Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/42**

Paper 4 A Level Structured Questions **October/November 2020**

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 October/November 2020 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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GENERIC RULES FOR MARKING ORGANIC STRUCTURES/MECHANISMS

If two or more structures drawn

- mark first structure seen (work left to right then down and across) based on question rubric for example, "Draw a structure of …" ALLOW any unambiguous structure
  "Draw the skeletal formula of …." MUST be a skeletal structure

- If ANY structure looks like working-out, e.g. a repeat of the structures given in the stem, done in pencil when the answer is in pen then IGNORE

- Then mark subsequent structures – if any part of the structure directly CONs the first structure withhold those marks, e.g. first structure has a correct displayed amide bond but second structure has no amide bond – this mark is withheld

- If any labelled carbons "C" are trivalent – NO MARK for this aspect of the structure [this does not refer to skeletal structures]

- If any bonds (sticks) are shown without a label – this is wrong and cannot be given credit UNLESS a skeletal -these are assumed to be CH_3 groups [do not allow slips].

- DO NOT penalise connectivity on attached groups unless drawn as a displayed formula or as specified in the MS, e.g. allow OH_- NH_{2-} $COOH_-$ etc. [BUT **CON** connectivity for Ona_-]

- ALLOW use of C_2H_5 for CH_3CH_2 but do not allow use of C_3H_7 as it is ambiguous ($CH_3CH_2CH_2$ or $(CH_3)_2CH$)

- ALLOW use of C_6H_5 and Kekule structure for delocalised benzene structure

If question rubric asks for skeletal, and mixed skeletal and displayed structures drawn

- apply above rules
- BUT if skeletal = displayed and it looks like working then mark skeletal and ignore displayed formula otherwise **CON**

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Transition metal complexes

- Writing formulae
  - if a stray charge has been included inside the bracket on the ligand–**ignore** and mark the overall charge
- Drawing structures –
  - we normally apply rule above [**ignore** charges on individual ligands]
  - bond attachments – normally no penalty for H_2O, NH_3 unless drawn out and clearly bonding via the H. This matches organic rules above
  - Formulae in isomers **DO NOT ALLOW** use of $_2HO$, O_2H for H_2O;$^{-}{}_3HN$ for NH_3 **apply ecf**

Polymers

- Skeletal polymer repeat unit – either brackets need to be used to indicate the repeat unit **OR** the continuation bonds must be hashed line (or similar) to **distinguish this bond from a CH_3 group**
- Rubric asks for a repeat unit
  - If more than one repeat unit is drawn no mark for this mark
- Rubric asks for a section of the polymer
  - If more than one repeat unit drawn – allow as long as structure section is correct and continuation bonds are seen
  - For polymers containing two monomers allow 1.5 repeat units etc seen
  - For those requires displayed linkage bonds – only one displayed required but any linkages between monomers seen must be correct otherwise CON
- Polyalkenes – allow syndiotactic, atactic structures as well as alkenes joined head to head [this is more for Paper 2 to apply for consistency]- chemistry is correct

Calculations

- Where there is an answer line for a response, we mark what is on the line. **Exception for DS on 2019–2021 syllabus**
- If the answer is incorrect and there are no other marks available we do not look in the working to see if the candidate has written the correct answer in the working space.
- If answer is incorrect- examine their working to see if ecf can be applied based on the MS guidance

Use of sf and dp in final answer

If not asked for in the rubric and their answer has been rounded from the correct answer seen in their working (min sf/dp) – **ALLOW**

Powers for units ALL NEGATIVE CHARGES MUST have a numerical value **DO NOT ALLOW** mol dm^{-3} s^{-} **OR** mol– dm^3 s^{-1} **OR** dm^3/mol s

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Question	Answer	Marks
1(a)(i)	so it won't change / so it stays constant [1]	**1**
1(a)(ii)	constant half-life / both half-lives = 45–55 [1] two half-lives taken (evidence needed) [1]	**2**
1(b)(i)	first order [1] any two rows of data quoted, effect of $[H_2]$ specified [1] effect of $[I_2]$ specified and linked to first order [1]	**3**
1(b)(ii)	rate = $k[H_2][I_2]$ [1]	**1**
1(b)(iii)	2×10^{-13} [1] $mol^{-1}\ dm^3\ s^{-1}$ [1]	**2**
1(c)(i)	forward reaction is faster than backward reaction **and** reaches equilibrium on product side / to the right [1]	**1**
1(c)(ii)	forward reaction is negative **AND** backward reaction is positive [1] equilibrium position further left at higher T [1]	**2**

Question	Answer	Marks
2(a)	$[H^+][A^-] / [HA]$ [1]	**1**
2(b)(i)	$[H^+] = 3.9 \times 10^{-5}$ [1] $K_a = 1.5 \times 10^{-6}$ [1]	**2**
2(b)(ii)	5.82 [1]	**1**
2(c)	$4 \times {}^3 = 1.1 \times 10^{-11}$ [1] $x = 1.4 \times 10^{-4}$ [1]	**2**

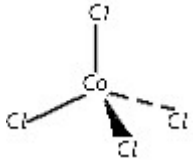
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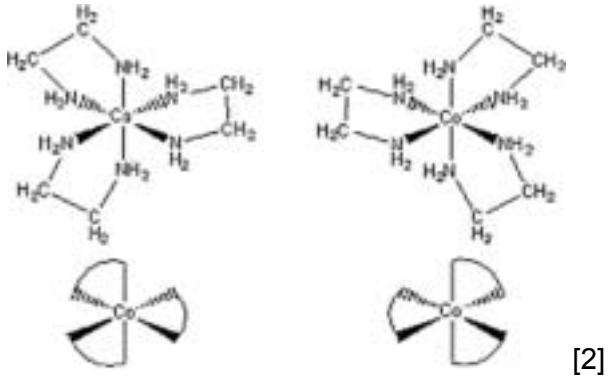
Question	Answer	Marks
3(a)(i)	(+193 + 242 + 590 + 1150 + (2 × –349)) [1] answer (+)1477 [1]	**2**
3(a)(ii)	(–795 – 83 – 1477) [1] –2355 [1]	**2**
3(a)(iii)	(–2355 –(2 × –364)) [1] –1627 [1]	**2**
3(a)(iv)	Z–Y or X–W [1]	**1**
3(a)(v)	less (exothermic) and both ions (in $CaCl_2$) are larger [1]	1
3(b)(i)	soluble barium salt **AND** soluble sulfate [1]	1
3(b)(ii)	less soluble (down the group) [1] ΔH_{lat} and ΔH_{hyd} both decrease down the group [1] ΔH_{hyd} decreases more / faster / is dominant factor [1] ΔH_{sol} gets less exo / more endo [1]	**4**

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Question	Answer	Marks
4(a)	chlorine **AND** hydrogen [1]	**1**
4(b)	15 × 60 × 0.75 = 675 C [1] 675 / 96 500 = 7.0×10^{-3} moles e^- [1] $7.0 \times 10^{-3} \times 0.25$ gives 1.75×10^{-3} moles O_2 $1.75 \times 10^{-3} \times 24000 = 42$ (41.969) cm^3 O_2 [1] **OR** 15 × 60 × 0.75 = 675 C [1] 675 / $1.60 \times 10^{-19} = 4.22 \times 10^{21}$ $e^- = 7.01 \times 10^{-3}$ moles e^- [1] gives 1.75×10^{-3} moles $O_2 = 42$ (42.047) cm^3 [1]	**3**
4(c)(i)	1.36 1.07 0.54 [1]	**1**
4(c)(ii)	all of them [1] (all $E^\ominus$ values) greater than 0.15 / $E^\ominus_{cell}$ greater than zero [1] e.g. $Sn^{2+} + X_2 \rightarrow Sn^{4+} + 2X$ [1]	**3**
4(c)(iii)	MnO_2 [1]	**1**
4(d)(i)	1.24 V [1]	**1**
4(d)(ii)	platinum, platinum [1]	**1**
4(d)(iii)	increase $[Fe^{2+}]$ or decrease $[Fe^{3+}]$ increase $[S_2O_8^{2-}]$ or decrease $[SO_4^{2-}]$ [1]	**1**

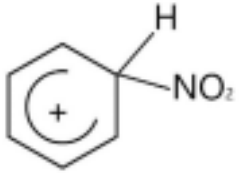
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Question	Answer	Marks
5(a)	(element forming) • one or more stable ions with **AND** • incomplete / partially filled d-orbitals / d-subshell [1]	**1**
5(b)(i)	($1s^2$) $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^5$ ($4s^o$) [1]	**1**
5(b)(ii)	chromium and manganese [1]	**1**
5(c)(i)	 [1] 2– (charge) [1]	**2**
5(c)(ii)	<u>ligand</u> exchange / substitution / replacement / displacement [1]	**1**
5(c)(iii)	**M1** (complexes have two sets of) **d orbital(s)** of different energy **OR d** orbital(s)/d (sub)-shell splits **OR (**inferred from a movement of an electron) from a **lower d** to **higher d orbital** [1] **M2** wavelength / frequency / light / photon / hn **absorbed** **OR** radiation / energy from <u>visible</u> (region) **absorbed** [1] **M3 electron**(s) promoted / excited **OR electron**(s) moves to higher (d-) orbital **OR electron**(s) jumps up (to d-orbital) / jumps to higher (d-orbital) [1] **M4** colour seen is complementary (to colour absorbed) **OR** colour / light not absorbed is transmitted / reflected [1]	**4**
5(c)(iv)	The gap between the d-orbitals / ΔE is different [1] wavelength (**OR** photon**,** frequency) absorbed is different / changed etc 1]	**2**
5(d)(i)	Oxidation [1]	**1**

Question	Answer	Marks
5(d)(ii)	 [2]	**2**
5(d)(iii)	optical [1]	**1**
5(d)(iv)	six [1]	**1**
5(e)(i)	$[[Hg(CN)_4]^{2-}] / [Hg^{2+}][CN^-]^4$ or $[Hg(CN)_4^{2-}] / [Hg^{2+}][CN^-]^4$ [1]	**1**
5(e)(ii)	concentration: highest $[Hg(CN)_4]^{2-}$ lowest $[HgCl_4]^{2-}$ [1] K_{stab} value: highest $[Hg(CN)_4]^{2-}$ lowest $[HgCl_4]^{2-}$ **OR** stability: highest $[Hg(CN)_4]^{2-}$ lowest $[HgCl_4]^{2-}$ [1]	**2**

Question	Answer	Marks
6(a)	ethanamide – ethanoic acid – trichloroethanoic acid [1] • ethanamide is neutral / not a proton donor • chlorine is electronegative / electron withdrawing [1] • O–H bond weakened / anion stabilised • correct statement linking acid strength to H^+ donation [1]	**3**
6(b)(i)	methanoic acid [1]	**1**
6(b)(ii)	methanoic and ethanedioic acids [1]	**1**
6(c)(i)	CH_3COCl [1] ethanoyl chloride [1]	**2**
6(c)(ii)	Step 1: PCl_5 / PCl_3 / $SOCl_2$ or names [1] Step 2: NH_3 / ammonia [1]	**2**
6(d)(i)	(because $CDCl_3$) doesn't give a signal / peak / absorption **OR** because $CHCl_3$ does give a signal / peak / absorption [1]	**1**
6(d)(ii)	Clockwise from left: absorption at σ = 1.9 to 2.1 absorption at σ = 6.5 to 7 [1] absorption at σ = 3 to 3.5 absorption at σ = 1 to 1.5 [1]	**2**
6(d)(iii)	the peak at 6.6 to 6.8 / due to NH would disappear [1] H exchanges with D [1]	**2**
6(e)	fragment with *m*/*e* = 58 is CH_3CONH^+ [1]	**1**
6(f)(i)	$LiAlH_4$ [1]	**1**
6(f)(ii)	2 [1]	**1**

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Question	Answer	Marks
7(a)	Any four from the following points: • (regular) hexagon **OR** planar • all C–C bonds same length [1] • all bond angles 120° • all carbon atoms sp^2 hybridised [1] • C–H bonds are s–sp^2 overlap [1] • C–C bonds have sp^2–sp^2 overlap [1] • C–C bonds have p–p overlap • π used correctly and σ used correctly once each	**4**
7(b)(i)	curly arrow from within hexagon towards NO_2+ **AND** curly arrow from C–H bond to within hexagon [1]  intermediate [1]	**2**
7(b)(ii)	electrophilic substitution [1]	**1**
7(b)(iii)	conc nitric acid and sulfuric acid [1] $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ **OR** [1] $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + SO_4^{2-}$ $2HNO_3 + H_2SO_4 \rightarrow 2NO_2^+ + H_2O + SO_4^{2-}$ $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + H_2O + HSO_4^-$	**2**
7(b)(iv)	tin and HC*l* [1] conc and heat / boil / reflux [1]	**2**
7(c)(i)	$C_6H_5NH_2 + 3Br_2 \rightarrow C_6H_2Br_3NH_2 + 3HBr$ [1]	**1**
7(c)(ii)	2,4,6-tribromophenylamine [1]	**1**
7(c)(iii)	decolourisation of bromine **AND** white precipitate [1]	**1**

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Question	Answer	Marks
7(d)	phenylamine < ammonia < ethylamine [1] • lp on nitrogen of phenylamine delocalised into ring • alkyl group of ethylamine electron donating / has positive inductive effect [1] • correct statement about availability of lone pair to accept proton once [1]	**3**
7(e)(i)	either a dioic acid or a dioyl chloride [1]	**1**
7(e)(ii)	• trailing bonds • two of each monomer residue, consistent with ei [1] • repeat unit identified • amide link showing C=O [1]	**2**

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