Mark Scheme (Results)

Summer 2014

IAL Chemistry (WCH01/01)

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Summer 2014
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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

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

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

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

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

Question Number	Correct Answer	Mark
5	D	**1**

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

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

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

Question Number	Correct Answer	Mark
9	D	**1**

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

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

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

Question Number	Correct Answer	Mark
13	A	**1**

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

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

Question Number	Correct Answer	Mark
16	A	**1**

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

Question Number	Correct Answer	Mark
18	D	**1**

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

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

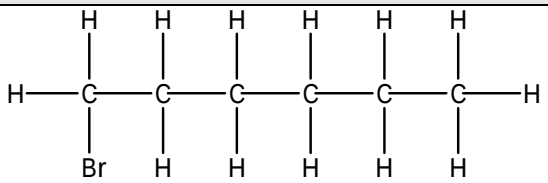
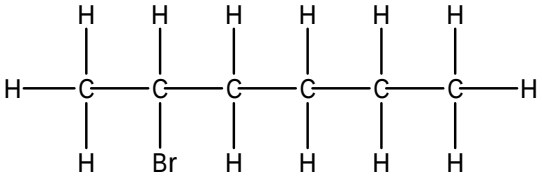
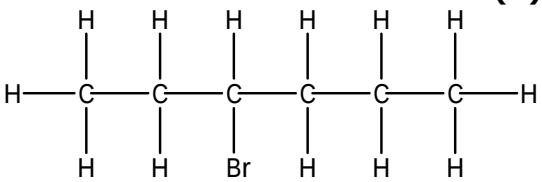
SECTION A = 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	Penalise use of chlorine once only in Q21(a)(i), (ii) and (iii) IGNORE lone pairs of electrons, even if incorrect in Q21(a)(i), (ii) and (iii) ALLOW one slip in the formula of the element if it is correctly given elsewhere in the answer e.g B for Br $Br_2 \rightarrow Br\bullet + Br\bullet$ / $Br_2 \rightarrow 2Br\bullet$ Ignore position of dot Ignore state symbols and curly arrows even if incorrect	Br	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(ii)	$Br_2 \rightarrow Br^+ + Br^-$ Ignore state symbols and curly arrows even if incorrect	$\boldsymbol{\delta^+}$ / $\boldsymbol{\delta^-}$ for the + or −	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iii)	(free radical) $Br\bullet$ NOTE: No TE, except $Cl\bullet$ **(1)** Penalise omission of the dot only once in (a)(i) and (a)(iii) (electrophile) $\boldsymbol{Br^+}$ NOTE: No TE, except Cl^+ **(1)**	Br	**2**

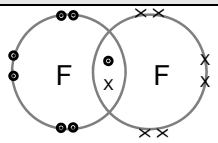
Question Number	Acceptable Answers	Reject	Mark
21 (b)(i)	 **(1)**  **(1)**  **(1)** Isomers can be in any order ALLOW skeletal or structural formulae	Any branched-chain isomers	**3**

Question Number	Acceptable Answers	Reject	Mark
21 (b)(ii)	Corrosive / toxic / poisonous Allow correct symbols for corrosive or toxic / poisonous   IGNORE harmful / dangerous / irritant / acidic / volatile / any references to state of HBr IGNORE Any precautions taken, EXCEPT those related to flammability	Flammable / 'naked flames'	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (b)(iii)	**First mark** Calculation of the $C_6H_{13}Br$ M_r value and the total of the product Mr EXPECTED 164.9 **AND** 245.8 ALLOW 165 **AND** 246 **(1)** **Second mark** EXPECTED $\frac{164.9}{245.8}$ (x 100%) = 67.08706265(%) **= 67.1(%) to 3 s.f.** ALLOW $\frac{165}{246}$ (x 100%) = 67.07317073 (%) = **67.1(%) to 3 s.f.** ALLOW TE from any incorrect M_r value(s) provided answer is not greater than 100% **(1)** Answer **MUST** be rounded correctly to 3 s.f. for the second mark Correct answer with no working **(2)**		**2**

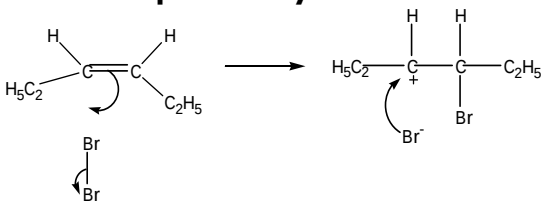
Question Number	Acceptable Answers	Reject	Mark
21 (c)(i)	$CH_4 + F_2 \rightarrow CH_3F + HF$ IGNORE state symbols, even if incorrect	Cl_2 "Fl" if used more than once	**1**

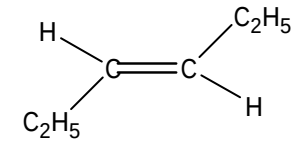
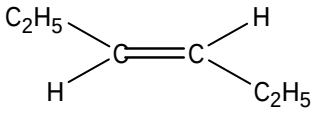
Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii)	NOTE Allow reverse argument throughout **1st Mark** Fluorine / F (atom is) **smaller** (than a Cl atom) **(1)** **2nd Mark** Any ONE of:- (so expect) F—F **bond** to be shorter (than the Cl—Cl bond) OR F—F **bonding** electrons / **bond** pair / / **shared** pair closer to (both) nuclei OR (so) attraction between nuclei and **bonding** electrons / **bond** pair / **shared** pair expected to be stronger **(1)** IGNORE Any references to the strengths of the F-F and/or Cl-Cl bonds Any references to the 'repulsion between nuclei' Any references to 'shielding' / 'Charge density' / 'Electronegativity' / outer electrons	F_2 / 'fluorine **molecule**' Mention of 'Intermolecular forces' (no **2nd** mark)	**2**

Question Number	Acceptable Answers	Reject	Mark
21 (c)(iii)	 Shared pair of electrons shown **(1)** The remaining six electrons on each F atom **(1)** NOTE Can be dots or crosses – only total number of electrons matters Circles not required IGNORE Two inner-shell electrons ALLOW 'Fl' or F symbol missing		**2**

Question Number	Acceptable Answers	Reject	Mark
21 (c)(iv)	'**Repulsion** between electrons' scores (1) BUT '**Repulsion** between lone pairs (of electrons)' scores (2) ALLOW 'Non-bonding electrons' for lone pairs	Just repulsion between bonding / shared electrons	**2**

Question Number	Acceptable Answers	Reject	Mark
21 (c)(v)	UV (light) / (sun) light / heat / energy required to break Cl—Cl bond OR UV (light) / (sun) light / heat / energy required to form Cl• OR F—F requires less energy to break OR F—F requires less energy to form F• IGNORE **Just** F_2 more reactive (than Cl_2) **Just** F—F bond is weaker (than Cl—Cl) **Just** F—F bond energy is lower (than Cl—Cl)		**1**

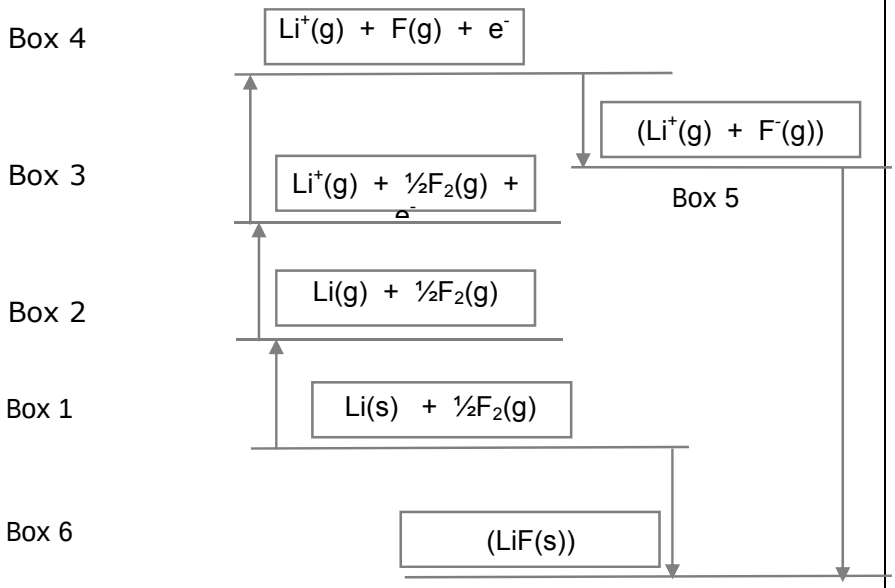
Question Number	Acceptable Answers	Reject	Mark
21 (d)	**Mark independently**  **First mark:** For **both arrows** in initial step Allow upper arrow as in diagram or directly to Br atom **(1)** **Second mark:** Carbocation intermediate **(1)** **Third mark:** Arrow from anywhere on the bromide ion to the C or to the + sign on the intermediate **(1)** Lone pair(s) on Br^- not required	**Half-arrow(s)** **Incorrect polarities** **Full**-charges on Br_2 **Half-arrow(s)** **δ**$^-$ instead of the full **–** sign on the Br^-	**3**

Question Number	Acceptable Answers	Reject	Mark
21(e)(i)	 OR  Diagram **clearly shows** that H atoms are diagonal to each other in the *E*-isomer/correct relative positions of hydrogen atoms and ethyl groups ALLOW Skeletal or displayed formula		**1**

Question Number	Acceptable Answers	Reject	Mark
21(e)(ii)	EITHER **Rotation** around C—C bond (in product molecule) OR Double bond is broken so **rotation** (is now possible) ALLOW Same carbocation / intermediate formed (so product is the same) IGNORE Comments about optical isomerism		**1**

(Total for Question 21 = 23 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)	(The energy / enthalpy change / released that accompanies the formation of) **one mole** of a(n ionic) compound **(1)** ALLOW as alternative for compound: lattice /crystal / substance / solid / product / salt from (its) **gaseous ions** **(1)** IGNORE References to 'standard conditions' or any incorrect standard conditions **ALTERNATIVE RESPONSE** If no mark(s) already awarded from above, can answer by giving:- energy change **per mole** / enthalpy change **per mole** **(1)** Li^+(**g**) + F^-(**g**) → LiF(s) **(1)** **NOTE** If lattice energy of dissociation is given (e.g. "energy required to break down 1 mol of an ionic lattice into its gaseous ions") max (1) for the 2nd scoring point 'gaseous ions'	'energy required' / 'energy needed' / 'energy it takes' 'from **one mole of gaseous ions**' (no 2nd mark) Just 'from gaseous **elements**' (no 2nd mark)	**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	 IGNORE missing electrons / e^- **First mark (Box 1):** **$Li(s) + ½F_2(g)$** **(1)** **Second mark (Box 4):** **$Li^+(g) + F(g)$** $(+e^-)$ **(1)** **Third and Fourth marks (if box 1 is correct):** 'Box 2' as above i.e. $Li(g) + ½F_2(g)$ as above **(1)** 'Box 3' as above i.e. $Li^+(g) + ½F_2(g)$ $(+ e^-)$ as above **(1)** OR 'Box 2' Li(s) + F (g) **(1)** 'Box 3' Li(g) + F(g) **(1)** OR 'Box 2' $Li(g) + ½F_2(g)$ **(1)** 'Box 3' Li(g) + F(g) **(1)**		**4**

	Penalise use of 'Fl' instead of 'F' once only If Box 1 is INCORRECT max (2) for correct transitions e.g if use F(g) or F_2(g) instead of ½F_2(g), then 2 marks available for two correct transitions involving lithium.		

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	**FIRST, CHECK THE FINAL ANSWER** **IF answer = −1046 (kJ mol^{-1}) then** **award (2) marks, with or without working** Otherwise look for −616 = (+159) + (+520) + (+79) + (−328) + ΔH_{LE} **OR** ΔH_{LE} = −616 − [(+159) + (+520) + (+79) + (−328)] **(1)** = −616 − 430 = −**1046** (kJ mol^{-1}) **(1)** NOTE **ALLOW** for **1 mark**: (+)1046 (wrong sign) −186 (+430 instead of −430) (+)186 (+616 instead of −616) −1006.5 (+79 halved to +39.5) −1702 (wrong sign for 328)		**2**

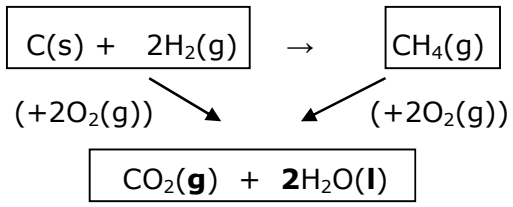
Question Number	Acceptable Answers	Reject	Mark
***22(c)(i)**	ALLOW reverse argument where appropriate (NaF more negative than NaCl because) **First mark** F^- smaller (than Cl^-) ALLOW 'fluorine **ion** is smaller (than a chlorine **ion**') OR F^- larger **charge density** (than Cl^-) **(1)** **Second mark:** F^- (forms) stronger (electrostatic) **attractions** (than Cl^-) IGNORE just 'stronger (ionic) bonds' **(1)** **Penalise ONCE ONLY in (c)(i) and (c)(ii)** the use of the word 'atom(s)' or 'molecule(s)'/ use of **just formulae** such as 'Mg', 'Na', 'F', 'F_2', 'Cl', 'Cl_2', etc. OR **Penalise ONCE ONLY in (c)(i) and (c)(ii)** the use of **words** such as **just '**magnesium' (instead of magnesium ions/Mg^{2+}) and/or **just '**fluorine' (instead of fluoride ions/F^-) /and or **just** 'chlorine' (instead of chloride ions/Cl^-) IGNORE Any comments about polarization of the anion (by the cation) / covalent character	"**NaF** is smaller than **NaCl**" F^- has a smaller **atomic** radius than Cl^-	**2**

Question Number	Acceptable Answers	Reject	Mark
***22(c)(ii)**	ALLOW reverse argument where appropriate (NaF less negative than MgF_2 because) **First mark - size:** Mg^{2+} smaller (than Na^+) OR 'Magnesium ion' is smaller (than Na^+) **(1)** **Second mark - charge:** Mg^{2+} has a greater charge (density) (than Na^+) OR 'Magnesium ion' has a greater charge (density) (than Na^+) **(1)** **[NOTE:** It follows that the statement that "Mg^{2+} ions are smaller than Na^+ ions" would score BOTH marks**]** IGNORE Any comments about polarization of the anion (by the cation) / covalent character	"**MgF_2** is smaller than **NaF**" Mg^{2+} has a smaller **atomic** radius than Na^+	**2**

(Total for Question 22 = 12 marks)

Question Number	Acceptable Answers	Reject	Mark
23(a)	(Enthalpy/energy change when) **one mole** of a compound / **one mole** of a substance IGNORE Statements such as "energy released" or "energy required" here **(1)** is formed from its elements (in their standard states, under standard conditions) **(1)** (Standard temperature is) 298 K / 25°C ALLOW '°K' IGNORE References to room temperature (Standard pressure is) 1 atm / 101 kPa / 100 kPa **(1)**	'is formed from its **gaseous** elements'	**3**

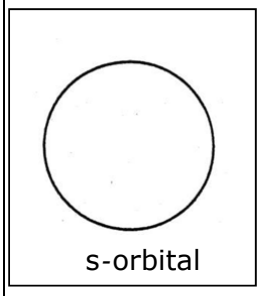
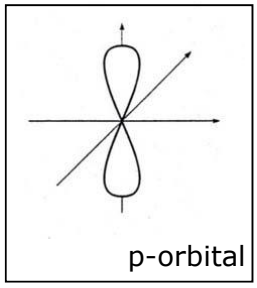
Question Number	Acceptable Answers	Reject	Mark
23(b)	$6C(s, graphite) + 7H_2(g) \rightarrow C_6H_{14}(l)$ **ALLOW** 6C(s) / 6C(graphite) Species **and** balancing correct **(1)** State symbols correct **(1)** State symbols mark is dependent on correct species but allow this mark if 14H used instead of $7H_2$ **NOTE** $C_6H_{14}(l) \rightarrow 6C(s, graphite) + 7H_2(g)$ scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
23(c)	 **First mark:** Both arrows point downwards **(1)** **Second mark:** CO_2(**g**) + **2**H_2O(**l**) **(1)** **Third mark:** ((1 x −394) + (2 x −286) − (1 x −890) =) **−76** (kJ mol^{-1}) No TE from cycle arrows **(1)**	**2**H_2O(**g**) If incorrect units with a final answer, no 3rd mark	**3**

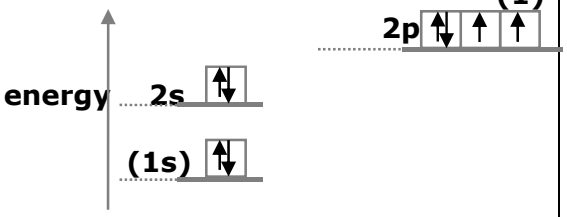
Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	(+1652÷4 =) (+)**413** (kJ mol^{-1})	**−**413	**1**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	**First mark:** (+2825 − 6 x answer to (d)(i)) ALLOW TE only from a **positive** value given as answer to (d)(i) **(1)** **Second mark:** = (+)347 (kJ mol^{-1}) **(1)** Second mark is CQ on first mark Correct answer with or without working scores **(2)** **NOTE** **−**347 (kJ mol^{-1}) **scores (1)**		**2**

(Total for Question 23 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
24(a)	 s-orbital  p-orbital **(s-orbital)** Circle drawn ALLOW Concentric circles drawn **(1)** **(p-orbital)** Figure of '8' / 'dumb-bell' drawn NOTE: p-orbital can be drawn along any axis (axis does not have to be shown) **(1)** ALLOW If one, two or three p-orbitals of correct shapes are shown If **overlapping** orbitals are shown of correct shape in both cases, award **(1)** mark		**2**

Question Number	Acceptable Answers	Reject	Mark
24(b)	**(region)** **(no. of electrons)** (a d-orbital) **2** **(1)** (a p sub-shell) **6** **(1)** (the third shell) **18** **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
24(c)	**First mark: BOTH** 2s and 2p labelled ALLOW $2s^2$ and $2p^4$ **(1)** **Second mark: ALL** eight e^- shown correctly **(1)**  ALLOW Half-arrows or full arrows for each electron Paired arrows in any one of the 2p orbitals NOTE Single arrows must be orientated in same direction Paired arrows must have opposite spins	$2p^6$	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	**First mark:** Makes mention of energy/enthalpy/(heat) energy/heat (change/required) AND to remove an electron **(1)** **Second mark:** one mole/1 mol **(1)** **Third mark:** Makes mention of **gaseous atom(s)** **(1)** **ALTERNATIVE ANSWER** Energy change per mole / kJ mol^{-1} for **(1)** $X(\mathbf{g}) \rightarrow X^{+}(\mathbf{g}) + e^{(-)}$ **(2)** One mark for species One mark for correct state symbols Mark independently IGNORE any references to standard conditions	"Energy **given out**…" for first mark **Just** 'gaseous element'/ 'gaseous substance'	**3**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	$O^{2+}(g) - e^{-} \rightarrow O^{3+}(g)$ OR $O^{2+}(g) \rightarrow O^{3+}(g) + e^{-}$ All species and balancing correct **(1)** State symbols correct **(1)** 2nd mark is dependent on 1st mark ALLOW 'e' for 'e^{-}' IGNORE (g) on the e^{-}	Reverse equation scores **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	**First mark:** **Big** 'jump' / **large** increase **(1)** **Second mark:** between **6th** and **7th** (IE) OR after the **6th** OR to the **7th** OR from 13327 to 71337 OR of 58010 **IGNORE** Additional jump identified between **4th** and **5th** (IE) if justified in terms of a change of **sub-shell** OR Additional jump identified between **4th** and **5th** (IE) if justified in terms of NOT being a change of shell **(1)**	Any other ionization jumps mentioned	**2**

(Total for Question 24 = 14 marks)
SECTION B = 60 marks
TOTAL FOR PAPER = 80 marks