Cambridge Assessment International Education

Cambridge Pre-U

CHEMISTRY **9791/02**

Paper 2 Part A 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.

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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.

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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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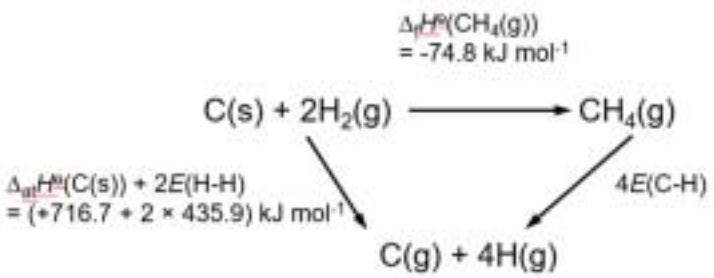
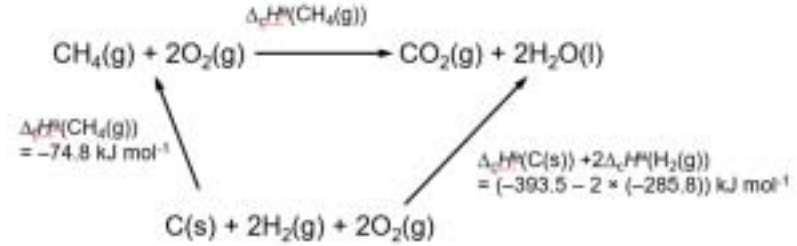
Question	Answer	Marks
1(a)(i)	(enthalpy change when) 1 mol of substance (1) is formed from its elements (1) under standard conditions OR in their standard states (1)	**3**
1(a)(ii)	 Use of all relevant data: $\Delta_f H^\ominus(CH_4)$ = –74.8 kJ mol^{-1}, $\Delta_{at}H^\ominus(C)$ = 716.7 kJ mol^{-1} and E(H–H) = 435.9 kJ mol^{-1} (1) Use of a correct cycle, $\Delta_f H^\ominus(CH_4) = \Delta_{at}H^\ominus(C) + (2)E(H–H) – (4)E(C–H)$ leading to (4)E(C–H) = (716.7 + 2 × 435.9 + 74.8) kJ mol^{-1} = 1663.3 kJ mol^{-1} (1) M3 E(C–H) = 1663.3 kJ mol^{-1} / 4 = (+)415.8 kJ mol^{-1} (1)	**3**
1(a)(iii)	 Use of $\Delta_f H^\ominus(CH_4)$ (1) Evidence of a correct cycle OR $\Delta_c H^\ominus(CH_4) = \Delta_c H^\ominus(C) + (2)\Delta_c H^\ominus(H_2) – \Delta_f H^\ominus(CH_4)$ (1) $\Delta_c H^\ominus(CH_4)$ = (–393.5 – 2 × 285.8 + 74.8) kJ mol^{-1} = –890.3 kJ mol^{-1} (1)	
1(b)	lower activation energy	**1**
1(c)(i)	25%	**1**
1(c)(ii)	(methanol is easier to store / transport) because it is a liquid (at temperatures at which it is likely to be used).	**1**

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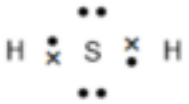
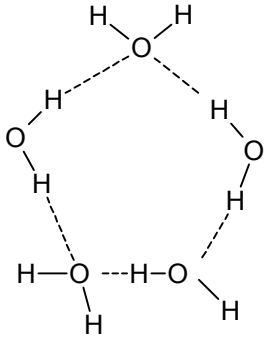
Question	Answer	Marks
2(a)		**1**
2(b)(i)	increase in the sequence $H_2S < H_2Se < H_2Te$ (1) due to increasing van der Waals / London / dispersion / IDID forces (1) because there are more electrons on descending the group (1)	**3**
2(b)(ii)	higher (than **all** the other hydrides / higher than H_2Te)	**1**
2(c)	division by 6.02×10^{23} (1) 1.79×10^{-22} (1)	**2**
2(d)	 Complete drawing to show covalent bonds in 5 water molecules (1) Five hydrogen bonds connect the H from one water to the O of an adjacent one (1) Bond angle of 180° around each H involved in an hydrogen bond in at least 4 hydrogen bonds (1)	**3**

Question	Answer	Marks
3(a)	$4P + 5O_2 \rightarrow 2P_2O_5$ OR $4P + 5O_2 \rightarrow P_4O_{10}$	**1**
3(b)	different forms of the same element (1) in the same state (1)	**2**
3(c)(i)	P_4	**1**
3(c)(ii)	 structure where each P atom is bonded to the other three P atoms	**1**
3(d)(i)	$3PCl_5 + 5NH_4Cl \rightarrow P_3N_5 + 20HCl$ species (1) balancing (1)	**2**
3(d)(ii)	electronegativity decreases on descending Group 15	**1**
3(d)(iii)	P = +5; N = –3	**1**
3(d)(iv)	$P_3N_5 + 12H_2O \rightarrow 3H_3PO_4 + 5NH_3$ H_3PO_4 as product (1) fully correct (1)	**2**
3(d)(v)	amount of P_3N_5 = 1.00 g / 163 g mol^{-1} = 6.13×10^{-3} mol (1) amount of gas = 147 cm^3 / 24 000 cm^3 mol^{-1} = 6.13×10^{-3} mol (1) $P_3N_5 \rightarrow P_3N_3 + N_2$ (1) empirical formula = PN (1)	**4**

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Question	Answer	Marks
4(a)	as the group is descended oxidising power decreases (1) atomic radius increases (1) attraction between the nucleus and the (outer) electrons decreases (1) electrons are gained less easily (1)	**4**
4(b)	iod**ide** OR astat**ide**	**1**
4(c)(i)	m = 2a + b AND n = b	**1**
4(c)(ii)	water is (highly) polar (1) I_3^- interacts more strongly with water OR I_2 interacts less strongly with water (1)	**2**
4(d)	$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$	**1**
4(e)	square planar (1) four bonding pairs; 2 lone pairs (around the I atom) (1) lone pairs repel more than bonding pairs (1)	**3**

Question	Answer	Marks
5(a)(i)	$C_7H_{16}O$ (1) 4-methylhexan-2-ol (1)	**2**
5(a)(ii)	sulfuric acid (1) sodium / potassium dichromate(VI) OR dichromate(VI) ions / $Cr_2O_7^{2-}$ (1)	**2**
5(a)(iii)	oxidation	**1**
5(b)(i)	water	**1**
5(b)(ii)	condensation	**1**

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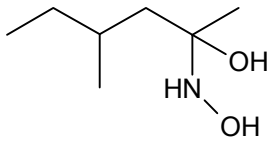
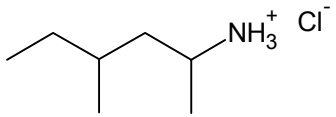
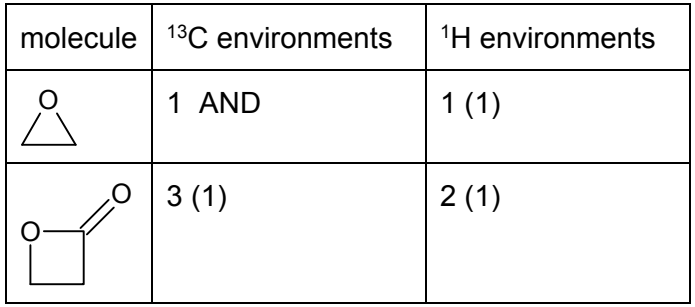
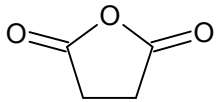
Question	Answer	Marks
5(b)(iii)		**1**
5(c)(i)	FGL (decreases) from 2 to 1	**1**
5(c)(ii)	water	**1**
5(d)(i)	(the N in) NH_3 has a lone pair of electrons	**1**
5(d)(ii)	lone pair of electrons (on N) is not available	**1**
5(e)(i)	hydrogen bonding	**1**
5(e)(ii)		**1**

Question	Answer	Marks
6(a)		**3**
6(b)(i)	$C_4H_4O_3$	**1**
6(b)(ii)	$C_4H_4O_3$	**1**

Question	Answer	Marks
6(b)(iii)	m / z = 28: CO^+ OR $C_2H_4^+$ (1) m / z = 56: $C_2H_4CO^+$ (1)	**2**
6(c)(i)	one carbon environment in C–C (alkane) range (1) one carbon environment in ester / carboxylic acid range (1)	**2**
6(c)(ii)	$C_4H_4O_3$ structure with four hydrogens in identical chemical environments AND with all other atoms with correct valencies (1)  (1)	**2**

Question	Answer	Marks
7(a)(i)	other (two) products are gaseous (1-chlorohexane is a liquid)	**1**
7(a)(ii)	It reacts with water (in the air) (1) $SOCl_2 + H_2O \rightarrow SO_2 + 2HCl$ (1)	**2**
7(a)(iii)	(chemically-resistant) gloves (1) keep away from naked flames (1)	**2**
7(a)(iv)	amount of hexan-1-ol = 10.20 / 102.0 = 0.1(00) mol (1) mass of thionyl chloride = 22 $cm^3 \times$ 1.66 g cm^{-3} = 36(.52) g (1) amount of thionyl chloride = 36(.52) g / 119.1 g mol^{-1} = 0.3066 / 0.307 / 0.31 mol ∴ excess = 0.3066 mol – 0.100 mol = 0.21 mol (2 s.f.) (1)	**3**
7(b)	dissipate evolved heat	**1**
7(c)(i)	to reduce the rate of reaction	**1**
7(c)(ii)	any named (organic) solvent expected to dissolve and not react with reactants (or products), e.g. hexane	**1**
7(d)	to reduce moisture / water entering the apparatus	**1**

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Question	Answer	Marks
7(e)	one (Liebig) condenser leading downwards from side arm (1) thermometer with bulb level with side arm (1) sealed above flask / around thermometer (1) receiver vessel (unsealed) (1)	**4**
7(f)(i)	separating funnel	**1**
7(f)(ii)	first water washing: (excess) thionyl chloride (1) aqueous sodium carbonate: HCl or SO_2 (1) second water washing: NaCl OR Na_2SO_3 (1)	**3**
7(g)(i)	as drying agent	**1**
7(g)(ii)	the (white) powder becomes less fine.	**1**
7(h)	step 7: Filter (and collect filtrate) (1) step 8: Distil (and collect the product at 135°C) (1)	**2**
7(i)	maximum yield from 10.2 g is 10.2 g $\times$ 120.5 / 102.0 = 12.05 g (1) percentage yield = 6.6 / 12.05 $\times$ 100% = 54.8% (1)	**2**

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