Cambridge Assessment International Education

Cambridge Pre-U

CHEMISTRY **9791/02**

Paper 2 Part A Written **May/June 2022**

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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This document consists of **12** printed pages.

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.

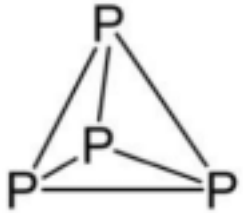
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)</td><td>(1s^2) 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^3</td><td>1</td></tr>
<tr><td>1(b)(i)</td><td>The mass spectrum to show a peak height ratio of 3:2 (1)

With lines plotted at 121 and 123 and correct way around for ratio 3:2 for 121:123 (1)</td><td>2</td></tr>
<tr><td>1(b)(ii)</td><td><table><tr><th></th><th>number of protons</th><th>number of neutrons</th><th>number of electrons</th></tr><tr><td>$^{123}Sb^{3+}$</td><td>51</td><td>72</td><td>48</td></tr></table></td><td>1</td></tr>
<tr><td>1(c)(i)</td><td>In first part of answer Al-Si :
M1 Al-Si Nuclear charge increasing (1)
M2 Atomic radius decreasing (1)

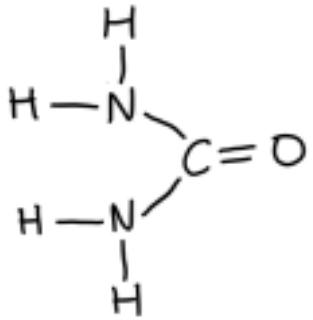
In second part of answer Al-Mg:
M3 Outer electron is lost form a different subshell/orbital (higher energy), 3p electron in Al and 3s electron in Mg (lower energy) (1)

In either part:
M4 Shielding mark:
Al-Si shielding of electron is similar
OR Al-Mg electron removed is more shielded (1)

M5 Attraction between electron and nucleus
Increases from Al-Si
OR Less in Al than Mg (1)</td><td>5</td></tr>
<tr><td>1(c)(ii)</td><td>Al^{2+}(g) $\rightarrow$ Al^{3+}(g) + e$^-$
equation without state symbols (1)
state symbols (1)</td><td>2</td></tr>
</table>

Question	Answer	Marks
1(c)(iii)	an array/lattice of Mg^{2+} ions (1) surrounded by <u>delocalised</u> electrons (1) <u>Attraction</u> between electrons and ions (1)	**3**
1(c)(iv)	Diagram of tetrahedral P_4  	**1**
1(c)(v)	(Strong Si-Si) covalent bonds (1) forming a giant lattice / structure (1) large amount of energy is required to break the bonds (1)	**3**
1(d)(i)	An allotrope is when an <u>element</u> exists in more than one structure in the same physical state	**1**
1(d)(ii)	$3O_2 \rightleftharpoons 2O_3$	**1**

Question	Answer	Marks
2(a)	The standard enthalpy change of formation is the energy change when one mole of a substance (1) is formed from its elements in their standard states (1)	**2**
2(b)	$\Delta_f H^\ominus$(products) – $\Delta_f H^\ominus$(reactants) = –285.8 –333.1 + 2 × 45.9 +393.5 (1) –133.6 (1)	**2**
2(c)	–133.6–23.1= –156.7	**1**
2(d)(i)	cause acid rain when mixed with rain water **OR** photochemical smog **OR** eye irritation **OR** respiratory problems	**1**

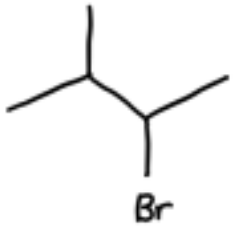
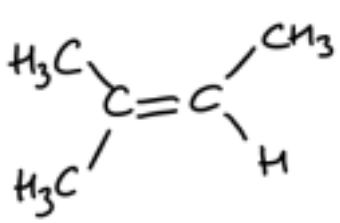
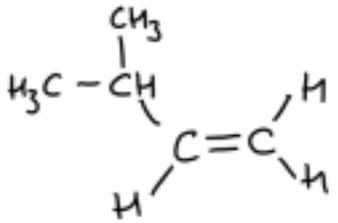
Question	Answer	Marks
2(d)(ii)	$4NH_3 + 6NO \rightarrow 5N_2 + 6H_2O$	**1**
2(d)(iii)	Urea is in the liquid state, which is easier to handle / store / transport than a gas	**1**
2(e)	Nitrogen is reduced and carbon is oxidised (1) Oxidation state changes are +2 to 0 for nitrogen **and** +2 to +4 for carbon (1)	**2**
2(f)		**1**
2(g)	The change in geometry is from linear to trigonal planar (1) The change in bond angle is from 180° to 120° (1)	**2**
2(h)(i)	$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$ Equation with equilibrium sign	**1**
2(h)(ii)	The ammonia molecule reacts with / accepts a H^+ ion / proton (from the water)	**1**

Question	Answer	Marks
3(a)	(2-)methylpropan-1-ol	**1**
3(b)(i)	$C_4H_{10}O + 6O_2 \rightarrow 4CO_2 + 5H_2O$	**1**

Question	Answer	Marks
3(b)(ii)	compound **Y** = 2668.3 / 4 = 667 kJ mol^{-1} **and** ethanol 1371.2 / 2 = 686 kJ mol^{-1} (1) both answers rounded to nearest kJ mol^{-1} (1)	**2**
3(b)(iii)	Less CO_2 is produced per kJ energy output and CO_2 is a greenhouse gas	**1**
3(c)(i)	By bombardment with high energy electrons	**1**
3(c)(ii)	The ions are accelerated	**1**
3(c)(iii)	Ions may collide (with the background gas)	**1**
3(c)(iv)	(After acceleration) all the ions have the same kinetic energy (1) ions have different speeds (1) lower mass ions arrive earlier (1)	**3**
3(d)(i)	75 is the molecular ion with one C-12 replaced by C-13	**1**
3(d)(ii)	$C_4H_{10}O^+(1) \rightarrow (CH_3)_2CH^+(1) + \bullet CH_2OH$ (1)	**3**

Question	Answer	Marks
4(a)	15	**1**
4(b)	There are no H atoms bonded to highly electronegative atoms such as F, O or N	**1**
4(c)(i)	showing all bond energies in the calculation (1) 488 (1)	**2**
4(c)(ii)	bond energy values are averages **OR** Bond energies are measured in the gas phase	**1**

Question	Answer	Marks
4(d)	(2)p orbitals to overlap sideways to form a π bond (1) (2)p orbitals overlap end-to-end to form a σ bond **AND** Less overlap (of p orbitals) forms a weaker bond (π bond) **OR** More overlap forms a stronger bond (σ bond) (1) M3 for sigma bond along intermolecular axis and pi bond above and below/parallel (1)	**3**
4(e)	Longest bond O_2^{2-} Strongest bond O_2	**1**
4(f)	92 kJ mol^{-1} = 92 × 10^3 / 6.02 × 10^{23} J (= 1.5282 × 10^{-19}) (1) f = E / h = 92 × 10^3 / (6.63 × 10^{-34} × 6.02 × 10^{23}) = 2.3 × 10^{14} Hz (1)	**2**
4(g)(i)	Number of moles O_2 = 550 / 24 = 22.9 mol (1) number of moles Na_2O_2 = 2 × 22.9 = 45.8 mol **AND** Na_2O_2 M_r = 23 × 2 + 16 × 2 = 46 + 32 = 78 (1) mass of Na_2O_2 = 45.8 × 78.0 g = 3.6 kg (1)	**3**
4(g)(ii)	32 / 244 × 100% = 13.1 %	**1**
4(g)(iii)	Li_2O_2 because it has a greater atom economy	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>5(a)</td><td> 
</td><td>1</td></tr>
<tr><td>5(b)</td><td>
<table>
<tr><th>Reaction</th><th>Substitution</th><th>Elimination</th><th>Functional group level changes</th></tr>
<tr><td>A</td><td>✓</td><td>×</td><td>×</td></tr>
<tr><td>B</td><td>✓</td><td>×</td><td>✓</td></tr>
<tr><td>C</td><td>✓</td><td>×</td><td>×</td></tr>
<tr><td>D</td><td>×</td><td>×</td><td>✓</td></tr>
<tr><td>E</td><td>×</td><td>✓</td><td>×</td></tr>
</table>
1 mark for each row correct</td><td>4</td></tr>
<tr><td>5(c)</td><td>(2-)methylbut-2-ene and 3-methylbut-(1)-ene
 

1 mark for each correct name and drawing</td><td>2</td></tr>
<tr><td>5(d)</td><td>$C_5H_{11}Br + HCN \rightarrow C_5H_{11}CN + HBr$</td><td>1</td></tr>
</table>

Question	Answer	Marks
5(e)(i)	An electron pair donor	**1**
5(e)(ii)	Lone pair on first N **and** curly arrow from lone pair to C atom (1) Dipole $C\delta^+$-$Br\delta^-$ **and** curly arrow from middle of C-Br bond to Br (1) – charge on intermediate Br **and** + charge on product H (1) + charge on intermediate N (1) Curly arrow from middle of N-H bond to N (1)	**5**
5(e)(iii)	The product amine will react with more reactant **X** to give other products	**1**
5(f)	PBr_3	**1**

Question	Answer	Marks
6(a)	Weigh 0.971 g K_2CrO_4 (into a beaker) (1) Add deionised / distilled water (less than 100 cm^3) and dissolve (1) Transfer to 100 cm^3 volumetric flask with washings (1) Make up to the line with deionised water and mix well (1)	**4**
6(b)	$Pb^{2+}(aq) + CrO_4^{2-}(aq) \rightarrow PbCrO_4(s)$	**1**
6(c)	Use chemically resistant gloves	**1**
6(d)	To ensure complete reaction (1) **and** To ensure uniform mixture (1)	**2**
6(e)	To remove unreacted K_2CrO_4 (which is in excess and soluble)	**1**
6(f)(i)	Plot all the points correctly (1) Suitable linear scale on y-axis using more than half of graph paper in and both axis labels present (1) Draw a smooth curve (1)	**3**
6(f)(ii)	66 ppb	**1**

Question	Answer	Marks
6(f)(iii)	Mass of 1 dm^3 water = 1000 g AND For 1.37 ppb, 1 dm^3 water requires $1.37 \times 10^{-9} \times 1000$ g Pb^{2+} ions (1) 1.37×10^{-6} g is $1.37 \times 10^{-6} / 207.2 = 6.61 \times 10^{-9}$ mol so the concentration is 6.61×10^{-9} mol dm^{-3} (1)	**2**
6(g)	The error is 3 ppb so as a percentage this is $3 / 68 \times 100$ % = 4.4%	**1**
6(h)	Add (dilute) acid (1) $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$ (1)	**2**