.
		(iii) (B)	To purify (the hippuric acid) **OR** To remove impurities **OR** It was impure	**1**	
	(b)	(i)	Different (types of) vibration/stretch or bend **OR** Different atoms (in bond) **OR** Different strength (of bond)	**1**	
		(ii)	Any value from 3340 to 3400 (cm^{-1})	**1**	Mark not awarded for quoting 3300-3500 cm^{-1} range from Data Booklet on its own. Units not required but must be correct if given.

Question			Expected response	Max mark	Additional guidance
4.	(c)	(i)	6	1	
		(ii)	doublet **OR** diagram with 2 lines of equal height	1	
		(iii)	(Hydrogen nuclei) flip/drop/fall to low energy/align with the (strong) magnetic field **(1)** Different energy/wavelength/frequency emitted (for different hydrogen environments) **OR** (Different hydrogen environments have) different energy gaps between high and low states **(1)**	2	
	(d)		This is an open-ended question **1 mark:** The candidate has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. They have made some statement(s) that are relevant to the situation, showing that they have understood at least a little of the chemistry within the context. **2 marks:** The candidate has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. They make some statement(s) that are relevant to the situation, showing that they understand the context. **3 marks:** The maximum available mark would be awarded to a candidate who has demonstrated, at an appropriate level, a good understanding, of the chemistry involved. The candidate 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. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks.	3	**Award 0 marks** where the candidate has not demonstrated, at an appropriate level, an understanding of the chemistry involved. There is no evidence that they have recognised the area of chemistry involved, or they have not given any statement of a relevant chemistry principle. Award zero marks also if the candidate merely restates the chemistry given in the question..

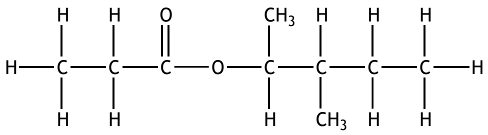
Question			Expected response	Max mark	Additional guidance
5.	(a)		Repulsion from electrons/ lone pair (in the ligand) **OR** (Non-bonding) electrons/ lone pairs in the ligand	1	Repulsion from ligands is not acceptable.
	(b)	(i)	Electrons fill orbitals in order of increasing energy.	1	
		(ii) (A)	Two of any of the following: high spin P > Δ / Δ < P low spin Δ > P / P < Δ **OR** Δ is lower for high spin than low spin **OR** as oxidation state increases, P increases **OR** as oxidation state increases, Δ increases **OR** +3 higher P than +2/+2 lower P than +3 OR +3 higher Δ than +2/+2 lower Δ than +3 **OR** type of ligand does not affect P **OR** spectrochemical series order CN^- > H_2O > F^- **OR** CN^- ligand is strongest / F^- ligand is weakest **OR** any other valid conclusion	2	Two valid conclusions that are direct opposites would be worth 1 mark.

Question			Expected response	Max mark	Additional guidance
5.	(b)	(ii) (B)	Hexafluoridocobaltate(III)	**1**	Answer must be correctly spelled as shown.
		(ii) (C)		**1**	Allow follow through for wrong oxidation state in (b)(ii)(B). Accept the pair of electrons in any of the lower boxes. Single electrons must have parallel spins. The electron pair must have opposite spins.

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	Maximum structure of chromophore is shown by top line and minimum structure of chromophore is shown by bottom line in the diagram below.  	1	
		(ii)	Anti-bonding higher energy (than bonding) **OR** Anti-bonding unfilled and bonding filled	1	The answer must be a comparison, for example, 'different energy' would not be acceptable.
	(b)	(i)	Two different groups attached to each carbon atom (of the double bond) **(1)** Lack of (free) rotation (around the carbon-carbon double bond) **(1)**	2	Example of cis and trans isomerism on its own is not enough for the first mark.
		(ii)	 	1	Any one hydrogen bond. Any hydrogen bond drawn between H and N/O is acceptable, except for within a carboxyl group or amide group.
	(c)	(i)	(Blue light is the) complementary colour to yellow. **OR** Bilirubin absorbs blue light.	1	Reference to yellow colour being observed/seen/emitted is a cancelling error.
		(ii)	258 (kJ mol^{-1}) **(2)** Partial marking 1 mark may be awarded for the following: correct equations – $c=f\lambda$ and $E = Lhf$ **OR** substitution into the correct equations	2	260/257.5/257.50 Unit not required but must be correct if given.

Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	Weigh/record • Mass/weight of empty container • Mass/weight of container with fertiliser/sample **OR** Weigh/record • Mass/weight of container and excess fertiliser/sample • Mass/weight of container (and remaining sample) after transferring fertiliser/sample to reaction container/beaker **(1)** Calculate mass of fertiliser/sample by subtraction **(1)**	**2**	If the candidate describes the subtraction, then it must be the correct way round for the second mark. Any reference to heat to constant mass is a cancelling error for both marks.
		(ii)	0.020 (%) **(2)** Partial marking 1 mark may be awarded for any of the following: Permanganate concentration = 2.1×10^{-4} (mol l^{-1}) **OR** Correctly calculated mass of manganese(II) using an incorrectly determined permanganate concentration (divide by 10, multiply by 54.9) **OR** Correctly calculate % of manganese(II) ions in sample (calculated mass/5.66) $\times$ 100	**2**	0.02 / 0.0204 / 0.02037 are also acceptable answers.

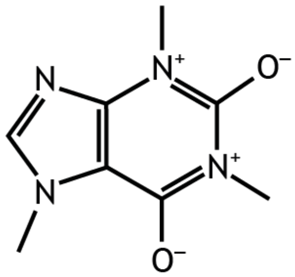
Question			Expected response	Max mark	Additional guidance
7.	(b)	(i)	Any **one** from: • available in a high state of purity • stable (as a solid and in solution) • soluble • (reasonably) high GFM • does not absorb water/moisture	**1**	Cancelling error applies if more than one characteristic is given and one is incorrect.
		(ii)	0.36 (g) **(3)** Partial marking Up to 2 marks may be awarded for any two of the following: Correctly calculating moles of dichromate = 1.07×10^{-4} **OR** Application of 1:6 mole ratio. **OR** Correctly calculating a mass of iron in sample from a calculated moles of iron(II). (calculated moles of iron(II) x 55.8) **OR** Multiplying a calculated moles or mass of iron by 10.	**3**	0.4 / 0.358 / 0.3582 are also acceptable answers. Unit not required but must be correct if given.
		(iii)	Electrons move from HOMO to LUMO **(1)** Yellow-green light absorbed / wavelength of 560-580 nm absorbed/ complementary colour (to violet) absorbed **(1)**	**2**	The direction of electron movement must be correct and clear for the first mark. Any mention of emission/dropping down energy levels is a cancelling error for the second mark.

Question			Expected response	Max mark	Additional guidance
8.	(a)		H_3PO_3	**1**	Any order including $P(OH)_3$ is acceptable.
	(b)	(i)	Negatively charged ions or neutral molecules that are electron rich.	**1**	
		(ii)	One curly full arrow from hydroxyl O to carbonyl C.	**1**	Additional arrows are cancelling.
		(iii)	 Or any other correctly drawn structure.	**1**	
		(iv)	Hydrogen chloride/HCl	**1**	Hydrochloric acid/HCl (aq) is a cancelling error.
		(v)	Faster reaction **OR** Catalyst not required	**1**	
	(c)	(i)	Secondary	**1**	
		(ii)	Amide	**1**	
	(d)	(i)	Electrophilic substitution	**1**	Nucleophilic is a cancelling error. Alkylation is not an acceptable answer.
		(ii)	65.2 (%) Partial marking 1 mark may be awarded for the following: Correctly calculating the theoretical yield = 28.2 (g) **OR** Correctly calculating moles of reactant and product **OR** A correctly calculated percentage yield from incorrectly calculated numbers	**2**	65/65.16/65.158 are also acceptable answers.

Question			Expected response	Max mark	Additional guidance
9.			This is an open-ended question **1 mark:** The candidate has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. They have made some statement(s) that are relevant to the situation, showing that they have understood at least a little of the chemistry within the context . **2 marks:** The candidate has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. They make some statement(s) that are relevant to the situation, showing that they understand the context . **3 marks:** The maximum available mark would be awarded to a candidate who has demonstrated, at an appropriate level, a good understanding, of the chemistry involved. The candidate 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. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks.	3	**Award 0 marks** where the candidate has not demonstrated, at an appropriate level, an understanding of the chemistry involved. There is no evidence that they have recognised the area of chemistry involved, or they have not given any statement of a relevant chemistry principle. Award zero marks also if the candidate merely restates the chemistry given in the question.

Question			Expected response	Max mark	Additional guidance
10.	(a)		(An antagonist) binds to a receptor/ blocks a receptor/prevents the natural compound from binding to a receptor **AND** prevents/stops the (natural) response.	1	Any mention of enzymes or inhibitor is a cancelling error.
	(b)	(i)	5 (cm^3)	1	Accept 5.0 and 5.00 Units not required but must be correct if given. 0 marks awarded for 5 cm^3 is added to 500 cm^3
		(ii)	0.0598/5.98×10^{-2} (mol l^{-1}) **(2)** Partial marking 1 mark may be awarded for one of the following: Correct mass of eucalyptol (4.605 g) **OR** Correctly calculating moles from a calculated mass of eucalyptol **OR** Dividing a calculated number of moles of eucalyptol by 0.5/multiplying by 2	2	Allow follow through from (b)(i) Units are not required but must be correct if given.
		(iii)	6	1	

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	$C_8H_{10}N_4O_2$	**1**	Any order
		(ii)	Same structural fragment/similar structures/similar shape/similar interactions with the receptor/same functional groups that bind with the receptor **OR** Identifying/drawing any structural fragment that is common to both molecules.	**1**	
	(b)	(i) (A)	Separating funnel **OR** A clearly drawn diagram **(1)** All three of the following steps: • shake/mix • leave to separate (into layers) • run off (lower) layer **(1)**	**2**	'Funnel' is not acceptable.
		(i) (B)	4.6 **(3)** Partial marking Up to two marks may be awarded for any two of the following: Correct expression for K **OR** Any correct concentration in dichloromethane = 0.392(mg cm^{-3})/2.02 x 10^{-3}(mol l^{-1}) **OR** Any correct mass (8.5 mg) or concentration in (aq) = 0.085(mg cm^{-3})/4.38 x 10^{-4}(mol l^{-1}) **OR** Correctly calculated value for K from incorrect concentrations of caffeine.	**3**	5/4.61/4.608 are also acceptable answers. Correct expression must have: • capital K • square brackets • clearly identified caffeine in water and caffeine in dichloromethane
		(ii)	Use a higher number of extractions with a smaller volume (of solvent). **OR** Correct description/example.	**1**	Using a smaller volume of solvent with a smaller volume of soft drink is not acceptable.

Question			Expected response	Max mark	Additional guidance
11.	(c)			**1**	Both charges required.

[END OF 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.
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.

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.

This marking instruction must only be applied a maximum of once per question.

The example below would be incorrect.