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Examiners' Report
June 2011

GCE Chemistry 6CH01 01

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Introduction

This paper tested the full range of Unit 1 material and provided good opportunities for candidates to show their knowledge and understanding of the Chemistry covered by the Specification. Section A proved accessible to almost all candidates and the mean score for the section was 12.8/20. In Section B, for the most part, candidates' work was clearly set out and they made sensible use of the space provided although, in some cases, there was wasteful repetition both of the statements in the question and of the candidate's responses.

Candidates showed a good understanding of the core concepts underlying chemical calculations but the correct use of significant figures still eludes some. While many candidates used scientific vocabulary with skill and accuracy, there remain a significant number whose use of basic chemical terms appeared to lack an appreciation of their precise meaning; for example terms such as atom, ion and molecule can be taken by some candidates as interchangeable.

The Organic Chemistry question was overall the best answered with candidates demonstrating that the basic ideas were well known and understood. In contrast, the Hess's Law question illustrated some key failings. All too frequently candidates did not appear to have read the parts of this question with the requisite care and offered answers to questions quite different from those on the paper. Far too many candidates showed little awareness of the simple practical techniques involved in the determination of an enthalpy change in a school laboratory.

Question 16 (a)

Most candidates scored well on this definition, the most common errors were the omission of the mole quantity, despite the units being given in the question, and the failure to appreciate that the species being ionized is always a gaseous atom. Standard conditions were often quoted; this is incorrect but was not penalised.

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

(3)

(~~The enthalpy~~) The energy required to remove 1 mole of electrons from 1 mole of an element under standard conditions of 25°C and 1 atm pressure. i.e remove the outermost electron from an atom. e.g:

~~Ionisation~~ $X_{g} \rightarrow X^{+} + e^{-}$

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Examiner Comments

This candidate refers to the ionization of the element rather than gaseous atoms of the element. Note also the reference to standard conditions.

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

(3)

The energy required to remove one mole of electrons from each atom in one mole of gaseous ~~at~~ atoms to form 1 mole of gaseous 1+ ions.

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Examiner Comments

A textbook answer! The removal of electrons and the formation of unipositive ions are equivalent statements.

$1s^2 2s^2 2p^6 3s^2 3p$

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

(3)

energy needed to remove 1electron from each ~~mole~~ atom ~~of~~ in a gaseous ~~atom~~ state to produce +1 ions in gaseous state

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Examiner Comments

This candidate has omitted to mention that ionization energy is a molar quantity.

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Examiner Tip

Consider the units of a quantity that you are defining. Ionization energy is measured in $kJmol^{-1}$.

Question 16 (b)

There were many excellent answers to this question, covering the key points with admirable clarity and conciseness; however, there were also common confusions. Some candidates used the terms orbital, subshell and quantum (or energy) shell as interchangeable and there were references to ions, rather than atoms, both directly and by implication from mention of charge density. The ill-defined term 'energy level' was also quite common; s and p orbitals are in the same quantum shell but (except for hydrogen atoms) at different energy levels.

(b) Explain why, in moving from Na to Ar, the general trend is for the first ionization energy to increase.

(3)

The general trend is for the first ionisation energy to increase from Na to Ar, because proton number increases from Na to Ar, so effective nuclear charge increases and so attraction between the nucleus and outer-shell electron is more and so more energy is ~~ove~~ needed to overcome this attraction and thus first ionisation energy increases

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Examiner Comments

This candidate establishes a key marking point (the increased number of protons) but fails to explain why the 'effective nuclear charge' increases across the period. Note also the repetition of the question and of parts of the answer.

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Examiner Tip

The question should not be repeated and the use of bullet points can clarify your thinking and ensure that you are making distinct marking points in your answer.

(b) Explain why, in moving from Na to Ar, the general trend is for the first ionization energy to increase.

(3)

Moving accross the period there is a greater atomic number hence greater nuclear charge acting on the electrons meaning the nucleus holds the electrons tighter so the ionisation energy required would increase across the period.
The number of shells across a period remains the same so with the added nuclear charge the atomic radius decreases so ~~they are closer to~~ the outermost electrons are closer to the nucleus making the energy needed to remove them greater.

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Examiner Comments

This is a good answer but note that the candidate has approached the question in two parts.

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Examiner Tip

Try to think carefully through your whole answer; this can save time as well as improving the structure of your answer.

Question 16 (c)

The approach to this question which involved considering the effect of electron pairing on the ionization energy was the more popular and more likely to yield both marks. Those candidates whose answer was framed in terms of the stability of the half-filled 3p subshell rarely appreciated that this electronic structure was present in unipositive sulfur ion. Once again some used the terms orbital, subshell and shell indiscriminately.

(c) Explain why the first ionization energy decreases from $_{15}$P to $_{16}$S.

(2)

The first ionisation energy decreases from P to S because in the subshells ~~8~~ P has the $3p^3$ as its last sub shell and for S it has $3p^4$ as it last sub shell, Causing repulsion between the 4 electrons in the 3p subshell.

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Examiner Comments

The basic idea is correct here but the answer is not specific enough: the candidate needs to refer to the pairing of electrons (in the $3p_x$ orbital) and the fact that repulsion between these electrons leads to the ionization energy being lower than might be expected.

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Examiner Tip

Generalised statements are less likely to score than answers that are very specific to the question.

(c) Explain why the first ionization energy decreases from P to S.

(2)

~~P_{15} [↑↓] [↑↓|↑↓|↑↓|↑↓] [↑↓|↑↓|↑ ↑↑] / P_{15} 2s, 4s, 3p6~~

A half filled shelled is more stable than a partly filled shell ~~while~~ and since P has half filled 3p orbitall thus it requires more energy to break its stability and got more electron than it is for partly filled partly filled 3p orbitall of Sulphur. to get electron to stablize itself.

(d) Estimate the value of the first ionization energy of potassium, K, and write your

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Examiner Comments

This candidate uses the terms 'shell' and 'orbital' as interchangeable. The meaning of the last part of the answer is far from clear.

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Examiner Tip

Do read through your answers and ensure that you have written exactly what you intended to convey to the examiner.

(c) Explain why the first ionization energy decreases from P to S.

(2)

S has got 2 electrons in the 3px shell. ∴ there are more repulsion between the electrons in that shell. This means that less energy is required to remove an electron from that shell. P is stable having one electron in each px, py and pz ∴ more energy required to remove an electron.

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Examiner Comments

In many ways a most impressive answer although the effect is diminished by the use of 'shell' rather than 'orbital'.

Question 16 (d)

The majority of candidates realised that the ionization energy of potassium had to be lower than that of sodium and their estimate was usually above the rather generous lower limit given in the mark scheme. A significant minority made a linear extrapolation of the graph giving a highly improbable answer.

Question 17

Most candidates found the calculations in this question straightforward and a higher proportion were able to round their final answer in 17(e) correctly than has been the case with similar questions in earlier papers in this series. However, a significant number of candidates still expressed their answers to the first three parts of the question incorrectly with excessive and incorrect rounding being the common errors. While the stoichiometric ratio question seemed well understood by most candidates, the mark was often lost by either failing to make the necessary link between the calculation and the equation or looking at only two figures, usually the magnesium and the acid.

(a) Calculate the amount (in moles) of magnesium used. (1)

$\frac{0.4}{24.3} = 0.01646$ moles

(b) Calculate the amount (in moles) of hydrochloric acid used. (1)

$\frac{1.5 \times 22.2}{1000} = 0.0333$

(c) Calculate the amount (in moles) of hydrogen produced.

[Molar volume of any gas at room temperature and pressure = 24 000 $cm^3 mol^{-1}$] (1)

$\frac{400}{24000} = 0.01667$ moles

(d) Show that the calculated amounts of magnesium, hydrochloric acid and hydrogen are consistent with the following equation for the reaction

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

(1)

Magnesium to HCl ratio ~~24~~ 1:2

~~volume of~~

Moles of HCl = 0.0333

0.0333 ÷ 2 = 0.0165 = moles of magnesium

Magnesium to H_2 ratio 1:1

Moles of H_2 = 0.01667 Moles of Mg = 0.01646

(e) Calculate the maximum mass of magnesium chloride that would be formed in this reaction. Give your answer to **three** significant figures.

(3)

Mr of $MgCl_2$ = 95.3g

0.01646 × 95.3 = 1.57g

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Examiner Comments

An excellent answer although the candidate has chosen to use the A_r of magnesium given in the Periodic Table rather than the approximate value stated in the question.

(a) Calculate the amount (in moles) of magnesium used.

(1)

1 mole of Mg → 24g
x moles of Mg → 0.400g } x = 0.0167 moles of Mg

(b) Calculate the amount (in moles) of hydrochloric acid used.

(1)

1.5 moles of HCl → 1000 cm^3
x moles of HCl → 22.2 cm^3 } $x = \frac{22.2 \times 1.5}{1000}$ = 0.0333 moles of HCl

(c) Calculate the amount (in moles) of hydrogen produced.

[Molar volume of any gas at room temperature and pressure = 24 000 cm^3 mol^{-1}]

(1)

1 mole of H_2 → 24000 cm^3
x moles of H_2 → 400 cm^3 } x = 0.0167 moles of H_2

(d) Show that the calculated amounts of magnesium, hydrochloric acid and hydrogen are consistent with the following equation for the reaction

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

(1)

1 mole of Mg ~~gave~~ produced 1 mole of H_2, according to the equation.

ratio of Mg : H_2
0.0167 : 0.0167
1 : 1

(e) Calculate the maximum mass of magnesium chloride that would be formed in this reaction. Give your answer to **three** significant figures.

(3)

1 mole of Mg gives 1 mole of $MgCl_2$, according to the equation

RFM of $MgCl_2$

$= 24 + (2 \times 35.5)$

$= 95$ amu

1 mole of Mg gives 95g of $MgCl_2$

0.0167 moles of Mg give x

$x = 1.5865$g

$= 1.59$g (3s.f)

ratio Mg : $MgCl_2$

1 : 1

0.0167 : 0.0167

Answer = 1.59g (3s.f)

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Examiner Comments

This candidate clearly understands how to do this question but in 17(d) fails to complete the answer, only considering the stoichiometric ratio of magnesium to hydrogen. Note also the use of a rounded value of the number of moles in 17(e).

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Examiner Tip

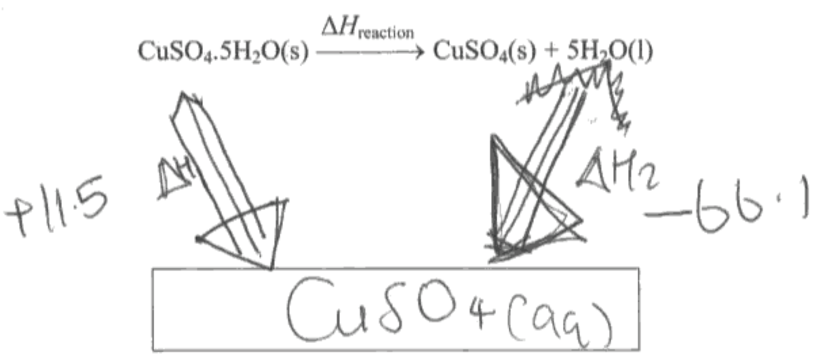
It is good practice to retain in your calculator unrounded values obtained in intermediate steps of a calculation and to use these rather than the rounded values that you write down.

Question 18 (a)

There were many excellent answers to this straightforward application of Hess's Law but there were a significant number of candidates who were unable to use the data provided to construct the appropriate cycle. The most common error was to insert incorrect species, usually the elements, in the box but both the direction and the labelling of the arrows also caused immense difficulty. Many candidates were unable to use the cycle they had constructed to calculate the required enthalpy of reaction.

(a) (i) Fill in the box and add labelled arrows to complete the Hess cycle to enable you to calculate $\Delta H_{reaction}$.

(3)



(ii) Calculate a value for the enthalpy change $\Delta H_{reaction}$.

(2)

$\Delta H_2 + \Delta H \text{reaction} = \Delta H_1$

$\Delta H \text{reaction} = \Delta H_1 - \Delta H_2$

$+11.5 - (-66.1) = 77.6 \text{ kJ mol}^{-1}$

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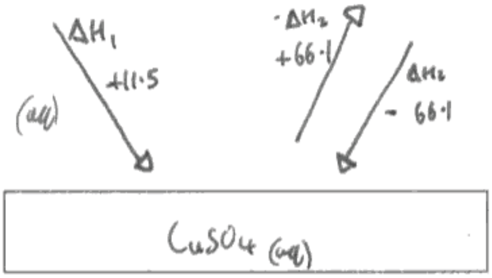
Examiner Comments

It's easy when you know how! The correct answer given with clear simplicity.

(a) (i) Fill in the box and add labelled arrows to complete the Hess cycle to enable you to calculate $\Delta H_{reaction}$.

(3)

$$CuSO_4.5H_2O(s) \xrightarrow{\Delta H_{reaction}} CuSO_4(s) + 5H_2O(l)$$



(ii) Calculate a value for the enthalpy change $\Delta H_{reaction}$.

(2)

$= 11{\cdot}5 + (+66{\cdot}1) = +77{\cdot}6\ kJmol^{-1}$

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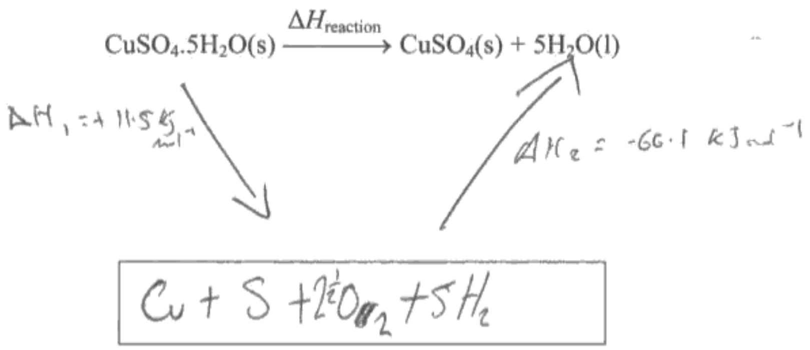
Examiner Comments

Note the reversed right hand arrow with the reversed sign on the ΔH value which the candidate uses to complete the calculation below. Again an excellent answer.

(a) (i) Fill in the box and add labelled arrows to complete the Hess cycle to enable you to calculate $\Delta H_{reaction}$.

(3)



(ii) Calculate a value for the enthalpy change $\Delta H_{reaction}$.

(2)

$11.5 + (-66.1) = \underline{-54.6 \text{ kJ mol}^{-1}}$

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Examiner Comments

This example shows some typical errors. The constituent elements have been put in the box rather than $CuSO_4$(aq) and the direction of the right-hand arrow has been reversed without changing the sign of the ΔH value. However, ignoring the contents of the box, the data in the cycle has been used correctly in (a)(ii) so consequential marking has been applied to the calculation.

Question 18 (b-c) (i)

Many of the attempts to 18(b) were stock answers to a different question about sources of error in experimental work or else plainly incorrect assertions, the most common of which was that it is impossible to measure the temperature of a solid. Relatively few candidates appeared prepared to think about the practical issues raised by the question.

There were some excellent answers to 18(c)(i) but, sadly, these were few and far between. Very many candidates did not appear to have read the question with any care at all and there were many answers which described in great detail the preparation of blue copper(II) sulfate crystals and many more which referred to the dehydration of blue copper(II) sulfate; a sigificant number of responses described enthalpy of combustion reactions. Of those that did correctly identify the reaction and had some idea of the appropriate procedure, many omitted crucial experimental details while giving extensive descriptions of the calculations required despite being specifically told that this was not required. A number of candidates referred to the use of a bomb calorimeter although it was far from clear that they understood its purpose.

(b) Suggest why it is not possible to directly measure the enthalpy change for the conversion of the blue hydrated copper(II) sulfate crystals into the white anhydrous crystals.

(1)

~~The enthalpy change is not large enough to produce a measurable temperature change~~ Because heat is needed to convert the hydrated crystals to their anhydrous state, so you would not be able to measure the temperature change in order to work out enthalpy *(c)(i) $CuSO_4.5H_2O(s) + aq \rightarrow CuSO_4(aq)$ $\Delta H_1 = +11.5$ kJ mol^{-1} endothermic

Describe briefly the experimental procedure that **you** would use to obtain the data necessary to calculate ΔH_1, given a known mass of hydrated copper(II) sulfate crystals, $CuSO_4.5H_2O(s)$.

You should state the apparatus that you would use and any measurements that you would make. $q = mc\,\Delta T$

You are **not** required to calculate the amounts of substances or to explain how you would use the data obtained.

(4)

I would carry out a calorimetry experiment. To the known mass of hydrated copper (II) sulfate crystals in a shyrofoam cup, I would add a specific volume of water (for which the mass in g is equal to the volume in cm^3). A shyrofoam cup is used to minimise conduction of heat from the surroundings. As the reaction progressed I would measure the largest temperature change that occured using a thermometer. To measure the volume of water used, a measuring cylinder would be used (or a pippete for higher accuracy).

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Examiner Comments

This candidate makes a reasonable attempt at these two questions.
In 18(b) the candidate has appreciated that direct dehydration of the blue copper(II) sulfate crystals will require an input of heat energy and it will not be possible to discriminate between the heat supplied by an external source and the heat absorbed due to the endothermic nature of the reaction the reaction.
In 18(c)(i) a correct experimental procedure has been selected but the vital importance of stirring to ensure thermal equilibrium has not been appreciated.

Question 18 (c) (ii)

As elsewhere in question 18 there were excellent answers interspersed with responses that drew on a stock list of 'errors in practical work' without regard either to the specifics of this experiment or, indeed, to the clear exclusions given in the stem of the question. Other incorrect responses were based on arguments used to discuss the discrepancy between calculated and experimental values for quantities such as Lattice Energy.

temperature needed to reduce mass -

(ii) The value for the enthalpy change from (c)(i) obtained by experiments in a school laboratory is likely to be significantly different from a data book value.

List **three** possible reasons for this which do **not** relate to the quality of the apparatus or chemicals used or possible mistakes in carrying out the procedure.

(3)

1 Experiment may not have been carried out under standard conditions. 298k + 1 Atm. Pressure

2 Heat may be lost to surroundings eg. calorimeter

3 Bond enthalpies may not take into account some covalent character.

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Examiner Comments

This candidate gives two sensible practical possibilities to answer the question and a vague proposal of the sort that might be used in a quite different context to explain the discrepancy between a calculated and experimental value.

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Examiner Tip

This type of question requires the candidate to think about the specific experiment in the question and also the way in which the data will be used to calculate the required value. Avoid vague generalisations!

(ii) The value for the enthalpy change from (c)(i) obtained by experiments in a school laboratory is likely to be significantly different from a data book value.

List **three** possible reasons for this which do **not** relate to the quality of the apparatus or chemicals used or possible mistakes in carrying out the procedure.

(3)

1 Students could have made mistakes when reading the values.

2 ~~The~~ ~~small~~ Some substances might have been left in the container.

3 Some of aqueous solution could have bee split on the floor.

(Total for Question 18 = 13 marks)

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Examiner Comments

Despite the clear instruction in the question, this candidate gives an answer based on simple mistakes in carrying out the experiment.

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Examiner Tip

Do read the question.

(ii) The value for the enthalpy change from (c)(i) obtained by experiments in a school laboratory is likely to be significantly different from a data book value.

List **three** possible reasons for this which do **not** relate to the quality of the apparatus or chemicals used or possible mistakes in carrying out the procedure.

(3)

1 The heat is lost to the surroundings

2 There might be parallen error in taking the temperature reading

3 Reaction time while ~~turn~~ operating the stop watch.

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Examiner Comments

Parallax errors in measuring a scale arise from faulty technique and are easily avoidable. It is unclear why accurate timing might have been a factor in this experiment indicating that this suggestion also has been selected from a general list of possible experimental errors.

Question 19 (a) (i)

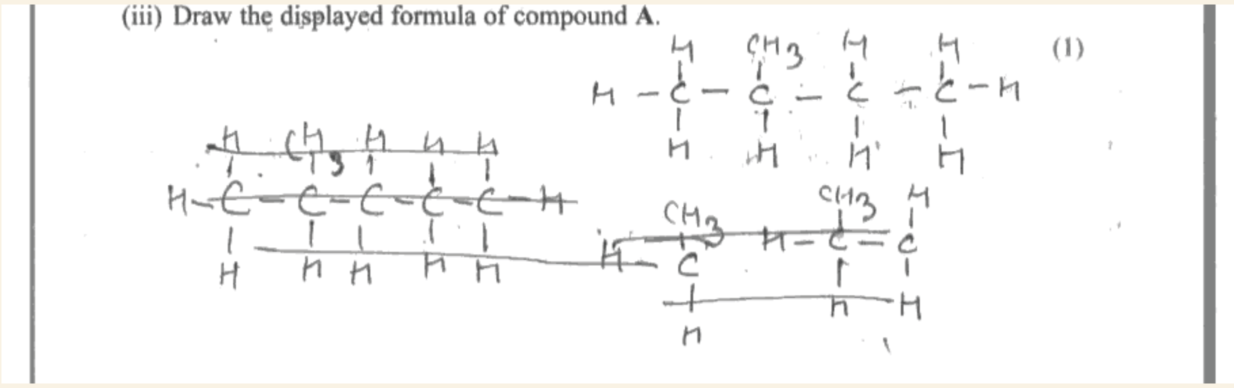
Almost all candidates were familiar with the general formula of the alkanes with just a few giving the formula of pentane instead.

Question 19 (a) (ii)

Again this question was usually answered correctly, some candidates specifying structural or chain isomers.

Question 19 (a) (iii)

The majority of candidates gave a correct displayed formula. The common errors were omission of a hydrogen atom from the structure, using CH_3 for the branched methyl group and giving a bent pentane molecule.



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Examiner Comments

Not a fully displayed formula.

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Examiner Tip

The different types of organic formulae must be known.

Question 19 (a) (iv)

The systematic naming of compound B presented few difficulties although a small number of candidates seemed unfamiliar with the basic principles of nomenclature, suggesting names like tetramethylmethane.

Question 19 (b) (i)

There were many correct equations but also a significant number with errors. In an attempt to balance the equation, some candidates changed the products, usually CO to CO_2 or, more rarely, CO_3; others replaced O_2 with O. Many candidates either left the equation unbalanced or used incorrect stoichiometric coefficients.

(i) An incomplete combustion of methane, CH_4, results in the formation of carbon monoxide and water only.

Write the equation for this reaction. State symbols are **not** required.

(2)

$CH_4 + 1\frac{1}{2}O_2 \longrightarrow CO + 2H_2O$

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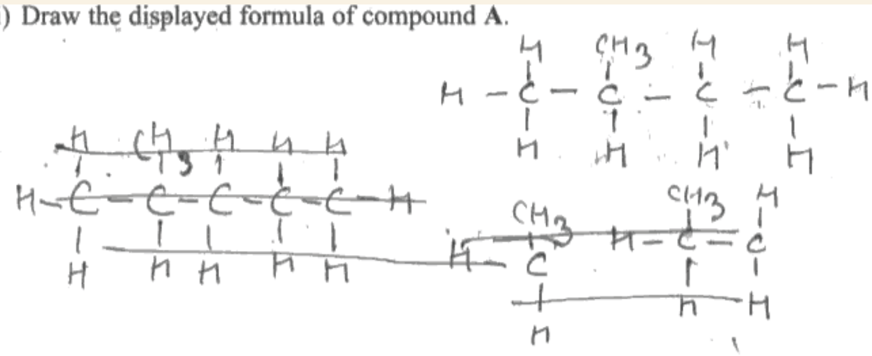
Examiner Comments

A typical correct response using the fractional amount of oxygen.

(iii) Draw the displayed formula of compound **A**.

(1)



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Examiner Comments

The equally popular scaled up version to give whole numbers for the coefficients.

(i) An incomplete combustion of methane, CH_4, results in the formation of carbon monoxide and water only.

Write the equation for this reaction. State symbols are **not** required.

(2)

$CH_4 + O_2 \rightarrow CO + H_2O$

ResultsPlus
Examiner Comments

It is unclear whether the candidate has overlooked the hydrogen and thinks this equation is balanced or cannot balance it.

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Examiner Tip

Do check equations carefully.

Question 19 (b) (ii)

The cause of incomplete combustion was well understood although some candidates simply re-stated the question.

(ii) When does incomplete combustion occur?

(1)

when reaction takes place ~~with~~ and insufficient amounts of oxygen are present.

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Examiner Comments

A typical correct response.

(ii) When does incomplete combustion occur?

(1)

This is when not all of the fuel is combletly/ fully burned in oxygen.

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Examiner Comments

This response just re-states the question using a different form of words.

Question 19(b) (iii)

The effects of incomplete combustion were generally well known although some candidates managed to confuse complete and incomplete combustion and others rolled out the familiar environmental standbys: global warming, acid rain and damage to the ozone layer.

(iii) State **two** problems that result from the incomplete combustion of alkane fuels.

(2)

1 Toxic chemicals are produced for example Carbon monoxide.

2 Pollution of the products formed; soot or very fine carbon monoxide.

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Examiner Comments

Two scoring points made but the second answer is negated by the superfluous inclusion of 'very fine carbon monoxide'.

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Examiner Tip

Listing several alternative answers for the same question is poor technique. All the answers in such a list need to be correct to gain the mark.

Question 19 (b) (iv)

The first two marks on this question were relatively easy to score but the basic mechanism of global warming was not well understood, even when candidates realised that an explanation of this was required. Some candidates described the role of carbon dioxide in the atmosphere in terms of absorbing energy from the sun (either as UV or IR) and thereby increasing global temperature while others believed that carbon dioxide was involved in depletion of the ozone layer which some suggested as a cause of global warming. A significant number of candidates focused on the effects of global warming rather than its mechanism.

*(iv) State and explain the main environmental problem arising from the **complete** combustion of alkane fuels.

(3)

If complete combustion takes place with alkane fuels, CO_2 and H_2O are released. CO_2 is extremely harmful as it is a greenhouse gas that protects the earth. CO_2 can help absorbtion of IR radiation into the earth causing heating up of the Earth. Which causes polar ice caps melting, climate change, sea level rising.

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Examiner Comments

While this response has the right idea, the execution suffers from poor explanation of global warming which is implied but not mentioned explicitly.

Question 19 (c) (i)

Precision was frequently lacking in the answers to this question. Many candidates explained the curly arrows purely in terms of bond fission. Where the identification of the type of bond fission was accompanied by a description of what happened to the electron pair, this was enough to gain the marks although it does omit significant aspects of the use of curly arrows in mechanism. Candidates referred to the electron pair being 'given' to an atom which is correct in heterolytic fission but not in nucleophilic attack. As elsewhere in the paper, some candidates used the terms atom, ion and molecule interchangeably.

(c) The reactions of organic compounds, including alkanes, may be broken down into a series of steps; this is the mechanism for the reaction. The reaction between methane and chlorine may be represented by a mechanism involving three stages – **initiation**, **propagation** and **termination**.

(i) Reaction mechanisms often involve the use of 'curly arrows'. Explain the meaning of the curly arrows shown below.

(2)

Arrow I   Arrow II

Arrow I This arrow is when an pair of bonding electrons is distributed evenly between the 2 atoms, 1 atom takes one electron each.

Arrow II This arrow is when one atom takes ~~both~~ electrons from a bond. Both ~~atom~~ electrons taken by 1 atom.

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Examiner Comments

This response deals with the special cases of bond fission, which is sufficient to gain both marks.

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Examiner Tip

Curly arrows are very important in organic mechanism so a clear understanding of how they are used will improve your grasp of mechanism and gain marks across the advanced level specification.

(c) The reactions of organic compounds, including alkanes, may be broken down into a series of steps; this is the mechanism for the reaction. The reaction between methane and chlorine may be represented by a mechanism involving three stages – **initiation**, **propagation** and **termination**.

(i) Reaction mechanisms often involve the use of 'curly arrows'. Explain the meaning of the curly arrows shown below.

(2)

Arrow I Arrow II

Arrow I homolytic fission

Arrow II heterolytic fission

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Examiner Comments

These statements are insufficient to score.

(c) The reactions of organic compounds, including alkanes, may be broken down into a series of steps; this is the mechanism for the reaction. The reaction between methane and chlorine may be represented by a mechanism involving three stages – **initiation**, **propagation** and **termination**.

(i) Reaction mechanisms often involve the use of 'curly arrows'. Explain the meaning of the curly arrows shown below.

movement of electrons

(2)

Arrow I Arrow II

Arrow I movement of 1 electron

Arrow II movement of a pair of electrons

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Examiner Comments

This is all that is needed to gain the two marks.

(c) The reactions of organic compounds, including alkanes, may be broken down into a series of steps; this is the mechanism for the reaction. The reaction between methane and chlorine may be represented by a mechanism involving three stages – **initiation**, **propagation** and **termination**.

(i) Reaction mechanisms often involve the use of 'curly arrows'. Explain the meaning of the curly arrows shown below.

(2)

Arrow I Arrow II

Shows homolytic fission.

Arrow I Arrow I shows that the shared electron pair is shared equally between the two atoms when a bond is broken

Shows heterolytic fission.

Arrow II This means both electrons in a shared pair goto one atom when the bond breaks

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Examiner Comments

The idea of the arrows showing how electrons are shared is, at best, confusing. The mark awarded here is for the idea of arrow 1 referring to one electron and arrow 2 for two electrons.

Question 19 (c) (ii-iv)

Many candidates were able to write the initiation and propagation steps correctly but 19(c) (iv) tested their understanding of the sequence and proved highly discriminating.

(ii) Using the curly arrow notation, show the **initiation** step of the reaction between methane and chlorine.

(2)

$Cl-Cl \rightarrow 2Cl\bullet$

(iii) Give the two **propagation** steps of the reaction between methane and chlorine.

Curly arrows are **not** required.

(2)

$Cl\bullet + CH_4 \rightarrow CH_3\bullet + HCl$

$CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$

(iv) Suggest why a small amount of UV light can result in the formation of a large amount of product.

(1)

The Cl• free radical is regenerated at the end of the reaction, so once a free radical is produced it takes part in many reactions, forming large quantities of product.

(v) Ethane is a trace product of this reaction. By means of an equation, show how

ResultsPlus
Examiner Comments

An excellent answer. The final part is particularly noteworthy as it shows that the candidate appreciates the role of the propagation stage in both forming the product and regenerating the chlorine free radical.

(ii) Using the curly arrow notation, show the **initiation** step of the reaction between methane and chlorine.

(2)

$$Cl-Cl \longrightarrow 2Cl\bullet$$

(iii) Give the two **propagation** steps of the reaction between methane and chlorine.

Curly arrows are **not** required.

(2)

1 $CH_4 + Cl\bullet \rightarrow CH_3\bullet + HCl$

2 $CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$

(iv) Suggest why a small amount of UV light can result in the formation of a large amount of product.

(1)

The reaction facilitates its own continuation by forming free radicals

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Examiner Comments

This answer to 19(c)(iv) stops short of showing that the chlorine free radical is regenerated by the sequence.

(ii) Using the curly arrow notation, show the **initiation** step of the reaction between methane and chlorine.

(2)

$$Cl-Cl \rightarrow Cl\cdot + Cl\cdot$$

(iii) Give the two **propagation** steps of the reaction between methane and chlorine.

Curly arrows are **not** required.

(2)

$$CH_4 + Cl\cdot \rightarrow CH_3\cdot + HCl$$

$$CH_3\cdot + Cl_2 \rightarrow CH_3Cl + Cl\cdot$$

(iv) Suggest why a small amount of UV light can result in the formation of a large amount of product.

(1)

UV light breaks the bonds between Cl_2 molecules to make free radicals

ResultsPlus
Examiner Comments

A common incorrect approach in 19(c)(iv) was to consider how the UV light sustained the reaction.

Question 19 (c) (v)

Candidates who had a reasonable idea of the mechanism had no problem with writing the correct termination step forming ethane.

Question 19 (d)

Most candidates realised that the energy of the UV light was not large enough to break the C—H bond but few of these mentioned that, because hydrogen atoms / radicals were not formed, this prevented the formation of hydrogen gas.

(d) Scientists never detect molecular hydrogen, H_2, amongst the products of the chlorination of methane.

H_2
H – H
C – H – 435
Cl – Cl – 243
UV – 400

Use the data below to suggest why this is so.

The frequency of UV light used corresponds to an energy of about 400 kJ mol^{-1}.

Bond	Bond enthalpy / kJ mol^{-1}
C—H	435
Cl—Cl	243

reactants – products
6 x 435

(2)

The bond enthalpy of H–H is so small in comparison to C–H or Cl – Cl, it cannot be detected, also because a very tiny amount of H–H is produced in the reaction. It is outrun by any of the other two products.

(Total for Question 19 = 22 marks)

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Examiner Comments

This confusion was not unusual . The candidate appears to be thinking about UV radiation being used to detect the molecular hydrogen i.e that the hydrogen may be there but not observed.

ResultsPlus
Examiner Tip

Read a question carefully and consider how any data provided might be used in your answer.

(d) Scientists never detect molecular hydrogen, H_2, amongst the products of the chlorination of methane.

Use the data below to suggest why this is so.

The frequency of UV light used corresponds to an energy of about 400 kJ mol^{-1}.

Bond	Bond enthalpy / kJ mol^{-1}
C—H	435
Cl—Cl	243

(2)

UV light does not have enough energy to break a C-H bond but does have enough to break a Cl - Cl bond.

ResultsPlus

Examiner Comments

This answer is fine for one mark but stops short.

ResultsPlus

Examiner Tip

There are two marks for this question, so two marking points will be needed.

(d) Scientists never detect molecular hydrogen, H_2, amongst the products of the chlorination of methane.

Use the data below to suggest why this is so.

The frequency of UV light used corresponds to an energy of about 400 kJ mol^{-1}.

Bond	Bond enthalpy/kJ mol^{-1}
C—H	435
Cl—Cl	243

(2)

This is because the UV light doesn't have enough energy to break the C—H bond fully so due to this no ~~hydrogen~~ moleculer hydrogen could be formed

ResultsPlus

Examiner Comments

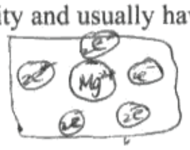
Again a key point in the logic of the answer is omitted.

Question 20 (a)

There were many high-scoring responses to this question but relatively few that showed a clear distinction between structure (what particles are present and how they are arranged) and bonding (how the particles are held together). This lack of clarity often resulted in needless repetition. The mark most usually lost by candidates who otherwise scored well was for the idea of a lattice structure i.e. an ordered three dimensional array of particles. The most frequently scored marked was for delocalized electrons although these were all too often described as part of an ionic or molecular structure. 'Metallic bonding' was sometimes the sole description offered in 20(a)(ii) and some candidates appeared to be describing the bonding between two different metals. There were many superfluous descriptions of the physical properties of metals.

20 Metals are good conductors of heat and electricity and usually have high melting temperatures and boiling temperatures.

(a) (i) Describe the **structure** of a metal.



(2)

The structure of a metal consists of ~~an~~ ions and delocalised electrons around them; carrying the opposite charge. The metal lattice is as it is because the negative electrons and positive ions attract they ~~and~~ are able to ~~keep~~ stay in their positions without having the electrons flowing away.

(ii) Describe the **bonding** in a metal.

(2)

The positive ions and negative (delocalised) electrons are bonded together by electrostatic attraction. The positive ions attract the negative electrons because of their opposite charges. This means that the bonding within the metal lattice is consistent.

ResultsPlus
Examiner Comments

This response scores maximum marks but there is a great deal of repetition because the candidate seems uncertain of the distinction between structure and bonding.

ResultsPlus
Examiner Tip

Structuring your answer to this type of question is vital. Using bullet points may help.

20 Metals are good conductors of heat and electricity and usually have high melting temperatures and boiling temperatures.

(a) (i) Describe the **structure** of a metal.

(2)

A metal consists of cations closely packed together and being surrounded by a sea of the delocalised electrons. It is very dense because of the strong metallic bonds. The structure is called giant metallic lattice.

(ii) Describe the **bonding** in a metal.

(2)

Metallic bonding is the electrostatic force of attraction between the positively charged cations and the delocalised electrons which come from the outer shell of each atom, that have a negative charge.

ResultsPlus

Examiner Comments

An excellent answer covering the key points clearly and in good detail.

20 Metals are good conductors of heat and electricity and usually have high melting temperatures and boiling temperatures.

(a) (i) Describe the **structure** of a metal.

(2)

A metal is made up of positive ions in a regular arrangement, surrounded by a 'sea' of delocalised electrons.

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Examiner Comments

A good description of the particles present in a metal and of metallic bonding but no mention of the arrangement of the metal ions (lattice).

Question 20 (b)

This question tested candidates understanding very effectively. Confusion often arose between bond strength and ionization energy and between ion charge and nuclear charge. Candidates who had a good grasp of the nature of metallic bonding, not surprisingly, scored well on this question.

(b) Explain why the melting temperature of magnesium (650 °C) is much higher than that of sodium (98 °C).

(3)

Mg donates 2 delocalised e^-s per Mg^{2+} ion ~~[illegible]~~, Na donates 1 and the Mg^{2+} ion has a larger charge and is smaller ∴ has a greater charge density so the electrostatic forces of attraction are greater (stronger) ~~[illegible]~~ between the +ve ion and e^-s in Mg so more energy is required to break these strong bonds.

ResultsPlus
Examiner Comments

A well-constructed answer.

ResultsPlus
Examiner Tip

In this type of question it is important to do more than state the facts e.g. Mg^{2+} has a larger charge.

(b) Explain why the melting temperature of magnesium (650 °C) is much higher than that of sodium (98 °C).

(3)

Magnesium has twice as many delocalised electrons because it has two electrons in its outer shell which can become delocalised, ~~of~~ creating stronger bonding between ~~the~~ metal ions than sodium which only has one delocalised electron per atom

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Examiner Comments

This answer ignores the link between marks available and the number of distinct points the candidate is expected to make.

ResultsPlus
Examiner Tip

Use the clues in the paper such as marks and space for an answer.

(b) Explain why the melting temperature of magnesium (650 °C) is much higher than that of sodium (98 °C).

(3)

magnesium has a higher charge of 2+ unlike sodium with a 1+ charge. Therefore magnesium has a higher nuclear charge, and has a smaller radius and less shielding, making the attraction between the nucleus and the electrons stronger, requiring more energy to break.

ResultsPlus
Examiner Comments

The candidate makes a promising start and then veers off into a discussion that seems to be more about ioniization than melting.

ResultsPlus
Examiner Tip

Read what you have written and check that it answers the question. If nuclear charge determined melting temperature, potassium would have a higher melting point than aluminium!

Question 20 (c)

Most candidates scored well on this question although few candidates appreciated the distinction between the ideas of electrons moving and flowing under a potential difference.

(c) Explain how metals conduct electricity.

(2)

Metals can conduct electricity, when at a liquid or molten state as well as a solid, as it has delocalised electrons that can easily carry or pass current through.

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Examiner Comments

This candidate identifies the delocalized electrons as the charge carriers but does not provide any further information.

ResultsPlus
Examiner Tip

Two marks means two scoring points.

(c) Explain how metals conduct electricity.

(2)

Metals conduct electricity because the delocalised electrons are free to move and are able to carry an electrical current. This means they can carry the current throughout the metal.

ResultsPlus
Examiner Comments

A typical answer scoring two marks.

(c) Explain how metals conduct electricity.

(2)

Metals consits of delocalised electrons, Therefore when a current is given to a metal the delocalised electrons vibrate and pass the current through the metal. Therefore the electrons pass the current through the metal.

(Total for Question 20 = 9 marks)

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

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Examiner Comments

This response confuses the current (a flow of electrons) and the transmission of heat energy through a solid.

Paper Summary

Do look for clues on the question paper. The number of marks for a question indicates the the number of scoring points the examiner will be looking for and the number of lines shows the **maximum** likely length of a reasonable reponse.

Try to ensure that you understand the basic terms used in advanced level chemistry and the differences in meaning between terms used in a particular context; the terms orbital, sub-shell and quantum shell in electronic structure are examples of terms each with a distinctive meaning that need to be understood clearly.

You can expect to be tested on your knowledge of practical techniques and how to carry out the standard experiments which are also tested in the coursework.

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