Cambridge Assessment International Education

Cambridge Pre-U

CHEMISTRY **9791/02**

Paper 2 Part A Written **May/June 2023**

MARK SCHEME

Maximum Mark: 100

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.

Cambridge International is publishing the mark schemes for the May/June 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

This syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

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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.

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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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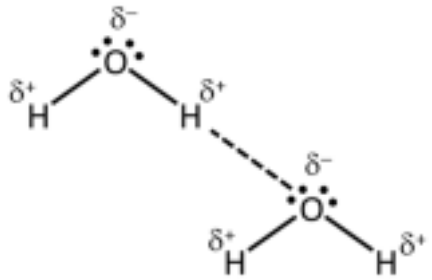
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)(i)</td><td>[Ne] $3s^2$ $3p^3$</td><td>1</td></tr>
<tr><td>1(a)(ii)</td><td>$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$</td><td>1</td></tr>
<tr><td>1(b)</td><td>
<table>
<tr><td>element</td><td>Metal / metalloid / non-metal</td><td>Gas / liquid / solid</td><td>Simple / giant structure</td><td>Formula if simple structure</td></tr>
<tr><td>sodium</td><td>Metal</td><td>Solid</td><td>Giant</td><td></td></tr>
<tr><td>silicon</td><td>Metalloid</td><td>Solid</td><td>Giant</td><td></td></tr>
<tr><td>white phosphorus</td><td>Non-metal</td><td>Solid</td><td>Simple</td><td>P_4</td></tr>
</table>
One mark for each row</td><td>3</td></tr>
<tr><td>1(c)(i)</td><td> 

One hydrogen bond shown (1)
All lone pairs and 2 OH dipoles (1)
180° around H in hydrogen bond, H bond longer than O-H bonds and H-bond draw to lone pair (1)</td><td>3</td></tr>
<tr><td>1(c)(ii)</td><td>sulfur is not <u>electronegative</u> enough</td><td>1</td></tr>
<tr><td>1(c)(iii)</td><td>permanent dipole-dipole interactions (1)
induced dipole-induced dipole interactions (1)</td><td>2</td></tr>
<tr><td>1(d)</td><td>+5</td><td>1</td></tr>
<tr><td>1(e)(i)</td><td>10</td><td>1</td></tr>
</table>

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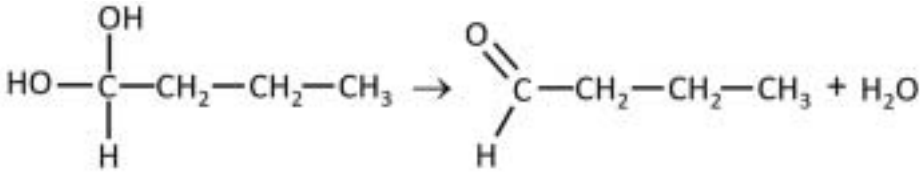
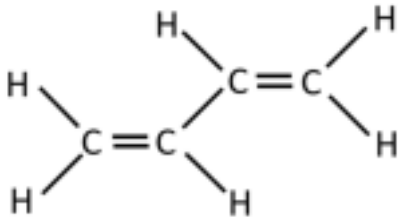
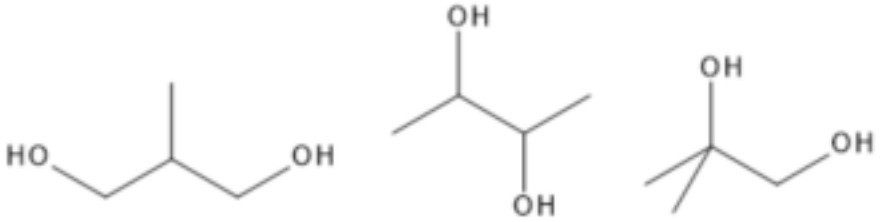
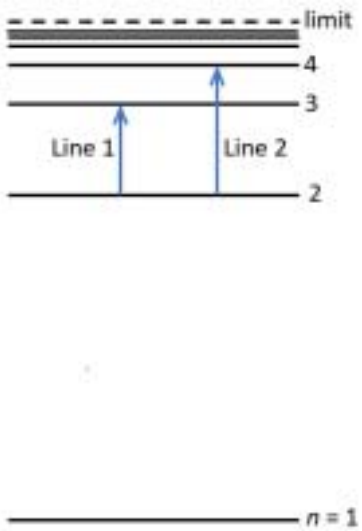
Question	Answer	Marks
1(e)(ii)	the chemical breakdown of a molecule by reaction with water.	**1**
1(e)(iii)	CH_2O	**1**
1(e)(iv)	40 (%)	**1**
1(f)(i)	10.7 cm^3 $EDTA^{4-}$ contains (10.7 / 1000) × 0.0300 mol = 3.21×10^{-4} mol (1) Number of mol Ca^{2+} in original 10cm^3 is 3.21×10^{-4} mol which has a mass of $3.21 \times 10^{-4} \times 40.1$ = 12.9 mg (1) 12.9 mg in 10 cm^3 is **1.29** mg cm^{-3} (1)	**3**
1(f)(ii)	(800 mg) / **(f)(i)**	**1**
1(f)(iii)	so indicator colour can be seen more easily (1)	**1**

Question	Answer	Marks
2(a)	1,3-butanediol **OR** butane-1,3-diol	**1**
2(b)	**D** contains OH / functional group **OR** butane does not have a functional group (1) **D** has C-O bonds or OH bonds which have a dipole **OR** butane does not have a dipole (1)	**2**
2(c)		**1**
2(d)	reagent: NaOH (1) solvent: water (1)	**2**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(e)(i)</td><td>
<table>
<tr><td>carbon</td><td>FGL before reaction</td><td>FGL after reaction</td></tr>
<tr><td>(x)</td><td>Alcohol / 1</td><td>Carboxylic acid / 3</td></tr>
<tr><td>(y)</td><td>Alcohol / 1</td><td>Carbonyl / 2</td></tr>
</table>
‘before’ column correct (1)
‘after’ column correct (1)
</td><td>2</td></tr>
<tr><td>2(e)(ii)</td><td>acidified (potassium) dichromate ((VI))</td><td>1</td></tr>
<tr><td>2(f)(i)</td><td>  </td><td>1</td></tr>
<tr><td>2(f)(ii)</td><td>conc. H_2SO_4 / H_3PO_4 (1)
high temperature / heat (1)</td><td>2</td></tr>
<tr><td>2(g)</td><td>D
AND 2 <u>carbon environments</u></td><td>1</td></tr>
<tr><td>2(h)</td><td>Any two of:
  </td><td>2</td></tr>
</table>

Question	Answer	Marks
3(a)(i)	 Arrows pointing upwards (1) Arrows start at *n*=2 (1) Arrows finish at *n*=3 and *n*=4 and labelled (1)	**3**
3(a)(ii)	E=hc/λ (1) (=$6.63 \times 10^{-34} \times 3.00 \times 10^{8} / 410 \times 10^{-9}$) = 4.85×10^{-19} J (1)	**2**
3(a)(iii)	Hydrogen has only one electron (1) All the subshells within a (quantum) shell have the same energy (1) because there is no shielding from other electrons (1)	**3**
3(a)(iv)	$H(g) \rightarrow H^{+}(g) + e^{-}$	**1**
3(a)(v)	328 kJ mol^{-1}	**1**
3(a)(vi)	The ionisation energy is for ionisation of the atom in its ground state energy level (*n*=1).	**1**
3(b)	Sketch and name of a spherical s orbital (sphere) (1) Sketch and name of a dumb-bell p orbital (dumb-bell) (1)	**2**

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Question	Answer	Marks
3(c)		**1**
3(d)	<table><tr><th></th><th>number of protons</th><th>number of neutrons</th><th>number of electrons</th></tr><tr><td>$^{40}Ca^{+}$</td><td>20</td><td>20</td><td>19</td></tr></table>	**1**

Question	Answer	Marks
4(a)	M1 **EITHER** limestone / $CaCO_3$ SO_2 from the emission gases will react with limestone / $CaCO_3$ **OR** equation: $CaCO_3(s) + SO_2(g) \rightarrow CaSO_3(s) + CO_2(g)$ (1) **OR** magnesium oxide / MgO SO_2 from the emission gases will react with magnesium oxide **OR** equation: $MgO(s) + SO_2(g) \rightarrow MgSO_3(s)$ (1) M2 To release the SO_2 the MSO_3 is heated **OR** equation: $MSO_3(s) \rightarrow MO(s) + SO_2(g)$ where M = Ca or Mg following M1 (1)	**2**
4(b)(i)	forward and backward reactions are going at the same rate (1) overall concentrations of the reactants and products remain constant (1)	**2**
4(b)(ii)	$-98.4\ kJ\ mol^{-1}$	**1**
4(c)(i)	$-89.3\ (kJ\ mol^{-1})$	**1**
4(c)(ii)	two steps so easier to dissipate heat (1)	**1**
4(d)(i)	12	**1**

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Question	Answer	Marks
4(d)(ii)	M1 104.5° (1) M2 non-linear (1) M3 oxygen has four pairs of electrons around it (which repel each other) (1) M4 lone pairs repel more than bonding pairs(1)	**4**
4(e)(i)	it has a high boiling point (1)	**1**
4(e)(ii)	hydrogen bonds (1)	**1**
4(e)(iii)	fully dissociated (1) into ions, including H^+ ions (1)	**2**
4(e)(iv)	$2H^+(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g)$	**1**
4(f)	M1 misty fumes (of HCl) (1) M2 $KCl + H_2SO_4 \rightarrow HCl + KHSO_4$ (1) M3 orange/brown (of Br_2) (1) M4 $2KBr + 3H_2SO_4 \rightarrow Br_2 + 2KHSO_4 + 2H_2O + SO_2$ (1) M5 black / brown / purple (for I_2) (1) M6 $8KI + 9H_2SO_4 \rightarrow 4I_2 + H_2S + 8KHSO_4 + 4H_2O$ (1) M7 Oxidation number change from +6 to –2 (1)	**7**
4(g)(i)	x-axis label: energy y-axis label: number of molecules	**1**
4(g)(ii)	If a catalyst is added the <u>activation energy</u> is reduced (or show on diagram) (1) The <u>area</u> under the curve to the right of the activation energy lines represents the number of molecules that have enough energy to react (or show areas on diagram) (1) The area for the catalysed reaction is larger so the catalysed reaction goes faster (1)	**3**

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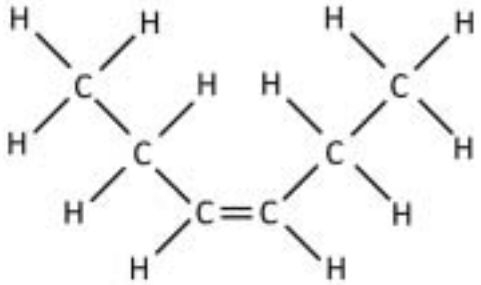
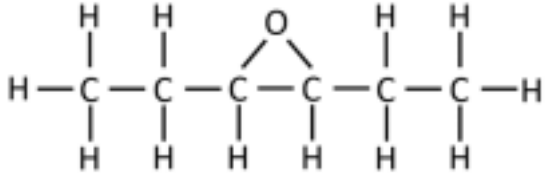
Question	Answer	Marks
5(a)(i)		**1**
5(a)(ii)		**1**
5(b)(i)	0.350 mol H_2O_2 is 0.350 × 34 g = 11.9 g 11.9 g is 30% so 100% is 11.9 × 100 / 30 = 39.7 g (1) Volume required = mass / density 39.7 / 1.11 = 35.7 cm^3 (1)	**2**
5(b)(ii)	burette (1)	**1**
5(b)(iii)	use chemically resistant gloves (1)	**1**
5(b)(iv)	0.350 x 84% = 0.294 mol	**1**
5(c)	add dropwise (so the reaction is slow) (1) cool conical flask in an ice bath (1)	**2**

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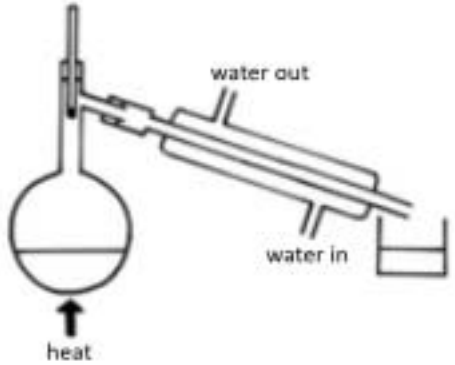
Question	Answer	Marks
5(d)(i)	use a separating funnel (1) Then: • Add an organic solvent and mix well • (Leave to stand so that) the organic and aqueous layers separate • Collect the organic layer which will contain the diethyl oxirane • Carry out second extraction *1 mark for 1 bullet* *2 marks for 3 bullets*	**3**
5(d)(ii)	Add (sodium) hydrogen carbonate / carbonate to see if it fizzes (1)	**1**
5(d)(iii)	removes water (1)	**1**
5(d)(iv)	filtration (1)	**1**
5(d)(v)	no naked flames (1)	**1**
5(e)(i)	 heat source and thermometer with bulb level with side arm (1) sealed above flask/around thermometer (1) one (Liebig) condenser leaning downwards from side arm, with labels to show water in and water out (1) receiving vessel (unsealed) (1)	**4**
5(e)(ii)	a (very) broad peak (due to OH in a carboxylic acid) between 2500–3330 cm^{-1}	**1**

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