Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/21**

Paper 2 AS Structured Questions **October/November 2023**

MARK SCHEME

Maximum Mark: 60

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

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Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	‘List rule’ guidance For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

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6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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Examples of how to apply the list rule
State **three** reasons…. [3]

A	1 Correct	✓	**2**
	2 Correct	✓	
	3 Wrong	×	

B	1 Correct, Correct	✓, ✓	**3**
(4 responses)	2 Correct	✓	
	3 Wrong	ignore	

C	1 Correct	✓	**2**
(4 responses)	2 Correct, Wrong	✓, ×	
	3 Correct	ignore	

D	1 Correct	✓	**2**
(4 responses)	2 Correct, CON (of 2.)	×, (discount 2)	
	3 Correct	✓	

E	1 Correct	✓	**3**
(4 responses)	2 Correct	✓	
	3 Correct, Wrong	✓	

F	1 Correct	✓	**2**
(4 responses)	2 Correct	✓	
	3 Correct CON (of 3.)	× (discount 3)	

G	1 Correct	✓	**3**
(5 responses)	2 Correct	✓	
	3 Correct Correct CON (of 4.)	✓ ignore ignore	

H	1 Correct	✓	**2**
(4 responses)	2 Correct	×	
	3 CON (of 2.) Correct	(discount 2) ✓	

I	1 Correct	✓	**2**
(4 responses)	2 Correct	×	
	3 Correct CON (of 2.)	✓ (discount 2)	

General Guidance for 9701/2

All guidance given (page 2–5) applies unless Additional Guidance, AG, in the Mark Scheme states otherwise.

1. All marks are independent.

2. Allow unambiguous representation of letters in chemical symbols eg MGO, Mgo but **NOT** Co2 for CO_2 OR MN for manganese.

3. Ignore use of ⇌ instead of →, or vice versa,in equations – also see Science Specific Marking Principles regarding equations.

4. Use of sig.figs (SF) and decimal places (dp) in final answer – also see Science Specific Marking Principles.
   If the final answer is correctly rounded to a number of SF / dp that are less than that required from the rubric or mark scheme, then credit may be given if an **ANSWER** with appropriate sig figs / dp is seen in their working.

5. Naming organic structures. Look at Additional guidance, AG, for items which ask specifically for names of organic molecules. If no AG given use generic science marking principles AND ignore punctuation. Numbers must be used (for annotating positions of groups / functional groups) if they are not bracketed in the answer in the mark scheme.

6. **Organic structures** can be identified as skeletal, structural, displayed or a non-ambiguous mixture of these provided a specific type of structure is not specified.

   (a) When question item asks for **one / a structure** and two or more structures are given
   - **IGNORE** any structure which looks like working-out (e.g a repeat of the structures given in the stem or structures done in pencil when the answer is in pen (appears darker).
   - **CON** any part of a structure which directly contradicts the other correct structure e.g. first structure shows a correct displayed amide bond but second structure has no amide bond
   - **×** any carbon labelled 'C' on a structure which is trivalent. [This does not refer to skeletal structures]
   - if any structure shows any bonds (sticks) without a label – assume they are representing methyl groups; do not allow 'slips' for missing H's on a displayed formula once only. (This does not apply to polymer continuation bonds).
   - **IGNORE** connectivity issue on attached groups unless drawn as a displayed formula or as specified in the MS e.g. **ALLOW** OH—, NH_2—, COOH—, etc.

   (b) When question rubric asks for a specific formula to be identified / deduced, ie a skeletal formula, for X and two types of formula representing X are shown as answers with no indication of working mark the first structure given (working from left to right and top to bottom) and ignore the other(s).
   If the two structures are not equivalent molecules apply 6(a).

   (c) **ALLOW** use of C_2H_5 for CH_3CH_2 but ignore use of C_3H_7 as it is ambiguous ($CH_3CH_2CH_2$ or $(CH_3)_2CH$).

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owtte = or words to that effect. It applies throughout the mark scheme **ora** = or reverse argument **TE** = transcription error **AE** = arithmetic error
When an entire answer is shown within the answer space (and no other indication from candidate) treat work outside the space as working – IGNORE

Annotating scripts

- ✓ must be used on one mark items if a judgement is made ie BOD ✓or ecf ✓
- ✓ must be used for every mark awarded on all items worth two or more marks
- **ALL** judgements made must be suitably annotated to show which mark(s) have been awarded with a clear indication of the judgement made. using ecf ✓ / BOD ✓ / NBOD / CON × where appropriate.

Use of annotations for judgements
IGNORE – irrelevant response. This applies when a piece of incorrect Chemistry is used in any answer but it is not relevant to the marking point
^ – omission mark
CON – if a statement contradicts a marking point. Put **CON** next to the **correct** statement and × next to the **incorrect** statement which contradicts the marking point.
BOD / NBOD – when a judgement has to be made regarding whether a statement is worthy of credit. If you think the statement is worthy of credit give the mark BOD. [If you think that it is not worthy of credit annotate as *NBOD*.]
ECF – error carried forward. This may be awarded in numerical questions by following the candidate's answer through from the point of the error and re-calculating to check that credit should be given. Where ECF is to be applied from an earlier question item(s) the relevant answers should be linked to the item, scroll down to find it.
On occasions ECF's can also be awarded from prose. Check in notes under Guidance to see if specific instructions have been given regarding ECF in each particular question. If no note is made in guidance assume all marking points are independent.

Blank pages, page with table of values and constants and Periodic Table Mark with *SEEN* annotation if blank OR if answers to specific questions are on any of these pages link to relevant question part so it can be marked.

Additional pages with responses to question(s) must be linked to the appropriate question(s) and marked with it. Annotate as required. If an answer extends beyond the answer space this must be linked and marked / annotated.

NR (No response) – if a question item has no writing in the answer space or there is an unrelated comment like 'don't know' or '?' (Just type # key – and NR will register). **Marking crossed out work** If all the answer has been crossed out but **not** replaced and is legible then it should be marked. If all the answer has been crossed and replaced with another answer, **IGNORE** the crossed-out material.

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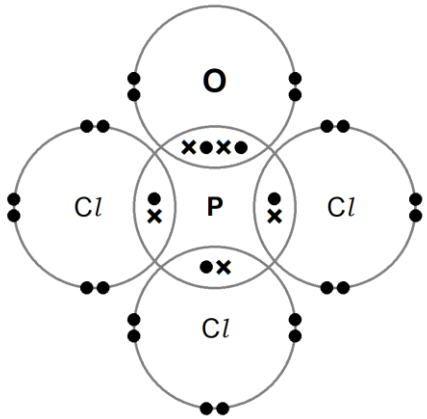
Language and handwriting
Remember that for many candidates, English is not their first language so do not be too prescriptive.

JUDGEMENT OF ARROWS
π bonds
- starts from anywhere on the π bond (and goes to a specific atom) ✓
- when extrapolated back the base of the arrow hits the π bond (and the arrow end goes to a specific atom)✓
- starts from an **explicit** atom at either end of the π bond **x**
- starts from an **explicit** end of a skeletal representation of the π bond **NBOD**

Lone Pairs
The arrow can start from anywhere that is approximately associated with the lone pair.
- starts mid-way between the negative charge and the lone pair adjacent to it **BOD** ✓
  (if all else OK)
- starts closer to the lone pair than the negative charge **BOD** ✓ (if all else OK)
- starts from the negative charge and not the lone pair **x**
- shown as **Y:** ⁻ and when extrapolated back the arrow hits the ─ **(**before the **:) NBOD**

Question	Answer	Marks
1(a)(i)	total # 3p e^- 3 4 5	**1**
	total # unpaired e^- 3 2 1	**1**
1(a)(ii)	$P(g) \rightarrow P^+(g) + e^{(-)}$	**1**
1(a)(iii)	1000 ($kJmol^{-1}$)	**1**
	(S) less / least / lowest nuclear attraction (to outer electrons) (than P **OR** Cl) **OR** nuclear attraction for Cl is stronger (compared to S (and or P))	**1**
	<u>S less nuclear charge than Cl</u> OR **<u>Cl has a greater nuclear charge than S</u>**	**1**
	(**S** has a greater nuclear charge (of outer electrons) than **P BUT)** S has two electrons in a (3)**p orbital AND** resulting in spin-pair repulsion	**1**
1(b)(i)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$	**1**
1(b)(ii)	● decreases (from P^{3-} to Cl^-) ● increased attraction (of outer e^-) for nucleus **owtte** ● increased nuclear charge ● same shielding ●√●√	**2**

Question	Answer	Marks
1(c)	(Br_2) no visible reaction OR colourless to orange / brown / yellow solution	**1**
	(conc. H_2SO_4) no visible reaction OR Solution remains colourless	**1**
	(dil. $AgNO_3$) white precipitate forms	**1**
1(d)(i)	(relatively low melting and boiling points suggests) weak intermolecular / VdW forces	**1**
	(vigorous reaction with water suggests) **hydrolysis**	**1**
1(d)(ii)	$POCl_3 + 3H_2O \rightarrow H_3PO_4 + 3HCl$	**1**
1(d)(iii)	 Correct bonding e^-	**1**
	rest of electrons **correct (i.e. to make 32 electrons in total)**	**1**

Question	Answer	Marks
1(e)(i)	enthalpy change when one mole of a compound / substance is formed	**1**
	from its constituent elements in their standard states	**1**
1(e)(ii)	2(–592) = 2(–289) + (496) – 2(P=O) OR (2) P=O = 2(–289) + (496) + 2(592)	**1**
	$E_{P=O}$ = ½(1102) = +551 (kJ mol^{-1})	**1**

Question	Answer	Marks
2(a)(i)	increases down the group	**1**
2(a)(ii)	white solid disappears	**1**
2(a)(iii)	CO_2 / carbon dioxide	**1**
2(a)(iv)	$Ba(CH_3COO)_2$ / barium ethanoate	**1**
2(a)(v)	$Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$	**1**
2(b)(i)	$CaCO_3$ **AND** thermal stability of carbonates **increases** down the group	**1**
2(b)(ii)	$BaCa(CO_3)_2 \rightarrow BaO + CaO + 2CO_2$	**1**

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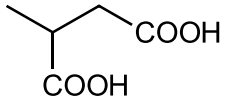
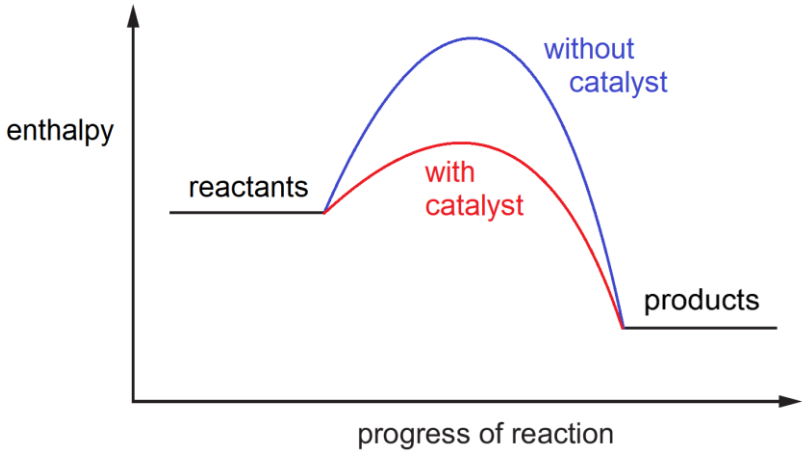
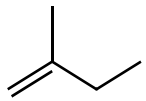
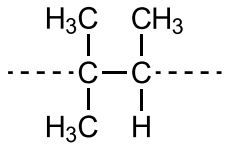
Question	Answer	Marks
2(c)	CH_3OH	**1**
	 one COOH group **AND** correct carbon framework (5C's) (each C has the correct valency)	**1**
	both COOH groups	**1**

Question	Answer	Marks
3(a)	compound / molecule / substance that oxidises another / is reduced	**1**
3(b)	 uncatalysed hump	**1**
	catalysed hump lower than uncatalysed	**1**
3(c)	**C*l*/ chlorine** is both oxidised and reduced	**1**

Question	Answer	Marks
3(d)(i)	$pV = nRT \therefore V = 8.31 \times 630 \div 100\,000 =$ **<u>0.0524</u>** (m^3)	**1**
3(d)(ii)	moles of gas = $12 \times 5.00 / 180$	**1**
	volume of gas = M1 × **(d)(i)** = **0.0175** (m^3)	**1**
3(e)(i)	1 4 0	**1**
3(e)(ii)	Solution turns from purple to colourless	**1**
	Orange / red precipitate forms	**1**
	no reaction	**1**
3(e)(iii)	molecules with the same molecular formula but different structural formulae	**1**

Question	Answer	Marks
4(a)(i)	3-methylbut-1-ene	**1**
4(a)(ii)	one end / one C of the C=C bond has the same groups attached	**1**
4(a)(iii)		**1**
4(a)(iv)	$(CH_3)_2CHCH_2CH_3$	**1**
4(a)(v)		**1**

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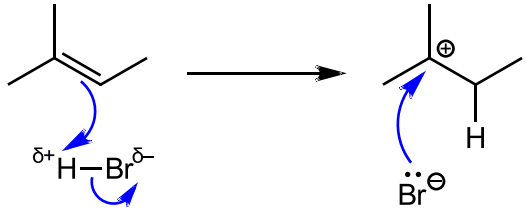
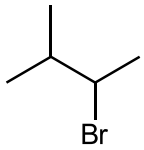
Question	Answer	Marks
4(b)	$\frac{2.7}{48.7} \times \frac{100}{1.1} = 5(.04)$	**1**
	$M_r = 5 \times 12 + 10 \times 1 = 70$	**1**
4(c)(i)	 correct dipole on H-Br AND curly arrow from C=C bond to $H^{\sigma+}$ **AND** curly arrow from H—Br bond to $Br^{\sigma-}$	**1**
	correct (Markovnikoff) intermediate	**1**
	curly arrow from lone pair on Br^- to C^+ of intermediate	**1**
4(c)(ii)		**1**
4(c)(iii)	**●C has a tertiary carbocation and a 2ndry carbocation** **●D has a secondary carbocation and a primary carbocation** **● alkyl groups have a +ve / positive / +I / inductive effect** **● more alkyl groups / more inductive effects give a <u>more stable</u> intermediate / carbocation / C+** ● **In C** tertiary carbocation is more stable than the secondary carbocation Any **two** ● for 1 mark Any **four** ● for 2 marks	**2**

Question	Answer	Marks
4(d)	(reaction 2) NaOH**(aq)**	**1**
	(reaction 3) hot **acidified <u>concentrated</u>** $KMnO_4$	**1**
	(reaction 4) <u>conc</u> H_2SO_4 catalyst	**1**

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