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Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	C		**1**

Question Number	Correct Answer	Reject	Mark
2	B		**1**

Question Number	Correct Answer	Reject	Mark
3	C		**1**

Question Number	Correct Answer	Reject	Mark
4	A		**1**

Question Number	Correct Answer	Reject	Mark
5	B		**1**

Question Number	Correct Answer	Reject	Mark
6	C		**1**

Question Number	Correct Answer	Reject	Mark
7	B		**1**

Question Number	Correct Answer	Reject	Mark
8	A		**1**

Question Number	Correct Answer	Reject	Mark
9	A		**1**

Question Number	Correct Answer	Reject	Mark
10	D		**1**

Question Number	Correct Answer	Reject	Mark
11	B		**1**

Question Number	Correct Answer	Reject	Mark
12	A		**1**

Question Number	Correct Answer	Reject	Mark
13	D		**1**

Question Number	Correct Answer	Reject	Mark
14	C		**1**

Question Number	Correct Answer	Reject	Mark
15	A		**1**

Question Number	Correct Answer	Reject	Mark
16	D		**1**

Question Number	Correct Answer	Reject	Mark
17	B		**1**

Question Number	Correct Answer	Reject	Mark
18	C		**1**

Question Number	Correct Answer	Reject	Mark
19	C		**1**

Question Number	Correct Answer	Reject	Mark
20	D		**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)	**First mark:** Mass of **an atom**/mass of **an isotope** (of an element) **(1)** IGNORE any references to average or (weighted) mean **Second mark:** relative to 1/12th the mass of a ^{12}C atom **(1)** NOTE: The second mark is awarded for **any mention of ^{12}C** IGNORE throughout the candidate's answer any references to 'moles' or '1 mol' or '12 g' Mark the two points independently	Mass of (all the) isotope**s** /atom**s** 'Mass of an element'	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	{(35 x 75.53) + (37 x 24.47)} ÷ 100 **(1)** = 35.4894 = 35.49 **(1)** **Answer to 4 s.f. only**. Correct answer no working **(2)** IGNORE units of any kind (e.g. 'g' 'g mol^{-1}' 'amu', etc.)		**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	$^{35}Cl_2^{+}$/(^{35}Cl —^{35}Cl)$^{+}$ **(1)** $^{37}Cl_2^{+}$/(^{37}Cl —^{37}Cl)$^{+}$ **(1)** ALLOW (^{35}Cl + ^{35}Cl)$^{+}$ and/or (^{37}Cl + ^{37}Cl)$^{+}$ OR (^{35}Cl^{35}Cl)$^{+}$ and/or (^{37}Cl^{37}Cl)$^{+}$ OR (^{35}Cl and ^{35}Cl)$^{+}$ and/or (^{37}Cl and ^{37}Cl)$^{+}$ If the 'formal' charge is omitted on either ion (or both the ions), then award **(1)** mark only. NOTE: $^{35}Cl^{+}$ $^{35}Cl^{+}$ and $^{37}Cl^{+}$ $^{37}Cl^{+}$ scores **(1)** as each ion has an extra + charge. 2$^{35}Cl^{+}$ and 2$^{37}Cl^{+}$ scores **(1)** Accept mass number written as superscript to right of symbol.	$^{70}Cl_2^{+}$ $^{74}Cl_2^{+}$ 2^{35}Cl and/or 2^{37}Cl scores **(0)**	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	**72** **(1)** ^{35}Cl —^{37}Cl$^{(+)}$ **(1)** ALLOW (^{35}Cl + ^{37}Cl)$^{(+)}$ and/or (^{37}Cl + ^{35}Cl)$^{(+)}$ OR (^{37}Cl^{35}Cl)$^{(+)}$ and/or (^{37}Cl^{35}Cl)$^{(+)}$ OR (^{35}Cl and ^{37}Cl)$^{(+)}$ and/or (^{37}Cl and ^{35}Cl)$^{(+)}$ NOTE: The + charge is not needed on **this ion** IGNORE extra + charges, so ALLOW $^{35}Cl^{+}$ $^{37}Cl^{+}$ and/or $^{37}Cl^{+}$ $^{35}Cl^{+}$		**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)	**First mark:-** Makes mention of energy/enthalpy/(heat) energy/heat (change) AND to remove an electron AND one mole/1 mol **Second mark:** Makes mention of **gaseous atom(s)** **ALTERNATIVE ANSWER** Energy change per mole for **(1)** $X(g) \rightarrow X^{+}(g) + e^{(-)}$ **(1)** Mark the two points independently IGNORE any references to standard conditions	"Energy **given out**..." for first mark **Just** 'gaseous element'/ 'gaseous substance'	**2**

Question Number	Acceptable Answers	Reject	Mark
***22(b)**	**Any two from three:-** (Atomic) radius increases/there are more shells/(outermost) electron further from the nucleus **(1)** there is '**more** shielding' or '**more** screening' (down group) **(1)** the nuclear attraction decreases OR attraction between nucleus and (outermost) electron decreases OR the increased shielding/increased distance outweighs the increased nuclear charge **(1)** IGNORE any references to 'more protons' and/just 'increasing nuclear charge' IGNORE references to "effective nuclear charge"	**Ionic** radius increases	**2**

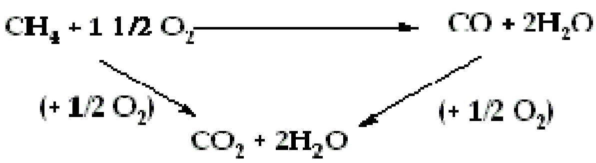
Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	**Any ONE from:** (Electrons are being removed from an) increasingly positive ion/ charge on the ion (successively) increases/ increasing proton : electron ratio/ same number of protons (attracting) fewer electrons / ions get smaller/ the electron repulsion decreases/ the shielding decreases/ electrons (being removed are) closer to the nucleus/ **effective** nuclear charge increases		**1**

Question Number	Acceptable Answers	Reject	Mark
***22(c)(ii)**	**First mark: <u>Two</u> jumps** **Two** (large) jumps (between 1st and 2nd and 9th and 10th IEs) **(1)** NOTE: A sketch graph with **two** (large) jumps can score this first mark Note if the jumps are specified, they must be between 1st and 2nd **and** 9th and 10th IEs **Second mark: Electronic configuration of Na** 2, 8, 1 mentioned in words, **annotated** on a sketch graph or drawn out in a diagram (e.g. electrons shown in orbits/shells around the centre of the atom) but NOT just inferred **(1)** ALLOW “1, 8, 2” OR $1s^22s^22p^63s^1$ Mark the two points independently	1st mark if the graph is sketched ‘back to front’	**2**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	Credit any of the following representations (but need **BOTH** Mg **AND** Al to be correct) Mg $1s^2 2s^2 2p^6 3s^2$ **and** Al $1s^2 2s^2 2p^6 3s^2 3p^1$ Mg $1s_2 2s_2 2p_6 3s_2$ **and** Al $1s_2 2s_2 2p_6 3s_2 3p_1$ Mg $1S^2 2S^2 2P^6 3S^2$ **and** Al $1S^2 2S^2 2P^6 3S^2 3P^1$ Mg $1S_2 2S_2 2P_6 3S_2$ **and** Al $1S_2 2S_2 2P_6 3S_2 3P_1$		**1**

Question Number	Acceptable Answers	Reject	Mark
***22(d)(ii)**	NOTE: ALLOW an argument focusing on **either** the Al **or** the Mg atom **EITHER** **In Al**, (3p) **electron** (lost is) at higher energy/more shielded (by 3s electrons)/further from the nucleus IGNORE any reference to an unpaired electron in Al **OR** **In Mg**, (3s) **electron** (lost is) at lower energy/less shielded/ nearer to the nucleus/from a **full subshell**/from a full orbital/from (stable) $(3)s^2$ Any reference to an Al atom being **larger** in size than an Mg atom scores zero overall.	Al has one more **shell** than Mg **Just** (lost from) a new sub-shell Electron lost in Mg from a "full **shell**"	**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)	The heat/enthalpy/energy change (for a reaction) is independent of the path(way)/route IGNORE any extra detail referring to "initial and final states"		**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	 CO_2 + **2**H_2O **(1)** Both arrows in correct direction downwards **(1)** IGNORE state symbols, even if incorrect Mark the two points independently		**2**

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	ΔH = − 890 −(− 283) **(1)** = − 607 (kJ mol^{-1}) **(1)** Correct answer with no working scores **(2)** NOTE: **+**607 (kJ mol^{-1}) scores **(1)** only		**2**

Question Number	Acceptable Answers	Reject	Mark
***23 (b) (iii)**	Cannot stop the reaction at CO OR the reaction produces CO_2/complete combustion occurs OR may produce some carbon/soot OR cannot react exact amounts of methane to oxygen	non-standard conditions **Just** incomplete combustion occurs **Just** forming 'other products' /**just** a 'mixture of products' **Just** methane is 'very reactive'/ 'explosive' **Just** heat loss Cannot measure the temperature change	**1**

Question Number	Acceptable Answers	Reject	Mark
23(c)	**First mark: State of the H_2O** Water is in the gas phase/water is (formed) as steam/water is not in its standard state/water is not (formed as a) liquid **(1)** **Second mark: Idea of an energy change when there is a change of state** Change of state involves an energy change /energy change (for the reaction given) is less exothermic **(1)** ALLOW 'more endothermic' instead of 'less exothermic' IGNORE references to non-standard conditions	Energy change is more exothermic /less endothermic Heat loss 'Incomplete combustion'	**2**

Question Number	Acceptable Answers	Reject	Mark
24(a)	C_nH_{2n} ALLOW letters other than *n*		**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)	A compound which contains (C=C) double bonds OR A compound that will undergo addition reactions OR Does not contain the maximum number of hydrogen atoms		**1**

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	*E*-3-ethylhex-2-ene **(2)** **(1)** mark for 3-ethylhex-2-ene **(1)** mark for '**E'** IGNORE any missing hyphens or any hyphens replaced by commas Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	The four atoms/four groups around the C=C double bond are different OR No two groups are the same OR There are no common groups on either side of the C=C double bond OR There are two alkyl groups on one of the carbon atoms (in the C=C double bond) OR There are three alkyl groups around the double bond OR An indication of the existence of Priority Rules (for E-Z nomenclature) OR One of the carbon atoms (of the C=C double bond) is not bonded to a hydrogen atom ALLOW 'functional groups' for 'groups'	Each side is not symmetrical	**1**

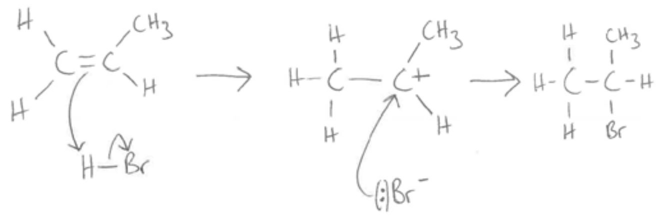
ALLOW displayed or skeletal formulae throughout 24(d)

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	CH_3CH_3 ALLOW displayed or skeletal formulae throughout 24(d)	C_2H_6	**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	$ClCH_2CH_2Cl$ / CH_2ClCH_2Cl	$C_2H_4Cl_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	$HOCH_2CH_2OH$ / CH_2OHCH_2OH	$C_2H_6O_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iv)	$HOCH_2CH_2Br$ / CH_2OHCH_2Br	$BrCH_2CH_2Br$; C_2H_5OBr; $C_2H_4Br_2$	**1**

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>24(e)</td><td>Major product route:

First mark:
Curly arrow from C=C to the H (in H-Br) AND curly arrow from the bond in H—Br to the Br (1)

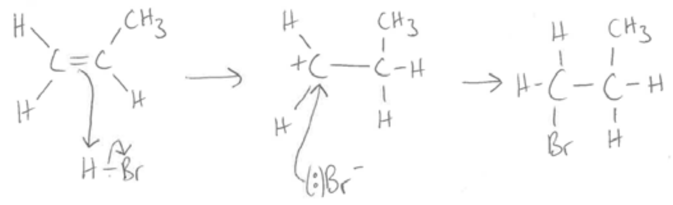
Second mark:
Structure of correct secondary carbocation (1)

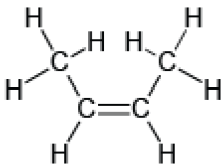
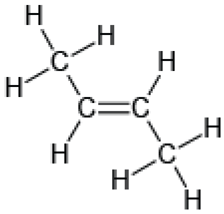
Third mark:
Curly arrow from anywhere on the bromide ion towards the C+ on the carbocation (1)

NOTE:
The bromide ion must have a full negative charge, but the lone pair of electrons on the Br^- NEED NOT be shown

Fourth mark:
Choice of 2-bromopropane as major product (1)

For showing the major product mechanism correctly (4)
both arrows (1)
carbocation intermediate (1)
attack by bromide ion (1)
(Bromide ion must show a full negative charge. The lone pair of electrons need not be shown)
choice of 2-bromopropane as major product (1)</td><td></td><td>4</td></tr>
</table>

	Single-headed arrows used throughout **max (3)** Minor product route **max (3)**  If the minor product route is shown, the last mark is lost, but the first three marks can be scored consequentially as follows:- • both arrows **(1)** • carbocation intermediate **(1)** • attack of bromide ion **(1)** (NOTE: The bromide ion must show a full negative charge. The lone pair of electrons need not be shown) NOTE: If a correct mechanism for the electrophilic addition of HBr to **ethene** is shown then max **(2)** (i.e. the first and the third marks in the mechanism)		

Question Number	Acceptable Answers	Reject	Mark
24(f)(i)	 **(1)**  **(1)** NOTE: CH_3 group does not have to be displayed. IGNORE if any connectivity is shown from the $\mathbf{H_3}$ in a C$\mathbf{H_3}$ group IGNORE bond angles ALLOW one mark for just but-2-ene's structural formula		**2**

Question Number	Acceptable Answers	Reject	Mark
24(f)(ii)	**Any ONE of:-** • No atoms lost (or gained) • No elements lost (or gained) • (Only) one product (is formed) • (Produced by) an addition reaction • Addition polymer(ization) • Polymer is a repeat of the monomer • No small molecules (formed) • No co-products • No waste products • Same C:H ratio • Same ratio of carbon:hydrogen atoms • Same ratio of each element • Same ratio of atoms	(Monomer and polymer have) '**same number** of carbon and hydrogen atoms'	**1**

Question Number	Acceptable Answers	Reject	Mark
24(f)(iii)	**100% AND** some correct justification is needed **ONE answer from:-** 100% as addition reaction 100% because all the atoms are incorporated into the polymer 100% because (only) one product is formed 100% because (only) one desired product is formed 100% because no atoms are lost 100% because no waste products 100% because no small molecules (formed) 100% as no co-products 100% as no by-products	Statements such as 'the atom economy is **almost** 100%' OR **Just** "it has a high atom economy"	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	Amount Na = 1.73 (g) ÷ 23 (g mol^{-1}) = 0.075(22) (mol) Amount O = 1.20 (g) ÷ 16 (g mol^{-1}) = 0.075 (mol) **(1)** IGNORE sf, even if 1 sf NaO **(1)** Correct answer no working **(2)** NOTE: Correct answer can be obtained via incorrect working and all responses should be read carefully e.g. Amount Na = 23 ÷ 1.73 = 13.3 Amount O = 16 ÷ 1.20 = 13.3 scores second mark only for NaO if obtained by incorrect working OR e.g. Use of atomic numbers gives the Na : O ratio as 0.157 : 0.150 and an empirical formula of NaO. This scores (1) overall (i.e. the 2nd mark). OR e.g Use of atomic number ONLY for Na (i.e. Na = 11) gives the Na : O ratio as 0.157 : 0.075 and an empirical formula of Na_2O. This scores (1) overall (i.e. the 2nd mark). NOTE: Use of **O** = 32 gives Na_2O and scores second mark	 Na_2O_2	**2**

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	(NaO = 39 hence molar mass twice that of NaO ∴) so $\mathbf{Na_2O_2}$	‘2NaO’	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	$2Na(s) + O_2(g) \rightarrow Na_2O_2(s)$ All species correct **(1)** State symbols and balancing **(1)** NOTE: 2nd mark is conditional on correct species. NOTE: $2Na(s) + O_2(g) \rightarrow 2NaO(s)$ scores **(1)** $Na(s) + O_2(g) \rightarrow NaO_2(s)$ scores **(1)** $4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$ scores **(2)**		**2**

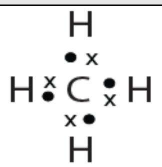
Question Number	Acceptable Answers	Reject	Mark
25(a)(iv)	Moles of O_2 = 0.075 ÷ 2 = 0.0375 OR 1.2 ÷ 32 = 0.0375 (mol) **(1)** 0.0375 mol x 24 dm^3 mol^{-1} = 0.9(0) (dm^3) **(1)** ALLOW 900 **cm^3 (units must be present here)** Correct answer no working **(2)** OR Moles of Na = 1.73 ÷ 23 = 0.075217 = moles of O Moles of O_2 = 0.075217 ÷ 2 = 0.0376085 0.0376085 x 24 = 0.903 (dm^3) or 903 **cm^3** IGNORE s.f., including ONE s.f. NOTE: If number of moles x 24 (dm^3 mol^{-1}) is clearly evident and correctly calculated in stated units, award second mark		**2**

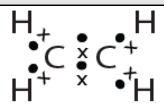
Question Number	Acceptable Answers	Reject	Mark
25(a)(v)	0.0375 x 6.02 x 10^{23} (= 2.2575 x 10^{22} (molecules)) = 2.26 x 10^{22} (molecules) IGNORE s.f. unless 1 s.f.		**1**

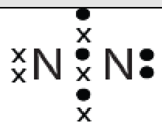
Question Number	Acceptable Answers	Reject	Mark
25(b)	Sodium might react with nitrogen in the air/sodium forms a nitride/ nitrogen (gas) is present in the air (which reacts with the sodium) OR sodium might form a different oxide (e.g. Na_2O or allow NaO_2) NOTE: If nitrogen / N_2 is mentioned as part of a 'list' of substances that can be present in air, award the mark	**Just** 'very reactive' OR 'very explosive' sodium forms Na_2O_2 alone References to hydrogen in the air **Just** 'reacts with other substances in the air' (as nitrogen not identified Sodium nitrate formation **Just** sodium hydroxide formation	**1**

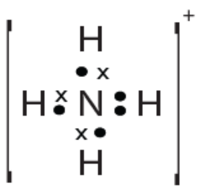
Question Number	Acceptable Answers	Reject	Mark
26(a)	(Electrostatic) attraction between (bonding) electrons and nuclei/protons	**Just** a 'shared pair of electrons'	**1**

- IGNORE ANY INNER SHELL ELECTRONS DRAWN
- ONLY THE TOTAL NUMBERS OF ELECTRONS IN OUTER SHELLS ARE BEING ASSESSED
- ALLOW ELECTRONS TO BE ALL DOTS OR ALL CROSSES OR BOTH

Question Number	Acceptable Answers	Reject	Mark
26(b)(i)			**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(ii)			**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(iii)	 NOTE: The lone pair of electrons on each N atom do not have to be shown as a pair		**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(iv)	 The **+** sign can be shown anywhere Ignore missing brackets Ignore if the **+** is missing		**1**

Question Number	Acceptable Answers	Reject	Mark
26(c)(i)	IGNORE any references to 'molecules' in this part only **First mark: Location of silicon's electrons** Silicon's (outer) electrons are fixed (in covalent bonds)/ silicon's (outer) electrons are in fixed positions (in covalent bonds)/ silicon's (outer) electrons are involved in bonding **(1)** **Second mark: Lack of mobility of silicon's electrons** (therefore) silicon's electrons are not free (to move)/ silicon has no free electrons/ there are no mobile electrons in silicon/ silicon has no delocalized electrons/ silicon's electrons cannot flow **(1)** IGNORE references to **lack of** ions	'Silicon is ionic' scores **(0)** for the question 'silicon's **ions** are not free to move' scores **(0)** for the question	**2**

Question Number	Acceptable Answers	Reject	Mark
26(c)(ii)	(The covalent) bonds are **strong** (throughout the lattice) **(1)** (therefore) a lot of **energy** is required to break the bonds / a lot of **energy** is needed to overcome the attractions **(1)** IGNORE any references to 'giant molecular'	'(simple) molecular silicon' **(0)** /'molecules of silicon' **(0)** /'silicon has ions' **(0)** /'intermolecular forces' / 'van der Waals' forces'/ 'London forces' **(0)** ALL THE ABOVE SCORE **(0)** OVERALL	**2**

TOTAL FOR SECTION B = 60 MARKS

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