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Mark Scheme (Results)

Summer 2016

Pearson Edexcel GCE
in 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. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

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	B		(1)

Question Number	Correct Answer	Reject	Mark
2	C		(1)

Question Number	Correct Answer	Reject	Mark
3	D		(1)

Question Number	Correct Answer	Reject	Mark
4	D		(1)

Question Number	Correct Answer	Reject	Mark
5	B		(1)

Question Number	Correct Answer	Reject	Mark
6	B		(1)

Question Number	Correct Answer	Reject	Mark
7	B		(1)

Question Number	Correct Answer	Reject	Mark
8a	A		(1)

Question Number	Correct Answer	Reject	Mark
8b	B		(1)

Question Number	Correct Answer	Reject	Mark
8c	D		(1)

Question Number	Correct Answer	Reject	Mark
9	D		(1)

Question Number	Correct Answer	Reject	Mark
10	A		(1)

Question Number	Correct Answer	Reject	Mark
11	A		(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	D		(1)

Question Number	Correct Answer	Reject	Mark
16a	C		(1)

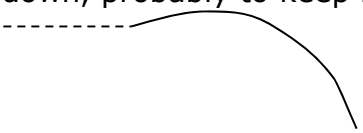
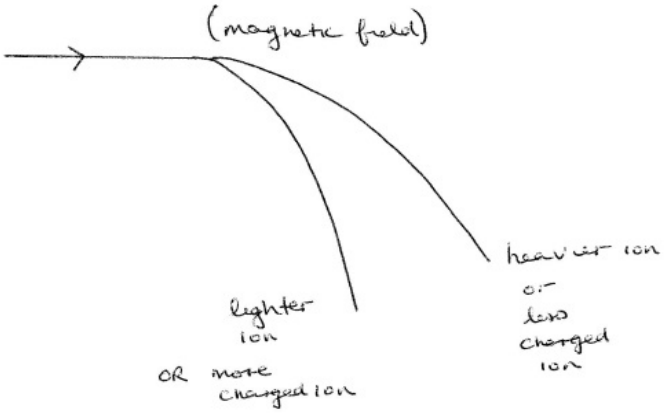
Question Number	Correct Answer	Reject	Mark
16b	C		(1)

Question Number	Correct Answer	Reject	Mark
17	B		(1)

Section B

Question Number	Acceptable Answers	Reject	Mark
18a(i)	Any two of O^+, O^{2+}, O_2^+, O_2^{2+} (1) for each correct ion ALLOW $^{16}O^+$, $^{16}O^{2+}$, $(^{16}O)_2^+$, $(^{16}O)_2^{2+}$ $^{16}O_2^+$, $^{16}O_2^{2+}$ $O=O^+$/ $O=O^{2+}$ for O_2 ions Added mass numbers which describe a diatomic ion eg $^{32}O_2^+$ Added round or square brackets	O^- O^{2-} Ions of O_3 Incorrect mass numbers eg $^{32}O^+$ Added incorrect atomic numbers Eg $^{16}_{9}O^+$	(2)

Question Number	Acceptable Answers	Reject	Mark
18a(ii)	The magnetic field/ electromagnet/ electromagnetic field OR Deflection by magnetic field ALLOW Deflection and magnetic field	Gravitational field Just deflector/deflection Electric field Vacuum and magnetic field Detector/ detection	(1)

Question Number	Acceptable Answers	Reject	Mark
18a(iii)	Two curved lines going towards the detector region with at least one hitting the detector ALLOW Section of straight line before curve starts if magnetic field position is not shown Line may go up very slightly before it curves down, probably to keep it clear of lower line. ---------  (1) Labelling of paths depends on ions chosen: Heavier ion shown as less deflected OR O^{2+} more deflected than O_2^+ OR Ion with lower charge shown as less deflected ALLOW Ions with negative charges (as already penalised in (i)) (1) If chosen ions are O^+ and O_2^{2+} they will not be separated – answer must make this clear 	Straight lines Curvature away from detector/ concave curvature Line turning back upwards Species which are not ions of oxygen	(2)

Question Number	Acceptable Answers	Reject	Mark
18(b)	Look at final answer 16.004 scores (2) 16.00445 scores (1) Correct expression with incorrect final answer scores (1) (16x99.759 + 17x0.037 + 18x0.204)/100 OR (16x0.99759 + 17x0.00037 + 18x0.00204) (1) =16.00445 =16.004 (1) Ignore units	 16.005	(2)

Question Number	Acceptable Answers	Reject	Mark
18(c)	Isotopic composition of oxygen in air varies ALLOW The abundance of the isotopes of oxygen varies OR Oxygen standard was introduced before existence of oxygen isotopes was known OR Some scientists used a standard based on one isotope while others used a value based on mixture in natural abundance OR The answer is inaccurate unless a specified isotope is used OR 12C standard used because there are many 12C compounds which can be used to calibrate the mass spectrometer ALLOW It was difficult to obtain pure oxygen from air.	Air contains other gases Air contains many isotopes Oxygen has many isotopes Just '12C standard is better' 12C standard gives a whole number	(1)

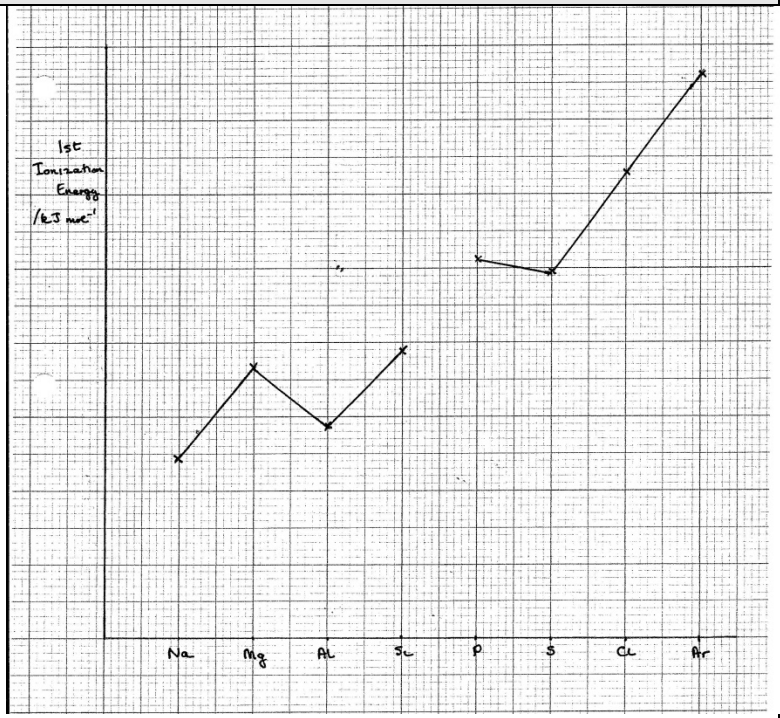
Question Number	Acceptable Answers	Reject	Mark
18(d)	No difference as both isotopes have the same number of protons (and electrons)/ the same nuclear charge IGNORE Same electronic configuration OR No difference as only number of neutrons is different		(1)

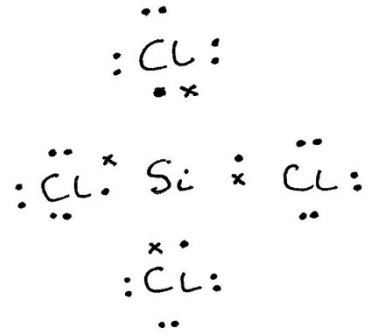
(Total for Question 18 = 9 marks)

Question Number	Acceptable Answers	Reject	Mark
19(a)	$Mg(g) \rightarrow Mg^{+}(g) + e^{(-)}$ ALLOW $Mg(g) - e^{(-)} \rightarrow Mg^{+}(g)$ Loss of electron to form Mg^{+} (1) IGNORE (g) sign on electron State symbols ALLOW Provided the equation involves magnesium, even if electron is added to the wrong side. (1)	Formation of Mg^{2+}	(2)

Question Number	Acceptable Answers	Reject	Mark
19(b)	$(1s^2)\ 2s^2 2p^6\ 3s^2 3p^1$ ALLOW Capital s and/or p, subscripts $2p_x^2\ 2p_y^2\ 2p_z^2\ 3p_x^1$ $3p_y^1$ / $3p_z^1$ for $3p_x^1$		(1)

Question Number	Acceptable Answers	Reject	Mark
* 19(c)(i)	MP1 Mg to Al: Electron removed from Al is from a higher energy level (3p rather than 3s) ALLOW Electron removed in Al is (more) shielded (by 3s) IGNORE Outer electron is further from nucleus Full sub-shell is more stable than part filled sub-shell (1) MP2 Al to Si: Si has one more proton than Al/ has greater nuclear charge, and electrons removed in both cases are 3p / same sub-shell / are equally shielded (1) MP3 EITHER The attraction of the extra proton in Al is less than the effect of the higher energy level/ the shielding OR Electron removed from Si is closer to nucleus (than Al) ALLOW Silicon is smaller in size (1)		(3)

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	 MP1 S does not follow trend (P is above Si followed by dip in graph from P to S rising again to Cl and Ar) (1) MP2 S has one (3)p orbital which has two electrons/ paired electrons/ is fully occupied OR S has $3p_x^2$, $3p_y^1$, $3p_z^1$ OR Electron in box diagram for S ALLOW S has a pair of electrons in the (3)p subshell (1) MP3 A paired electron is easier to remove OR paired electrons repel each other ALLOW half filled sub-shell (in P) is stable (1)	Just "S has $3p^4$" d orbital P has a half filled orbital	(3)

Question Number	Acceptable Answers	Reject	Mark
19(d)	Four x round Si sharing one ● with each Cl (1) Seven ● round each Cl sharing one x with each Si (1)  ALLOW Reversed symbols		(2)

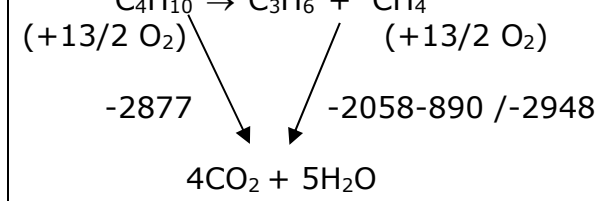
Question Number	Acceptable Answers	Reject	Mark
* 19(e)(i)	MP1 I^- / anion becomes distorted / not spherical. May be shown in a diagram (1) MP2 Mg^{2+} has high(er) charge and small(er) radius/ Mg^{2+} has high charge density (1) MP3 Bonding in magnesium iodide has some covalent character OR Orbitals of Mg^{2+} and I^- overlap/ Mg^{2+} shares some of the I^- electrons OR Mg^{2+} and I^- ions are not completely separate (1)	Iodine becomes distorted Just "electrons in outer shell are attracted" Atoms of Mg have a small (atomic) radius	(3)

Question Number	Acceptable Answers	Reject	Mark
19(e)(ii)	Experimental/ Born Haber cycle and theoretical/ calculated lattice energies are different OR Experimental/ Born Haber cycle lattice energy is more exothermic/ more negative than theoretical/ calculated lattice energy ALLOW Greater for more negative IGNORE Comments about melting temperature	Just "Compare Experimental/ Born Haber cycle and theoretical/ calculated lattice energies" Use of electron density map	(1)

(Total for Question 19 = 15 marks)

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	(Different) boiling temperatures/ boiling points ALLOW Range of boiling temperatures		(1)

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	Cracking: breaking of carbon chain (in a hydrocarbon/ alkane) to give shorter chain hydrocarbon(s)/ smaller molecules OR breaking a hydrocarbon/ alkane to give smaller molecules OR Breaking an alkane to give an alkene and (a smaller) alkane/ hydrogen (1) Reforming: converting straight chain to a (more) branched chain/ ring/ arene / aromatic compound ALLOW Specific examples (1) IGNORE Makes more useful compounds Converting low octane (fuels) into high octane (fuels)	Just "Breaking a hydrocarbon" Just "Breaking a molecule" Breaking a hydrocarbon to form branched chains or ring structures	(2)

Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	Look at final answer: + 71 (kJ mol^{-1}) scores 3 marks -71/ 71 (kJ mol^{-1}) scores 2 marks -5825 (kJ mol^{-1}) scores 1 mark Method:  MP1 Labelled cycle OR use of $\Delta H = \Sigma\Delta H_{combustion}$ reactants - $\Sigma\Delta H_{combustion}$ products (1) MP2 ΔH = (-2877 -(-2058+ (-890)) (1) MP3 =+ 71 (kJ mol^{-1}) (1)	Incorrect units	(3)

Question Number	Acceptable Answers	Reject	Mark
20(a)(iv)	$C_4H_{10} \rightarrow C_2H_6 + C_2H_4$ OR $C_4H_{10} \rightarrow C_4H_8 + H_2$ OR $C_4H_{10} \rightarrow 2C_2H_4 + H_2$ ALLOW Breakdown of multiple butanes Ignore state symbols, even if incorrect	$C_4H_{10} \rightarrow C_3H_6 + CH_4$ Charged products eg $C_2H_5^+$ Free radicals eg $C_2H_5^{\bullet}$	(1)

Question Number	Acceptable Answers	Reject	Mark
20b(i)	Look at final answer: -2050 (kJ mol^{-1}) or anything correctly rounded from –2046.528 (-2047, -2046.5, -2046.53) scores 3 marks +2050/ 2050 (kJ mol^{-1}) scores 2 marks Incorrect rounding scores 2 marks Correct value without sign scores 2 marks Energy transferred = (200 x 4.18 x 34.0) =28424 (J) IGNORE Sign if given (1) Mol pentane =(1.0/72) = 0.01389 / 0.0139 (1) ΔH = – (-28424 ÷ (1/72 x 1000)) = –2046.528 (kJ mol^{-1}) ALLOW TE from MP 1 and 2 provided moles of pentane is not taken as 1 (1) NOTE Use of 0.0139 mol gives -2044.9 (kJ mol^{-1}) giving 3 marks Use of 0.0138 mol gives -2059.7 (kJ mol^{-1}) giving 2 marks Use of 0.014 mol gives -2030.29 (kJ mol^{-1}) giving 2 marks Ignore SF except one or two		(3)

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	Incomplete combustion OR Loss of pentane by evaporation ALLOW Volume of water too large to heat evenly Water not stirred evenly Small change in mass inaccurate Heat capacity of /energy needed to heat calorimeter not included	Incomplete reaction Loss of water by evaporation Heat losses Conditions not standard Measuring errors Pentane impure	(1)

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	Pentane is very volatile/ has low boiling temperature so risk of explosion OR Has high flammability IGNORE Reaction is very exothermic	 Just "it is flammable" Vapour is toxic Combustion products/ CO toxic	(1)

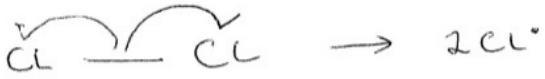
Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ Allow multiples Ignore state symbols even if incorrect		(1)

Question Number	Acceptable Answers	Reject	Mark
20(c)(ii)	Bonds broken are four C-C twelve C-H eight O=O (1) Bonds made are ten C=O twelve O-H (1) ALLOW TE from (c)(i) If all five bonds are named but formulae not given eg oxygen-oxygen bonds, max 1 If all five bonds are correctly identified by formula but numbers are incorrect or missing, max 1	O-O single bonds C-O single bonds	(2)

Question Number	Acceptable Answers	Reject	Mark
20(c)(iii)	The (total) bond energy of the bonds formed is greater than the bond energy of the bonds broken OR Energy released forming new bonds > energy needed to break old bonds OR The sum of the bond energies of the products is greater than the sum of the bond energies of the reactants.	Just"more bonds are made than broken" Answers referring to energy needed to make bonds Energy contained by bonds in reactants> energy contained by bonds in products	(1)

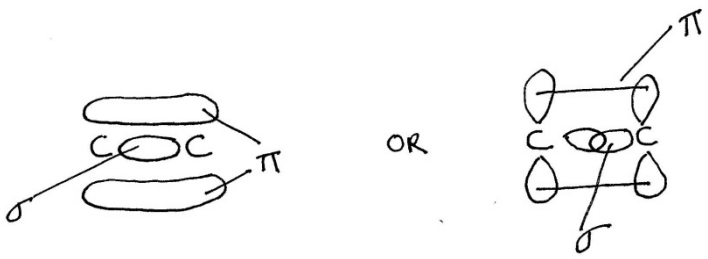
(Total for question 20 = 16 marks)

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	Species/ atom/ molecule/ particle with an unpaired electron ALLOW An element with an unpaired electron IGNORE Reference to neutral species /lack of charge	Just "with a single electron" A lone electron Charged particle with an unpaired electron	(1)

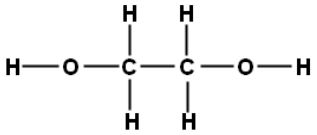
Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	 Half arrows going from bond to Cl or just beyond and product 2Cl• / Cl• + Cl•	Cl without •	(1)

Question Number	Acceptable Answers	Reject	Mark
21a(iii)	$C_2H_6 + Cl• \rightarrow C_2H_5• + HCl$ ALLOW Structural formulae e.g. CH_3CH_3 OR displayed IGNORE Production of C_2H_5Cl from $C_2H_5•$ if first step is correct (1) Propagation (1) The second mark is independent of the first	$C_2H_5^+$	(2)

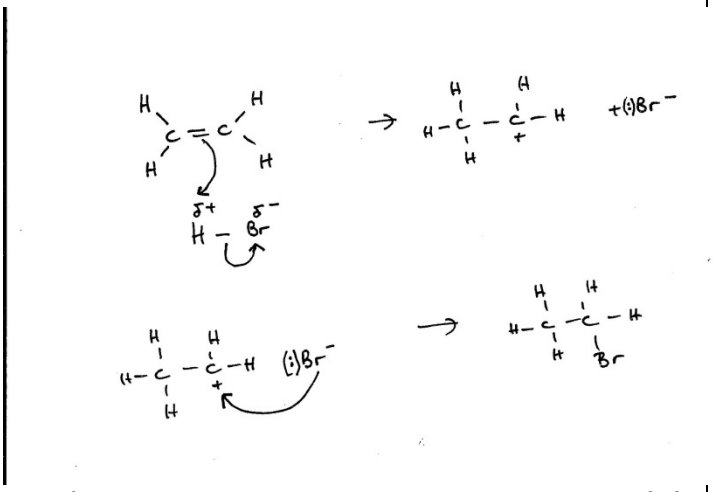
Question Number	Acceptable Answers	Reject	Mark
21a(iv)	$C_2H_5\bullet + C_2H_5\bullet \rightarrow C_4H_{10}$ ALLOW Structural formulae e.g. $CH_3CH_2\bullet$ /$\bullet CH_3CH_2$ OR displayed IGNORE $Cl\bullet + Cl\bullet \rightarrow Cl_2$	Methyl or propyl radicals	(1)

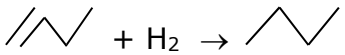
Question Number	Acceptable Answers	Reject	Mark
21b(i)	 σ bond between C atoms shown as 2 overlapping orbitals/ one electron cloud/ single bond (1) π bond above and below σ bond shown as two electron clouds/ overlapping p orbitals/ p orbitals linked by a line / a curved line above and below single bond (1) Both bonds must be labelled for 2 marks.		(2)

Question Number	Acceptable Answers	Reject	Mark
* 21b(ii)	MP1 σ bond remains ALLOW The product contains σ bonds only (1) MP2 π bonds break because they are weaker (than σ bonds) ALLOW π bonds break because σ bonds are stronger (1) MP3 Breaking the π bond results in carbocation intermediate / positively charged carbon forming OR π orbital overlap is lateral/ sideways /between parallel orbitals (making π bonds break/ weak) OR The σ bonds are much stronger (than the π bond) because of more effective (orbital) overlap (1)		(3)

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	From: Purple/ pink (solution) To: colourless (1)  (1) Any orientation Don't penalise undisplayed OH Don't penalise bonds going to middle of undisplayed OH	To brown Molecular/ structural/ skeletal formulae C bonded to H of OH	(2)

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Second mark depends on use of bromine/ solution of bromine for test. EITHER Test: add bromine water / $Br_2(aq)$ ALLOW Add bromine in organic solvent/ bromine dissolved in hexane/ bromine in 1,1,1-trichloroethane (1) From: brown/ red-brown/orange/ yellow To: colourless (1) OR Add bromine / Br_2 (1) From: brown/ red-brown To: colourless (1)		(2)

Question Number	Acceptable Answers	Reject	Mark
21(b)(v)	 Dipole on HBr (1) Curly arrow from C=C double bond to $H^{\delta+}$ of HBr and curly arrow from H-Br bond to Br (1) Correct intermediate with + charge (1) Curly arrow from Br^- to C^+ and formula of product ALLOW Curly arrow from anywhere on Br, including the – sign or lone pair (which is optional) (1)	Half arrows	(4)

Question Number	Acceptable Answers	Reject	Mark
21(c)	 (1) Suitable catalyst nickel/ platinum/ palladium (1) Ignore references to temperature, pressure, uv light	Use of H, H^+ Zeolite catalyst	(2)

(Total for Question 21 = 20 marks)

TOTAL FOR PAPER = 80 MARKS

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