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Examiners' Report
June 2014

IAL Chemistry WCH01 01

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June 2014

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Introduction

The paper proved accessible to most candidates and provided them with the opportunity to demonstrate their knowledge and understanding of the key concepts in Unit 1. There was very little evidence of candidates having insufficient time to complete the paper.

The mean score for the multiple-choice questions in Section A was 13.6/20. Questions 7, 11, 13 and 20 were found to be the most straightforward, whilst Questions 6, 9, 16 and 17 were found to be the most demanding of the multiple-choice items.

Strengths shown by candidates on this paper included a mastery of the key definitions and sound techniques employed when tackling calculation questions. However, areas for development included the Quality of Written Communication, in particular the precision of language, especially when referring to specific particles such as atoms, ions and molecules. Also, more use needed to be made by candidates of information contained within each question, in order to structure their answers appropriately.

Question 21 (a)

(a)(i) Write an equation to show the **homolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

$Br - Br \rightarrow 2Br\cdot$

(ii) Write an equation to show the **heterolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

$Br - Br \rightarrow Br^{\delta+} + Br^{\delta-}$

(iii) Choosing from the products you have given in (a)(i) and (a)(ii), write the formula of a free radical and an electrophile.

(2)

Free radical Br·

Electrophile $Br_2 - Br$

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Examiner Comments

In (a)(ii), full positive and negative charges were required on the ions, not just delta plus and delta minus partial charges.

In (a)(iii), the electrophile should have been given as the Brion.

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Examiner Tip

Know when to use full charges and when to use partial charges on species.

(a) (i) Write an equation to show the **homolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

$Br-Br \rightarrow Br^{\bullet} + Br^{\bullet}$

(ii) Write an equation to show the **heterolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

$Br-Br \rightarrow Br^{+} + :Br^{-}$

(iii) Choosing from the products you have given in (a)(i) and (a)(ii), write the formula of a free radical and an electrophile.

(2)

Free radical $Br^{\bullet}$

Electrophile Br^{+}

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Examiner Comments

In (a)(i), the incorrect inclusion of partial charges above the free radicals negated the mark.

In (a)(ii), it was OK to include a lone pair on the bromide ion, $:Br^{-}$.

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Examiner Tip

Make sure that you know the difference between homolytic and heterolytic bond fission.

Question 21 (b) (i)

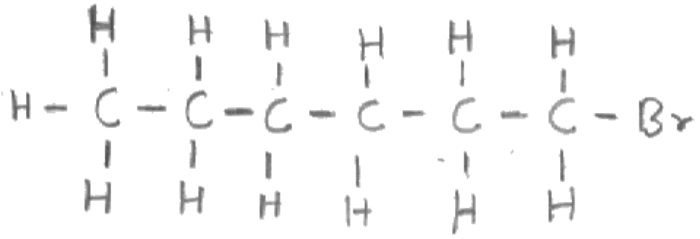
(b) The compound hexane, C_6H_{14}, can react with bromine, in the presence of UV light, according to the equation

$$C_6H_{14} + Br_2 \rightarrow C_6H_{13}Br + HBr$$

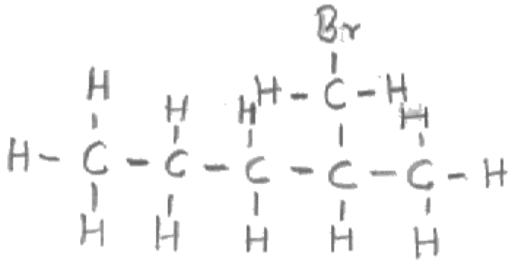
(i) Give the displayed formulae of the three structural isomers of $C_6H_{13}Br$ that could be formed in the above reaction.

(3)

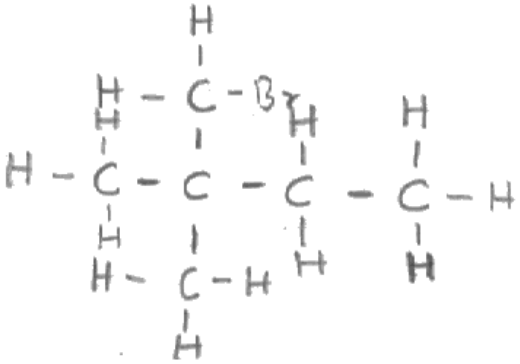
First isomer



Second isomer



Third isomer



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Examiner Comments

Branched-chain isomers could not form when the starting organic molecule in the substitution reaction was the straight-chain compound, hexane. So one mark was awarded for this response, for correctly drawing 1-bromohexane.

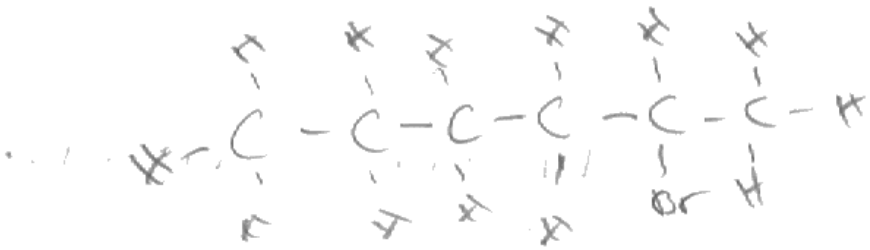
(b) The compound hexane, C_6H_{14}, can react with bromine, in the presence of UV light, according to the equation

$$C_6H_{14} + Br_2 \rightarrow C_6H_{13}Br + HBr$$

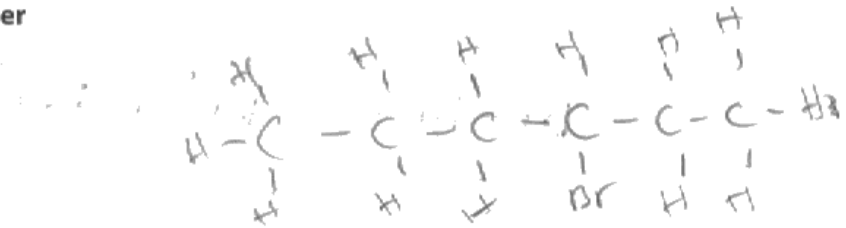
(i) Give the displayed formulae of the three structural isomers of $C_6H_{13}Br$ that could be formed in the above reaction.

(3)

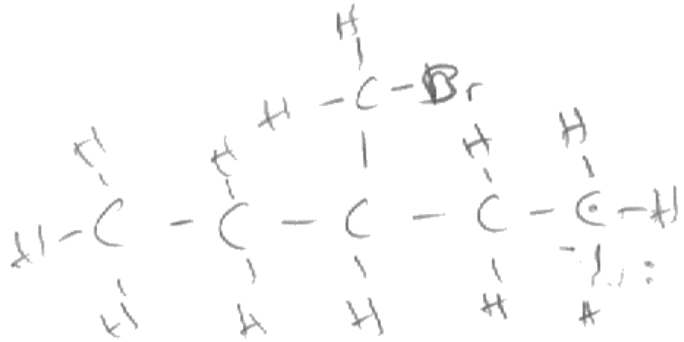
First isomer



Second isomer



Third isomer



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Examiner Comments

The first and second isomers given were correct.
The third isomer should have been 1-bromohexane.

ResultsPlus
Examiner Tip

Check that all the structural isomers you suggest are possible, given the identity of the organic starting molecule in the reaction.

Question 21 (b) (ii)

(ii) The bromoalkanes and the hydrogen bromide formed in this reaction are hazardous.

The bromoalkanes would be labelled as 'flammable'. Suggest a suitable hazard warning for the hydrogen bromide.

(1)

Keep it away from burner / heat.

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Examiner Comments

To be awarded the mark, the answer had to refer to the corrosive or toxic or poisonous nature of hydrogen bromide.

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Examiner Tip

Flammability is not an issue with hydrogen halide gases.

Question 21 (b) (iii)

(iii) Calculate the percentage atom economy by mass for the formation of $C_6H_{13}Br$.

Give your answer to **three** significant figures.

Use the expression

$$\text{atom economy} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100\%$$

Molar mass of $C_6H_{13}Br = 164.9\ g\,mol^{-1}$ (2)

Molar mass of all products = $(164.9 + 80.9)\ g\,mol^{-1}$

$= 245.8\ g\,mol^{-1}$

$\therefore$ atom economy $= \frac{164.9}{245.8} \times 100 = 67.087\ldots\%$

$= 67.1\%$

ResultsPlus
Examiner Comments

A correct answer, clearly set out.

ResultsPlus
Examiner Tip

Practise calculations involving percentage atom economy and also percentage yield.

Question 21 (c) (i)

(i) Write an equation for the reaction between **methane** and fluorine, assuming they react in a 1:1 mole ratio. State symbols are not required.

(1)

$CH_4 + F_2 \rightarrow CH_3F + HF$

ResultsPlus
Examiner Comments

A correct answer, scoring the mark available.

ResultsPlus
Examiner Tip

When writing equations, always check whether or not state symbols are required.

Question 21 (c) (ii)

*(ii) On the basis of comparing the relative sizes of the fluorine and chlorine atoms, it might be predicted that the F—F bond energy would be greater than the Cl—Cl bond energy.
Suggest an explanation for this prediction.

(2)

This is because the size of fluorine atom is small and hence the ~~distance~~ internuclear distance is less between two fluorine atoms. The Internuclear distance less means shorter bond length and hence a lot of energy to break the bond. ~~But the Cl atom is large and hence it~~ as there will be greater force of attraction.

ResultsPlus
Examiner Comments

Both scoring points were addressed here, so two marks were awarded.

*(ii) On the basis of comparing the relative sizes of the fluorine and chlorine atoms, it might be predicted that the F—F bond energy would be greater than the Cl—Cl bond energy.
Suggest an explanation for this prediction.

(2)

The F_2 atom is smaller than the Cl atom as it has one less shell, so less shielding electrons and the outer shell electrons are attracted by the protons in the nucleus more strongly. Therefore, the F-F bond is stronger than the Cl-Cl bond because there are stronger electrostatic attractions so more energy would be needed to break their bond.

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Examiner Comments

One mark (the first scoring point on the Mark Scheme) was awarded for this answer. The candidate has stated that the fluorine atom is smaller than the chlorine atom. However, the resulting shorter bond length in fluorine, F_2, compared with that in chlorine, Cl_2, has not been mentioned.

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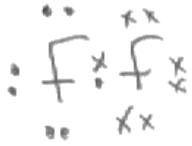
Examiner Tip

Be aware that the length of a covalent bond is dependent on the size of the atoms present.

Question 21 (c) (iii)

(iii) Draw a dot and cross diagram to show the arrangement of the outermost electrons in a fluorine molecule, F_2.

(2)



ResultsPlus
Examiner Comments

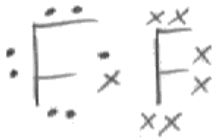
This correct answer scored both marks.

ResultsPlus
Examiner Tip

Circles do not have to be drawn to represent the atoms.

(iii) Draw a dot and cross diagram to show the arrangement of the outermost electrons in a fluorine molecule, F_2.

(2)



ResultsPlus
Examiner Comments

This response scored both the available marks.

ResultsPlus
Examiner Tip

Always remember to draw any lone pairs of electrons, neatly!

Question 21 (c) (iv)

By referring to your dot and cross diagram in your answer to (c)(iii), suggest an explanation for the fact that the F—F bond energy is **less** than that of the Cl—Cl bond energy.

(2)

This is because F_2 has a very small atom and therefore the electrons are very close to each other and forces of repulsion between the electrons mean that less energy is needed to break the F-F bond, whereas the Cl_2 is a larger

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Examiner Comments

The candidate has mentioned that there is 'repulsion between the electrons' and so scores the first mark. However, the fact that it is due to the repulsion between the lone pairs of electrons on adjacent fluorine atoms in the F-F bond that weakens the bond has not been specified. And so the second scoring point was not awarded.

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Examiner Tip

Try to include all relevant details in your answers.

By referring to your dot and cross diagram in your answer to (c)(iii), suggest an explanation for the fact that the F—F bond energy is **less** than that of the Cl—Cl bond energy.

(2)

Flourine atom is too small so that the outer electron repel with the shared pair of electron. ∴ less energy needed to break F-F than Cl-Cl

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Examiner Comments

The influence of the three lone pairs of electrons, on each fluorine atom, in such close proximity has not been mentioned. The idea of repulsion between electrons gained one of the two marks available.

Question 21 (c) (v)

(v) Suggest why a mixture of methane and chlorine requires exposure to UV light, or heat, before a reaction occurs, whereas methane reacts rapidly with fluorine at room temperature in the absence of UV light or heat.

(1)

The energy required to break the Fluorine bond is much smaller than the Chlorine bond and can be achieved at standard conditions for fluorine.

ResultsPlus
Examiner Comments

This answer scored the mark available, for realising that the F-F bond requires less energy to break than the Cl-Cl bond.

(v) Suggest why a mixture of methane and chlorine requires exposure to UV light, or heat, before a reaction occurs, whereas methane reacts rapidly with fluorine at room temperature in the absence of UV light or heat.

(1)

less energy is required to break the F–F bond ~~as~~ when compared to the Cl–Cl bond

ResultsPlus
Examiner Comments

Knowledge from data given earlier in the question has been suitably applied to deduce the correct answer.

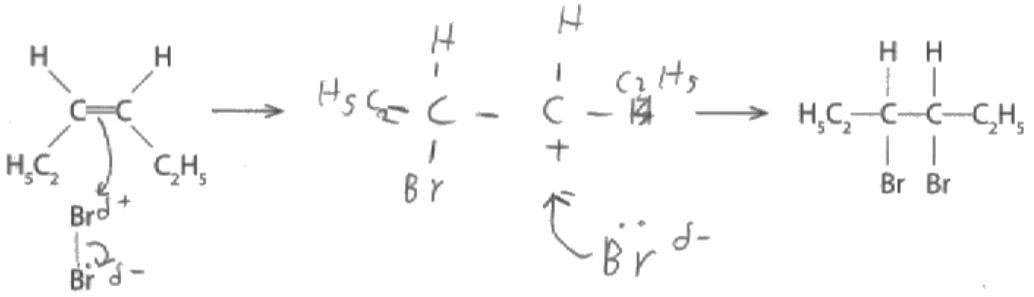
ResultsPlus
Examiner Tip

Make sure that you read the question carefully, including data provided, as such information can help you to answer questions at a later stage!

Question 21 (d)

(d) The alkene hex-3-ene reacts with bromine to produce 3,4-dibromohexane. Complete the mechanism below by adding curly arrows to show the movement of electron pairs in both steps and by giving the structural formula of the intermediate carbocation.

(3)



3,4-dibromohexane

ResultsPlus
Examiner Comments

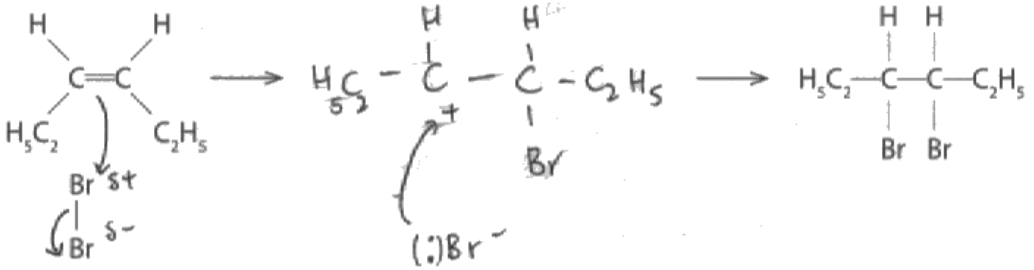
This response scored two out of the three available marks. The third mark was not awarded as only a partial charge was shown on the "bromide ion", instead of a full negative charge.

ResultsPlus
Examiner Tip

Make sure you know the difference between a partial negative charge and a full negative charge on a species. The C-Br bond broke heterolytically.

(d) The alkene hex-3-ene reacts with bromine to produce 3,4-dibromohexane. Complete the mechanism below by adding curly arrows to show the movement of electron pairs in both steps and by giving the structural formula of the intermediate carbocation.

(3)



3,4-dibromohexane

ResultsPlus
Examiner Comments

This response scored all three available marks.

ResultsPlus
Examiner Tip

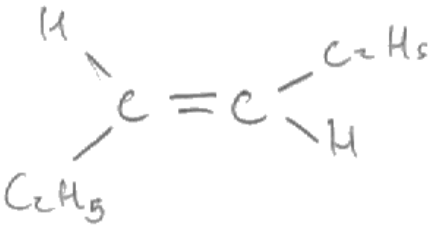
Make sure you are familiar with all the mechanisms mentioned in the specification!

Question 21 (e) (i)

(e) The mechanism shown in (d) shows *Z*-hex-3-ene reacting with bromine. *E*-hex-3-ene also reacts with bromine to form 3,4-dibromohexane.

(i) Draw the structure of *E*-hex-3-ene.

(1)



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Examiner Comments

The mark was awarded, even though the lower left-hand bond seems to point to the H, rather than the C, in the ethyl group.

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Examiner Tip

Think about the 'connectivity' of each bond when drawing out organic structures (i.e. are you drawing a C-C bond or a C-H bond?).

Question 21 (e) (ii)

(ii) Explain why both *Z*-hex-3-ene and *E*-hex-3-ene react with bromine to produce the **same** structural isomer.

(1)

They have same [redacted] chemical properties.

(Total for Question 21 = 23 marks)

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Examiner Comments

This was found to be a demanding question. The key point was that, after the addition reaction with bromine had occurred, there is a C-C single bond in the product whereas there was a C=C double bond in the reactant. As free rotation is possible around a C-C single bond, the same structural isomer is formed as the product on addition of bromine to both Z-hex-3-ene and E-hex-3-ene.

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Examiner Tip

Be aware that there is restricted rotation around a C=C double bond, whereas there is free rotation around a C-C single bond.

Question 22 (a)

(a) Define the term **lattice energy**.

(2)

Is the energy evolved when 1 mole of ~~gaseous~~ electrons is added to 1 mole of gaseous atoms to make 1 moles of gaseous anions of charge -1.

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Examiner Comments

This candidate has muddled up the definition of 'lattice energy' with that of 'first electron affinity'.

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Examiner Tip

Make sure that you know which definition is which!

(a) Define the term **lattice energy**.

(2)

Lattic energy is the energy released when one mole of solid ionic lattice # is formed from ~~of~~ gaseous ions (under standard conditions)

ResultsPlus
Examiner Comments

This answer earned both the available marks.

ResultsPlus
Examiner Tip

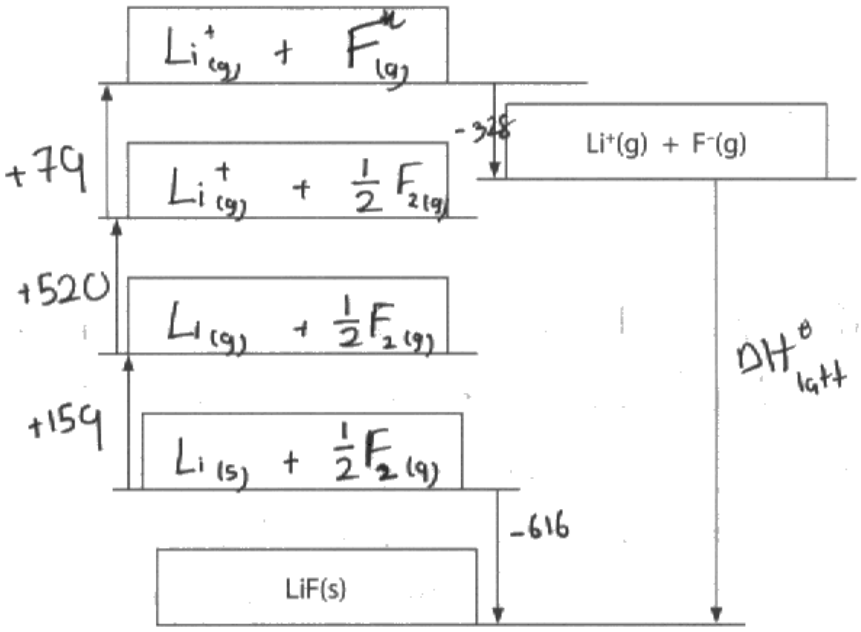
Make sure that you learn all key definitions thoroughly!

Question 22 (b)

(b) The diagram below shows an incomplete Born-Haber cycle for the formation of lithium fluoride from lithium and fluorine.

(i) Complete the diagram by writing the formulae of the correct species, including state symbols, in the four empty boxes.

(4)



(ii) Calculate the lattice energy of lithium fluoride, in kJ mol^{-1}.

(2)

$-616 = +159 + 520 + 79 - 328 + \Delta H$

$-616 = +430 + \Delta H$

$\Delta H = -616 - 430$

$\Delta H = -1046$

lattice energy = −1046 kJ mol^{-1}

ResultsPlus
Examiner Comments

These answers to question 22(b)(i) and (b)(ii) were both awarded full marks. In (b)(i), note that the absence of the electron, e^-, missing from the top two boxes on the left-hand side of the cycle, was not penalised. The calculation has been well set out in (b)(ii).

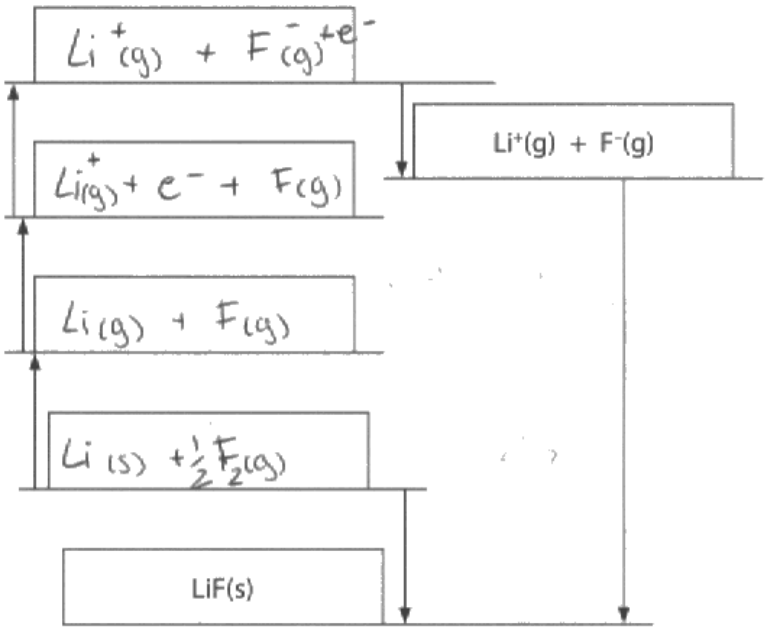
ResultsPlus
Examiner Tip

Check that the boxes balance for both species and for overall charge!

(b) The diagram below shows an incomplete Born-Haber cycle for the formation of lithium fluoride from lithium and fluorine.

(i) Complete the diagram by writing the formulae of the correct species, including state symbols, in the four empty boxes.

(4)



(ii) Calculate the lattice energy of lithium fluoride, in kJ mol^{-1}.

(2)

$-616 = +159 + 79 + 520 - 328 + \Delta H_{latt}$

$-616 - 159 - 79 - 520 + 328 = \Delta H_{latt}$

$\Delta H_{latt} = -~~1702~~ -1046$ kJ/mol

lattice energy = ~~−1702~~ −1046 kJ mol^{-1}

ResultsPlus
Examiner Comments

Two out of the four boxes were correct, so two out of the four marks available were awarded for question 22(b)(i). The answer to the calculation was correct in (b)(ii), so both marks were awarded.

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Examiner Tip

Learn the key stages in the Born-Haber cycle for an ionic compound.

Question 22 (c)

*(c) The lattice energies of sodium fluoride, sodium chloride and magnesium fluoride are shown in the table below.

Compound	Lattice energy / kJ mol^{-1}
Sodium fluoride, NaF	−918
Sodium chloride, NaCl	−780
Magnesium fluoride, MgF_2	−2957

Explain, in terms of the sizes and charges of the ions involved, the differences between the lattice energy values of

(i) NaF and NaCl

(2)

The lattice energy of NaF = -918 & NaCl = -780.
The ionic radii of both the ions are small. Due to which they have more ionic behaviour.
whereas in NaCl Cl^- ion has larger radius due to which it's lattice energy is less.

(ii) NaF and MgF_2

(2)

The lattice energy of MgF_2 is very high due to two ~~flourine~~ F^- ions attached to the Mg^{+2} ion due to which the lattice energy is high & the radius of flourine & magnesium both are small. NaF has less than MgF_2 due to single F ion attached.

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Examiner Comments

For question 22(c)(i), one mark out of the two marks available was awarded. The candidate has appreciated that the chloride ion has a larger radius than the fluoride ion. No marks were awarded for the answer to (c)(ii) as the candidate has neither mentioned that the magnesium ion is smaller than the sodium ion, nor that the charge on the magnesium ion is greater than that on the sodium ion.

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Examiner Tip

Remember that the lattice energy value for an ionic compound is dependent on both the size and the charge of each ion present.

Question 23 (a)

(a) Define the term **standard enthalpy change of formation** of a compound.

Give the conditions of temperature and pressure that are used when measuring a **standard** enthalpy change.

(3)

Definition It is the ~~enthal~~ energy change when 1 mol of a compound is formed from their respective atom in ~~stable~~ ~~standard~~ stable condition under standard condition.

Standard temperature is 298 K

Standard pressure is 1 atm.

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Examiner Comments

This response scored two out of the three available marks. The candidate has incorrectly mentioned formation from 'their respective atom', instead of formation from 'elements'.

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Examiner Tip

It is important to remember how easy it is to lose marks if definitions are not learned, and understood, thoroughly.

(a) Define the term **standard enthalpy change of formation** of a compound.

Give the conditions of temperature and pressure that are used when measuring a **standard** enthalpy change.

(3)

Definition it is the enthalpy change needed to form a substance from its elements under standard conditions. in its ground state

Standard temperature is 25°C

Standard pressure is 100 atm

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Examiner Comments

This response scored one out of the three marks available. The first scoring point in the Mark Scheme was not awarded as there is no reference to one mole of substance. The second scoring point was awarded as there is a reference to formation from elements. The third scoring point was not awarded as standard pressure should have been given as 1 atm rather than '100 atm'.

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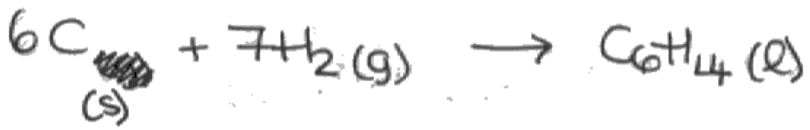
Examiner Tip

Remember to learn all the thermochemical definitions mentioned in the specification!

Question 23 (b)

(b) Write the equation, with state symbols, that accompanies the enthalpy change of formation of hexane, $C_6H_{14}(l)$.

(2)



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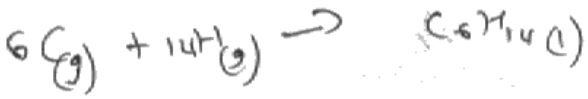
Examiner Comments

This scored both marks as all species, balancing and state symbols are correct.

(b) Write the equation, with state symbols, that accompanies the enthalpy change of formation of hexane, $C_6H_{14}(l)$.

(2)



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Examiner Comments

It is important to remember that hydrogen in its standard state is diatomic, H_2, and not monatomic. Carbon is a solid, rather than a gas, under standard conditions.

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Examiner Tip

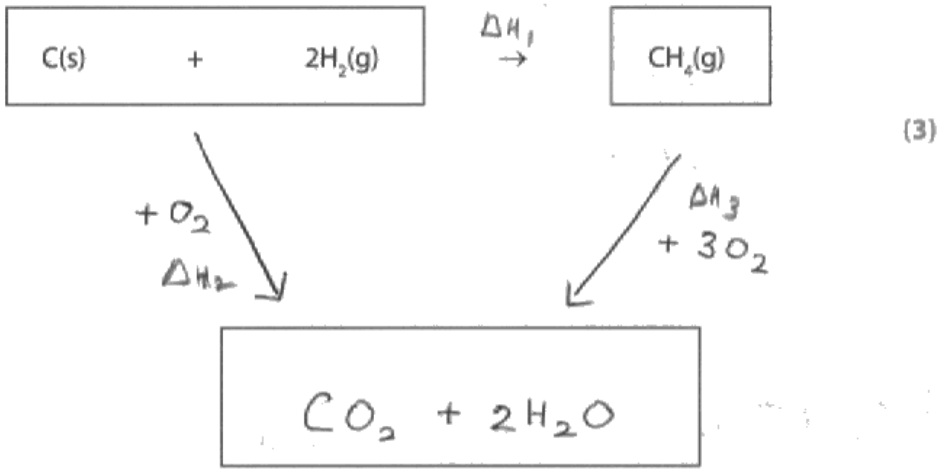
Be aware of the correct state symbols, under standard conditions, for elements such as carbon and hydrogen.

Question 23 (c)

(c) Enthalpy changes can be calculated using enthalpy changes of combustion. Values for some standard enthalpy changes of combustion are shown in the table below.

Substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s)	−394
$H_2(g)$	−286
$CH_4(g)$	−890

Use these data to complete the Hess cycle below for the reaction and then calculate the standard enthalpy change for the reaction, in kJ mol^{-1}.



(3)

Space for working

$\Delta H_1 + \Delta H_3 \longrightarrow \Delta H_2$

$\Delta H_2 = (-394) + (2 \times -286)$

$= -966$ kJmol

$\Delta H_3 = -890$ kJmol

$\therefore \Delta H_1 = -966 + 890$

$= -76$ kJmol

standard enthalpy change for the reaction = −76 kJ mol^{-1}

ResultsPlus
Examiner Comments

This response scored two out of three marks. The state symbols for carbon dioxide and water were omitted.

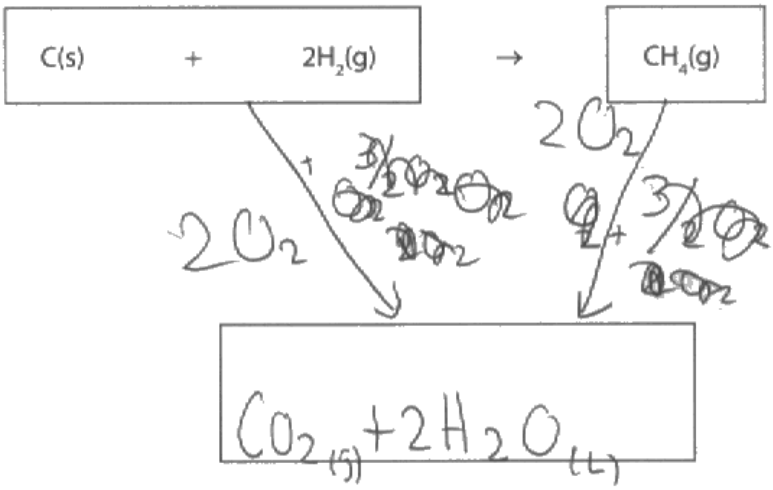
ResultsPlus
Examiner Tip

Remember to include state symbols when completing Hess cycles such as these!

(c) Enthalpy changes can be calculated using enthalpy changes of combustion. Values for some standard enthalpy changes of combustion are shown in the table below.

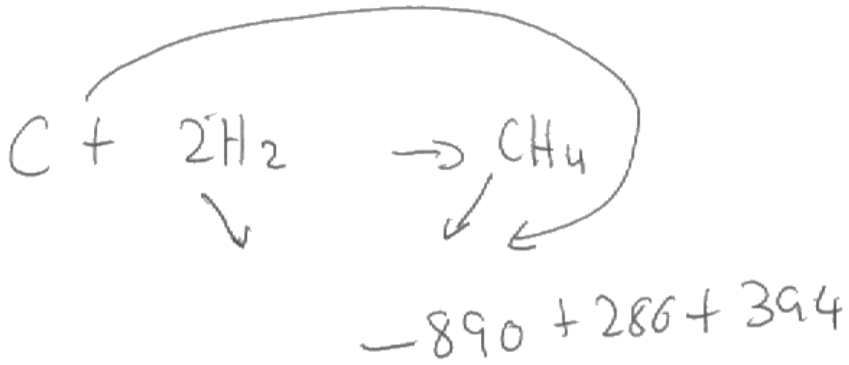
Substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s)	−394
$H_2(g)$	−286
$CH_4(g)$	−890

Use these data to complete the Hess cycle below for the reaction and then calculate the standard enthalpy change for the reaction, in kJ mol^{-1}.



(3)

Space for working



standard enthalpy change for the reaction = −207 kJ mol^{-1}

ResultsPlus
Examiner Comments

This response scored two out of three marks. The standard enthalpy change for this reaction should have been calculated as -76 kJ mol^{-1}, not the value calculated here.

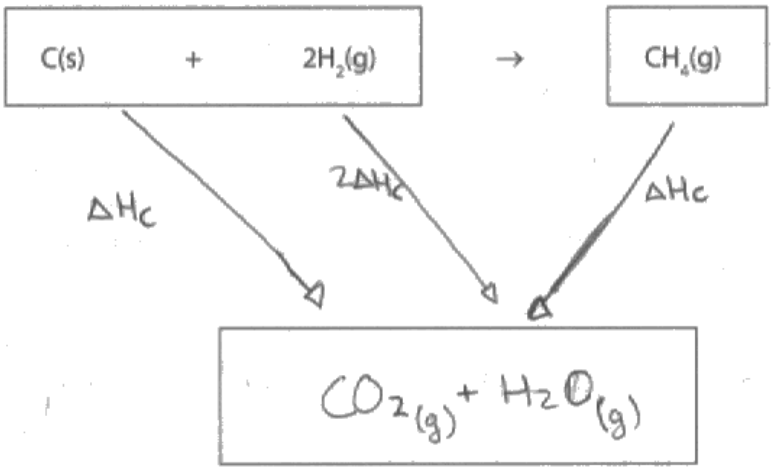
ResultsPlus
Examiner Tip

Practise more calculations relating to Hess cycles!

(c) Enthalpy changes can be calculated using enthalpy changes of combustion. Values for some standard enthalpy changes of combustion are shown in the table below.

Substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s)	−394
$H_2(g)$	−286
$CH_4(g)$	−890

Use these data to complete the Hess cycle below for the reaction and then calculate the standard enthalpy change for the reaction, in kJ mol^{-1}.



(3)

Space for working

$\Delta H = \Delta H_{c(C)} + 2\Delta H_{c(H_2)} - \Delta H_{c(CH_4)}$

$\Delta H = -394 + (2 * -286) + 890$

$\Delta H = -966 + 890$

$= -76 \text{ KJmol}^{-1}$

standard enthalpy change for the reaction = -76* kJ mol^{-1}

ResultsPlus
Examiner Comments

This response scored two out of the three available marks. There should have been two moles of water in the liquid state, $2H_2O(l)$.

ResultsPlus
Examiner Tip

Always check balancing and the state symbols of any species you add to complete a Hess cycle.

Question 23 (d)

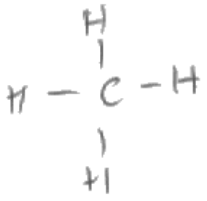
(d) The equations for the combination of gaseous carbon atoms and gaseous hydrogen atoms to form methane, CH_4, and ethane, C_2H_6, are shown below.

$$C(g) + 4H(g) \rightarrow CH_4(g) \qquad \Delta H = -1652 \text{ kJ mol}^{-1}$$

$$2C(g) + 6H(g) \rightarrow C_2H_6(g) \qquad \Delta H = -2825 \text{ kJ mol}^{-1}$$

Use these data to calculate

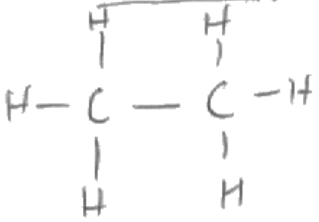
(i) the mean bond enthalpy of a C—H bond in methane, in kJ mol^{-1}. (1)



C–H × 4 ⇒ $\frac{-1652}{4}$

= −413 kJ mol^{-1}

(ii) the bond enthalpy of a C—C bond, in kJ mol^{-1}, clearly showing your working. (2)



⇒ (C–H) × 6 = −413 × 6

= −2478

∴ −2825 + 2478

= −347 kJ mol^{-1}

ResultsPlus
Examiner Comments

In (d)(i), the value of the mean bond enthalpy should have been given as a positive value, as the process relates to the endothermic process of bond breaking. In (d)(ii), consequential marking allows the award of one out of the two available marks as the calculated value should have been **+**347 kJ mol^{-1}.

ResultsPlus
Examiner Tip

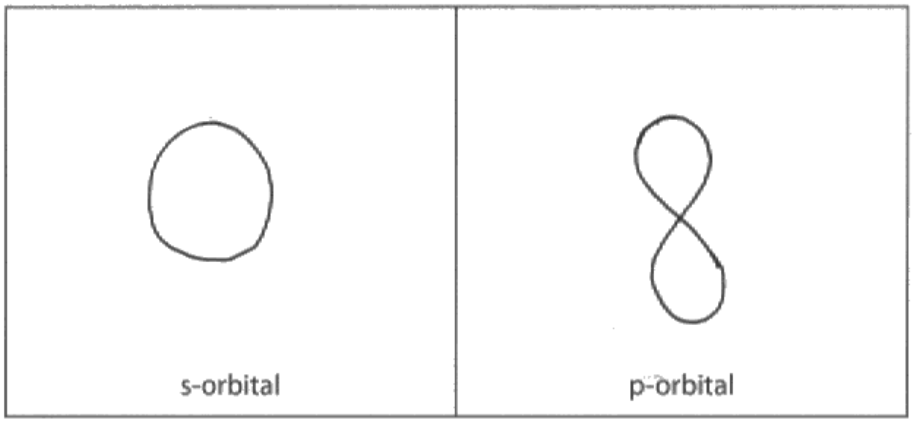
Remember that values for mean bond enthalpies and bond enthalpies have positive signs as they refer to breaking of bonds!

Question 24 (a)

24 This question is about atomic structure.

(a) Draw diagrams to show the shape of an s-orbital and of a p-orbital.

(2)



ResultsPlus
Examiner Comments

Both shapes were drawn correctly, so two marks out of two were awarded.

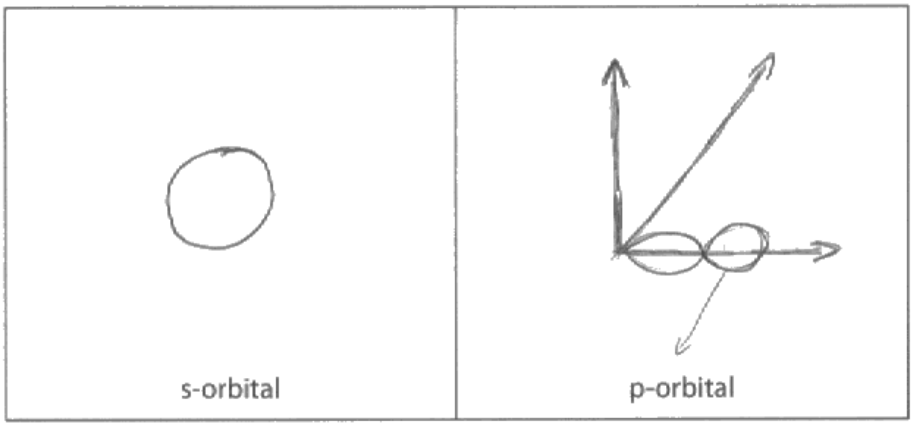
ResultsPlus
Examiner Tip

Draw diagrams neatly, as shown here!

24 This question is about atomic structure.

(a) Draw diagrams to show the shape of an s-orbital and of a p-orbital.

(2)



ResultsPlus
Examiner Comments

This response scored both marks. The three-dimensional axes did not have to be included in the diagram showing the p-orbital.

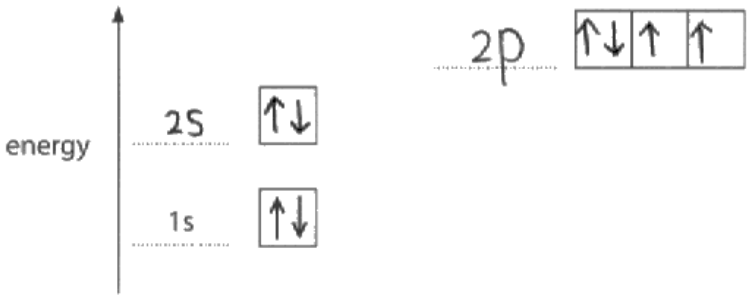
Question 24 (c)

8 → $1s^2\ 2s^2\ 2p^4$

(c) The energy diagram below is for the eight electrons present in an oxygen atom. Complete the diagram for an oxygen atom by adding

- labels to identify the other occupied sub-shells
- arrows to show how the remaining six electrons are arranged in the orbitals.

(2)



ResultsPlus
Examiner Comments

This correct response scored both the available marks.

Question 24 (d) (i)

(d) Successive ionization energies provide evidence for the arrangement of electrons in atoms. The eight successive ionization energies of oxygen are shown in the table below.

Ionization number	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionization energy / kJ mol^{-1}	1314	3388	5301	7469	10989	13327	71337	84080

(i) Define the term **first ionization energy**.

(3)

It is the energy needed to ~~form~~ remove one mole of electron from one mole of a gaseous atom to form one mole of a gaseous ion with a single positive charge.

ResultsPlus
Examiner Comments

All three scoring points in the Mark Scheme were addressed, so three marks were awarded for this response.

ResultsPlus
Examiner Tip

Learn all definitions thoroughly.

(d) Successive ionization energies provide evidence for the arrangement of electrons in atoms. The eight successive ionization energies of oxygen are shown in the table below.

Ionization number	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionization energy / kJ mol^{-1}	1314	3388	5301	7469	10989	13327	71337	84080

(i) Define the term **first ionization energy**.

(3)

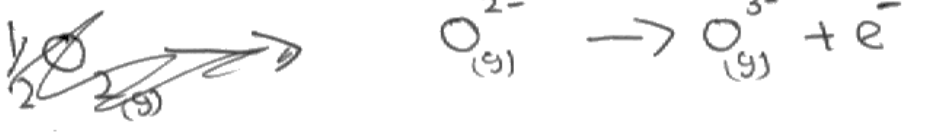
The energy required to remove one mole of electron from one mole of gaseous atom to form one mole of gaseous uni-positive ion.

ResultsPlus
Examiner Comments

This definition has been accurately recalled and so all three marks were awarded.

Question 24 (d) (ii)

(ii) Write an equation, with state symbols, to show the **third** ionization energy of oxygen.



(2)

ResultsPlus
Examiner Comments

Make sure that you can apply knowledge of definitions to novel situations. The expected equation was $O^{2+}(g) \square O^{3+}(g) + e^-$

ResultsPlus
Examiner Tip

Don't confuse ionization energies with electron affinities!

(ii) Write an equation, with state symbols, to show the **third** ionization energy of oxygen.

(2)

ResultsPlus
Examiner Comments

This equation shows the process that occurs when adding together the first three ionization energies of oxygen, so is not a valid response.

ResultsPlus
Examiner Tip

Make sure that you know the difference between the equation representing the process that occurs when the third ionization energy of oxygen is measured, as distinct from the equation which shows the sum of the first three ionization energies of oxygen.

Question 24 (d) (iii)

*(iii) Explain how the data in the table provide evidence that there are two occupied electron shells in an oxygen atom.

(2)

- The first jump ~~in~~ is after removing the 6th electron.
- ~~The energy required is more than others for the 7th and 8th electrons~~
- Electronic configuration is 2,6
- The energy required to remove 7th and 8th electrons are more than others

ResultsPlus
Examiner Comments

This scored one of the two marks available. The idea of the jump between the sixth and seventh ionization energies being a large one has not been included in this response.

ResultsPlus
Examiner Tip

Look for where there is a large jump in the successive ionization energies to ascertain a change of shell from where the electron is being removed.

*(iii) Explain how the data in the table provide evidence that there are two occupied electron shells in an oxygen atom.

(2)

because between the 6th and 7th ionization energies there is a huge sudden peak indicating a change in electron shells. Hence proves that there are two occupied electron shells in an oxygen atom.

ResultsPlus
Examiner Comments

This response scored both the marks available as the idea that there is a big jump between the 6th and 7th ionization energies of oxygen has been included.

ResultsPlus
Examiner Tip

Remember a big jump in ionization energies represents a change of shell from where the electron is being removed.

Paper Summary

On the basis of their performance on this paper, candidates are offered the following advice:

- Make sure that you read the questions very carefully;
- Make sure that you are clear as to what is being asked in every question and identify useful information given in the question to help you structure your answer;
- Practise constructing Hess cycles and Born-Haber cycles, from first principles;
- Ensure, when writing answers concerning particles, that your response clearly states the type of particle to which you are referring;
- Take care when writing state symbols, in particular (s) and (g), so that you make them unambiguous, especially if you amend them at any stage.

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