



Cambridge Pre-U

CHEMISTRY

9791/03

Paper 3 Part B Written

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.

PUBLISHED**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.

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.

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.

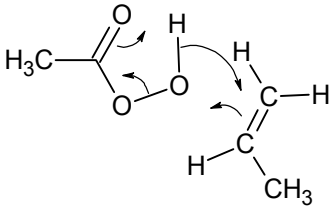
Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

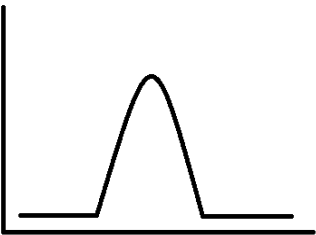
Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

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

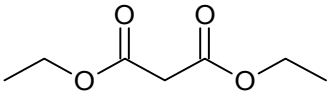
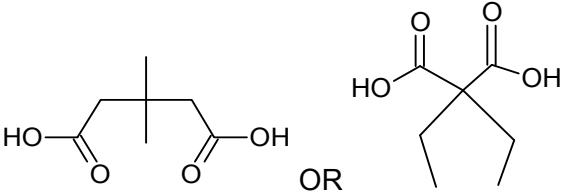
Question	Answer	Marks
1(a)(i)	only partially dissociates (in water) and dissociates to produce H ⁺ (aq)	1
1(a)(ii)	$K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$	1
1(a)(iii)	$K_a = 10^{-4.76} = 1.74 \times 10^{-5}$ (calc value 1.7378×10^{-5}) (1) $K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$ simplified to $K_a = \frac{[H^+]^2}{[CH_3COOH]}$ rearrange to $[H^+] = \sqrt{K_a \times [CH_3COOH]}$ $[H^+] = \sqrt{(1.74 \times 10^{-5}) \times 0.150} = 1.62 \times 10^{-3}$ (calculator value 1.6155×10^{-3}) (1) $pH = -\log_{10}(1.62 \times 10^{-3}) = 2.79$ (1)	3
1(b)(i)	resists changes to pH on addition of small amounts of acid or base	1
1(b)(ii)	on addition of acid, $CH_2ClCOO^- + H^+ \rightarrow CH_2ClCOOH$ (1) on addition of base, $CH_2ClCOOH + OH^- \rightarrow CH_2ClCOO^- + H_2O$ (1) to prevent large changes in [H ⁺] (1)	3
1(b)(iii)	$pK_a = pH - \log \frac{base}{acid}$ or $pK_a = pH + \log \frac{acid}{base}$ (1) $10^{(pH-pK_a)} \times 0.200 = 0.258 \text{ mol dm}^{-3}$ of base needed (1) $0.258 \div 4 = 0.0644$ mol of base needed RFM = 116.5, so $0.0644 \times 116.5 = 7.50$ g (1)	3

Question	Answer	Marks
1(c)	electron withdrawing Cl (is more electronegative than C) (1) the negative charge cannot delocalise across the carbonyl (1) as the adjacent oxygen is not π -bonded (1) stabilises anion / weakens O-H bond in chloroethanoic acid OR destabilises anion / stronger O-H bond in peroxyethanoic acid (1)	4
1(d)(i)	 each correct arrow (1)	3
1(d)(ii)	nucleophilic addition (1) lone pair on Cl^- and arrow from lone pair to C (1) arrow from C-O bond to O or +ve charge and correct product (1) isomers: as the Cl^- can attack either C, (two isomers are possible) (1)	4

Question	Answer	Marks
2(a)(i)	Two sets of construction lines on graph (1) Showing constant half-life (of ~65 min) (1)	2
2(a)(ii)	catalyst	1
2(b)(i)	(rate =) $k[C_{12}H_{22}O_{11}][H^+]$	1
2(b)(ii)	(units =) $mol^{-1} dm^3 s^{-1}$	1
2(c)	rearrangement to give $E_a = -RT(\ln k - \ln A)$ (1) $-8.31 \times 298 \times (-8.66 - 34.95)$ (1) $/ 1000 = 108 (kJ mol^{-1})$ (1)	3

Question	Answer	Marks
2(d)(i)	B because it donates a proton	1
2(d)(ii)	at high pH both A and B would be deprotonated OR at low pH both A and B would be protonated	1
2(d)(iii)		1
2(d)(iv)	at higher temperatures the active site is distorted	1

Question	Answer	Marks
3(a)(i)	$C = 52.5 / 12 = 4.375$ $H = 7.5 / 1 = 7.5$ $O = 40 / 16 = 2.5$ OR $C:H:O = 1.75 : 3.00 : 1.00$ (1) empirical formula = $C_7H_{12}O_4$ (1) use of 160 to get molecular formula is $C_7H_{12}O_4$ (1)	3
3(a)(ii)	peak due to ^{13}C isotope (in molecular ion) (1) 7.7% (1)	2
3(a)(iii)	$C_7H_{12}O_4^+ \rightarrow C_5H_7O_4^+ + C_2H_5^\bullet$ OR $C_7H_{12}O_4^+ \rightarrow C_6H_{11}O_3^+ + COH^\bullet$ M1 use of correct molecular ion (1) M2 loss of C_2H_5 OR COH (with no charge) (1) M3 feasible species with m/z of 131 (1)	3

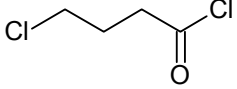
Question	Answer	Marks
3(b)(i)	it is deshielded (compared to the others) (1) it must be close to an electronegative atom / oxygen (1)	2
3(b)(ii)	X contains a CH ₂ group	1
3(b)(iii)	dichromate: no alcohol <u>or aldehyde</u> present (1) acid: ester group present (C ₂ H ₅ attached to oxygen (CO-O- C ₂ H ₅)) (1)	2
3(b)(iv)		1
3(c)	 M1 two carboxylic acid groups present M2 all correct	2

Question	Answer	Marks
4(a)(i)	oxidised: I -1 to 0 (1) reduced: O -1 to -2 (1)	2
4(a)(ii)	2.01 – 0.54 = 1.47 V	1
4(a)(iv)	electrodes (Pt) both (1) S ₂ O ₈ ²⁻ / SO ₄ ²⁻ (1) I ⁻ / I ₂ (1) Salt bridge and voltmeter (1)	4

Question	Answer	Marks
4(a)(v)	$\text{Pt} \text{I}^- (\text{aq}), \text{I}_2(\text{aq}) \text{S}_2\text{O}_8^{2-}(\text{aq}), \text{SO}_4^{2-}(\text{aq}) \text{Pt}$	1
4(a)(vi)	<p>AgNO_3 reacts with I^- (to produce $\text{AgI}(\text{s})$) (1) $[\text{I}^-]$ decreases so half-cell eqm shifts to the right to compensate (1) E^\ominus becomes more positive (1) E^\ominus_{cell} becomes more negative / reduces (1)</p>	4
4(b)(i)	both reacting ions are negative / have the same charge	1
4(b)(ii)	<p>calorimetry (1) by comparing absorption against calibration graph (1)</p>	2
4(c)(i)	<p>homogeneous (1) it is in the same state / phase as the reactants (1)</p>	2
4(c)(ii)	<p>$2\text{Fe}^{3+} + 2\text{I}^- \rightarrow 2\text{Fe}^{2+} + \text{I}_2$ (1) $2\text{Fe}^{2+} + \text{S}_2\text{O}_8^{2-} \rightarrow 2\text{Fe}^{3+} + 2\text{SO}_4^{2-}$ (1)</p>	2
4(c)(iii)	yes as the order of the steps would be reversed	1
4(c)(iv)	<p>(V^{2+} would reduce $\text{S}_2\text{O}_8^{2-}$ as $-0.26 < +2.01$) V^{3+} cannot oxidise I^- as -0.26 is not $> +0.54$ (1) ($E_{\text{cell}} = -0.80\text{V}$) Mn^{2+} can reduce $\text{S}_2\text{O}_8^{2-}$ as $+1.49 < +2.01$ (1) ($E_{\text{cell}} = +0.52\text{V}$) Mn^{3+} can oxidise I^- as $+1.49$ is $> +0.54$ (1) ($E_{\text{cell}} = +0.95\text{V}$)</p>	3

Question	Answer	Marks
5(a)	Fe: (1s ²) 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁶ 4s ² (1) Fe ³⁺ (1s ²) 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁵ (4s ⁰) (1)	2
5(b)(i)	(central) metal atom / ion surrounded by ligands (1) dative (covalent) / coordinate bonds (1)	2
5(b)(ii)	correct complex drawn (1) octahedral (1) bond angle 90° (1)	3
5(b)(iii)	(interaction with ligands splits the degenerate) d-subshell into two energy levels (with ΔE) (1) a photon of light / light of a certain energy is absorbed (1) promoting an electron from the lower to the higher level (1) the complementary colour is transmitted / seen (1)	4
5(c)(i)	$K_{sp} = [\text{Fe}^{2+}][\text{OH}^-]^2$	1
5(c)(ii)	Let $[\text{Fe}(\text{OH})_2] = x$ OR that $[\text{Fe}^{2+}] = 2[\text{OH}^-]$ (1) $K_{sp} = x \cdot (2x)^2 = 4x^3$ (1) $x = \sqrt[3]{\frac{8.0 \times 10^{-16}}{4}} = 5.85 \times 10^{-6}$ (1)	3

Question	Answer	Marks
6(a)	step 1 4-chlorobutan-1-ol or CH ₂ ClCH ₂ CH ₂ CH ₂ OH (1) AlCl ₃ (1) step 2 H ⁺ / Cr ₂ O ₇ ²⁻ (and reflux / heat) (1) step 3 SOCl ₂ or PCl ₃ or PCl ₅ (1) step 4 AlCl ₃ (1)	5
6(b)(i)	from alcohol / 1 to carboxylic acid / 3 (1) oxidation (1)	2

Question	Answer	Marks
6(b)(ii)	from carboxylic acid / 3 to carboxylic acid / 3 (1) substitution (1)	2
6(b)(iii)	from carboxylic acid / 3 to carbonyl / 2 (1) reduction (1)	2
6(c)	4-chlorobutanoyl chloride / $\text{CH}_2\text{ClCH}_2\text{CH}_2\text{COCl}$ 	1