Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/21**

Paper 2 AS Level Structured Questions **May/June 2022**

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.

Cambridge International is publishing the mark schemes for the May/June 2022 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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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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Question	Answer	Marks
1(a)	*Identify and draw the shape of highest energy orbital of Ca* 4s AND 	**1**
1(b)(i)	$Ca(NO_3)_2 \rightarrow CaO + 2NO_2 + ½O_2$	**1**
1(b)(ii)	radium (nitrate) as thermal stability increases down group / has the greatest thermal stability	**1**
1(c)	white precipitate / solid (of radium sulfate)	**1**
1(d)(i)	number of protons: 12 number of neutrons: 13	**1**
1(d)(ii)	$1s^2 2s^2 2p^6 3s^2$	**1**
1(e)(i)	1 / 12 (one twelfth) the mass of a carbon-12 / ^{12}C atom	**1**
1(e)(ii)	**M1** correct expression relating A_r to the mass / % abundance of the three isotopes $24.31 = \boldsymbol{x} \times 0.7899 + 24.99 \times 0.1000 + 25.98 \times 0.1101$ **M2** correct answer to 4 sig figs atomic mass of **X** = 23.99	**2**
1(e)(iii)	**M1** (magnesium isotopes have) identical chemical properties **AND** same electron(ic) arrangement / configuration **M2** different physical properties **AND** different number of neutrons	**2**
1(f)(i)	white flame / light **OR** white solid / smoke	**1**

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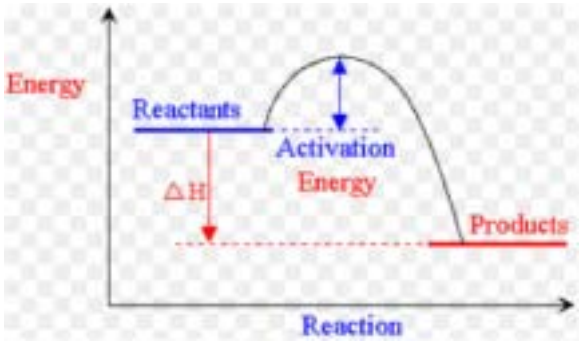
Question	Answer	Marks
1(f)(ii)	**M1** sketch shows exothermic reaction with a 'hump' **AND** labelled reactants (Mg + O_2) and products (MgO) **M2** arrow from reactants / Mg + O_2 to products / MgO shown as ΔH **M3** arrow showing activation energy / E_a / (+)148 	**3**
1(g)	**M1** (heat / energy released from burning Mg) provides more particles with energy ⩾ E_a **M2** frequency of successful / effective collisions is greater	**2**

Question	Answer	Marks
2(a)	**M1** one sigma / σ bond and two pi / π bonds **M2** sp hybridisation (in each N atom) **M3** sigma / σ forms from direct / head-on / end-on overlap of orbitals **AND** pi / π forms sideways / lateral overlap of (p) orbitals	**3**
2(b)(i)	**M1** react with (unburnt) hydrocarbons **M2** (form) PAN / peroxyac(et)yl nitrate	**2**
2(b)(ii)	$2NO + 2CO \rightarrow 2CO_2 + N_2$ **OR** $NO_2 + 2CO \rightarrow ½N_2 + 2CO_2$	**1**

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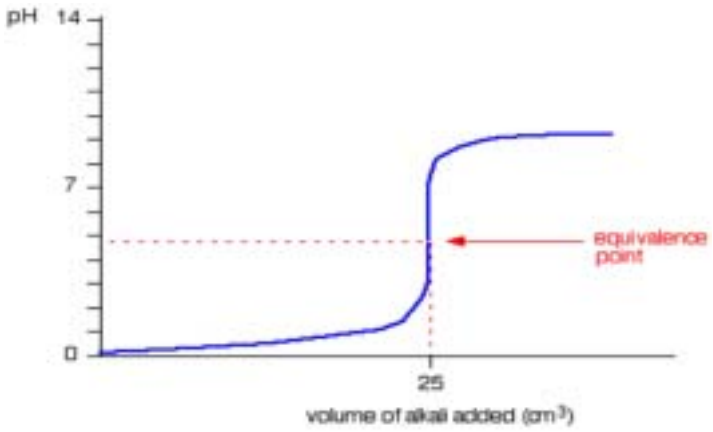
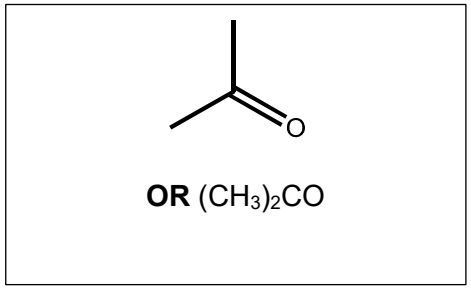
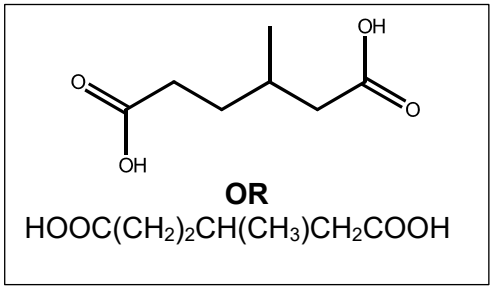
Question	Answer	Marks
2(c)	any Group 1 hydroxide or $Ca(OH)_2$ / $Sr(OH)_2$ / $Ba(OH)_2$	**1**
2(d)(i)	**M1** proton / H^+ donor **M2** fully dissociates (in aqueous solution / water / solvent)	**2**
2(d)(ii)	$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$	**1**
2(d)(iii)	**M1** correct basic shape extending to ~50 cm^3 with vertical portion of curve at 25 cm^3 **M2** initial pH at 0–2 (based on idea that HC*l* is a strong acid) **AND** final pH at between 8–12 (based on idea that NH_3 is a weak alkali) 	**2**

Question	Answer	Marks
3(a)	**M1** optical **M2** one of the C atoms has 4 different groups / atoms attached	**2**
3(b)	 **OR** $(CH_3)_2CO$  **OR** $HOOC(CH_2)_2CH(CH_3)CH_2COOH$	**2**
3(c)(i)	$NaBH_4$ / sodium borohydride / $LiAlH_4$ / lithium tetrahydridoaluminate	**1**
3(c)(ii)	**M1** $H_2O(g)$ / steam **M2** phosphoric acid (catalyst) / H_3PO_4 (catalyst)	**2**
3(c)(iii)	**M1 Q** AND intermediate / cation is (more) stable **M2** (as the) C^+ has 3 / more alkyl groups attached **M3** (so) greater (positive) inductive effect	**3**
3(d)(i)	**M1 Q** orange → green **M2 R** orange → green **M3** –CHO / aldehyde (in both) (and 2° / secondary alcohol in **R**) reacts / oxidised	**3**

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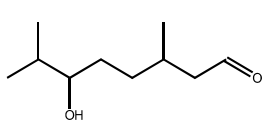
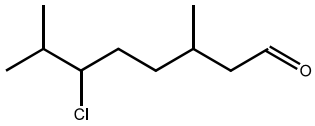
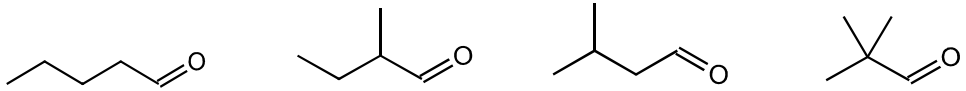
Question	Answer	Marks
3(d)(ii)	 + PCl_5 →  + HCl + $POCl_3$ / $C_{10}H_{19}ClO$ **M1** correct formula of organic product **M2** correct inorganic products	**2**
3(d)(iii)	**M1** water reacts with / hydrolyses PCl_5 **M2** H_2O + PCl_5 → $POCl_3$ + 2HCl **OR** $4H_2O$ + PCl_5 → H_3PO_4 + 5HCl	**2**

Question	Answer	Marks
4(a)	**M1** % / A_r for C H O **M2** each % / A_r for C H O divided by the smallest value for % / Ar to give simplest whole number ratio / empirical formula **M3** compare M_r from **M2** ratio with 280 to deduce the actual molecular formula C: 77.2 / 12 = 6.433; 9(.03) H: 11.4 / 1 = 11.4; 16 O: 11.4 / 16 = 0.7125; 1 $M_r(C_9H_{16}O)$ = 140 so molecular formula of **V** = $C_{18}H_{32}O_2$	**3**
4(b)(i)	**M1** (add) group 1 carbonate / group 1 bicarbonate / Na_2CO_3 / $NaHCO_3$ etc. **M2** effervescence / fizzing / bubbling	**2**
4(b)(ii)	3.196 g Br_2 = 3.196 / 159.8 (= 0.02 mol Br_2) **AND** 2.8(00) / 280 (= 0.01 mol **V**) 2 alkene / 2 C=C (groups)	**1**
4(c)(i)	carbonyl	**1**

Question	Answer	Marks
4(c)(ii)	CHI_3	**1**
4(c)(iii)	**M1** / **M2**  **M3** chain (isomerism)	**3**
4(d)	29 $C_2H_5^+$ 57 $COCH_2CH_3^+$ **OR** $C_3H_5O^+$ **OR** $CH_2COCH_3^+$ identity of **Z** pentan-3-one / $CH_3CH_2COCH_2CH_3$ pentan-2-one / $CH_3COCH_2CH_2CH_3$	**3**