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Examiners' Report
June 2012

GCE Chemistry 6CH01 01

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Introduction

Section A contained a good mix of straightforward and more challenging questions. The majority of candidates scored over half marks on this section of the paper. The structured questions in **Section B** provided opportunities for candidates across the ability range to show what they had learnt and understood. Each of questions 21 to 26 in Section B provided evidence for differentiation.

Answers to calculations were often well laid-out by candidates, although a significant minority wrote down only numbers without any accompanying words of explanation.

There was no evidence that candidates had found it difficult to complete the question paper within the allocated time.

Question 21(a)

A significant number of candidates gave the definition of relative atomic mass instead of relative isotopic mass. Both of these concepts are included in Section 1.5 a of the specification.

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 (a) Define the term **relative isotopic mass.**

(2)

The weighted average of all the masses of the isotopes of an element relative to 1/12 of carbon-12 atom.

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Examiner Comments

The first mark was not awarded as the plural (i.e. isotopes) has been used and confusion is evident with definition of relative atomic mass.

The second mark is awarded as carbon-12 is mentioned.

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Examiner Tip

Learn all definitions thoroughly!

Question 21(b)(i)

This calculation was done well by the majority of candidates. However, some candidates gave their answer to four decimal places, instead of four significant figures, whilst others rounded their answer to three significant figures instead of four.

(b) Naturally occurring chlorine contains 75.53% of ^{35}Cl and 24.47% of ^{37}Cl.

(i) Calculate the relative atomic mass of chlorine to **four** significant figures. **(2)**

$$= \frac{(75.53 \times 35) + (24.47 \times 37)}{100}$$

$= 35.4894$

$= 35.49$ to (4 sf)

ResultsPlus
Examiner Comments

This answer scored both marks - working and answer are correct.

ResultsPlus
Examiner Tip

Always show every step in your working!

(b) Naturally occurring chlorine contains 75.53% of ^{35}Cl and 24.47% of ^{37}Cl.

(i) Calculate the relative atomic mass of chlorine to **four** significant figures. **(2)**

no of moles $\frac{Mass}{Mr}$

2643.55

$$\frac{(75.53 \times 35) + (24.47 \times 37)}{100}$$

$= 35.489$

$= 35.49 = 35.50$

ResultsPlus
Examiner Comments

This response scores the first mark only. The second mark has not been given as the final answer has been incorrectly rounded.

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Examiner Tip

Make sure you understand how to round up answers to the required number of significant figures!

Question 21(b)(ii)

Few candidates scored both marks for this question. Many knew the formulae of the species involved, but omitted the + charge on each ion.

(ii) Two of the peaks in the mass spectrum of chlorine, Cl_2, are at *m/e* 70 and 74.
Identify the species giving rise to these peaks.

(2)

70 ($^{35}Cl\ ^{35}Cl$)

74 ($^{37}Cl\ ^{37}Cl$)

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Examiner Comments

This response scored one mark as the '+' charge has been omitted from both of the ions.

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Examiner Tip

Remember that positive ions are formed in the mass spectrometer.

Question 21(b)(iii)

The majority of candidates scored both marks for this question.

(iii) What is the *m/e* value of the other peak that you would expect to see in this region of the mass spectrum and the identity of the species giving rise to it?

(2)

Value 72

Species $^{37}Cl-^{35}Cl$ Chlorine 37 with Chlorine 35 or vice versa

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Examiner Comments

Both marks were awarded. The missing + charge on the ion was ignored here as any such omission was penalised in (b)(ii) earlier.

ResultsPlus
Examiner Tip

Remember that both atoms and molecules can form ions in a mass spectrometer!

Question 22(a)

This definition was correctly recalled by the majority of candidates. Sometimes the idea of 'one mole' was omitted or 'atoms' were referred to instead of 'gaseous atoms'.

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

(2)

It is the minimum energy required to remove one mole of electrons from one mole of gaseous atoms, forming one mole of unipositive ions. $M_{(g)} \rightarrow M^{+}_{(g)} + e^{-}$

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Examiner Comments

This answer scores the two available marks as it addresses both scoring points.

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Examiner Tip

Every word of a definition is important. Make sure that you understand all definitions rather than simply learning them by rote.

Question 22(b)

This question tested the candidates' Quality of Written Communication (QWC). Pleasingly, many excellent answers were seen showing both clear and logical thought.

*(b) Explain why the first ionization energy of the elements down Group 1 decreases even though the atomic number increases.

(2)

As the atomic number increases, so does the amount of shielding surrounding the nucleus of the atoms, so it requires less energy to remove the one outermost shell electron down group 1 as the attractive force between this electron and the nucleus decreases down group 1.

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Examiner Comments

This answer scores both marks. The increased shielding and the weaker attraction between the nucleus and (outermost) electron down the group are both included in this response.

*(b) Explain why the first ionization energy of the elements down Group 1 decreases even though the atomic number increases.

(2)

~~Because of~~ Due to the increase in shielding surrounding the nucleus as well as the increased proton number which increases the nuclear charge. These factors affect the first ionisation energy of elements greatly.

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Examiner Comments

This response scores one mark for the mention of increased shielding. NOTE: The references to 'increasing proton number' and 'increased nuclear charge', in this context, were ignored as per the Mark Scheme.

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Examiner Tip

Always be aware of all the factors that explain any particular trend in the Periodic Table.

Question 22(c)

Part (c)(i) was found challenging by many of the candidates. The idea that the remaining electrons were attracted more strongly by the nucleus was often evident in candidates' answers, but without any explanation being offered. The key point is that electrons are being removed from an increasingly positive ion.

In (c)(ii), reference was nearly always made to the large jump in ionization energy (IE) between the first IE and second IE. The large jump between the ninth IE and tenth IE was, however, frequently overlooked.

(c) The eleven successive ionization energies for sodium are given below.

Electron removed	1	2	3	4	5	6	7	8	9	10	11
Ionization energy / kJ mol^{-1}	496	4563	6913	9544	13352	16611	20115	24491	28934	141367	159079

(i) Explain why the successive ionization energies increase.

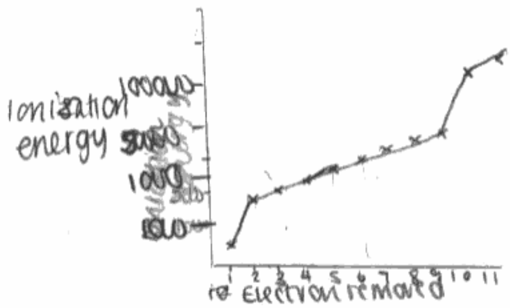
(1)

Because the the amount of negative electrons decrease to the number of positive protons so the ~~proton~~ nucleus has more of a pull on the electrons

*(ii) Explain how these ionization energies give evidence for the electronic structure of sodium. You may use a sketch graph if you wish.

(2)

for sodium



The jump from the first ionization energy shows the switch from the outer sub-shell to the next sub-shell. The next eight ionization energies then increase gradually but again there is then a big jump from the 9th to the 10th electron showing another switch to a shell. Also there is a small jump from the 5th to 6th ~~and 7th~~ ...

ResultsPlus Examiner Comments

Q22(c)(i): The statement is equivalent to an increasing proton:electron ratio, so the mark was awarded. Q22(c)(ii) First mark: This was awarded, as the two required jumps are evident from the sketch graph given and also in the written answer. Q22(c)(ii) Second mark: This was not awarded, as '2, 8, 1' (or the alternatives given in the Mark Scheme) must be clearly stated and not just implied from the correctly drawn sketch graph.

ResultsPlus Examiner Tip

Note how diagrams, including sketch graphs, are a very useful way of communicating chemical knowledge.

Question 22(d)(i)

This question was very well answered by the vast majority of candidates.

(d) The first ionization energy of aluminium (element 13) is lower than that of magnesium (element 12).

(i) Give the electronic structures of magnesium and of aluminium in *s*, *p* and *d* notation.

(1)

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

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

ResultsPlus

Examiner Comments

This correct response scores the mark.

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Examiner Tip

Make sure you can write out the electronic configuration of the atoms of the first 36 elements in the Periodic Table as required by Section 1.5g of the specification.

Question 22(d)(ii)

The Mark Scheme allowed several alternative approaches to enable the mark for this question to be awarded. The majority of correct responses referred to the extra shielding experienced by the 3p electron in aluminium, provided by the pair of electrons in the 3s sub-shell.

(d) The first ionization energy of aluminium (element 13) is lower than that of magnesium (element 12).

(i) Give the electronic structures of magnesium and of aluminium in *s*, *p* and *d* notation.

(1)

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

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

*(ii) Explain the difference in the first ionization energies of the two metals.

(1)

The outer electron in aluminium is in a different subshell, giving it more shielding from the nucleus.

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Examiner Comments

The mark was awarded for the idea of the outermost electron in aluminium experiencing more shielding than that in magnesium.

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Examiner Tip

Be aware of the discontinuities in the trend of a general increase in first ionization energy across the Periodic Table.

Question 23(a)

This question was answered reasonably well. The essential idea required was that the enthalpy change for a reaction is independent of the pathway (or route) followed.

23 (a) State Hess's Law.

(1)

Hess's law states that the energy change in a chemical reaction is ~~ind~~ dependent on the ~~initial~~ initial and final states and is independent on the route taken.

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Examiner Comments

This is a typical correct response to this question.

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Examiner Tip

Make sure you understand the fundamental principles underpinning Hess's Law.

Question 23(b)

In (b)(i), a mark was often lost for the omission of the '2' in the '$2H_2O$' required. Some of the cycles given had shown confusion between enthalpy changes of combustion and those of formation. Part (b)(ii) was well-answered, but (b)(iii) proved difficult for many candidates. Answers to (b)(iii) often focused on the toxicity of carbon monoxide or simply 'heat loss' rather than the formation of carbon dioxide.

(b) Methane burns in a limited supply of oxygen to give carbon monoxide and water.

$$CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(l)$$

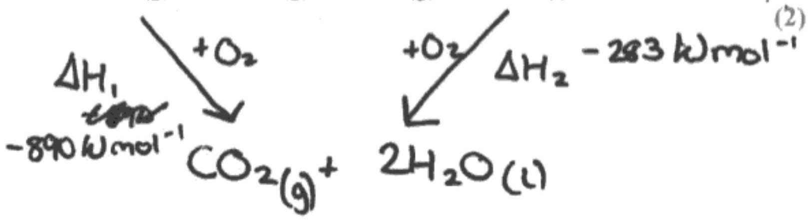
The enthalpy change for this reaction cannot be determined directly, but can be found using the standard enthalpy changes of combustion of methane and carbon monoxide, together with Hess's Law.

The standard enthalpy changes of combustion needed are for CH_4, −890 kJ mol^{-1}, and for CO, −283 kJ mol^{-1}.

(i) Draw a Hess's Law diagram which would enable you to calculate the enthalpy change for the combustion of methane to carbon monoxide.

$$CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(l)$$

(2)



(ii) Calculate the enthalpy change for this reaction, in kJ mol^{-1}.

(2)

$\Delta H_r = \Delta H_1 - \Delta H_2$

$-890 - (-283) =$

$= -607$ kJmol^{-1}

(iii) Explain why the enthalpy change for this reaction cannot be determined directly.

(1)

as temperature change ~~is~~ cannot be measured, directly as the reaction occurs too quickly.

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Examiner Comments

Parts (b)(i) and (b)(ii) are answered correctly. The response to (b)(iii) is incorrect.

ResultsPlus
Examiner Tip

Practise plenty of questions involving Hess Cycles. Understand when to use enthalpy changes of combustion and when to use enthalpy changes of formation. Always consider carefully the direction of every arrow drawn in any Hess Cycle.

Question 23(c)

This question proved to be a good discriminator. Whilst many candidates noticed that water had been produced in the gaseous state, fewer were able to reason the effect on the enthalpy change of the reaction given in (c).

(c) Explain why the calculation in part (b)(ii) would give an incorrect result for the enthalpy change for the reaction below.

$$CH_4(g) + 1\tfrac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(g)$$

(2)

The H_2O produced is in gaseous form, and thus has more energy. This reaction would have a less negative enthalpy change than the calculated one.

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Examiner Comments

This response scores the first mark as it states that the water is formed in the gaseous state. It also is awarded the second mark as the candidate realises that the energy change for the reaction as given is less exothermic than that in (b)(ii).

ResultsPlus
Examiner Tip

When comparing negative values, use terms such as 'less exothermic', rather than just 'greater' or 'smaller', to avoid ambiguity.

Question 24(a)

This was answered very well, with the incorrect response 'C_nH_{2n+2}' only given occasionally!

24 (a) Give the general formula for the homologous series of **alkenes**.

(1)

C_nH_{2n}

ResultsPlus
Examiner Comments

This is the correct answer and it scored the available mark.

ResultsPlus
Examiner Tip

Learn the general formula for every homologous series that you encounter.

Question 24(b)

The presence of the C=C double bond in the alkene was all that was required here. Many candidates also made reference to the fact that such compounds do not contain the maximum number of hydrogen atoms possible.

(b) What is meant by the term **unsaturated** as applied to alkenes?

(1)

There is the double bond between carbon ~~to~~ atoms.

ResultsPlus
Examiner Comments

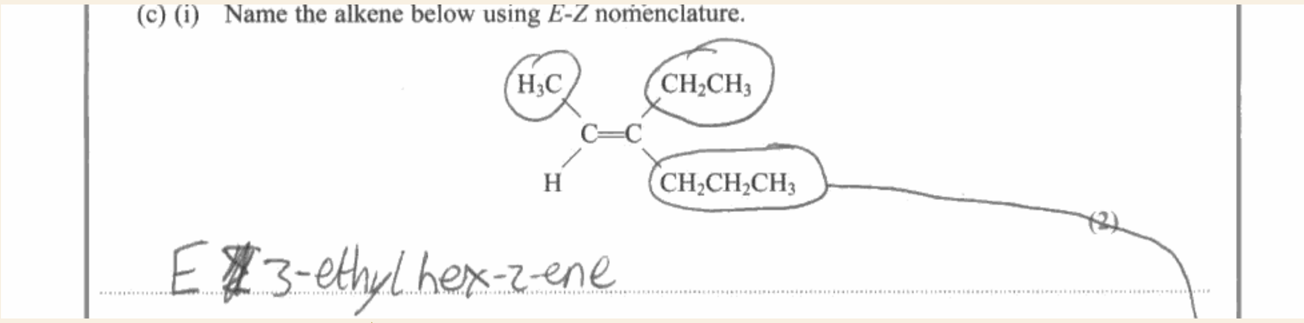
Although a brief response, this answer makes the required point. The mark was therefore awarded.

ResultsPlus
Examiner Tip

Understand terms such as 'saturated' and 'unsaturated', when used in this context.

Question 24(c)(i)

This was often answered well. The position of both the C=C double bond and the ethyl side-chain proved problematic for some candidates.


(c) (i) Name the alkene below using *E-Z* nomenclature.

(2)

E ~~Z~~ 3-ethyl hex-2-ene

ResultsPlus
Examiner Comments

This response scored both marks. The first mark was for '3-ethylhex-2-ene' and the second mark for the correct use of the '*E*' notation.

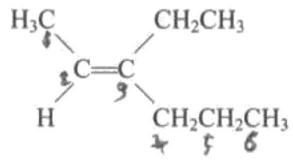
ResultsPlus
Examiner Tip

Practise naming organic molecules requiring the use of the *E-Z* notation.

Question 24(c)(ii)

Some candidates found it difficult to explain themselves coherently in order to answer this question correctly.

(c) (i) Name the alkene below using *E*-*Z* nomenclature.



(2)

E - 3 - ethylhex - 2 - ene

(ii) Suggest why this alkene cannot be named using the *cis*-*trans* naming system.

(1)

one of the unsaturated carbon atoms is not bonded to a hydrogen atom

~~atom so it is impossible for 2 hydrogen atoms~~

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Examiner Comments

This response scored the mark for effectively pointing out that the right-hand carbon atom of the C=C double bond is not connected to a hydrogen atom. If it were, the *cis-trans* nomenclature could have been used.

ResultsPlus
Examiner Tip

Make sure you understand when it is necessary to use the *E-Z* naming system.

Question 24(d)

This question was often very well answered with a significant number of candidates gaining full marks. Parts (d)(iii) and (iv) proved to be more difficult than (i) and (ii). Sometimes incorrect adducts involving potassium were offered as answers to (iii) and dibromoethane was suggested as the product in (iv).

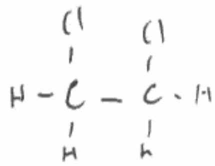
(d) Give the structural formula of the organic product of the reaction of ethene, $CH_2{=}CH_2$, with

(i) hydrogen. (1)

CH_3CH_3 (ethane)

(ii) chlorine. (1)

CH_2ClCH_2Cl



(1,2 dichloroethane)

(iii) acidified aqueous potassium manganate(VII). (1)

CH_2KCH_3

(iv) bromine **water**. (1)

~~CH_2CH~~ CH_3CH_2Br

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Examiner Comments

The answer to (d)(i) scores the mark for the correct formula of ethane. For (d)(ii), either representation of 1, 2-dichloroethane given by this candidate would have been credited. So the mark is awarded here. Parts (d)(iii) and (d)(iv) are both answered incorrectly.

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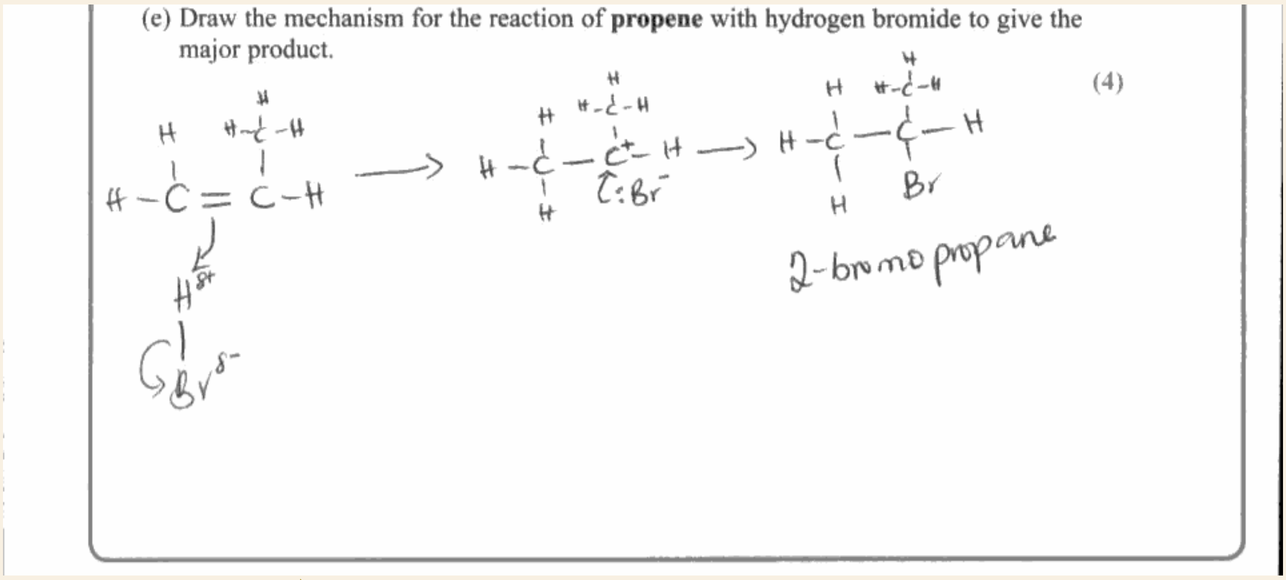
Examiner Tip

Learn the products of all the organic reactions mentioned in the specification!

Question 24(e)

The mechanism for this reaction was well-known with the result that many candidates scored full marks for this question. Sometimes the origin and destination of 'curly arrows' drawn by candidates needed to be made clearer and more accurate.



Examiner Comments

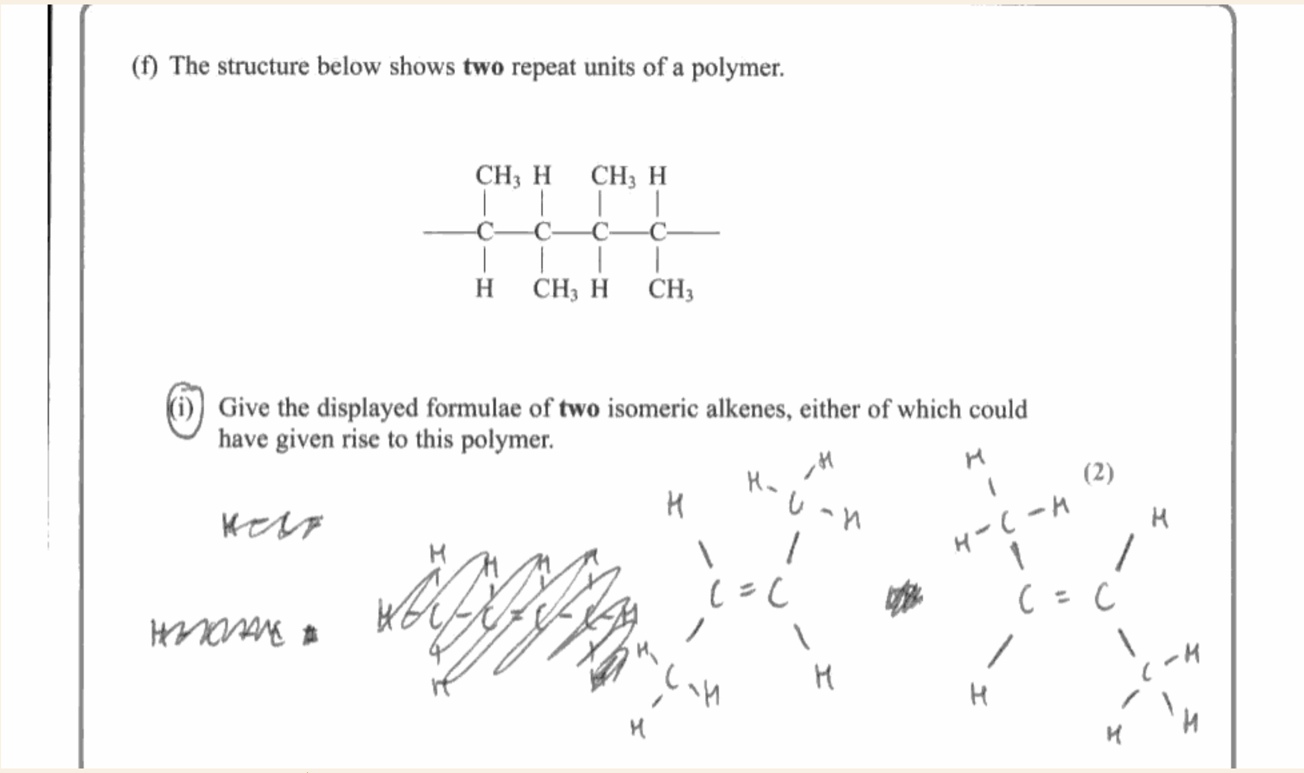
All four scoring points were awarded. As sometimes happens, the propene molecule has been drawn 'round the corner' rather than more 'obviously' in a straight line. Nonetheless, all aspects of the mechanism are correct.

Examiner Tip

Practise drawing out mechanisms, with 'curly arrows' carefully annotated.

Question 24(f)(i)

The most common errors were to draw out the *trans*-isomer twice (by simply turning it through 180°) or to include but-1-ene in the answer.



(f) The structure below shows **two** repeat units of a polymer.

(i) Give the displayed formulae of **two** isomeric alkenes, either of which could have given rise to this polymer.

(2)

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Examiner Comments

This response scored only one mark out of two. The same trans-isomer (*E*-isomer) has been drawn out twice.

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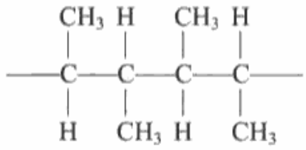
Examiner Tip

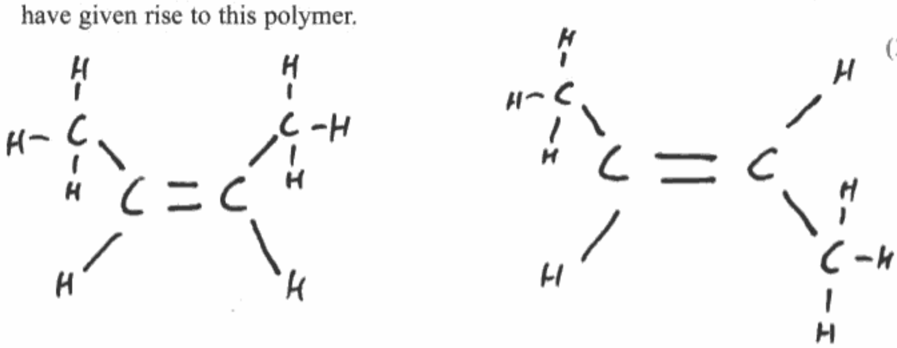
Make sure you can differentiate between *cis*- and *trans*- isomers.

(f) The structure below shows **two** repeat units of a polymer.



(i) Give the displayed formulae of **two** isomeric alkenes, either of which could have given rise to this polymer.

(2)



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Examiner Comments

Both marks were awarded. Two correct structures have been given and they are both clearly drawn out.

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Examiner Tip

Draw out organic molecules carefully and neatly!

Question 24(f)(ii)

This was generally answered well, but some candidates merely repeated the question by giving a definition of the term *empirical formula*.

(ii) State why the empirical formula of a poly(alkene) is the same as that of the monomer from which it is produced.

(1)

same ratios of each ~~ator~~ element, Just more ~~mol~~ units Joined together, so greater numbers but still representative of each molymer, therefore emperical formula

ResultsPlus
Examiner Comments
The mark was awarded as '...same ratio of each element' is an allowed response given in the published Mark Scheme.

Question 24(f)(iii)

The concept of atom economy was well understood. The mark was not awarded, however, if candidates simply stated that the atom economy was 'very high' rather than making some reference to the fact that it is 100% for this type of reaction.

(iii) State, with a reason, the atom economy for the production of a poly(alkene) from an alkene. the monomer have the same ratio.

(1)

It will be 100% because by-products are not being formed and materials are not wasted.

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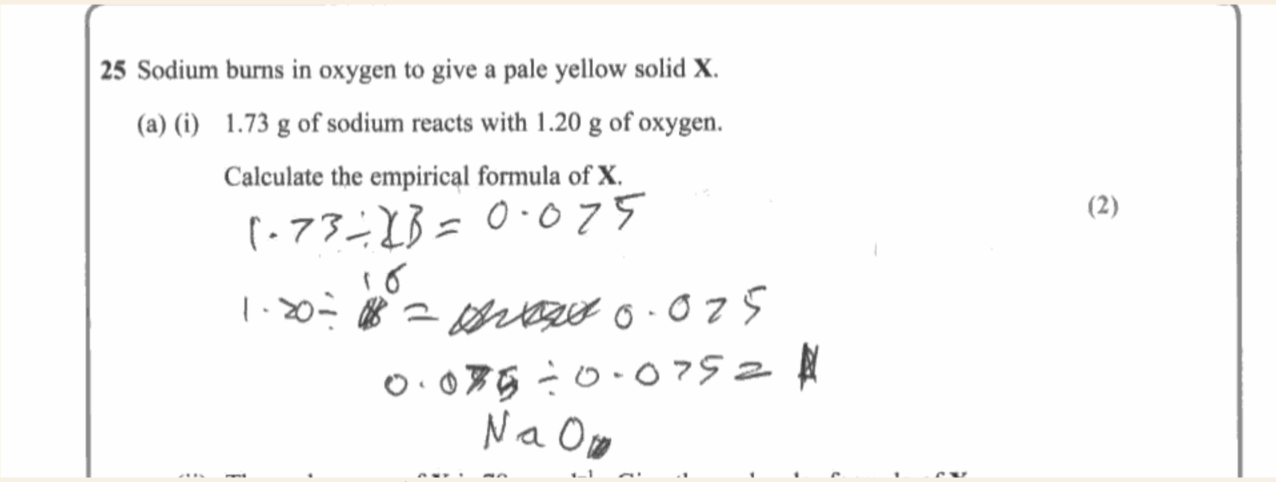
Examiner Comments
This answer scores the mark available as it makes the point that only one product is formed.

ResultsPlus
Examiner Tip
Make sure you understand that addition reactions have 100% atom economy.

Question 25(a)(i)

Many candidates calculated the empirical formula correctly as NaO.



25 Sodium burns in oxygen to give a pale yellow solid **X**.

(a) (i) 1.73 g of sodium reacts with 1.20 g of oxygen.

Calculate the empirical formula of **X**.

(2)

1·73 ÷ 23 = 0·075

1·20 ÷ 16 = 0·075

0·075 ÷ 0·075 = 1

NaO

ResultsPlus
Examiner Comments

1:1 ratio of Na:O had not been made explicit, but the correct answer NaO was given so both marks were awarded.

ResultsPlus
Examiner Tip

Always show every step in your working.

Question 25(a)(ii)

A surprising number of candidates gave a molecular formula for a compound for which the molar mass was not 78 g mol^{-1}.

Question 25(a)(iii)

Many candidates were awarded both marks, but a significant number gave the state symbol for Na_2O_2 as (aq) rather than (s).

(iii) Write the equation, including state symbols, for the reaction of sodium with oxygen to produce **X**. (2)

$2Na_{(s)} + O_{2(g)} \rightarrow Na_2O_{2\,(s)}$

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Examiner Comments

This is a correctly balanced equation, with the state symbols which are also correct, the answer scored both marks.

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Examiner Tip

Always consider state symbols carefully when asked for them in an equation.

Question 25(a)(iv)

Most candidates gained the second scoring point which required the calculated moles of oxygen, O_2, to be multiplied by 24 $dm^3\ mol^{-1}$ in order to obtain the volume of gas in units of dm^3. There was some confusion, however, between calculating moles of oxygen atoms, O(g), and moles of oxygen molecules, O_2(g).

(iv) Calculate the volume of oxygen in dm^3 (at room temperature and pressure) which reacts with 1.73 g of sodium. (The molar volume of any gas at room temperature and pressure is 24 $dm^3\ mol^{-1}$.) (2)

~~moles of~~

Ar of Na = 23 $g\,mol^{-1}$

Moles of Na = $\frac{1.73}{23}$ = 0.075

2 mol of Na : 1 mol of O_2

moles of O_2 = $\frac{1}{2}$ x 0.075 = 0.038 mol

Volume of O_2 = moles x 24 = 0.038 x 24 = 0.90 dm^3

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Examiner Comments

This is a well laid-out answer which scored both marks.

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Examiner Tip

Set out your answers to calculation questions in an orderly way as illustrated in the above response.

Question 25(a)(v)

This question was generally well answered, although sometimes candidates chose to calculate the number of oxygen atoms instead of molecules.

(v) Calculate the number of oxygen **molecules** that react with 1.73 g of sodium.
(The Avogadro constant = $6.02 \times 10^{23}\ mol^{-1}$.)

(1)

$0.0375 \times (6.02 \times 10^{23}) = 2.2575 \times 10^{22}$

$= 2.26 \times 10^{22}$ molecules.

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Examiner Comments

This was the correct response, which scored the mark available.

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Examiner Tip

Always check which type of particle (atom, ion or molecule) is being referred to in the question.

Question 25(b)

This proved difficult for the majority of candidates. A significant number of responses included incorrect references to the presence of hydrogen gas, H_2, in air.

(b) If sodium is burnt in **air**, compound **X** is not the only product. Suggest why this is so.

(1)

Other sodium oxide derivatives might be formed due to incomplete combustion.

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Examiner Comments

This response scored a mark as it acknowledged that other oxides of sodium may have been formed in the reaction described.

ResultsPlus
Examiner Tip

Be aware of the gases present in air.

Question 26(a)

Many candidates referred only to 'a shared pair of electrons' and failed to mention the two nuclei present in a hydrogen molecule.

26 (a) Explain how the atoms are held together by the covalent bond in a molecule of hydrogen.

(1)

Equal attraction by the nuclei to the shared pair of electrons holds the covalent bond together.

ResultsPlus
Examiner Comments

This response acknowledges the forces of attraction existing in a covalent bond. So the mark was awarded.

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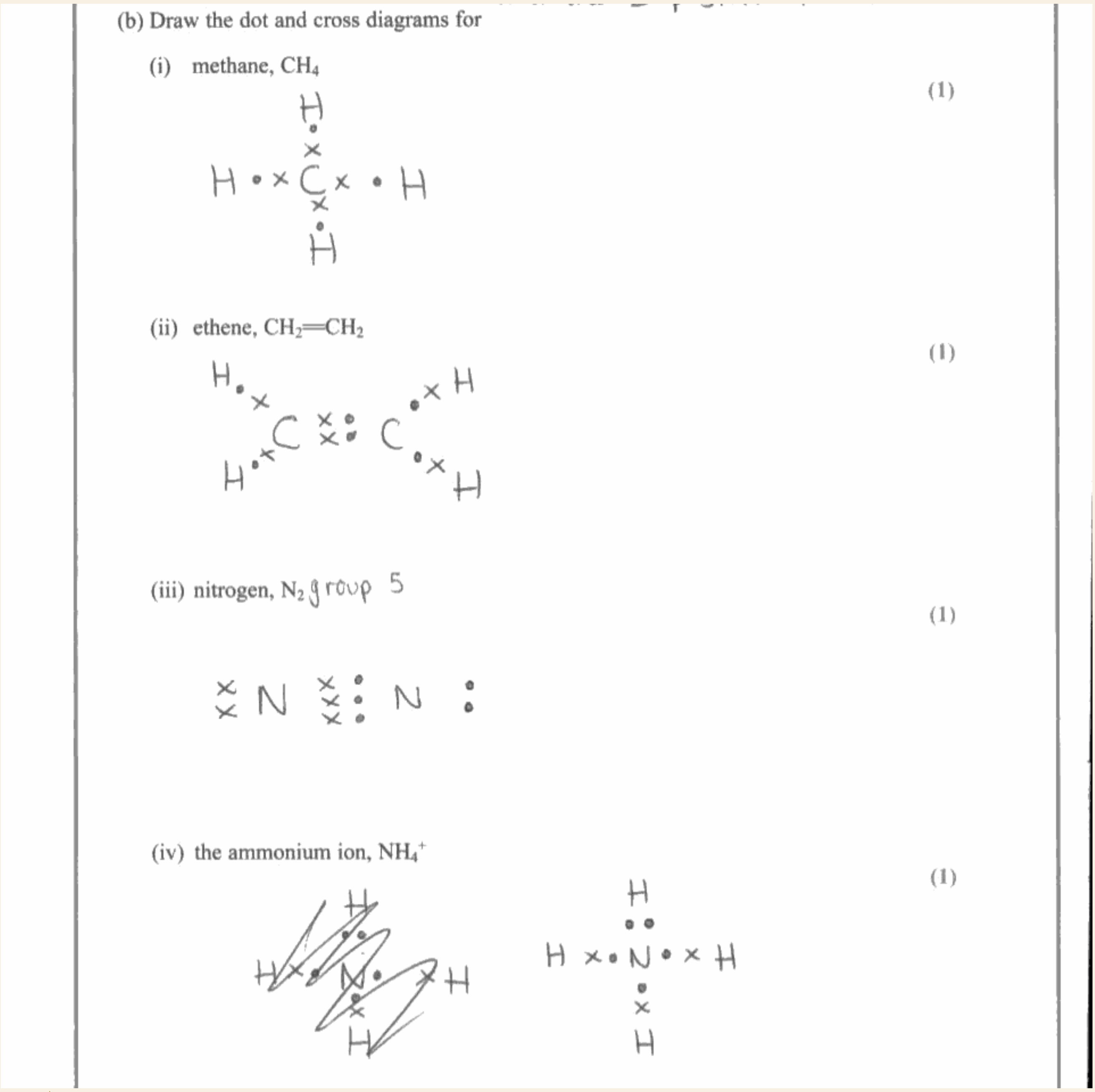
Examiner Tip

Be aware of the electrostatic forces of attraction present in each type of chemical bond.

Question 26(b)

This question was generally well answered, although the presence of a triple bond in the nitrogen molecule seemed unfamiliar to some candidates.


(b) Draw the dot and cross diagrams for

(i) methane, CH_4 (1)

(ii) ethene, $CH_2{=}CH_2$ (1)

(iii) nitrogen, N_2 group 5 (1)

(iv) the ammonium ion, NH_4^+ (1)

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Examiner Comments

All four marks were awarded. As mentioned in the published Mark Scheme, in (b)(iv), the missing + sign from the NH_4^+ dot and cross diagram was not penalised.

ResultsPlus
Examiner Tip

Always check dot-and-cross diagrams carefully.

Question 26(c)(i)

Most responses mentioned the lack of mobile electrons in silicon, but did not include the reason why they are not present.

(c) Silicon exists in a giant covalent lattice.

(i) The electrical conductivity of pure silicon is very low. Explain why this is so in terms of the bonding.

(2)

~~All electrons~~ all outer electrons are localised in covalent bonds.
there no free electrons to move and carry current.

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Examiner Comments

This response addresses both scoring points and so two marks were awarded. The first mark was awarded as the answer makes clear the location of the bonding electrons. The second mark was awarded as the lack of free electrons is mentioned in the response.

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Examiner Tip

If two marks are available for a question, make sure you make two distinct statements rather than re-wording the same answer!

Question 26(c)(ii)

The giant structure of silicon was often mentioned, but incorrect statements about 'overcoming intermolecular forces' were frequently included in answers.

(ii) Explain the high melting temperature of silicon in terms of the bonding.

(2)

The silicon structure is held together by strong covalent bonds. This means alot of energy is required to break them.

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Examiner Comments

Two marks were awarded, as both the scoring points were addressed.

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Examiner Tip

Remember to relate high melting temperature to the large amount of heat energy needed to break the bonds.

Paper Summary

Candidates should take note of the following points to further improve their performance.

- Make sure that your writing is legible.
- Make sure that you understand what you are being asked to do before you start to answer a question.
- Make sure that you understand clearly the difference between an atom, an ion and a molecule.
- Use the amount of space provided for each answer, along with the mark allocation, as a guide as to how much detail is required in your response.

Grade Boundaries

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

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