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Mark Scheme (Results)
January 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.

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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.

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Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

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Question Number	Correct Answer	Reject	Mark
13(a)	C **(1)**		
13(b)	D **(1)**		**2**

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

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

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

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

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

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

TOTAL FOR SECTION A = 20 MARKS

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Section B

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	(Amount CO_2 = 0.0584 dm^3 ÷ 24 dm^3 mol^{-1}) = 0.0024333/2.4333 x 10^{-3} (mol) IGNORE sf except 1 No working needed Mark final answer	0.002/2 x 10^{-3} or any other value WRONG units with correct numerical answer scores (0)	**1**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	**First mark:** amount CO_2 = amount $NaHCO_3$ **OR** use of candidate's answer to (a)(i) stated (or implied by final answer given) **(1)** **Second mark:** ∴ mass $NaHCO_3$ = 0.0024333 (mol) **x 84** (g mol^{-1}) = 0.2044 (g) ALLOW **0.2 (g)** This mark is for evidence of multiplying their moles of $NaHCO_3$ **by 84** **(1)** IGNORE sf including 1 sf Correct answer with no working scores **(2)** ALLOW consequentially from (i).		**2**

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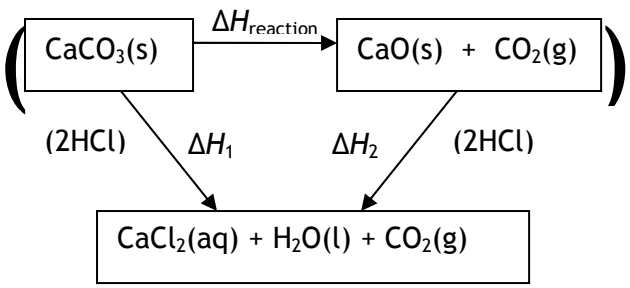
Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	**%** purity **=** (0.2044 g x 100) ÷ 0.227g = 90.04 **%** **(1)** = 90% **(1) (2 sf only)** ALLLOW consequentially from (i) and (ii) NOTE: The second mark to be awarded for 2sf answers less than a 100% (e.g. 10% scores **(1).** This is the percentage **impurity**) Correct answer with no working scores **(2)** Can score both marks via moles rather than masses	Answers not to 2 sf or answers incorrectly rounded up do not score 2nd mark Answers > 100% score **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	0.4 / 58.4 x 100 = (±) 0.68493(%) IGNORE sf (including 1 sf so (±) 0.7 (%) **is** OK here)	(±) 1.37 (%) etc., as the uncertainty should NOT be doubled Answers incorrectly rounded (e.g. 0.684 / 0.67 / 0.68492)	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	Any one of:- CO_2 dissolves /soluble (in water) CO_2 reacts (with water) / CO_2 forms carbonic acid / $CO_2 + H_2O \rightarrow H_2CO_3$ ALLOW CO_2 absorbed (by water) IGNORE suggestions to use a gas syringe	"CO_2 not the only gas given off" CO_2 diffuses/is lost/mixes with water "Water is also a product of the experiment" "Suck-back"	**1**

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Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ ALLOW multiples No other species to be allowed IGNORE state symbols even if incorrect	H_2CO_3 instead of "$H_2O + CO_2$" on right hand side of equation	**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	 **Mark each point independently** **First mark:** All three formulae in box, ignoring state symbols (even if incorrect) **This mark is stand alone, NOT to be marked CQ on answer to (a)(i)** **(1)** **Second mark:** Two arrows, BOTH pointing downwards **(1)** **Third mark:** Left hand arrow labelled as ΔH_1 **AND** right hand arrow labelled ΔH_2 (whatever the direction of the arrows) **(1)**	Any other formulae	**3**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	$(\Delta H_{reaction}) = \mathbf{\Delta H_1 - \Delta H_2}$ This is a stand alone answer NOT to be marked CQ on (a)(ii) and/or (a)(i)	Any other expression	**1**

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Question Number	Acceptable Answers	Reject	Mark
21(b)	**Any two from:** Heat /energy loss OR Heat /energy loss to surroundings OR Heat /energy loss to apparatus **(1)** Measured under non-standard conditions **(1)** Specific heat capacity of solutions is approximate **(1)** Density of solution assumed to be 1 g cm^{-3}/same as (pure) water **(1)** Large relative error in temperature measurement **(1)**	"Incomplete reaction" "Incomplete combustion" "Inaccuracy of equipment/apparatus" "Human error" CO_2 escapes Bond enthalpies Impurity of reactants Transfer losses Side-reactions	**2**

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Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	**The mark is for the idea of impact by high energy electrons** **Any ONE of:** High-energy electrons Bombard with electrons Fast electrons (fired at sample) Accelerated electrons (fired at sample) (High-energy) electrons fired (at sample) (Sample) blasted with electrons Electron gun ALLOW "beam of electrons" IGNORE any comments (correct or incorrect) re subsequent ionization of the sample	High-**density** electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	Electric field /electrostatic field / charged plates /voltage plates	**Positively-charged** plates /electronic field /electric current /(electro) magnetic field / electric coil	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	Magnetic field/magnet / electromagnet /magnetic plates/ electromagnetic field	**"Negative** magnetic field"/ negatively-charged magnet	**1**

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Question Number	Acceptable Answers	Reject	Mark
22(b)	(Molecular mass of a substance is) that of the molecular ion/parent ion OR (m/e value for) peak/ion of largest mass OR (m/e value for) peak/ion furthest to the right ALLOW "last peak"/"peak at the end"	Highest peak/ tallest peak/ comments about determination of relative atomic mass	**1**

Question Number	Acceptable Answers	Reject	Mark
22(c)	**Mark independently:** **First mark:** Any mention of (determination of) amount /mass/abundance of ^{14}**C** (in cloth) ALLOW Any mention of (determination of) concentration/content/percentage of ^{14}**C** (in cloth) **OR** find proportion of ^{12}**C : ^{14}C** (in cloth) **(1)** **Second mark:** Any mention of any one of the following:- (Use) half-life of ^{14}**C** / mention that amount of ^{14}**C** (in cloth) decreases (over time) / ^{14}**C** decays over time / comparison of amount of ^{14}**C** in living systems / comparison of amount of ^{14}**C** in modern materials / compare with ^{12}**C : ^{14}C** in living systems **(1)**	amount of ^{14}**C** (in cloth) increases (over time)	**2**

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Question Number	Acceptable Answers	Reject	Mark
***23(a)**	**ALLOW reverse arguments in each case** **Any three from:-** • **sodium atoms/sodium ions** are larger (than magnesium atoms/ions) **NOTE:** Allow symbols (eg Na or Na^+) **(1)** • sodium ions are Na^+ whereas magnesium ions are Mg^{2+} OR Na^+/sodium **ions** have smaller charge (density) than Mg^{2+}/ magnesium **ions** **(1)** **[NOTE:** It follows that the statement that "Na^+ ions are larger than Mg^{2+} ions" would score the first two scoring points above**]** • sodium has fewer **delocalized** electrons (than magnesium) **(1)** • attraction between the positive ions and (delocalized) electrons is weaker in sodium (than magnesium) **(1)** • sodium is not close-packed (but magnesium is close-packed) **(1)** • less energy needed (to break bonds) **(1)**	Attraction between **nucleus** and (delocalized) electrons Mention of **intermolecular forces/molecules** negates the energy mark **NOTE:** Arguments based on ionization energies **OR** suggestion of removal of outer shell electrons as part of the melting process scores **(0) overall**	**3**

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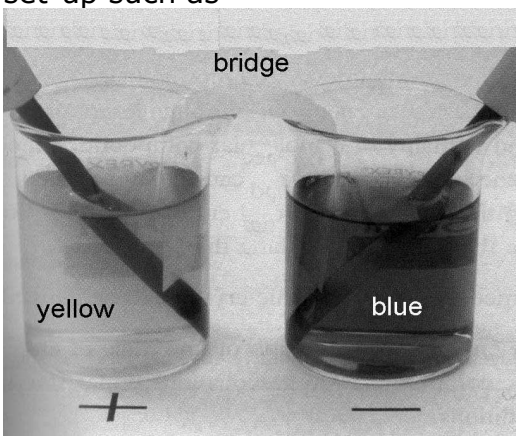
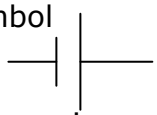
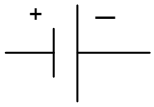
Question Number	Acceptable Answers	Reject	Mark
***23(b)**	**First mark:** Idea of (breaking) **covalent bonds** in silicon **(1)** **Second and third marks:** **ANY TWO FROM** • Silicon is **giant** covalent / giant atomic/giant molecular/ macromolecular/giant structure/giant lattice IGNORE just "giant" **(1)** • Phosphorus made up of simple molecules /small molecules/ P_4 molecules /phosphorus is molecular covalent /molecular/simple covalent IGNORE just "simple"/"simple structure" **(1)** • Between phosphorus molecules: weak forces/weak intermolecular forces/weak London forces/weak van der Waals' forces/weak dispersion forces/weak induced-dipole forces **(1)** **[ALLOW** "weak bonds" if implies between phosphorus **molecules]** • More energy needed (to break bonds in silicon) **(1)**	Intermolecular forces broken in silicon/ covalent bonds broken in phosphorus "silicon giant ionic"/"silicon giant metallic" Weak bonds between phosphorus **atoms**	**3**

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Question Number	Acceptable Answers	Reject	Mark
***23(c)**	**IGNORE any references to "energy" in this part of the question** Argon monatomic/argon (composed of) single atoms **NOTE:** This must be stated in words, not just by use of its symbol Ar IGNORE any comments about argon atoms having a full outer shell or argon being a noble gas IGNORE any comment about forces/bonds between argon particles	Any suggestion that argon is molecular Argon having a giant structure (of atoms)	**1**

Question Number	Acceptable Answers	Reject	Mark
***23(d)**	**First mark:** Mg has mobile electrons/delocalized electrons/free electrons/sea of electrons (to carry the charge) ALLOW Mg^{2+} instead of Mg or magnesium **(1)** **Second mark:** Sulfur's electrons are fixed (in covalent bonds)/sulfur's electrons are involved in bonding/sulfur's electrons are not free (to move)/no delocalized electrons in sulfur/no mobile electrons in sulfur **(1)**	Mg has free ions/Mg has mobile ions Sulfur has 'no free **ions**'/sulfur **has** delocalized electrons/just "sulfur has covalent bonds"/ just "sulfur is not a metal"	**2**

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Question Number	Acceptable Answers	Reject	Mark
24(a)	**First mark:** **Diagram** showing U-tube OR filter paper on a microscope slide OR electrodes in a beaker OR other feasible set-up such as  **but a + and a — sign must be shown somewhere on the diagram by signs or words, positive and negative.** **NOTES** If set-up in the picture above is used, in addition to the + and — signs a bridge between the two beakers must also be shown. External circuits do not have to be complete (e.g. wires can be shown attached to a slide, provided the **+** and **—** labels included). **If** the words cathode and/or anode are included, for the first mark to be awarded the cathode must be shown as —ve and/or the anode as +ve **If** a battery symbol  shown, IGNORE any incorrect polarities, that is  **IGNORE** any electrode materials **EXCEPT** Cu^{2+} and/or CrO_4^{2-} **(1)**		4

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	Second mark: Description to include the idea that the **ions move**/**ions** are **mobile**/**ions migrate** **MUST BE IN WORDS** ALLOW if description focuses on the movement of one of the ions to the oppositely-charged electrode **(1)** **Third mark:** Yellow ion/yellow (colour)/CrO_4^{2-} moves towards the/+ve (electrode)/ anode **(1)** **Fourth mark:** Blue ion/blue (colour)/Cu^{2+} moves towards cathode /—ve (electrode) **(1)** Mark CQ on candidate's cathode and anode signs for the **3rd** and **4th** marks	**Just** ions are attracted to the electrodes of opposite charge	

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	(Forces of attraction between) oppositely-charged ions/positive and negative ions/cations and anions IGNORE comments about electron transfer	Just ionic bonds/ Just "electrostatic forces of attraction"	**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	**First mark:** Ions of the same charge (repel)/ positive ions (repel)/negative ions (repel) **(1)** **Second mark:** Nuclei (of the ions repel) ALLOW 'protons' (in the ions repel) OR Electron clouds OR electrons (in the ions repel) **(1)**	"**Magnetic** repulsion" negates first mark "Electrons repel nuclei"	**2**

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Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	$Mg^{2+}(g)$ **(1)** O^{2-} (g) **(1)** Penalise missing /incorrect state symbols once only Max 1 if include "$2e^-$"		**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	(**A** is enthalpy change of) **formation** (of MgO) **(1)** ALLOW just "ΔH_f" ALLOW (enthalpy change of) combustion **of magnesium** (**C** is) (sum of) first plus second ionization energies (of Mg) / $IE_1 + IE_2$ (for Mg) **(1)** ALLOW "first and second ionization energies (of Mg)" IGNORE references to "standard"	"(enthalpy change of) **reaction**" Just "ionization energy"/ "second ionization energy" (of Mg)	**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(iii)	(**F** =) A – B – C – D – E NOTE: These letters may be in any order, but the signs MUST be correct ALLOW answers when the enthalpy changes are identified correctly in words or symbols in lieu of the letters		**1**

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Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	**First mark:** **Mg^{2+} AND O^{2-}** higher charge / **Mg^{2+} AND O^{2-}** higher charge density (than Mg^{+} and O^{-}) NOTE: **both** ions needed **(1)** **Second mark:** Mg^{2+} smaller (than Mg^{+}) **(1)** IGNORE comparisons of the relative sizes of O^{-} with O^{2-} even if INCORRECT IGNORE any references to polarization (of ions) and/or covalent character	Any mention of 'intermolecular forces' scores **(0)** overall for this question	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	(Lattice energy of $Mg^{2+}O^{2-}$ is) more exothermic/more negative ALLOW greater/increased/higher/ more/larger/bigger IGNORE "stronger lattice"	"energy **required**" OR Lower/less/ smaller	**1**

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N.B. Throughout, ALLOW C_2H_6 for CH_3CH_3 and C_2H_5Cl for CH_3CH_2Cl and $C_2H_5\bullet$ for $CH_3CH_2\bullet$ and C_4H_{10} for $CH_3CH_2CH_2CH_3$ etc

If CH_4 used instead of CH_3CH_3 max (1) mark overall for (a)(i) and (a)(ii) taken together
Then mark (a)(iii) and (a)(iv) CQ as for CH_4

IGNORE positions of the dots in free radicals; dots must be shown in each radical

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	$CH_3CH_3 + Cl\cdot \rightarrow CH_3CH_2\cdot + HCl$ OR $CH_3CH_2\cdot + Cl_2 \rightarrow CH_3CH_2Cl + Cl\cdot$		**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	$CH_3CH_2\cdot + Cl_2 \rightarrow CH_3CH_2Cl + Cl\cdot$ OR $CH_3CH_3 + Cl\cdot \rightarrow CH_3CH_2\cdot + HCl$ N.B. different answers for (i) and (ii) needed		**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	$2CH_3CH_2\cdot \rightarrow CH_3CH_2CH_2CH_3$ OR $CH_3CH_2\cdot + Cl\cdot \rightarrow CH_3CH_2Cl$	$Cl\cdot + Cl\cdot \rightarrow Cl_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iv)	$CH_3CH_2\cdot + Cl\cdot \rightarrow CH_3CH_2Cl$ OR $2CH_3CH_2\cdot \rightarrow CH_3CH_2CH_2CH_3$ N.B. different answers for (iii) and (iv) needed		**1**

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Question Number	Acceptable Answers	Reject	Mark
25(b)	**First mark:** Structural formula (enough to see the structure) **of any polyhalogenated ethane derivative** OR **any polyhalogenated methane derivative** ALLOW correct displayed or skeletal formula **(1)** **Second mark:** If first mark awarded the name must be consequentially correct IGNORE any missing or incorrect numbering in name (e.g. "dichloroethane" scores the mark) IGNORE missing or incorrect hyphens If first mark NOT awarded then only ALLOW correct name **of any polyhalogenated ethane or polyhalogenated methane derivative** **(1)**	Butane /C_4H_{10} / $CH_3CH_2CH_2CH_3$ / chlorobutane / hexane / chloromethane	**2**

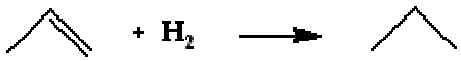
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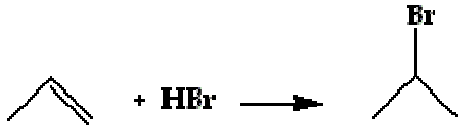
Question Number	Acceptable Answers	Reject	Mark
25(c)(i)	**1st mark for HAZARD:** This mark is for the idea of: (substance or procedure that) can cause harm/may cause harm/has the potential to do harm/can be dangerous ALLOW references to specific hazards such as toxic/flammable /harmful/ irritant /corrosive /oxidizing/ carcinogenic for the mark **(1)** **2nd mark for RISK:** This mark is for the idea of likelihood/probability/chance that harm will result (from the use of a substance or a procedure) **(1)**	**Just** "causes harm"/**just** "is a danger"	**2**

Question Number	Acceptable Answers	Reject	Mark
25(c)(ii)	fume cupboard OR gloves OR **u.v.** goggles	**Just** 'open windows'/**Just** well-ventilated lab/**Just** 'gas mask'/**Just** "use of smaller quantities"/closed system/closed experiment	**1**

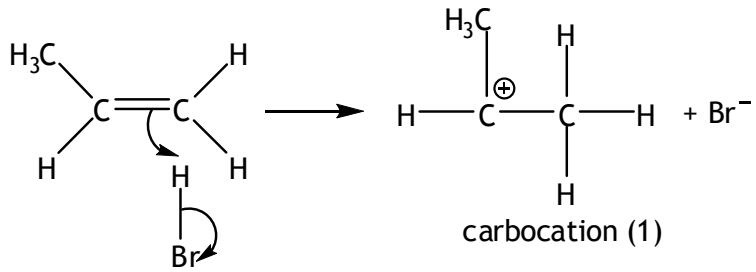
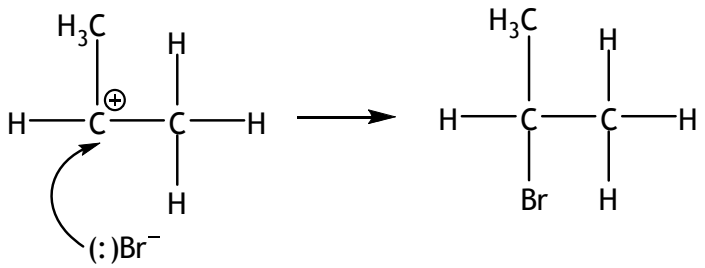
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Question Number	Acceptable Answers	Reject	Mark
26(a)	(C_nH_{2n} could be a) ring / cyclic (compound) ALLOW identification of any specific cyclic compound (e.g. cyclohexane) IGNORE any reference to "fewer hydrogen atoms"		**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(i)	 All must be correct for the mark		**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(ii)	 **First mark:-** An equation with the reactants shown correctly and EITHER 2-bromopropane OR 1-bromopropane shown as the product NOTE: The C-Br bond MUST be shown in the skeletal formula for the first mark **(1)** **Second mark (stand alone, even if no equation attempted or left-hand side of equation incorrect):-** Correct skeletal formula of **2-bromopropane** **(1)** Penalise lack of skeletal formulae once only in (b)(i) and (b)(ii) when taken together		**2**

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Question Number	Acceptable Answers	Reject	Mark
26(c)	 both arrows (1) carbocation (1)  attack of bromide ion (1) **First mark:** Curly arrow from C=C to H (in H-Br) **AND** curly arrow from bond in H-Br to the Br IGNORE polarity of HBr even if incorrect **(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 **NOTE:** The bromide ion must have a full negative charge, but the lone pair of electrons on the Br^- NEED NOT be shown **NOTE:** A correct mechanism leading to the formation of 1-bromopropane scores the **first** and **third** marks only (so max **(2)**) Skeletal formulae can be used	**Full** + and - charges on HBr Extra / spare bond dangling from the C+ carbon δ^- on bromide ion instead of Br^-	3

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	If but-2-ene is the starting alkene, only 3rd mark can be awarded If but-1-ene is the starting alkene, 2nd and 3rd marks can be awarded ***If single-headed arrows used throughout but all else correct, then max (2) can be awarded for mechanism***		

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

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