2016 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 <u>always</u> 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) Half marks may not be awarded.

(e) 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 or partial marks.

(f) Unless a numerical question specifically requires evidence of working to be shown, full marks should be awarded for a correct final answer (including units) on its own.

(g) Larger mark allocations may be fully accessed whether responses are provided in continuous prose, linked statements or a series of developed bullet points.

(h) 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. Exceptions to this rule will be given in the Additional Guidance column of the Detailed Marking Instructions.

(i) If a correct answer is followed by a wrong answer, 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 is followed by additional information which does not conflict with that, 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.

(j) 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.

(k) Units

In most questions units are not required. However, if the candidate writes units then they must be correct.

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.

(l) Significant figures.

If the data in a question is given to three significant figures, the final answer should also have three significant figures. However one less 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 outwith 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.

(m) Ignore the omission of one H atom from a full structural formula provided the bond is shown or the omission of one bond provided the attached H atom is shown.

(n) If a structural formula is asked for, CH_3 and CH_3CH_2 are acceptable as methyl and ethyl groups respectively.

(o) With structures involving an –OH or an –NH_2 group, mark should only be awarded if the "O" or "N" are bonded to a carbon, i.e. not OH-CH_2 and NH_2-CH_2.

When drawing structural formulae, mark should only be awarded if the bond points to the "correct" atom.

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

example would be incorrect
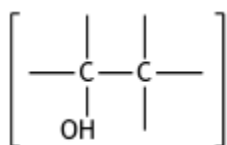
(p) A symbol or correct formula should be accepted in place of a name **unless stated otherwise in the Detailed Marking Instructions.**

(q) When formulae of ionic compounds are given as answers it will only be necessary to show ion charges if these have been specifically asked for. However, if ion charges are shown, they must all be included and be correct. If incorrect charges are shown, no marks should be awarded.

(r) If an answer comes directly from the text of the question, no marks should be given. **For example**, in response to the question, 'A student found that 0·05 mol of propane, C_3H_8 burned to give 82·4 kJ of energy. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$.' Name the kind of enthalpy change that the student measured', no marks should be given for "burning" since the word "burned" appears in the text.

(s) A guiding principle in marking is to give credit for correct elements of a response rather than to look for reasons not to give marks.

(t) Marks are awarded only for a valid response to the question asked. For example, in response to questions that ask candidates to:
- **compare**, they must demonstrate knowledge and understanding of the similarities and/or differences between things;
- **complete**, they must finish a chemical equation or fill in a table with information
- **describe**, they must provide a statement or structure of characteristics and/or features;
- **determine** or **calculate**, they must determine a number from given facts, figures or information;
- **draw**, they must draw a diagram or structural formula, eg "Draw a diagram to show the part of a poly(propene) molecule formed from two propene molecules"
- **estimate**, they must determine an approximate value for something;
- **evaluate**, they must make a judgement based on criteria;
- **explain**, they must relate cause and effect and/or make relationships between things clear;
- **identify, name, give** or **state**, they need only name or present in brief form;
- **predict**, they must suggest what may happen based on available information;
- **suggest**, they must apply their knowledge and understanding of chemistry to a new situation. A number of responses are acceptable; marks will be awarded for any suggestions that are supported by knowledge and understanding of chemistry;
- **use your knowledge of chemistry to comment on**, they must apply their skills, knowledge and understanding to respond appropriately to the problem/situation presented (for example by making a statement of principle(s) involved and/or a relationship or equation, and applying these to respond to the problem/situation). They will be rewarded for the breadth and/or depth of their conceptual understanding.
- **write**, they must complete a chemical or word equation, e.g. "Write the word equation for the complete combustion of ethanol."
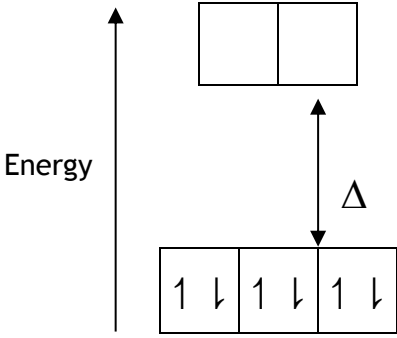
Detailed Marking Instructions for each question

Section 1

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

Section 2

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	-44 kJ mol^{-1}	1	-40 also acceptable. Units not needed but must be correct if given.
		(ii)	-130 J K^{-1}mol^{-1} **(3)** **OR** $\Delta G° = \sum G°$products $- \sum G°$reactants $\quad = -175 - (68 - 237)$ $\quad = -6$ (kJ mol^{-1}) **(1)** $\Delta S° = (\Delta H° - \Delta G°)\ /T$ (or use of $\Delta G° = \Delta H° - T\Delta S°$) **(1)** $\quad = (-44 - (-6))/298$ $\quad = -0\cdot128$ kJ K^{-1}mol^{-1} $\quad = -130$ J K^{-1}mol^{-1} **(1)**	3	$-100/-128/-127\cdot5$ also acceptable. Units not needed for final answer but must be correct if given. Follow through applies.
	(b)		340 K **(2)** **OR** Reaction becomes feasible when $\Delta G = 0$ **(1)** Therefore $T = \Delta H/\Delta S$ $T = 44/0\cdot130$ $T = 340$ K **(1)**	2	$300/338/338\cdot5$ are also acceptable. Follow through applies, from a(i) and/or a(ii). Units not needed for final answer but must be correct if given.
2.	(a)		$1s^2\ 2s^2\ 2p^6$	1	If orbital boxes are given they must be correct and the correct notation is also required.
	(b)			1	Any orientation of this shape allowed. If axes are drawn, then a lobe of the orbital must lie on an axis.
	(c)		-1, 0, (+)1	1	

Question			Expected response	Max mark	Additional guidance
3.	(a)	(i)		**1**	Full headed arrows are acceptable, but spin must be shown.
		(ii)	1 mark is awarded for recognising that there is a small energy gap. 1 mark is awarded for recognising that electrons are promoted.	**2**	Less energy is required to promote an electron **(2)** **OR** Δ is small/less (than for CN^-) **OR** Energy difference between levels is less **(1)** Electrons can occupy all of the d-orbitals **OR** Electrons can occupy the higher energy d-orbitals **OR** Electrons can be promoted between energy levels. **(1)**

Question			Expected response	Max mark	Additional guidance
		(iii)	Fe^{3+} has five/odd number of (d–)electrons **OR** It is $3d^5$ **OR** It has a half-filled d-subshell **OR** It has a half-filled d-orbital.	**1**	A mark should not be awarded for "It has an unpaired electron".
	(b)	(i)	4/four.	**1**	Zero marks are awarded for +4/4+/−4/4−/IV.
		(ii)	Flame test **OR** Atomic absorption **OR** Atomic emission.	**1**	
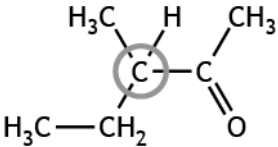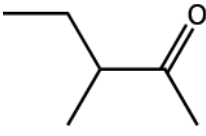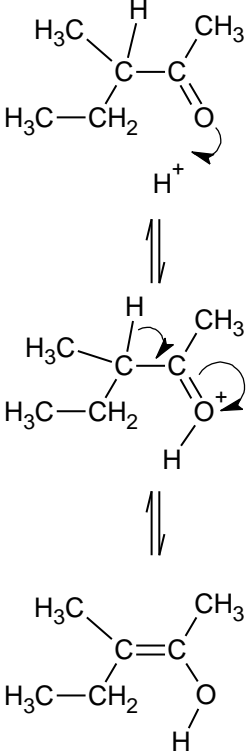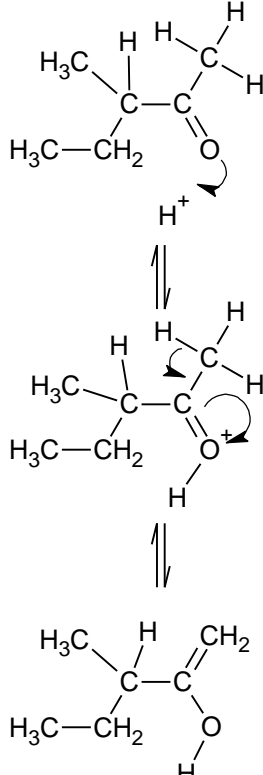
Question			Expected response	Max mark	Additional guidance
		(iii)	This is an open ended question **1 mark:** The student has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. The student has made some statement(s) which is/are relevant to the situation, showing that at least a little of the chemistry within the problem 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) which is/are relevant to the situation, showing that the problem 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 problem. 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 no understanding of the chemistry involved at an appropriate level. There is no evidence that the student has recognised the area of chemistry involved or has given any statement of a relevant chemistry principle. This mark would also be given when the student merely restates the chemistry given in the question.

Question			Expected response	Max mark	Additional guidance
4.	(a)	(i)	The exact mass should be known/measured and should be close to 4·25 g **OR** The mass should be around 4·25g but with an accurate reading.	**1**	
		(ii)	Dissolve/make a solution of the silver nitrate in distilled/deionised water (in a beaker). Transfer the solution/it and the rinsings (to the standard/volumetric flask) **(1)** Make (the solution) up to the mark in a standard/volumetric flask (with distilled/deionised water). **(1)**	**2**	The first mark should not be awarded if the solid is washed directly into the flask. Only one mention of distilled/deionised water is required. Only one mention of standard/volumetric flask is required.
		(iii)	Titrate a larger sample (of the seawater) **OR** Dilute the standard silver nitrate solution **OR** Prepare or use a lower concentration of silver nitrate solution **OR** Dilute the seawater less **OR** Use a micro-burette **OR** Use class A glassware.	**1**	A general statement such as "use more accurate apparatus" should not be awarded this mark.

Question			Expected response	Max mark	Additional guidance
	(b)	(i)	Vacuum filtration **OR** Acceptable diagram **OR** Filtration under suction **OR** Fluted filter paper.	1	A mark should not be awarded for "use a Buchner funnel/flask" without further explanation.
		(ii)	To check the reaction is complete **OR** To check all chloride ions have reacted **OR** To check that no more precipitate is formed **OR** If there is a precipitate the reaction is not complete.	1	A mark should not be awarded for "to see if there is excess reactant" on its own. An answer that refers only to chlorine should be awarded zero marks.
	(c)		Titration can be used with lower chloride concentrations **OR** Gravimetric method would produce too little/no precipitate.	1	If an answer refers to chlorine this should be ignored.

Question			Expected response	Max mark	Additional guidance
5.	(a)		$$K_a = \frac{[C_6H_5CH(OH)COO^-][H_3O^+]}{[C_6H_5CH(OH)COOH]}$$	1	Award mark for K without subscript a. [H$_2$O] should not be included. If state symbols are included they must be correct but do not need brackets. All square brackets and charges must be included.
	(b)	(i)	0·658 mol l^{-1} **(2)** **OR** moles of mandelic acid 10g/152g = 0·0658 **(1)** concentration of mandelic acid 0·0658/0·100 = 0·658 **(1)**	2	0·66/0·6579/0·65789 are also acceptable. Units not needed for final answer but must be correct if given.

		(ii)	1·97 **(3)**
			
			OR
			
			pH = ½pK$_a$ − ½logc **(1)**
			
			pK$_a$ (−logK$_a$ = 3·75) **(1)**
			
			pH = 1·875 − (−0·0909)
			   = 1·97
			                   (1)
			
			OR
			
			[H$^+$] = √(K$_a$ c) **(1)**
			
			[H$^+$] = √(1·78 × 10^{-4} × 0·658)
			   = 0·0108 **(1)**
			
			pH = 1·97 **(1)**
				3	2·0/1·966/1·9659 are also acceptable.
					
					The mark is not awarded for a final answer of pH2 (too few significant figures).
					
					Allow follow through.
					
					If incorrect equation is used, then maximum one mark can be awarded for use of the correct pKa value.

Question			Expected response		Max mark	Additional guidance
6.	(a)		196 kJ mol⁻¹ **(2)** **OR** $E = \dfrac{Lhc}{\lambda}$ **(1)** **OR** $= \dfrac{6\cdot02\times10^{23}\times6\cdot63\times10^{-34}\times3\cdot00\times10^{8}}{610\times10^{-9}}$ $= 1.96\times10^{5}$ $= 196$ kJ mol⁻¹ **(1)**		**2**	200/196·3/196·29 are also acceptable. Units not needed for final answer but must be correct if given.
	(b)	(i) (A)	2ⁿᵈ order/2/$[ClO_2]^2$		**1**	
		(i) (B)	1ˢᵗ order/1/$[OH^-]^1$		**1**	Mark not awarded for $[OH^-]$
		(ii)	Rate = k $[ClO_2]^2$ $[OH^-]$		**1**	Follow through allowed. Mark not awarded for capital K.
		(iii)	230 $l^2\,mol^{-2}\,s^{-1}$ **(2)** **OR** $k = \dfrac{2\cdot48\times10^{-2}}{[6\cdot00\times10^{-2}]^2 \times[3\cdot00\times10^{-2}]}$ $= 230$ **(1)** **OR** $l^2\,mol^{-2}\,s^{-1}$ **(1)**		**2**	200/229·6/229·63 are also acceptable. Any order of correct units is acceptable Follow through applies. Units and value must be consistent with answer from b (ii).

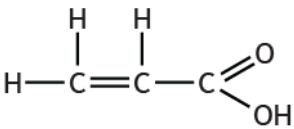| Question			Expected response	Max mark	Additional guidance
7.	(a)		Ethanal/the keto form/left hand side/ reactant.	**1**	
	(b)	(i)		**1**	
		(ii)	A racemic mixture is forming **OR** (When the enol form converts to the keto) the other enantiomer/optical isomer can be formed.	**1**	Mark not awarded if molecules described as tautomers.
		(iii)		**1**	Any orientation is accepted.
	(c)		Mechanism following example given in question. Correct alternative mechanism.	**3**	1 for product. 1 for the intermediate – positive charge must be shown. 1 for the curly arrows – all 3 must be correct and whole headed arrows must be used. C_2H_5 is acceptable and can be drawn in any position. If bond is drawn to wrong part of the alkyl group in the intermediate or product, then mark is not awarded. This would only be done once per question.

Question			Expected response	Max mark	Additional guidance
8.	(a)		An agonist is a molecule which behaves like/mimics/enhances/triggers the natural response (of the body) **OR** An agonist produces a response similar to the (body's) natural active compound.	**1**	Do not accept a response which only restates the question stem eg "stimulates receptors".
	(b)		Catalyst.	**1**	Ignore references to homogeneous and heterogeneous.
	(c)		UV (Light).	**1**	Light on its own is not acceptable.
	(d)		(Nucleophilic) substitution.	**1**	S_N1 or S_N2 would be acceptable. Mark is not awarded for electrophilic substitution.
	(e)		$LiAlH_4$ or lithium aluminium hydride or Lithal **OR** $NaBH_4$ or sodium borohydride.	**1**	Mark is not awarded for LAH.

Question			Expected response	Max mark	Additional guidance
	(f)		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) which is/are relevant to the situation, showing that at least a little of the chemistry within the problem 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) which is/are relevant to the situation, showing that the problem 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 problem. 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 no understanding of the chemistry involved at an appropriate level. There is no evidence that the student has recognised the area of chemistry involved or has given any statement of a relevant chemistry principle. This mark would also be given when the student merely restates the chemistry given in the question.

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	$C_9H_{10}O_3$	1	Any order is acceptable.
		(ii)	sp^2	1	The "2" must follow "sp".
		(iii)	Orbitals overlap sideways **OR** Orbitals bond side-on **OR** A suitable diagram.	1	No mark is awarded if any mention or drawing of s orbitals No mark is awarded for an answer that refers to molecular orbitals overlapping.
	(b)	(i)	Suitable diagram showing a workable method of condensing the vapour back into the reaction vessel.	1	Diagram should • be cross-sectional with inner wall shown • be an open system • be sealed around the flask neck • have water going in at bottom and out at top.
		(ii)	The (named) product/products are soluble/ miscible/have dissolved **OR** There are no reactants left **OR** There is only product left.	1	A mark should not be awarded for "The products are miscible with/soluble in each other" without further explanation.

Question			Expected response	Max mark	Additional guidance
		(iii)	The (4-hydroxybenzoate) ion from the salt removes/ reacts with H$^+$ from the water **OR** Conjugate base of a weak acid, removes/reacts with H$^+$ from the water **(1)** This results in the water equilibrium shifting to the right hand side **OR** shifting to the left hand side if candidate has written an equilibrium reaction with ions on the left hand side **OR** This results in the water equilibrium producing an excess of OH$^-$ ions. **(1)**	2	A mark should not be awarded for "It is the salt of a strong base and a weak acid" without further explanation.
		(iv)	Any two from: doesn't react with solute / reactivity **OR** being more soluble in the hot solvent than in the cold **OR** impurities to be soluble/insoluble in both hot and cold solvents/solubility of the impurities in it **OR** boiling point **OR** polarity.	2	Marks are not awarded for remove impurities on it is own. A mark should not be awarded for choosing a solvent with low boiling point.

Question			Expected response	Max mark	Additional guidance

		(v)	3·85 g **(2)**
			
			 OR
			
			 77·5% = 2·48
			 $100\% = \dfrac{2\cdot48}{0\cdot775} = 3\cdot20$ **(1)**
			
			 THEN:
			
			 1 mole 4-hydroxybenzoic acid = 138 g
			
			 $3\cdot20 \text{ g} = \dfrac{3\cdot20}{138} = 0\cdot0232 \text{ moles}$
			
			 1 mole 4-hydroxybenzoic acid is produced from 1 mole ethylparaben.
			
			 0·0232 moles ethylparaben required
			
			 1 mole ethylparaben = 166 g
			
			 0·0232 moles = 0·0232 × 166
			             = 3·85 g **(1)**
			
			 OR THEN:
			
			 4-hydroxybenzoic acid : ethylparaben
			       1 mole : 1 mole
			       138 g : 166 g
			     3·20 g :$\dfrac{3\cdot20\times166}{138}$
			            = 3·85 g **(1)**
			
			 OR
			
			 2·48/138 = 0·01797
			 0·01797 × 166
			 = 2·9832 **(1)**
			
			 2·9832/0·775
			 =3·85 g **(1)**
				2	3·9g/3·849g/3·8493g are also acceptable.
					
					 Correct unit, g or grams, is required for the second mark.

Question			Expected response		Max mark	Additional guidance
10.	(a)		$C_3H_4O_2$ **(2)**		**2**	Any order is acceptable.
			OR			1 mark for correct numbers of moles.
			C 50·0/12 : 4·167			
			H 5·60/1 : 5·60			1 mark for a correct formula from calculated number of moles.
			O 44·4/16 : 2·78 **(1)**			
			$C_3H_4O_2$ **(1)**			
	(b)		C = O (stretch)		**1**	A mark should not be awarded for carboxyl or carboxylic acid <u>by itself</u>.
			OR			
			Carbonyl			
			OR			
			C=O (stretch) carboxyl / carboxylic acid.			
	(c)	(i)	$C_3H_4O_2$		**1**	Any order is acceptable.
		(ii)	$[C_2H_3]^+$		**1**	The positive charge must be shown and not placed on a hydrogen atom eg not $C_2H_3^+$
			OR			
			$^+C_2H_3$			A mark is not awarded for $[CH_3C]^+$
			OR			
			$[CH_2CH]^+$			
			OR			
			Correct full structural formula of above.			
	(d)				**1**	Correct full structural, shortened structural or skeletal formulae can all be accepted. Allow correct follow though from ALL evidence that the candidate has written for parts (a), (b) and (c) of the question.

[END OF MARKING INSTRUCTIONS]