Mark Scheme (Results)

Summer 2016

Pearson Edexcel
International Advanced Level
in Chemistry (WCH01) 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.

WCH01 June 2016 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	A		**(1)**

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

Question Number	Correct Answer	Reject	Mark
5	C		**(1)**

Question Number	Correct Answer	Reject	Mark
6	B		**(1)**

Question Number	Correct Answer	Reject	Mark
7	D		**(1)**

Question Number	Correct Answer	Reject	Mark
8a	D		**(1)**

Question Number	Correct Answer	Reject	Mark
8b	D		**(1)**

Question Number	Correct Answer	Reject	Mark
8c	B		**(1)**

Question Number	Correct Answer	Reject	Mark
8d	C		**(1)**

Question Number	Correct Answer	Reject	Mark
8e	C		**(1)**

Question Number	Correct Answer	Reject	Mark
9	C		**(1)**

Question Number	Correct Answer	Reject	Mark
10	B		**(1)**

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

Question Number	Correct Answer	Reject	Mark
12	C		**(1)**

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

Question Number	Correct Answer	Reject	Mark
14	A		**(1)**

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

Question Number	Correct Answer	Reject	Mark
16	B		**(1)**

(Total for Section A = 20 marks)

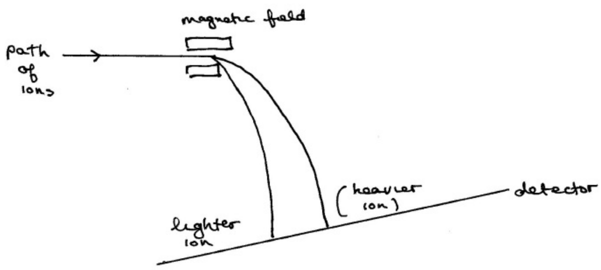
Section B

Question Number	Acceptable Answers	Reject	Mark
17(a)	Atoms of the **same** element / atomic number / proton number **and different** mass number / neutron number / nucleon number ALLOW Elements / they / isotopes have the same atomic number …etc Atomic mass for mass number IGNORE references to electrons	Molecule for atom Atomic mass number	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	High energy/fast moving/high speed electrons hit atoms/molecules/elements/sample (and knock electrons out.) ALLOW (Use) an electron gun/beam/stream Bombard with electrons IGNORE References to ionizing / forming (positive) ions Just an equation, e.g., $M(g) \rightarrow M^{+}(g) + e$		**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	$M(g) + e^- \rightarrow M^+(g) + 2e^-$ ALLOW $M(g) \rightarrow M^+(g) + e^-$ $M(g) - e^- \rightarrow M^+(g)$ ALLOW Use of $Mg^+(g)$ for $M^+(g)$ IGNORE omission of minus sign on electron state symbol on electron Rewritten M(g) on LHS Leading '1' before any charges e.g. $M(g)^{1+}$		**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	(With an) electric field / (negatively) charged plates (with slits in them) ALLOW Oppositely/alternatively charged plates IGNORE Electric plates	(Electro)magnetic field Positively charged plates Charged slits	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(iv)	Curved path showing lighter ion deflected more  ALLOW dotted line additional parallel path entering the magnet with correct deflection lines that do not reach but would extrapolate to detector on left of original beam	Straight line Lines originating from the magnet Lines deflected before passing through the magnet Lines which would not hit the detector	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(c)	$\dfrac{((28 \times 92.17) + (29 \times 4.71) + (30 \times 3.12))}{100}$ (1) (= 28.1095) = **28.11** (1) Final answer without working scores (2) IGNORE units	Answers not to 4sf (second mark)	**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(d)	**MP2 cannot be awarded without any attempt to do a calculation for MP1** **MP1** (6x12 + 12x1.0079) = 84.0948 OR (5x12 + 8x1.0079 + 15.9949) = 84.0581 (1) **MP2** So mass matches for C_5H_8O / doesn't match for C_6H_{12} (1) OR **MP1** Mass of 12H =12.0948 (1) **MP2** Remaining mass = 71.9633, so not exactly equal to 6C (1) OR **MP1** Mass of H_8O = 24.0581 (1) **MP2** Remaining mass = 60.0000 so exactly equal to 5C (1) **MP3** Assumption: (one atom of) C=12(.0000) / has mass (exactly) 12 ALLOW Other isotopes of H and/or O are not present (1) IGNORE Any units in calculations	Just use of C = 12 without indicating as an assumption	**(3)**

Question Number	Acceptable Answers	Reject	Mark
17(e)	Small atomic radius / small atom ALLOW Diffuses easily Not (significantly) present in air/ low density / less dense than air Non-toxic IGNORE Low mass / lighter than air / light(weight) / references to inertness or non-flammability / availability / gas at room temperature / monatomic / no isotopes / answers relating to cost	Small molecule	**(1)**

(Total for question 17 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
18(a)	($1s^2$) $2s^2$ $2p^6$ $3s^2$ $3p^1$ ALLOW Upper case, subscripts, P orbitals divided into x, y, z eg: $2s^2$ $2p_x^2$ $2p_y^2$ $2p_z^2$ $3s^2$ $3p_x^1$ IGNORE $1s^2$ if written again		**(1)**

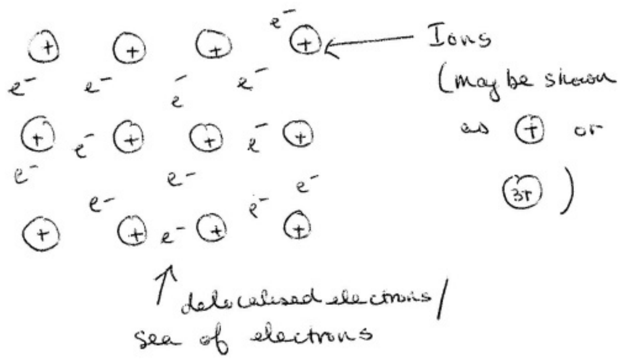
Question Number	Acceptable Answers	Reject	Mark
18(b)	<table><tr><td>protons</td><td>13</td></tr><tr><td>neutrons</td><td>14</td></tr><tr><td>electrons</td><td>10</td></tr></table> All three numbers needed for mark IGNORE any working out in table		**(1)**

Question Number	Acceptable Answers	Reject	Mark
18(c)(i)	<table><tr><td>First IE</td><td>Second IE</td><td>Third IE</td><td>Fourth IE</td></tr><tr><td>578</td><td>1817</td><td>2745</td><td>11578</td></tr><tr><td>3p</td><td>3s</td><td>3s</td><td>2p</td></tr></table>3p/ $3p_x$ and **both** 3s (1) 2p/ $2p_x$ / $2p_y$ / $2p_z$ (1) ALLOW p s s p for (1) mark <table><tr><td>$3p^1$</td><td>$3s^2$</td><td>$3s^1$</td><td>$2p^6$</td></tr></table>for (2) marks		**(2)**

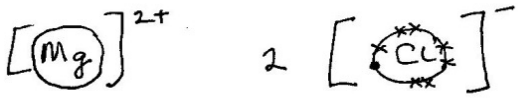
Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	Al^{+} (g) $\rightarrow$ Al^{2+}(g) + e^{-} OR Al^{+} (g) — e^{-} $\rightarrow$ Al^{2+}(g) **MP1** Balanced equation (1) **MP2** (g) symbols This is dependent on the equation involving aluminium even if electrons/charges are wrong (1) NOTE If correct equation for a second ionization using the wrong symbol is given with correct state symbols allow (1) max IGNORE lack of minus sign on electron / any state symbols for electron		**(2)**

Question Number	Acceptable Answers	Reject	Mark
***18(c)(iii)**	**MP1** Second electron is closer (to nucleus) / electron is removed from a positive ion / 1+ ion is smaller than atom ALLOW More protons than electrons (in ion) Effective nuclear charge greater (in ion) (1) **MP2** So greater attraction between electron and nucleus/protons OR More energy required to overcome attraction between electron and nucleus OR Less repulsion between electrons (1) IGNORE References to high charge-density in 1+ ion References to shielding / last electron / paired electrons / electron shell stability	Just 'more energy required to remove electron' / 'harder to remove electron' NOTE "Second I.E. loses 2 electrons" - scores **(0)** overall 1+ ion has more protons than atom - scores **(0)** overall	**(2)**

Question Number	Acceptable Answers	Reject	Mark
***18(c)(iv)**	**MP1 for** similarity between first and second electrons lost; 1st and 2nd (electrons are removed) from the same/3rd **shell** OR First (electron lost from) **3**p (subshell/orbital) **and** second (electron lost from) **3**s (subshell/orbital) **(1)** **MP2 for** difference between third and fourth electrons lost; Third (electron lost from) **3**s (subshell/orbital) **and** fourth (electron lost from) **2**p (subshell/orbital) OR (compared with the 3rd electron) the 4th electron is removed from a **shell** closer to the nucleus / from a new/lower/different **shell** / from a **shell** with less shielding **(1)** **If no other mark awarded**, allow **(1)** for: three electrons in the 3rd **shell** of Al **and** the fourth electron is removed from 2nd **shell** IGNORE References to charges on ion	1st and 2nd from same subshell	**(2)**

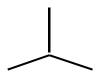
Question Number	Acceptable Answers	Reject	Mark
18(d)(i)	 Regular lattice of + OR 3+ (can be written in ions or labelled) ALLOW Ions which touch (1) Delocalised electrons/sea of electrons including some between ions, shown and labelled (1)	Protons / nucleus / atoms	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(d)(ii)	(Mg) lower (melting temperature) because *(no mark for this alone)* **and** any **two** from: (Mg) ion charge is less / (Mg) ion (radius) is larg**er** / (Mg) ion charge density is less / (any mention of) Mg^{2+} **and** Al^{3+} (1) (Mg) few**er** delocalised/free electrons / small**er** sea of electrons / one less electron donated (1) (Mg) weak**er** (forces of) attraction between (+ve) **ions** and (delocalised/free electrons / sea of electrons) / (Mg) **ions** are held less tightly to the sea of electrons / metallic bond is weaker (1)	"Mg has a higher melting point" scores **(0)** overall Atomic radius (of Mg) is larger References to ionic bonds / covalent bonds / intermolecular forces score (0) overall	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(d)(iii)	 **First mark** Correct dot and cross diagrams with 2+ on Mg and – / 1- / -1 charge on (both if drawn) Cl (1) ALLOW No electrons or 8 electrons on outer shell of Mg Dots or crosses or other valid symbols for electrons Paired or unpaired electrons Diagrams without brackets **Second mark** Ratio of one Mg to two Cl (ions) **(1)** ALLOW Number of Cl shown as 2 in front of a Cl, or as a subscript after the Cl The ratio mark even if no charges are shown (penalised in 1st mark) IGNORE any inner electrons ALLOW max 1 for incorrect symbols if charges and ratio are correct	Covalent bonding – scores (0) overall	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(d)(iv)	**MP1** Al (cat)ion polarises chloride / distorts chloride electron cloud OR Al (cat)ion has a greater polarising ability (than Mg ion) OR Chloride ion/anion **in $AlCl_3$** is distorted (by aluminium (ion)) **(1)** **MP2** EITHER Electrons are partly shared (by Al and Cl) OR (In $AlCl_3$) orbital overlap occurs OR (aluminium and chloride) ions are not totally discrete/separate **(1)** IGNORE fully shared electrons References to ionic size and charge References to atomic radius Ionic bond strength/stability Polarisation of $AlCl_3$ / polarisation power of $AlCl_3$ **MP3** Melting/boiling temperature (of $AlCl_3$) is lower (than that of $MgCl_2$) OR ($AlCl_3$) sublimes / **Molten** salt/$AlCl_3$ does not conduct electricity / cannot be electrolysed ALLOW BH cycle / experimental LE value greater / more negative / more exothermic than theoretical LE value of $AlCl_3$ ($AlCl_3$) forms a dimer ($AlCl_3$) forms dative covalent/coordinate bonds (with electron pair donors) Magnesium chloride solution is a better conductor than aluminium chloride solution (1)	References to Al / Mg or Cl atoms / chlorine	**(3)**

(Total for question 18 = 19 marks)

Question Number	Acceptable Answers	Reject	Mark
19(a)	 ALLOW Any orientation IGNORE bond angles, displayed formulae		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(b)	Combustion reaction is exothermic/ evolves heat/ releases energy (1) This keeps catalyst hot (1) IGNORE Activation energy		**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	The change $H_2O(g) \rightarrow H_2O(l)$ releases energy/ is exothermic / forms hydrogen bonds OR Extra heat is evolved when $H_2O(l)$ forms ALLOW reverse argument weaker intermolecular forces between $H_2O(g)$ than $H_2O(l)$		**(1)**

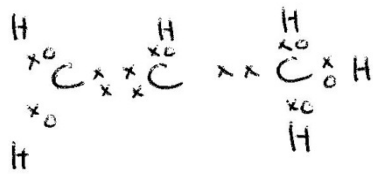
Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	Look at final answer Correct answer scores 3 ((4x—393.5 + 5x —285.8) —(—134.5)) = —2868.5/ —2869/ —2870 / —2900 (kJ mol^{-1}) (3) ALLOW Correct value with incorrect sign and /or incorrect unit (2) Correct expression written but calculator error for final value (2) Incorrect answer with correct Hess cycle $C_4H_{10}(g)$ + 6½$O_2(g)$ $\rightarrow$ 4$CO_2(g)$ + 5$H_2O(l)$ Elements / 4C(s) + 5$H_2(g)$ + 6½$O_2(g)$ (1) IGNORE SF except 1 NOTE -544.8 (kJ mol^{-1}) scores 1 mark (misses x5 and x4 in expression) -2648.5 (kJ mol^{-1}) scores 2 marks (uses -241.8 instead of -285.8) Answers worth (2) because of one error: (+)279.5 —10.5 —3137.5 —1688.0 —1725.3	-3000	**(3)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(iii)	ALLOW TE from 19c(ii) **First mark** – amount of 2-methylpropane (=15/ 58) = 0.2586206/ 0.259 (mol) (1) **Second mark** - energy produced = (0.2586206 x 2868.5) =741.85345 (kJ) OR (0.259 x 2868.5) =742.94 (kJ) (1) IGNORE SF except 1 SF − sign. ALLOW TE from first to second mark Use of rounded values of amount or ΔH for example use of 0.26 mol gives 750 (kJ). Final answers may need to be checked individually.	0.3 / 0.25	**(2)**

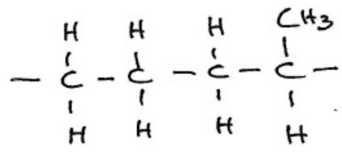
Question Number	Acceptable Answers	Reject	Mark
19(d)(i)	ΔH = (-11280 −(-8410)) = **−**2870 (kJ mol^{-1}) IGNORE units		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19d(ii)	Bond enthalpies / bond energies (of any or all of C-C, C-H, O=O, C=O, H-O) ALLOW Enthalpy change of bond breaking Enthalpy changes of atomization (of any or all of methylpropane / carbon dioxide/water/oxygen)	Bond enthalpies of compounds Enthalpy change of: Formation Combustion Specific heat capacity	**(1)**

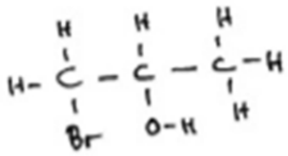
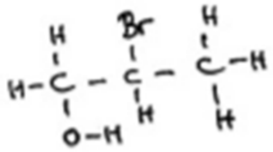
(Total for question 19 = 11 marks)

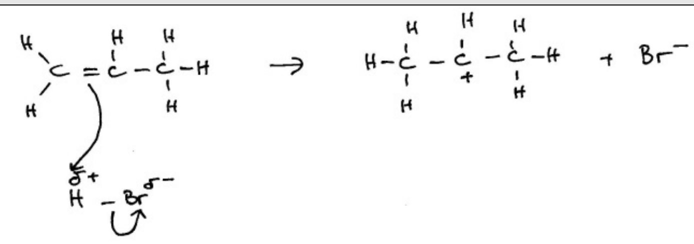
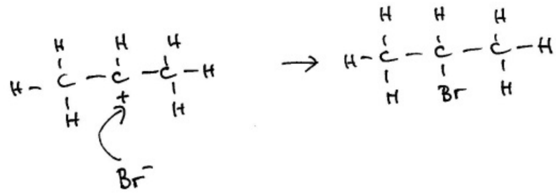
Question Number	Acceptable Answers	Reject	Mark
20(a)	 Electrons in C=C double bond within a hydrocarbon (1) Rest of molecule correct (1) ALLOW All dots / crosses		**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	$C_{10}H_{22} \rightarrow C_2H_4 + C_3H_6 + C_5H_{12}$ ALLOW Other types of correct formulae IGNORE state symbols even if incorrect any suggested conditions	H_2	**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	 OR —$CH_2CH_2CH_2CH(CH_3)$— **One** Methyl side-group on a carbon chain (1) **4**-Carbon backbone complete with hydrogens and continuation bonds (1) IGNORE Square brackets and n ALLOW (1) mark for both correct repeat units drawn separately for poly(ethene) **and** poly(propene) if no other marks awarded	Just poly(propene) Just poly(ethene)	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(c)	**MP1** Potassium manganate((VII)) / potassium permanganate / $KMnO_4$ (1) **MP2 depends on mention of manganate** H_2SO_4 ALLOW Acidified / acid / H^+ (1) **MP3 depends on mention of manganate** (Colour change from) purple / pink (to) colourless (1) OR **MP2 depends on mention of manganate** KOH / NaOH (1) **MP3 depends on mention of manganate and alkali** Colour change from purple to green/brown (ppt) (1)	 Incorrect oxidation numbers HCl To brown Just 'alkaline'	**(3)**

Question Number	Acceptable Answers	Reject	Mark
20(d)	Observation: (colour change from) brown/ yellow/orange/red-brown (to) colourless (1) **EITHER**  (1) 1-bromopropan-2-ol / 1-bromo-2-hydroxypropane (1) OR  (1) 2-bromopropan-1-ol / 2-bromo-1-hydroxypropane (1) ALLOW Skeletal or structural formula for 2nd mark TE in third mark for "1,2-dibromopropane" if this has been drawn, but this compound does not score the second mark	Red Bond directly from C to H in OH if displayed	**(3)**

Question Number	Acceptable Answers	Reject	Mark
20(e)	  **MP1** Dipole on H-Br (1) **MP2** Curly arrow from double bond to H **and** curly arrow from H—Br bond to Br or just beyond (1) **MP3** Correct carbocation intermediate (1) **MP4** Arrow from anywhere on Br^- to C+ **and** product (1) ALLOW formation of 1-bromopropane following from + on C1 if other arrows correct (max 3) A fully correct electrophilic addition mechanism using Br_2 scores (2) marks Electrophilic addition mechanism using Br_2 with 1 error scores (1) mark	C+ with 4 bonds drawn Br●	**(4)**

Question Number	Acceptable Answers	Reject	Mark
20(f)	**MP1** (Pi electrons in) double bond repel electrons in Br-Br / bromine ALLOW Region of high electron density repels, etc (1) **MP2** EITHER Produces a dipole / produces δ+ (and δ-) / polarises molecule ALLOW Diagram showing the dipole OR So electron pair (from C=C) / electrons can be accepted (1)	brom**ide** / partial positive bromi**de**	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(g)	MP1 EITHER Production of both polymers will increase (as shale gas supplies more ethane and propane) OR (Relatively) more poly(ethene) than poly(propene) will be produced because there is more ethane in the shale gas (than propane) (1) MP2 EITHER More ethene is produced than propene (by cracking alkanes in shale gas) OR Ethene can be produced from ethane/propane/butane/pentane OR Propene can be produced from propane/butane/pentane/fewer alkanes OR Propene cannot be produced from ethane (1)		**(2)**

(Total for question 20 = 19 marks)

TOTAL FOR PAPER = 80 MARKS

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