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June 2016

IAL Chemistry WCH01 01

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June 2016

Publications Code WCH01_01_1606_ER

Introduction

The concepts covered by the paper seemed accessible to most candidates as shown by many good performances in Section A.

However, the use of a number of novel contexts in Section B provided a more significant level of challenge, especially for those candidates who seemed to rely on the use of responses which they have practised, based on previous mark schemes.

Such questions, for instance 19 (b), often led to an outpouring of correct chemistry, in this case regarding activation energy, that was not always relevant to the question.

There was frustration amongst the team of examiners, as many of them felt that if candidates had read such questions with more care, they would have been in a better position to apply the chemical ideas they have studied.

Calculations were generally a strength, though there seemed to be a larger than usual number of rounding errors seen.

Inconsistent use of technical language was evident in some questions.

The distinction between orbitals, shells and sub-shells for instance, caused problems for some candidates.

Very few candidates did not finish the paper, suggesting that time management was not an issue.

Question 17 (a)

This question proved to be a straightforward start to Section B. It was usually answered correctly, though a few candidates confused atomic number and mass number.

17 A mass spectrometer can be used to measure relative isotopic masses.

(a) State the meaning of the term **isotopes**.

(1)

Isotopes are atoms of an element with different neutron number but the same atomic number and with different mass

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Examiner Comments

This gets the mark for reference to different neutron number and the same atomic number. The comment on atomic mass was ignored, and would not have been sufficient for mass number.

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Examiner Tip

Make sure you know the difference between mass number and relative atomic mass.

17 A mass spectrometer can be used to measure relative isotopic masses.

(a) State the meaning of the term **isotopes**.

(1)

isotope isotopes have the same displayed formula but different structural formula.

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Examiner Comments

This candidate has confused isotopes with isomers.

Question 17 (b) (i)

Most candidates had the right idea and scored the mark using the whole range of allowable phrases. In a few cases the answer implied that electrons were being bombarded, rather than doing the bombarding.

(b) (i) In a mass spectrometer, a sample of the vapour of an element is ionized. State how this ionization is carried out.

(1)

It is ionized in the ionizing chamber when the electrons are stripped off, when electrons are bombarded.

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Examiner Comments

This candidate may not understand the word "bombardment". The answer implies that electrons are bombarded, not that they are bombarding atoms. The mark was not allowed here.

(b) (i) In a mass spectrometer, a sample of the vapour of an element is ionized. State how this ionization is carried out.

(1)

By removing an electron from the atom.

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Examiner Comments

This answer shows that the candidate knows what an ion is, but it does not say how the ionization is carried out.

Question 17 (b) (ii)

The equation involving the fast moving electron on both sides of the equation was given by very few candidates. The number who offered totally incorrect suggestions for ionization was also small. A few candidates muddled M for Mg on the right-hand side of the equation, and this was ignored as long as the correct state symbol was given.

(ii) Complete the equation showing the simplest ionization of a vaporised element **M**.

(1)

$$M(g) + e^- \rightarrow M^{-1}_{(g)}$$

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Examiner Comments

An electron could be shown on the left of the equation here to represent the bombarding electron, but that way another electron would have been knocked out and a positive ion formed.

Question 17 (b) (iii)

Most candidates knew that ions in the mass spectrometer are accelerated by an electric field or by charged plates. However a few lost the mark by saying that positively charged plates were involved. A minority of candidates seemed to have confused acceleration with either ionization or deflection.

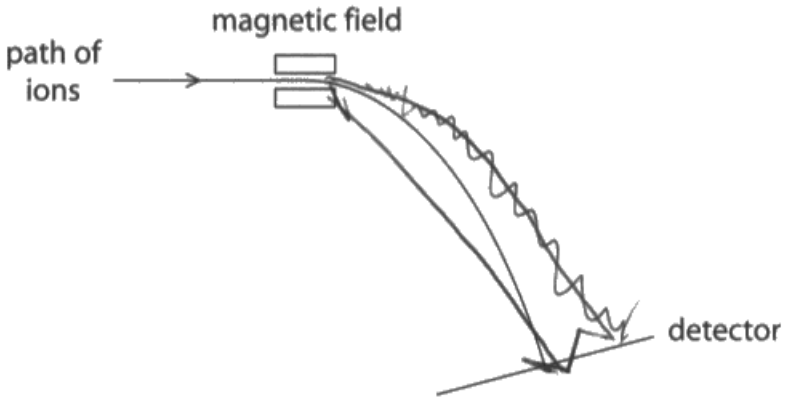
Question 17 (b) (iv)

The line showing the path of the lighter ion had to be drawn with more, not less, deflection. A few drew more deflecting lines that then missed the target completely.

A very small number of candidates drew a line showing a path which did not travel through the magnetic field or was deflected upwards.

(iv) Ions with the same charge and travelling with the same velocity are then passed through a magnetic field.

(1)



The path of one ion is shown.
Add a line to the diagram to show the path of a **lighter** ion as it passes through the magnetic field and travels to the detector.

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Examiner Comments

This diagram appears to show two lines with different deflection, but they end up at the same point on the detector so this did not score a mark.

Question 17 (c)

The most common error here was not fulfilling the requirement that the answer had to be quoted to four significant figures. The candidates almost all showed their working, so when this error occurred the first mark could often be given. A very commonly seen error was to round 28.1095 to 28.12.

(c) A sample of silicon is analysed in a mass spectrometer.

Relative isotopic mass	Relative abundance
28	92·17
29	4·71
30	3·12

Calculate the relative atomic mass of silicon, showing your working.
Give your answer to **four** significant figures.

(2)

$\left(\frac{92.17}{100} \times 28\right) + \left(\frac{4.71}{100} \times 29\right) + \left(\frac{3.12}{100} \times 30\right)$

$= 28.148$

$= 28.14$

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Examiner Comments

The method is shown clearly here even though there is an error in calculating the final value, so 1 mark was given.

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Examiner Tip

Always show your working in calculations. If the final answer is wrong you could still score some marks.

Question 17 (d)

Most candidates attempted this, and there were some well laid out answers. It was disappointing to see O=16 and H=1 used by too many, who clearly had not read the question.

A small number did not know where to start, or tried a percentage composition calculation.

Marks were lost by those candidates who did not give an assumption, while others believed that their 'conclusion' was their 'assumption'.

Use these data to deduce whether the compound is C_6H_{12} or C_5H_8O. Show your working, and state the assumption you make. **(3)**

C_6H_{12}: $(6 \times 12) + (12 \times 1.0079) = 84.0948$ g

C_5H_8O: $(5 \times 12) + (8 \times 1.0079) + (15.9949) = 84.0581$ g

hence it is C_5H_8O

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Examiner Comments

This is an example of a well laid out answer scoring full marks.

Use these data to deduce whether the compound is C_6H_{12} or C_5H_8O. Show your working, and state the assumption you make. **(3)**

$84.0581 - (15.9949 + (1.0079 \times 8))$

$= 60$

$= 5 \times 12$

It is C_5H_8O

Assumption

No other isotopes of carbon, hydrogen or oxygen are present. That the relative atomic mass of carbon is exactly 12 (only carbon-12 present and no other isotopes of it)

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Examiner Comments

In this method, the candidate has subtracted the mass of one O atom and 8 H atoms from the relative molecular mass, and shown that the remaining mass equals the mass of five C atoms. This scores all three marks.

Question 17 (e)

This question was not well answered. The most common response was to comment on the mass of helium rather than the size of the atom. Other responses included discussion on the relative stability of the atom (often said to have a full octet of outer electrons!), ease of detection, abundance, only having one isotope, etc. It seemed that many candidates thought they were simply being asked to state one property of helium, rather than being asked for a relevant property. They did not consider the property of helium which would allow it to leak out of a sealed container.

(e) A helium mass spectrometer is an instrument used to detect leaks in containers.

A sealed container filled with helium is placed in a vacuum chamber. Any helium leaking out of the container is detected by the mass spectrometer.

Suggest **one** reason that makes helium suitable for this purpose, other than its lack of reactivity.

(1)

It is very light so it can travel fast and through objects as it is small too

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Examiner Comments

This is on the right track but was not expressed well enough to score. It should have said that the atoms were small, and to say it is light without referring to a quantity is meaningless.

Question 18 (a)

Most candidates wrote the electron configuration correctly. A few confused atomic number with mass number and gave the configuration of an atom with 27 electrons.

18 This question is about the elements aluminium and magnesium.

(a) Complete the electronic configuration for an **atom** of aluminium.

(1)

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{17}$

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Examiner Comments

This answer is based on the relative atomic mass of aluminium, not the atomic number.

Question 18 (b)

A surprising number of errors appeared in this question which should have been easy for a careful candidate.

(b) Complete the table to show the composition of an aluminium ion, Al^{3+}.

(1)

Subatomic particle	Number of particles in Al^{3+}
proton	~~17~~ 27
neutron	~~27~~ 14
electron	10

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Examiner Comments

This candidate has used the atomic mass of aluminium instead of its atomic number but has then given the correct number of electrons in the ion. At this level candidates should be surprised that the number of protons and electrons is so different and should go back to check their work.

Question 18 (c) (i)

Various different errors occurred here. Some answers just identified the orbital as s or p (or occasionally d) without giving the quantum shell number as well. If all were correct this scored one mark. Other candidates gave four orbitals in the order in which they are filled instead of the order in which electrons would be removed.

(c) The table below shows the first four ionization energies of aluminium.

(i) Complete the table by identifying the orbital from which each electron is removed.

(2)

	First ionization energy	Second ionization energy	Third ionization energy	Fourth ionization energy
Ionization energy / kJ mol^{-1}	578	1817	2745	11 578
Orbital	~~3p~~ ~~3p~~ 3s	~~3s~~ 3p	3s	2p

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Examiner Comments

Answers like this show that candidates do not understand the different energy levels within quantum shells, and that it is easier to remove an electron from a sub-shell with higher energy than from a lower energy one.

Question 18 (c) (ii)

The question asked for state symbols in the equation showing the second ionization of aluminium, but these were often incorrect or missing. Sometimes an equation was given showing the loss of two electrons rather than the second electron, and on other occasions electrons were added to the wrong side, or negatively charged ions were shown.

(ii) Write the equation, including state symbols, which represents the second ionization energy of aluminium.

(2)

$$Al^{+}_{(g)} - e^{-} \longrightarrow Al^{2+}_{(g)}$$

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Examiner Comments

The equation can be written like this, or with an electron being produced on the right hand side. Most candidates find it easier to check that the charges in the equation are balanced if the second method is used.

Question 18 (c) (iii)

Many candidates made the point that the second ionization energy is higher than the first because there is a greater attraction between the electrons and the nucleus. However, justifying this proved difficult. The higher second ionization energy does not just apply to a Group 1 element, where the second electron is removed from a quantum shell closer to the nucleus, so a reason had to be given which is true in general and not just for Group 1.

The mark scheme allowed several possible answers.

*(iii) Explain why the second ionization energy of an element is always greater than the first ionization energy.

(2)

This is because when you remove ~~a electron~~ the first electron the subshell is not stable hence it is removed easily but when the second electron is removed it needs more energy as it is in a more stable subshell or a half filled subshell which is closer to the nucleus.

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Examiner Comments

This answer is partly true for an element in Group 1 but not for all Groups. The candidate seems to think there is an unstable sub-shell at the start but no justification is given.

*(iii) Explain why the second ionization energy of an element is always greater than the first ionization energy.

(2)

The electron removed is closer to the nucleus. There are more protons than electrons so the effective nuclear charge is greater so the electron is more strongly attracted to the nucleus. The electron is also removed from a positive ion where it is more strongly attracted so more energy needs to be supplied to

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This is an example of a good answer which scored both marks in more than one way.

Question 18 (c) (iv)

This question is asking for an explanation for the data in the table in 18(c)(i), which is that the difference in energy between 3p and 3s levels is greater than between 3s and 2p levels.

However, many candidates simply discussed the difference between the third and fourth ionization energies without mentioning the first and second. Others simply compared the first and second with the third and fourth ionization energies. Some candidates earned one mark by discussing the fourth electron being removed from the second shell.

*(iv) Explain why the difference between the third and fourth ionization energies of aluminium is much larger than the difference between the first and second ionization energies.

(2)

Fourth electron is lost from another orbital which is much closer to the nucleus. ~~Nuclear~~ shielding decreases and nuclear attraction increases after the ~~while removing~~ third electron is removed. So ionization energy increases.

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Examiner Comments

This answer does not address the difference between the two pairs of ionization energies.

*(iv) Explain why the difference between the third and fourth ionization energies of aluminium is much larger than the difference between the first and second ionization energies.

(2)

first and second ionization removes electrons from same shell but different subshells (from 3rd sets shell). However third ionization removes electrons from the 3rd shell and fourth electron is removed from the 2nd shell. Hence the energy difference is higher in third and fourth ionization.

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Examiner Comments

This explains that the first two electrons come from the same main shell, but the third and fourth electrons come from different main shells which is the key point in this question.

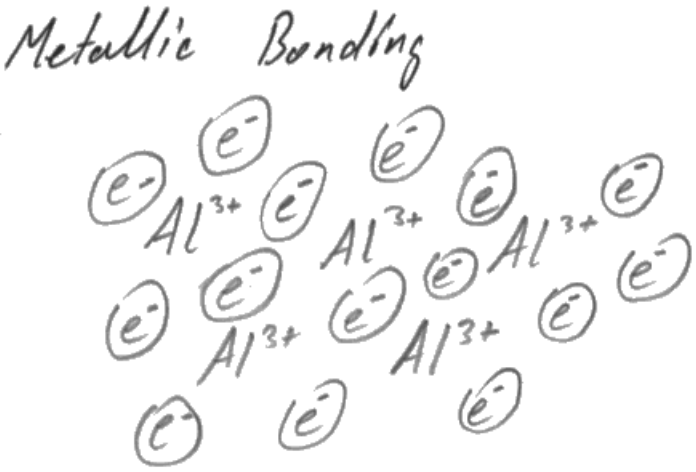
Question 18 (d) (i)

Many poor diagrams were seen. A common error was to leave out electrons from the spaces between the aluminium ions. Quite often labels were missing, or the cation labelled as a "proton" or "nucleus". There should be enough regularly arranged positively charged ions to make it obvious that the diagram represents a lattice, and the delocalised electrons should have been placed randomly between them. There should be approximately the same number of positive and negative charges shown but differences in numbers were not penalised on this occasion.

It was disappointing to see dot and cross diagrams attempting to show molecules of aluminium.

(d) Aluminium is a silvery metal with a melting temperature of 933 K.

(i) Draw a labelled diagram of the bonding in aluminium. (2)



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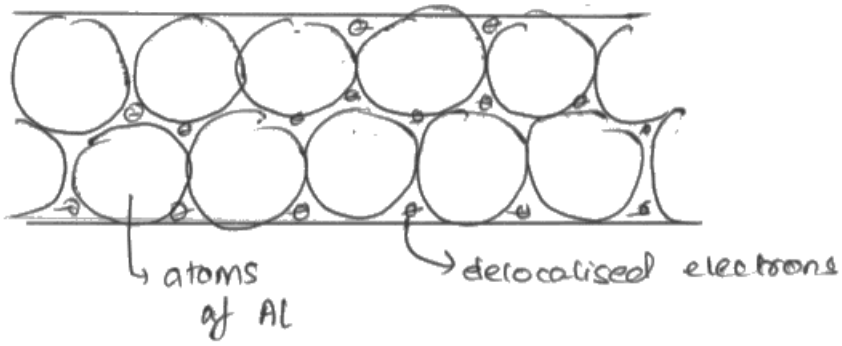
Examiner Comments

The diagram shows a regular array of aluminium ions, but the electrons are not labelled as delocalised or a sea of electrons so it scored 1 mark.

(d) Aluminium is a silvery metal with a melting temperature of 933 K.

(i) Draw a labelled diagram of the bonding in aluminium.

(2)



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Examiner Comments

The diagram showed a lattice and the delocalised electrons were correctly labelled, but the aluminium particles should be labelled ions. It scored 1 mark.

Question 18 (d) (ii)

Most candidates recognised that the melting temperature of magnesium would be lower than aluminium and the mark scheme allowed different ways of justifying this. All of the possibilities in the mark scheme were seen regularly. The best answers were brief and succinct.

(ii) The atomic number of magnesium is one less than aluminium. Would you expect magnesium to have a higher or lower melting temperature than aluminium? Justify your answer.

(2)

lower melting point. Mg forms 2+ ions & Al forms 3+. Al contributes 3 electrons to sea of delocalised electrons, Mg contributes only 2. Al^{3+} is also smaller than Mg^{2+}. This makes metallic bonding stronger in

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Examiner Comments

This is an example of a good answer. It gives a list of reasons for the lower melting temperature of magnesium but all are correct.

(ii) The atomic number of magnesium is one less than aluminium. Would you expect magnesium to have a higher or lower melting temperature than aluminium? Justify your answer.

(2)

Magnesium will have a lower melting temperature because the Mg^{2+} ion is smaller than the Al^{3+} ion and the charge is also lower on Mg^{2+} than on Al^{3+}. Therefore, the attractions between Mg^{2+} ions and its delocalised electrons is lower than that of Al^{3+} so it has a lower melting temperature.

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The force of attraction of magnesium ions to the delocalised electrons is weaker than for aluminium ions, but as magnesium ions have a greater ionic radius than aluminium ions this only scored 1 mark.

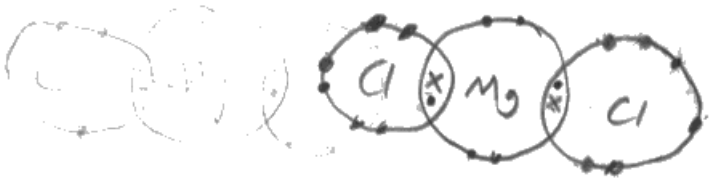
Question 18 (d) (iii)

It was disappointing to see so many diagrams of a covalently bonded structure. When an ionic structure was chosen there were only occasional slips relating to the charges on the ions or to the ratio.

(iii) Draw the dot and cross diagram for magnesium chloride, $MgCl_2$.

Show the outer electrons only.

(2)



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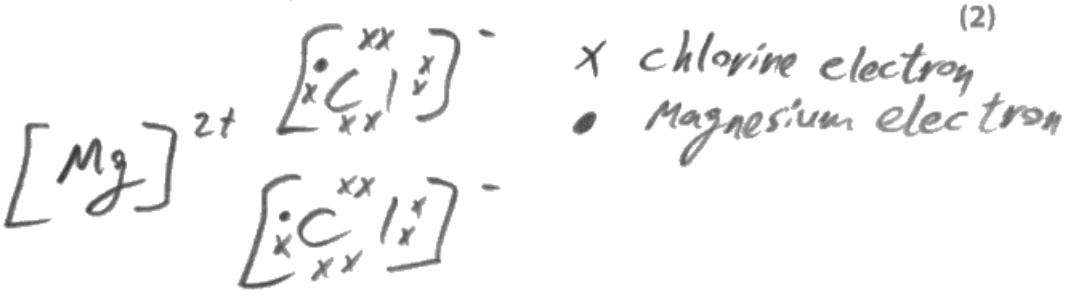
Examiner Comments

Covalent diagrams did not score, and the origin of the electrons round magnesium is a mystery.

(iii) Draw the dot and cross diagram for magnesium chloride, $MgCl_2$.

Show the outer electrons only.

(2)



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This scored both marks. The Mg ion could be shown with zero or eight electrons in the outer shell.

Question 18 (d) (iv)

Very few candidates scored all three marks in this question. Many said that the aluminium ion polarizes or distorts the chloride ion, and then went on to discuss how this occurs without answering the question which asked what "more covalent character" means.

It was rare to see any correct suggestions which would support the covalent character of aluminium chloride. The difference between theoretical and experimental lattice energy is a measure of covalent character. Another familiar difference between covalent and ionic compounds is electrical conductivity, but this was not often suggested.

Some candidates confused this with Q18dii and discussed aluminium and magnesium metals again.

*(iv) Aluminium chloride has more covalent character than magnesium chloride.

Explain what this statement means. By considering the physical properties of these two chlorides, suggest **one** piece of evidence showing that aluminium chloride has more covalent character than magnesium chloride.

(3)

The bond in aluminium chloride is not 100% ionic since the aluminium ion has a greater charge compared to the magnesium ion. Also the aluminium ion has a smaller ionic radius compared to the magnesium so it has a stronger polarization power compared to magnesium ion. Therefore the ~~magnesium~~ aluminium ion attracts the chloride ion more strongly thus giving the anion a distorted shape.

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This answer describes how polarization of ions occurs, but it does not explain the term "covalent character" so it scores the first mark only.

Question 19 (a)

Candidates were usually able to draw the skeletal formula of 2-methylpropane.

Answers could include a structural formula as rough work but a skeletal formula had to be given to gain a mark. A few answers showed 2-methylpentane.

Question 19 (b)

This question was badly answered. The reaction is exothermic and therefore heat produced in the reaction keeps the catalyst at a high temperature. However candidates often wrote extensively about catalysis, activation energy and chain reactions, none of which were relevant. They needed to read the question more carefully instead of producing an automatic response to the word "catalyst".

(b) When the hair-styler is switched on, the catalyst is heated using a battery.
Suggest why the battery is not needed after the catalyst has been heated initially.

(2)

Because an exothermic reaction occurs where heat will keep ~~on being~~ being given out to the surroundings so that the 2-methyl propane can react with the oxygen, and hence, give out even more energy, therefore, enabling the styler to work.

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This recognises that the reaction is exothermic so gets one mark, but does not go on to say that the heat produced in the reaction heats the catalyst.

(b) When the hair-styler is switched on, the catalyst is heated using a battery.
Suggest why the battery is not needed after the catalyst has been heated initially.

(2)

Catalyst will speed up the reaction without used up itself. It provides an alternative route with lower activation energy. So, battery is not needed.

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This does not answer the question as to why the battery is not needed. Writing about catalysis did not score.

Question 19 (c) (i)

Under standard conditions (298K) water is a liquid. This question was simply expecting candidates to realise that, if $H_2O(g)$ is formed, heat will be given out if it is then condensed to $H_2O(l)$. This makes the enthalpy change of formation of $H_2O(g)$ less negative than for formation of $H_2O(l)$. However, many candidates did not understand what was being asked.

(i) The standard enthalpy change of formation of $H_2O(g)$ is $-241.8\ kJ\ mol^{-1}$. Explain why this is less negative than the standard enthalpy change of formation of $H_2O(l)$.

(1)

The standard form of water is liquid. More energy to convert water to a gas. So less exothermic.

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Examiner Comments

The standard state of water at 298K is liquid, so this answer correctly stated that energy is needed to convert it to a gas. This would make the standard enthalpy change of formation less exothermic.

(i) The standard enthalpy change of formation of $H_2O(g)$ is $-241.8\ kJ\ mol^{-1}$. Explain why this is less negative than the standard enthalpy change of formation of $H_2O(l)$.

(1)

Change of phase involves change in energy. When water is converted from liquid to gas, some energy is supplied in order for the change in state to occur, hence formation of $H_2O_{(g)}$ has a less exothermic enthalpy change.

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This was given the mark for saying that the change of state from water to steam needs a supply of energy, implying that the reverse is exothermic.

Question 19 (c) (ii-iii)

The main errors in this question were incorrectly constructed Hess cycles (with arrows pointing in the wrong direction) and poor grasp of the correct multiples to use for an enthalpy change of formation.

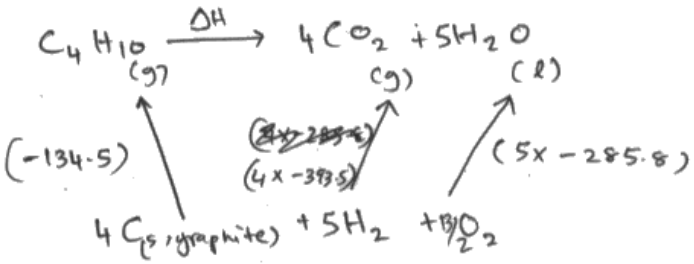
In part (c)(iii) many candidates divided the answer to (c)(ii) by the number of moles of gas in the canister instead of multiplying.

(ii) Use the data in the table to calculate the standard enthalpy change of combustion of 2-methylpropane in kJ mol^{-1}.

Show your method, which may involve the use of a Hess cycle.

Include a sign and units in your answer.

(3)



$\Delta H + (-134.5) = (4 \times (-393.5) + (5 \times -285.8)$

$= (-1574) + (-1429)$

$= (-3003) + 134.5$

$= -2868 \text{ kJ mol}^{-1}$

(iii) A refill canister for the cordless hair-styler holds 15 g of 2-methylpropane.

Calculate the energy in kJ which can be obtained from one canister.

(2)

$n = \frac{15}{58}$

$n = 0.259$

$E = \frac{2868}{0.259}$

$E = -11073 \text{ kJ}$

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Candidates should round their answers to a sensible number of significant figures at the end of their calculation. When rounded correctly the answer to (ii) is -2869 kJ mol^{-1}

In (iii) the number of moles is calculated correctly. The answer to (ii) is the energy produced by one mole of gas, so it should be multiplied by the number of moles to get the final answer.

Question 19 (d) (i)

The Hess cycle was given in this question, so it was a straightforward calculation. In answers where Hess's Law was not applied correctly the sign was wrong and no mark was awarded.

Question 19 (d) (ii)

The values shown on the cycle are obtained from bond enthalpies, or enthalpy changes of atomization.

There were often blank spaces in this question. Candidates commonly referred to enthalpy changes of formation, bond enthalpies of compounds, and enthalpy of decomposition of methylpropane or butane. Some candidates did not realise that experimental data were not required; they often suggested that the temperature, heat loss or number of moles of reactants should be known to calculate the enthalpy changes.

(ii) The enthalpy change of vaporization of water was one piece of data used to calculate the enthalpy changes shown beside the arrows in the cycle. What other information was needed?

(1)

The enthalpy change of ~~formation of Ethe~~ decomposition of carbon dioxide.

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If this had referred to atomization of carbon dioxide instead of decomposition it would have been allowed a mark. Enthalpy change of decomposition is not a correct term without an equation showing the reaction for the change.

(ii) The enthalpy change of vaporization of water was one piece of data used to calculate the enthalpy changes shown beside the arrows in the cycle. What other information was needed?

(1)

~~Etha~~ Enthalpy change for bond enthalpy of C_4H_{10}

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The candidate was on the right track when thinking about bond enthalpies, but the term cannot be applied to a compound so the mark was not awarded.

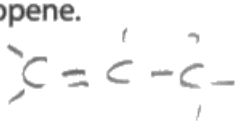
Question 20 (a)

Candidates made mistakes in this question which might have been avoided if they had drawn the displayed formula of propene first.

The mark for the double bond was often scored but many candidates tried to draw a molecule with structure $CH_2CH_2CH_2$ instead of CH_2CHCH_3. Answers were frequently very difficult to read and marks cannot be awarded if answers are illegible!

20 Propene is an alkene which can be produced by cracking some of the hydrocarbons in crude oil.

(a) Draw a dot and cross diagram showing the bonding in propene.
Show outer electrons only.



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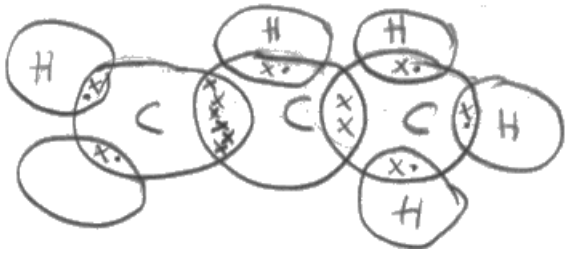

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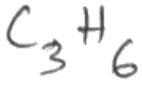
Examiner Comments

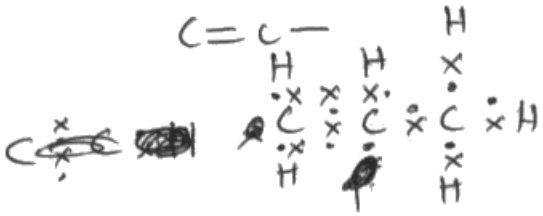
This candidate has shown the double bond correctly but has forgotten one of the hydrogen atoms on the left so has scored 1.

20 Propene is an alkene which can be produced by cracking some of the hydrocarbons in crude oil.

(a) Draw a dot and cross diagram showing the bonding in propene.
Show outer electrons only.

(2)





ResultsPlus
Examiner Comments

This candidate has an extra electron on the middle carbon atom

ResultsPlus
Examiner Tip

Make your diagram as clear as possible showing electrons in pairs, and check the total number of electrons round each atom when you have finished.

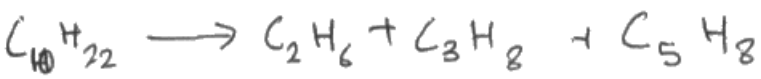
Question 20 (b) (i)

This was a straightforward question for candidates who knew the formulae of alkanes and alkenes and there were many correct answers.

(b) (i) Propene is one product of the cracking of decane, $C_{10}H_{22}$.

Write the equation for the reaction in which one mole of decane is cracked to produce one mole of ethene, one mole of propene and one other product. State symbols are not required.

(1)



ResultsPlus
Examiner Comments

This candidate gave the formula of ethane and propane, and should have realised that the remaining 5C and 8H would not make a likely product.

ResultsPlus
Examiner Tip

Think about whether the formulae you write are the hydrocarbon products you would expect to get after cracking.

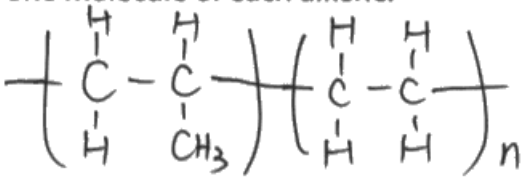
Question 20 (b) (ii)

Many candidates found it difficult to link the repeat units of poly(ethene) and poly(propene). Sometimes double bonds were shown in the final structure. On other occasions the two repeat units were shown separately, not linked, and this was allowed 1 mark. Answers showing a 5-carbon section of poly(ethene) were from candidates who had probably forgotten that when propene forms a polymer the carbon chain will be branched.

(ii) A synthetic rubber can be made by polymerizing a mixture of ethene and propene.

Draw the structural formula of the repeat unit of this polymer which forms from one molecule of each alkene.

(2)



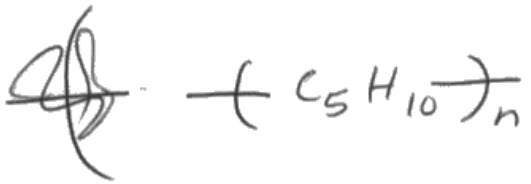
ResultsPlus
Examiner Comments

This scored both marks. The candidate has correctly linked the repeat units of poly(ethene) and poly(propene).

(ii) A synthetic rubber can be made by polymerizing a mixture of ethene and propene.

Draw the structural formula of the repeat unit of this polymer which forms from one molecule of each alkene.

(2)



ResultsPlus
Examiner Comments

The repeat unit formed when ethene and propene combine contains 5C and 10H atoms but the answer given here is not a structural formula. The candidate should have read the question more carefully.

Question 20 (c)

Potassium manganate was well known, as was the change from purple to colourless. However, many candidates lost the first mark for giving an incorrect oxidation state. Many candidates did not attempt to include any reference to an acid, but those who did usually identified the correct acid. A significant number of candidates thought that potassium dichromate would be a suitable reagent.

(c) Propene is also used to make propane-1,2-diol. Give the reagents and colour change when this product is made at room temperature.

(3)

Reagents K_2MnO_4 / H^+

Colour change from purple to colourless

ResultsPlus
Examiner Comments

The formula for potassium manganate(VII) was incorrect. In this question H^+ was allowed for the acid so this was given 2 marks.

Question 20 (d)

Many candidates gave the correct colour change, but gave the 1,2-dibromopropane molecule for the displayed formula of the product.

1-bromopropane was also quite a common incorrect answer. Nomenclature proved to be difficult for many, particularly for those who identified the Br group by name first and then omitted the positional identification of the –OH group.

It was rare to see the bond going directly to the H in OH from the carbon. Incorrect colour changes including purple to colourless and orange to green were sometimes given.

(d) The reaction of propene with bromine **water** is used as a test for the carbon-carbon double bond.

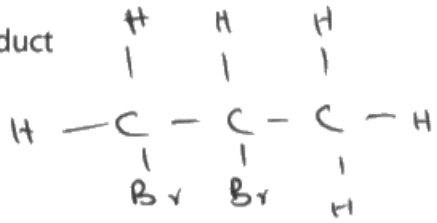
State the colour change in this test.

Draw the displayed formula of the organic product and give its name.

(3)

Colour change from brown to colourless

Displayed formula of product



Name 1,2 - dibromopropane

ResultsPlus
Examiner Comments

This was a common error for the formula of the product, but as long as the two Br were on adjacent C atoms a mark was allowed for the name.

(d) The reaction of propene with bromine **water** is used as a test for the carbon-carbon double bond.

C - C - C

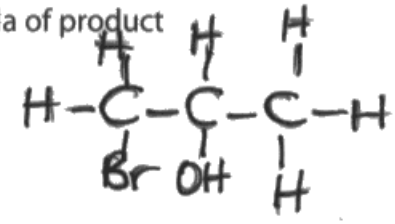
State the colour change in this test.

Draw the displayed formula of the organic product and give its name.

(3)

Colour change from Orange to colourless

Displayed formula of product



Name Bromo propane

ResultsPlus

Examiner Comments

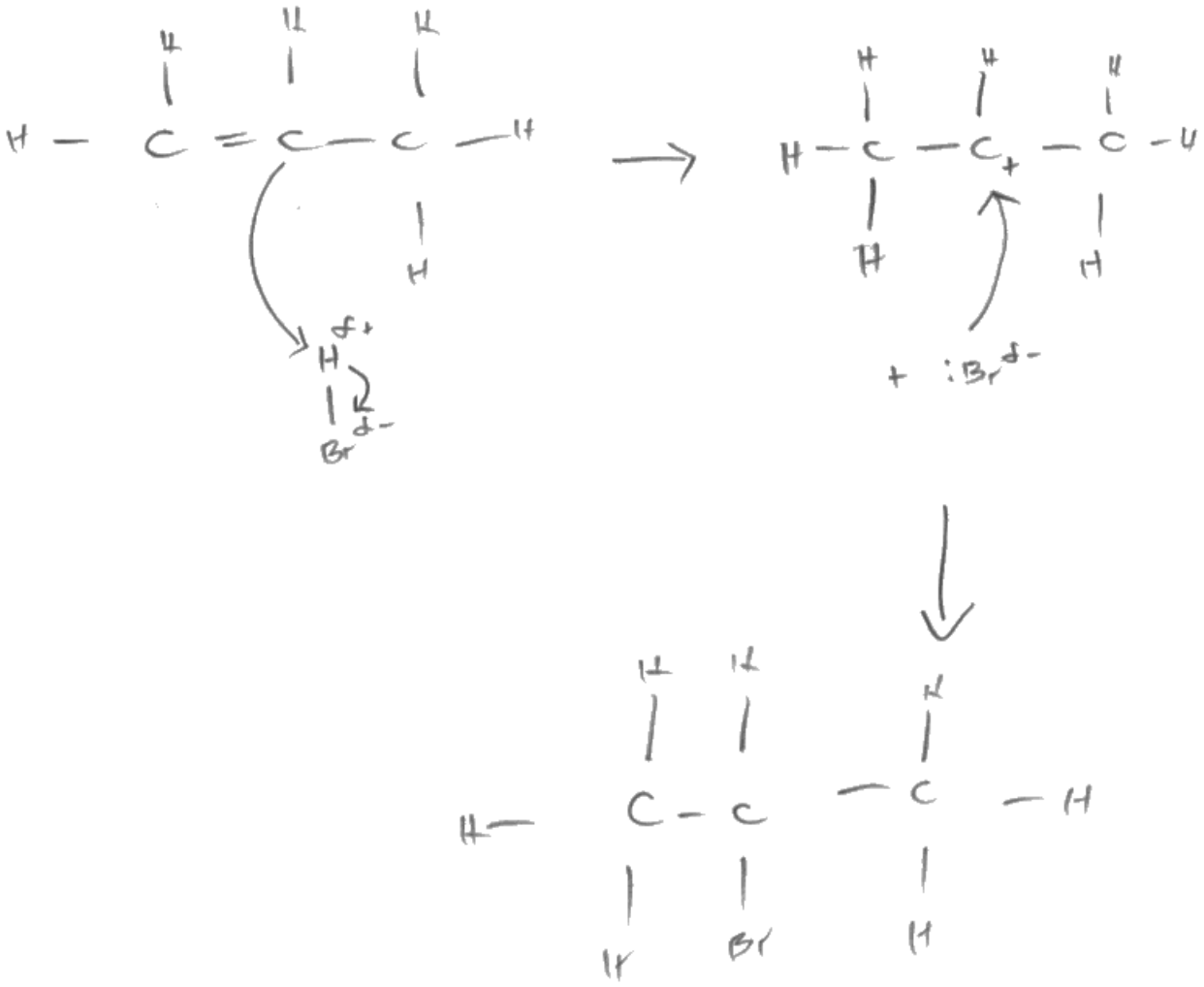
It looks as if this candidate has left a space for the name of the OH group but did not know how to include it. Even if "hydroxy" had been written in the space there should have been numbers to show the positions of the Br and OH.

Question 20 (e)

Many candidates were familiar with this mechanism and scored three or four marks. There were errors in drawing the curly arrows for the second marking point, sometimes because they were not placed carefully enough, but a few as a result of arrows being drawn the wrong way around. The primary carbocation intermediate was usually correct.

(e) Write the mechanism for the reaction of propene with **hydrogen bromide** to give the major product. Include relevant dipoles.

(4)



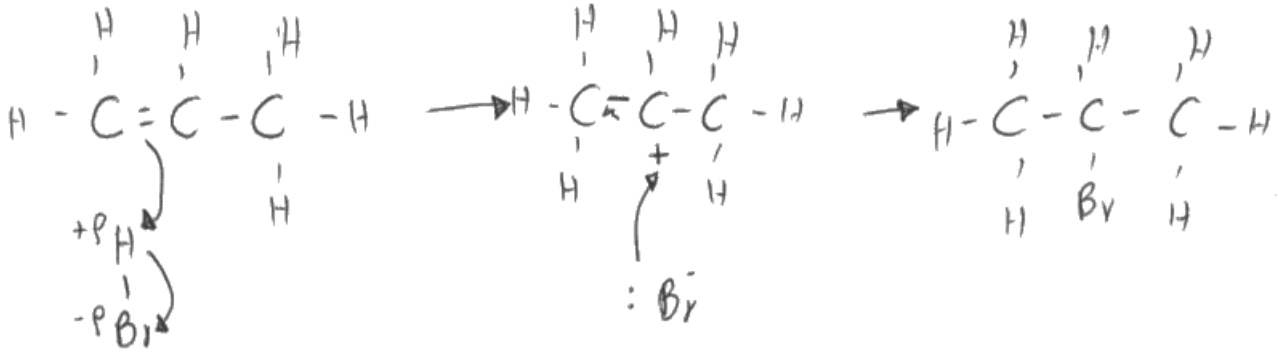
ResultsPlus

Examiner Comments

The arrows in the first step are both placed incorrectly, and a bromide ion with a full negative charge is formed, so this scored the marks for the dipole on H-Br and the formula of the intermediate only.

(e) Write the mechanism for the reaction of propene with **hydrogen bromide** to give the major product. Include relevant dipoles.

(4)



ResultsPlus
Examiner Comments

The curly arrow producing the bromide ion should have come from the H-Br bond to the Br. Curly arrows must be placed carefully.

Question 20 (f)

The answers to this question suggested that some candidates learn mechanisms without real understanding. There was a marked contrast in the standard of the explanations with the quality of mechanism drawings in 20(e), which were often good. This question was about addition of bromine rather than hydrogen bromide, but the way the reaction was described, and use of terms such as electrophile, showed less understanding than the drawings of the mechanism suggested.

Many candidates failed to explain that the electrons in the pi bond repel electrons in the bromine.

The second mark could be gained either by explaining that this produces a dipole, or by explaining that the bromine acts as an electrophile by accepting an electron pair from the double bond.

*(f) Molecules of the element bromine, Br_2, are not polar. Explain how **bromine** acts as an electrophile when it reacts with propene.

(2)

Br_2 is non polar. But Br_2 when comes near to electron rich area it becomes polar. one end of Bromine is 'δ+' and other end is 'δ-'.

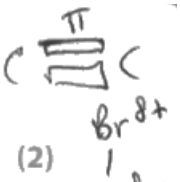
ResultsPlus

Examiner Comments

This explains that the bromine molecule becomes polar, but the first mark was not given as it does not say where the electron rich area is.

*(f) Molecules of the element bromine, Br_2, are not polar. Explain how **bromine** acts as an electrophile when it reacts with propene.

(2)



When the bromine molecule gets closer to the Pi bond, the electrons are repelled forming a partially positive bromine atom and a partially negative bromine atom. The partially positive one acts as the electrophile and accepts a pair of electrons to form a covalent bond

ResultsPlus
Examiner Comments

This is an example which scores both marks.

Question 20 (g)

The word "relative" in the question could be interpreted as a comparison of polymer production before and after shale gas was exploited, or the comparative amounts of poly(ethene) and poly(propene) which can be obtained from shale gas. These two routes allowed candidates different ways of gaining marks for this question.

However, many candidates did not read the question carefully enough to understand that shale gas production can affect polymer production. They tried to link the alkanes directly to the polymers, instead of realising that the alkanes are first converted to alkenes which in turn form the polymers.

Some answers went straight down the route of discussing renewable resources, biodegradable materials or other environmental issues which did not answer the question. Many answers said that there would be a reduction in polymer production, usually because the shale gas did not contain any alkenes. Very few gained the second mark by linking the cracking of an alkane to form an alkene.

(g) In the United States of America, large deposits of shale gas have been discovered. This gas is trapped in rocks and can be extracted by "fracking" which involves breaking up the rock with water under pressure.

Shale gas typically contains about 90% methane, mixed with about 3% ethane, 0.6% propane, 0.2% butane and 0.2% pentane. The rest is hydrogen, nitrogen and carbon dioxide.

Suggest how the use of shale gas may affect the relative amounts of poly(ethene) and poly(propene) which are produced in the USA and justify your answer.

(2)

The ~~amounts~~ production of poly(ethene) will increase more than the production of poly(propene) in the US, since ethane is 3% of the shale gas typically while propane is 0.6% and both ethene and propene ~~are~~ (the monomers for these polymers) ~~are~~ can be produced from propane and ethane so since the US found large deposits of the shale gas, poly(propene) will be a ~~least~~ less favored polymer to produce compared to poly(ethene)

ResultsPlus
Examiner Comments

This is an example of a good answer, where the candidate has thought about which components of shale gas can be used to make polymers. It scored both marks.

(g) In the United States of America, large deposits of shale gas have been discovered. This gas is trapped in rocks and can be extracted by "fracking" which involves breaking up the rock with water under pressure.

Shale gas typically contains about 90% methane, mixed with about 3% ethane, 0.6% propane, 0.2% butane and 0.2% pentane. The rest is hydrogen, nitrogen and carbon dioxide.

Suggest how the use of shale gas may affect the relative amounts of poly(ethene) and poly(propene) which are produced in the USA and justify your answer.

(2)

It will decrease the relative amounts of poly(ethene) and poly(propene) as it seems be a non renewable resource, also it may have a great effect on global warming and other reasons, this will again, decrease the relative amounts.

ResultsPlus
Examiner Comments

This candidate has not understood that ethene and propene can be prepared from the components of shale gas and has just made comments based on environmental factors which are not relevant.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- Ensure you read all the information in a question with great care. This will help you to be more selective with the ideas you use to answer the question.
- Take care when rounding numerical answers.
- Think carefully when using technical terms; for instance, make sure you understand the difference between orbitals, shells and sub-shells.
- Practice explaining organic mechanisms in words, as well as diagrams, to help gain a more in-depth understanding of the stages involved.
- Remember that although past paper mark scheme are helpful in revision you must consider the actual wording of the question, as it is likely that in most future questions the wording will not be the same and so the answers will be different.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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