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Examiners' Report
June 2013

GCE Chemistry 6CH01 01

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June 2013

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Introduction

All parts of the paper seemed to be accessible to all candidates. There was no evidence of lack of time to complete the paper. It was a privilege to see evidence of some very well prepared candidates from very good centres.

There were the usual problems of not reading the question and lack of knowledge of practical techniques.

Many candidates were unable to work with an unfamiliar Hess cycle.

The multiple choice questions were reasonably discriminating with an average of over 13 marks out of 20.

The first six questions were quite challenging. The questions were each managed successfully by about half of the candidates, but question 16 was much easier, each part managed by almost all the candidates.

Question 18 (a)

Candidates found few problems here. There were one or two problems with writing of the number 4. It is important that fours and nines are easily distinguished.

18 The radioactive isotope iodine-131, $^{131}_{53}I$, is formed in nuclear reactors providing nuclear power. Naturally occurring iodine contains only the isotope, $^{127}_{53}I$.

(a) Complete the table to show the number of protons and neutrons in these two isotopes.

(2)

Isotope	$^{131}_{53}I$	$^{127}_{53}I$
Number of protons	53	53
Number of neutrons	25	21

ResultsPlus
Examiner Comments

A rare incorrect answer in the second row. The numbers of protons are fine.

ResultsPlus
Examiner Tip

Make sure you can calculate the numbers of protons and neutrons for different nuclear formulae.

18 The radioactive isotope iodine-131, $^{131}_{53}I$, is formed in nuclear reactors providing nuclear power. Naturally occurring iodine contains only the isotope, $^{127}_{53}I$.

(a) Complete the table to show the number of protons and neutrons in these two isotopes.

(2)

Isotope	$^{131}_{53}I$	$^{127}_{53}I$
Number of protons	131	127
Number of neutrons	78	74

ResultsPlus
Examiner Comments

The numbers of protons has been confused with the number of nucleons.

The subtraction to find the number of neutrons has been carried out correctly.

Question 18 (b)

This proved more challenging but many successfully applied their knowledge of equations to work out the correct product. The most common error was to give iodine as a product not realising that with an extra proton the element changed.

(b) When iodine-131 decays, one of its neutrons emits an electron and forms a proton. Identify the new element formed by name or symbol.

(1)

$^{130}_{54}Xe$

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Examiner Comments

This is an unfortunate error. The candidate has the correct element and proton number but has forgotten the mass number remains the same at 131.

ResultsPlus
Examiner Tip

Remember that mass is conserved, unless measurement is made to a large number of decimal places.

(b) When iodine-131 decays, one of its neutrons emits an electron and forms a proton. Identify the new element formed by name or symbol.

(1)

Iodine-130

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Examiner Comments

The correct name and isotopic mass would have been acceptable, but this is the wrong element with the wrong mass.

ResultsPlus
Examiner Tip

Applying skills in equation balancing to unfamiliar equations is vital, make sure you master the skill.

Question 18 (c)

A soluble non-toxic iodide salt was needed. The vast majority gave potassium iodide, the actual chemical that was used in Japan after the tsunami damage to a nuclear power station.

(c) The problem with radioactive iodine is that it accumulates in humans in the thyroid gland. Its absorption can be reduced by taking an appropriate daily dose of a soluble iodine compound.

Suggest a suitable iodine compound which could be used.

(1)

AgI Silver iodide.

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Examiner Comments

Silver iodide is inappropriate as it is insoluble.

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Examiner Tip

Learn the solubilities of ionic salts.

(c) The problem with radioactive iodine is that it accumulates in humans in the thyroid gland. Its absorption can be reduced by taking an appropriate daily dose of a soluble iodine compound.

Suggest a suitable iodine compound which could be used.

(1)

CaI

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Examiner Comments

Calcium iodide would be acceptable but this is not the correct formula.

ResultsPlus
Examiner Tip

Learn how to write formulae of simple ionic compounds.

Question 18 (d)

There were many good answers here with a sensible country related to a good scientific justification, usually risk of earthquake or tsunami, though other reasonable suggestions were accepted. High population density was often given which was insufficient.

Suggest a country where, because of its location, the dangers of nuclear power may outweigh the advantages. Justify your answer.

(1)

Japan. Since earthquakes occur and nuclear radiation may be released to the environment and cause damage when destruction of the plate that generate nuclear power occurs (nuclear power station)

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Examiner Comments

This was the most popular correct choice of country but the justification is insufficient.

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Examiner Tip

It is worth noticing news items that relate to Chemistry and Science.

Suggest a country where, because of its location, the dangers of nuclear power may outweigh the advantages. Justify your answer.

(1)

In a heavily populated urban area. Despite it being able to power the city if the radioactive waste is not dealt with properly it could lead to ~~release~~ radiation poisoning to the surrounding people. In addition if something goes wrong, like chernobyl, the resulting meltdown could lead to massive loss of life.

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Examiner Comments

This answer does not answer the question as it does not identify the country. In addition the justification, while plausible, was deemed insufficient.

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Examiner Tip

Always check to see that the question asked has been answered.

Question 19 (a)

Though the question clearly refers to ionization energies, quite a few candidates gave a fully correct equation for the first electron affinity.

There were the usual problems of distinguishing the letters *'g'* and *'s'* as state symbols. It is best to write these in full size lower case letters and not as subscripts.

19 This question is about the elements arsenic to rubidium which have atomic numbers 33 to 37.

The first ionization energies, E_{m1}, of these elements are given in the table.

Element	As	Se	Br	Kr	Rb
E_{m1} / kJ mol^{-1}	947	941	1140	1351	403

(a) Write the equation, with state symbols, which represents the first ionization energy of arsenic.

(2)

$As(g) \longrightarrow As^{-}(g) + e^{-}$

ResultsPlus
Examiner Comments

This was a surprisingly common error.

ResultsPlus
Examiner Tip

When an atom loses a negative electron it becomes positive.

19 This question is about the elements arsenic to rubidium which have atomic numbers 33 to 37.

The first ionization energies, E_{m1}, of these elements are given in the table.

Element	As	Se	Br	Kr	Rb
E_{m1} / kJ mol^{-1}	947	941	1140	1351	403

(a) Write the equation, with state symbols, which represents the first ionization energy of arsenic.

(2)

$As(g) + e^{-} \longrightarrow As(g)^{-}$

ResultsPlus
Examiner Comments

An electron affinity equation.

ResultsPlus
Examiner Tip

Ionization refers to the production of positive ions only.

Electron affinity concerns the production of negative ions.

Question 19 (b)

This proved quite demanding. There was much confusion between hydride, hydroxide and hydrate. Attempted formulae involving OH and H_2O were common. Some hydrides had the wrong number of hydrogen atoms.

(b) Suggest the formulae of the hydrides of arsenic and selenium. (2)

AsH_3 , H_2S

ResultsPlus
Examiner Comments

An unfortunate slip. The symbol for selenium had been given in the question.

ResultsPlus
Examiner Tip

Check your answers for this type of error.

(b) Suggest the formulae of the hydrides of arsenic and selenium. (2)

$As(OH)_2$, $SeOH$

ResultsPlus
Examiner Comments

This confusion between hydride and hydroxide was quite common.

ResultsPlus
Examiner Tip

Learn the identity of common classes of inorganic compound, like hydride and hydroxide.

Question 19 (c) (i)

This was generally well done. Both full arrows and half-headed arrows were acceptable for representing electrons. Some answers did not have the idea of maximum spin multiplicity.

(c) (i) Complete the electronic configuration for an arsenic and a selenium atom using the electrons-in-boxes notation.

(2)

		4s	4p		
As	[Ar] $3d^{10}$	↑↓	↑↓	↑↓	↑
Se	[Ar] $3d^{10}$	↑↓	↑↓	↑	↑

ResultsPlus
Examiner Comments

The selenium configuration is fine. Arsenic seems to have two extra electrons.

ResultsPlus
Examiner Tip

Successive elements have one extra electron.

(c) (i) Complete the electronic configuration for an arsenic and a selenium atom using the electrons-in-boxes notation.

(2)

		4s	4p		
As	[Ar] $3d^{10}$	↑↓	↑↓	↑	
Se	[Ar] $3d^{10}$	↑↓	↑↓	↑↓	

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

Extra repulsion due to electrons pairing

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Examiner Comments

Though the correct numbers of electrons are given for each element, the idea of electrons entering different orbitals if possible was not known.

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Examiner Tip

Remember electrons repel each other, so will get as far from each other as possible.

Question 19 (c) (ii)

Many candidates were at a loss to explain this difference. The common way of gaining one mark was to refer to the stability of a half filled set of sub-levels in arsenic. Very few showed real understanding of the reason for this in terms of the repulsion of electrons in the same orbital.

*(ii) Explain why the first ionization energy of selenium is lower than that of arsenic.

(2)

This is because As has got 3 electrons in its 4p orbital which makes it half-filled and therefore more stable thus it's harder and required more energy to remove one electron. Also, Se has got 4 electrons in its 4p orbital thus it is easier to remove 1 electron to form half-filled orbital.

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Examiner Comments

An example of clear knowledge of the stability of half-filled p orbitals but no real understanding of the reason.

ResultsPlus
Examiner Tip

Try to answer the question 'why?'

*(ii) Explain why the first ionization energy of selenium is lower than that of arsenic.

(2)

the Selenium atom has 1 more electron than the arsenic atom therefore there is more electron repulsion in Selenium, therefore there is less force of attraction between Seleniums electrons and nucleus than in arsenic

ResultsPlus
Examiner Comments

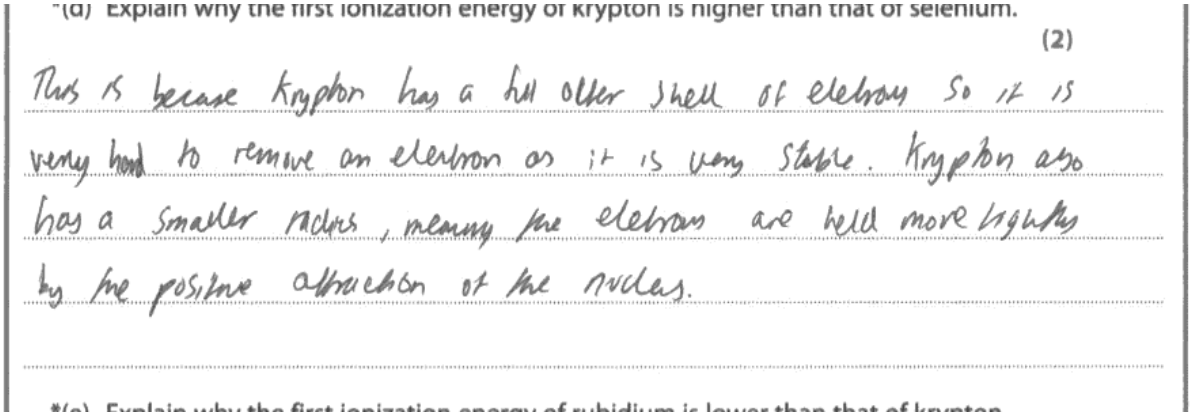
The idea of electron repulsion is given but it is not related to an electron going into an occupied orbital.

ResultsPlus
Examiner Tip

Make sure you can explain trends in ionization energies.

Question 19 (d)

Many candidates could only answer this in terms of GCSE knowledge. There were many references to the stability of filled shells without any explanation of the reason for this. The key to the explanation is the increased nuclear charge while electrons are added to the same quantum shell.



*(d) Explain why the first ionization energy of krypton is higher than that of selenium.

(2)

This is because krypton has a full outer shell of electrons so it is very hard to remove an electron as it is very stable. Krypton also has a smaller radius, meaning the electrons are held more tightly by the positive attraction of the nucleus.

*(e) Explain why the first ionization energy of rubidium is lower than that of krypton

ResultsPlus
Examiner Comments

Though the candidate has begun with the GCSE type statement about stability, they have gone on to an important point about the distance of electrons from the nucleus.

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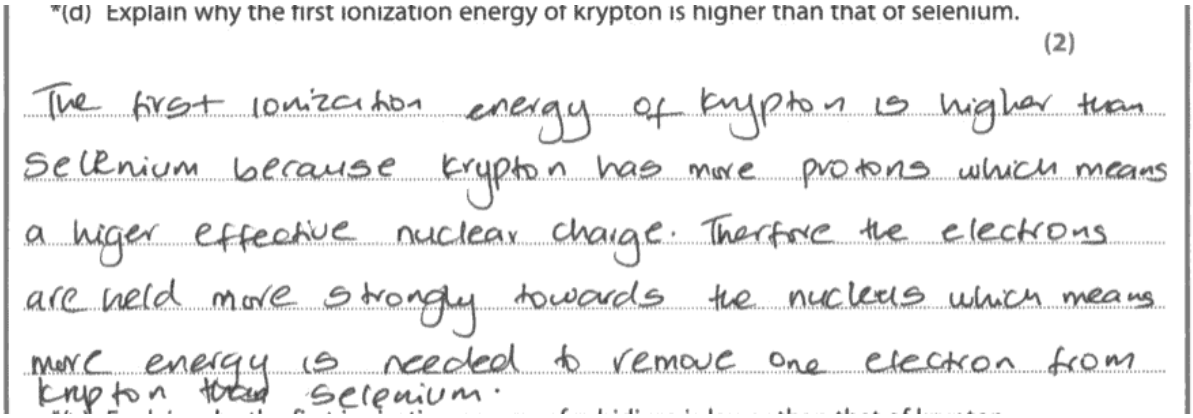
Examiner Tip

Remember the starting point for this difference is increased nuclear charge.



*(d) Explain why the first ionization energy of krypton is higher than that of selenium.

(2)

The first ionization energy of krypton is higher than selenium because krypton has more protons which means a higer effective nuclear charge. Therfore the electrons are held more strongly towards the nucleus which means more energy is needed to remove one electron from krypton than selenium.

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Examiner Comments

The idea of stonger nuclear charge is clear, but there is no mention of electrons in the same shell.

Question 19 (e)

Again many candidates could only answer this in terms of GCSE knowledge. There were many references to the stability of filled shells. Some referred to just more shells which is not strictly true without mention of electrons. The key here is the electron in rubidium is in a new, higher quantum shell and is further from the nucleus.

*(e) Explain why the first ionization energy of rubidium is lower than that of krypton.

(2)

Rubidium has a larger atomic radius than Krypton ∴ it is easier to remove the electrons. Krypton also has a full outer shell ∴ it is hard to remove e⁻s as it is a stable product.

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Examiner Comments

Here the candidate has nearly got a mark but has not quite related the question to the electron. The atomic radius is larger, so the electron is further from the nucleus. This needs to be stated.

Then the GCSE statement about filled shells stability is given which is insufficient at this level.

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Examiner Tip

Try to answer this type of question as fully as possible.

*(e) Explain why the first ionization energy of rubidium is lower than that of krypton.

(2)

Rb is a larger ~~atom~~ atom. So the electrons are further away from the positive nucleus so the first I.E is lower as the electron is easier to remove. Kr is a smaller in comparison and its electrons are closer to the positive nucleus many ~~it~~ harder to remove.

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Examiner Comments

Here the candidate has correctly developed the idea of atomic size. They have wisely compared rubidium with krypton, mentioning how krypton differs but have failed to offer new relevant information, like the electron is less shielded.

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Examiner Tip

Try to identify the two marking points in your answer.

Question 19 (f)

The understanding of how electron arrangements determine the radii of atoms could be used here to deduce the answer. No doubt many had learned the trend across a period.

(f) Which of the elements, arsenic to rubidium, is likely to have atoms with the smallest atomic radius?

(1)

As.

(Total for Question 19 = 13 marks)

ResultsPlus
Examiner Comments

A common wrong answer.

(f) Which of the elements, arsenic to rubidium, is likely to have atoms with the smallest atomic radius?

shielding.

(1)

Rubidium

(Total for Question 19 = 13 marks)

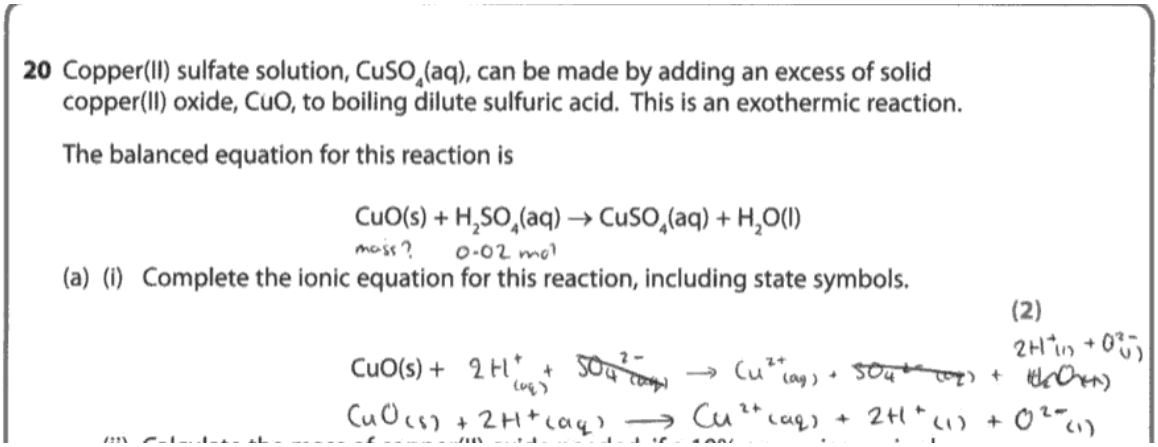
ResultsPlus
Examiner Comments

Another common wrong answer.

Question 20 (a) (i)

Candidates gave more correct ionic equations than usual, but there were still many errors. Some included spectator ions. Negative and singly charged copper ions were seen.

H_2^+ ions were quite common. States were often incorrect.



20 Copper(II) sulfate solution, $CuSO_4(aq)$, can be made by adding an excess of solid copper(II) oxide, CuO, to boiling dilute sulfuric acid. This is an exhaustive reaction.

The balanced equation for this reaction is

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$

(a) (i) Complete the ionic equation for this reaction, including state symbols.

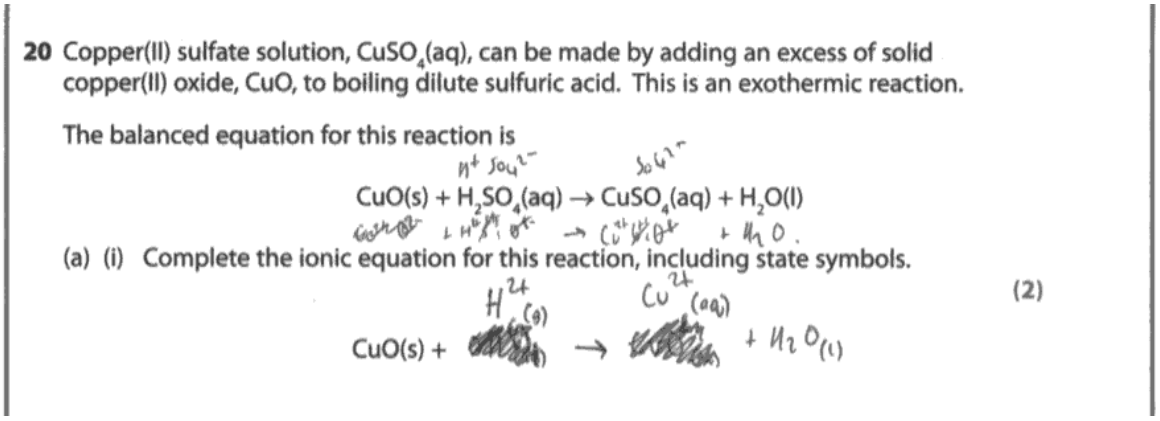
(2)

$CuO(s) + 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} + H_2O_{(l)}$

$CuO_{(s)} + 2H^+_{(aq)} \longrightarrow Cu^{2+}_{(aq)} + 2H^+_{(l)} + O^{2-}_{(l)}$

ResultsPlus
Examiner Comments

This is fine, apart from ionizing water.



20 Copper(II) sulfate solution, $CuSO_4(aq)$, can be made by adding an excess of solid copper(II) oxide, CuO, to boiling dilute sulfuric acid. This is an exothermic reaction.

The balanced equation for this reaction is

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$

(a) (i) Complete the ionic equation for this reaction, including state symbols.

(2)

$CuO(s) + H^{2+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + H_2O_{(l)}$

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Examiner Comments

This candidate has been fortunate with the mark scheme. The left side of their equation is correct, but they have made two errors on the right. Hydrogen is doubly charged and a gas.

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Examiner Tip

Try as many examples as you can of writing ionic equations for common reaction types like this.

Question 20 (a) (ii)

The common error was to omit the 10% excess. An incorrect molar mass could score an internal, transferred error, mark.

(ii) Calculate the mass of copper(II) oxide needed, if a 10% excess is required, when 0.020 mol of sulfuric acid is completely reacted.

[Relative atomic masses: Cu = 63.5 and O = 16.0]

(2)

$a = \frac{M}{Mr}$

$0.02 \times 63.5 = 1.27g$

moles Mr

$= 1.397g$

ResultsPlus
Examiner Comments

An example of an internal transferred error.

(ii) Calculate the mass of copper(II) oxide needed, if a 10% excess is required, when 0.020 mol of sulfuric acid is completely reacted.

[Relative atomic masses: Cu = 63.5 and O = 16.0]

(2)

$Mr = 79.5$

$n = \frac{M}{Mr}$

$m = n \times Mr$

$mass = 79.5 \times 0.02$

$= 1.59g$

ResultsPlus
Examiner Comments

This was the common one mark answer.

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Examiner Tip

Read the question carefully.

Question 20 (b) (i)

This question required the application of experience in practical work. Most candidates had prepared nickel sulphate from nickel carbonate and realised that a spatula was needed to add the copper oxide in small amounts. There was then some confusion as many suggested the reason as to prevent fizzing, which does not occur here.

(b) (i) Suggest, with a reason, how the copper(II) oxide should be added to the boiling sulfuric acid.

boiling tube. (2)

Using a spatula that fits into, as the boiling sulfuric acid will be very hot ~~at~~ and this way minising and Reduces the risk and hazard associated. You don't want to touch boiling sulfuric acid as you will burn yourself.

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Examiner Comments

There were many answers like this, scoring the first mark, and referring to the corrosive nature of sulfuric acid.

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Examiner Tip

The key here was to have read the question and realised the significance of the reaction being exothermic.

(b) (i) Suggest, with a reason, how the copper(II) oxide should be added to the boiling sulfuric acid.

(2)

using a spatula ~~to~~ with a grooved shelf as the boiling sulphuric acid will vigarously react with the copper (II) oxide.

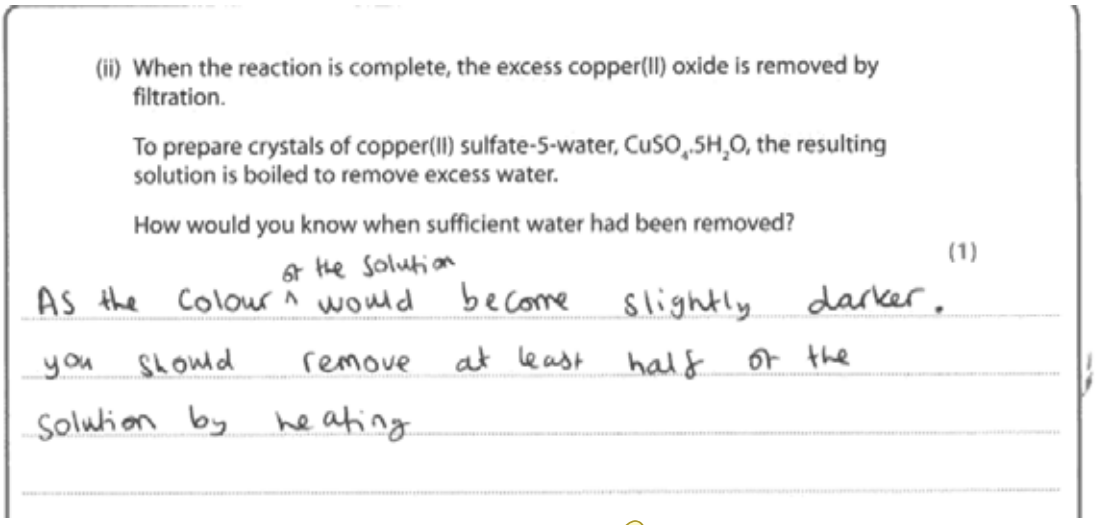
ResultsPlus
Examiner Comments

The first point is fine. The risk of the reaction mixture boiling over is missed.

Question 20 (b) (ii)

The correct method of dipping a glass rod into the mixture and cooling it to see if crystals form was given by the best candidates from centres where the practical work is well taught.

On this occasion the reduction to half the volume of solution was allowed.



(ii) When the reaction is complete, the excess copper(II) oxide is removed by filtration.

To prepare crystals of copper(II) sulfate-5-water, $CuSO_4.5H_2O$, the resulting solution is boiled to remove excess water.

How would you know when sufficient water had been removed?

(1)

AS the colour of the solution would become slightly darker.
you should remove at least half of the
solution by heating

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Examiner Comments

Though not the desired answer, this is sufficient. Notice how two sensible ideas have been given.

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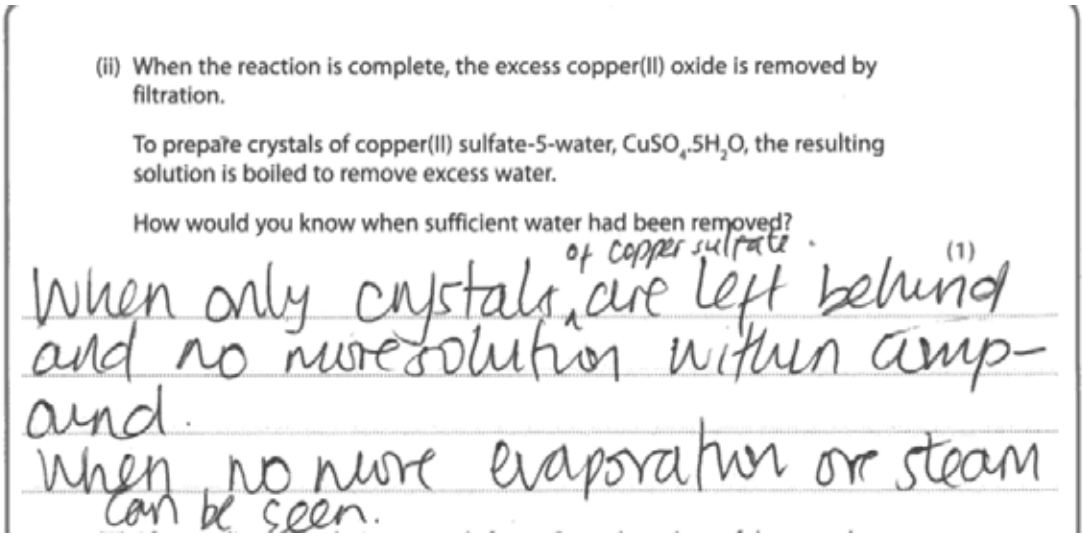
Examiner Tip

Answer each practial question as fully as possible, drawing on your practical experience.



(ii) When the reaction is complete, the excess copper(II) oxide is removed by filtration.

To prepare crystals of copper(II) sulfate-5-water, $CuSO_4.5H_2O$, the resulting solution is boiled to remove excess water.

How would you know when sufficient water had been removed?

(1)

When only crystals of copper sulfate are left behind and no more solution within compound.
When no more evaporation or steam can be seen.

ResultsPlus
Examiner Comments

This was a common incorrect response. The crystals would be covered by any impurities in the solution and would decompose if this method was used.

Question 20 (b) (iii)

Mixed colours were often given which were not accepted. White and colourless were also quite common.

(iii) After cooling the solution, crystals form. State the colour of the crystals.

(1)

Green

(iv) The crystals all have the same shape. What does this indicate about the

ResultsPlus
Examiner Comments

The candidate is thinking of nickel sulfate.

ResultsPlus
Examiner Tip

Learn the colours of the salts of common ions.

(iii) After cooling the solution, crystals form. State the colour of the crystals.

(1)

green/blue

ResultsPlus
Examiner Comments

The candidate appears to be offering two options.

ResultsPlus
Examiner Tip

If asked for a colour give a single colour.

Question 20 (b) (iv)

It was pleasing to see that the regular shape of crystals implied a regular arrangement of ions in a lattice. The ions are fixed was a common insufficient response.

(iv) The crystals all have the same shape. What does this indicate about the arrangement of the ions?

(1)

ions are arranged in lattice.

ResultsPlus
Examiner Comments

This was allowed but would have been better if it had used the term regular lattice.

(iv) The crystals all have the same shape. What does this indicate about the arrangement of the ions?

(1)

Ion arrangement is the the same

The lattice is a regular arrangement which ions arranged in the same

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Examiner Comments

A fully correct answer.

Question 20 (c) (i)

There were problems with the water of crystallization in the molar mass calculation. Some ignored the number five altogether, some thought it referred only to the hydrogen. However, most candidates gave the correct numerical answer.

The units g mol^{-1} were less known.

(c) (i) Calculate the molar mass of copper(II) sulfate-5-water, $CuSO_4.5H_2O$. Remember to include the appropriate units in your answer. You will need to use the Periodic Table as a source of data.

(2)

Cu = 63.5

S = 32.1 = 159.6

O_4 = 16 x 4

$5(H_2 = 1 \times 2, O = 16) = 90$

90 + 159.6 = 249.6

$CuSO_4.5H_2O$ = 249.6 A_r

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Examiner Comments

The calculation is fine but the correct SI units, g mol^{-1}, must be given.

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Examiner Tip

When learning relationships between moles, mass and molar mass learn all the units involved.

(c) (i) Calculate the molar mass of copper(II) sulfate-5-water, $CuSO_4.5H_2O$.
Remember to include the appropriate units in your answer. You will need to use the Periodic Table as a source of data.

(2)

mol = MM/M

63.5 + 32.1 + 64 + 10 + 16

185.6 gMM^{-1}

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Examiner Comments

Only the mass of hydrogen has been multiplied by five in the calculation. The unit is very strange.

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Examiner Tip

Try as many calculations of this type as you can.

Question 20 (c) (ii)

In calculating yields it is usually best to work entirely in moles, calculating the number of moles obtained and dividing by the number of moles expected. Calculations using masses were also acceptable. Here, transferred errors for incorrect molar masses were accepted. Many weak candidates divided the mass obtained by the mass of copper oxide.

(c) (i) Calculate the molar mass of copper(II) sulfate-5-water, $CuSO_4.5H_2O$.
Remember to include the appropriate units in your answer. You will need to use the Periodic Table as a source of data.

(2)

Cu S O +1
63.5 32.1 16 1

Cu S O_4 $5H_2$ 5O

(63.5) + (32.1) + (16 x 4) + (5 x 2 x 1) + (5 x 16)

= 249.6 g mol^{-1}

(ii) Calculate the percentage yield if 2.7 g of copper(II) sulfate-5-water is obtained from 0.020 mol of sulfuric acid.

(2)

$232.1 \quad 16\times4$

$H_2SO_4 = 98.1 = M_r \qquad 98.1 \times 0.02 = 1.962g$

$63.5 +$

$249.6 \times 0.02 = 4.98g$

$\frac{2.7}{4.98} \times 100 = 54.22$

$= 54.22\%$

ResultsPlus
Examiner Comments

The 5x in the molar mass has been omitted. An internal transferred error mark is given.

ResultsPlus
Examiner Tip

Always make your working clear.

(c) (i) Calculate the molar mass of copper(II) sulfate-5-water, $CuSO_4.5H_2O$. Remember to include the appropriate units in your answer. You will need to use the Periodic Table as a source of data.

(2)

$= 63.5 + 32.1 + (16\times4) + (5\times18)$

$= 249.6$ RAM

(ii) Calculate the percentage yield if 2.7 g of copper(II) sulfate-5-water is obtained from 0.020 mol of sulfuric acid.

(2)

mass of $CuSO_4 = 0.020 \times 159.6$

$= 4.992$

% yield $= \frac{2.7}{3.2} \times 100 = 84.37\%$

% yield $= \frac{4.992}{3.}$

% yield $= \frac{2.7}{3.2} \times 100 = 84.4\%$

ResultsPlus
Examiner Comments

The candidate has suddenly changed their previously correct molar mass to ignore the water! A transferred error mark was still possible. Unfortunately they reduced the number of significant figures in their denominator too soon.

ResultsPlus
Examiner Tip

It is always unwise to change an answer half way through a calculation, like this – it means one of your answers must be wrong. Reducing the number of significant figures should always be left to the end.

Question 20 (c) (iii)

Transfer errors' was the common insufficient response. This is insufficiently concise. The main reason for loss of product is that some remains in solution.

(iii) What is the most likely reason for the yield being well below 100%?

(1)

Not all of the reactants were used up.

ResultsPlus
Examiner Comments

Incomplete reaction was also quite a common incorrect response.

ResultsPlus
Examiner Tip

Always think about the reasons for the outcomes of experiments.

(iii) What is the most likely reason for the yield being well below 100%?

(1)

~~Some of the particles may not have reacted~~ Some of the solution may have been lost in the filtration stage ~~where~~ through which it was transferred

ResultsPlus
Examiner Comments

The amount of solution remaining on the filter paper would be negligible, but had this been clearly stated this would have been allowed.

Question 20 (d)

Many good candidates applied the information to realise that this was a test for water.

(d) When the crystals are heated, they turn white. On adding water, they return to their original colour. Suggest a use for this reaction.

(1)

The white crystals are anhydrous and contain no water particles so adding water will change the color to blue.

(Total for Question 20 = 15 marks)

ResultsPlus
Examiner Comments

This answer is simply repeating the information given in the question, so no mark awarded.

(d) When the crystals are heated, they turn white. On adding water, they return to their original colour. Suggest a use for this reaction.

(1)

Tells if water is present in the crystals or not. Whether crystals are hydrated or not.

(Total for Question 20 = 15 marks)

ResultsPlus
Examiner Comments

You could tell if water was present in a solution but not in crystals.

ResultsPlus
Examiner Tip

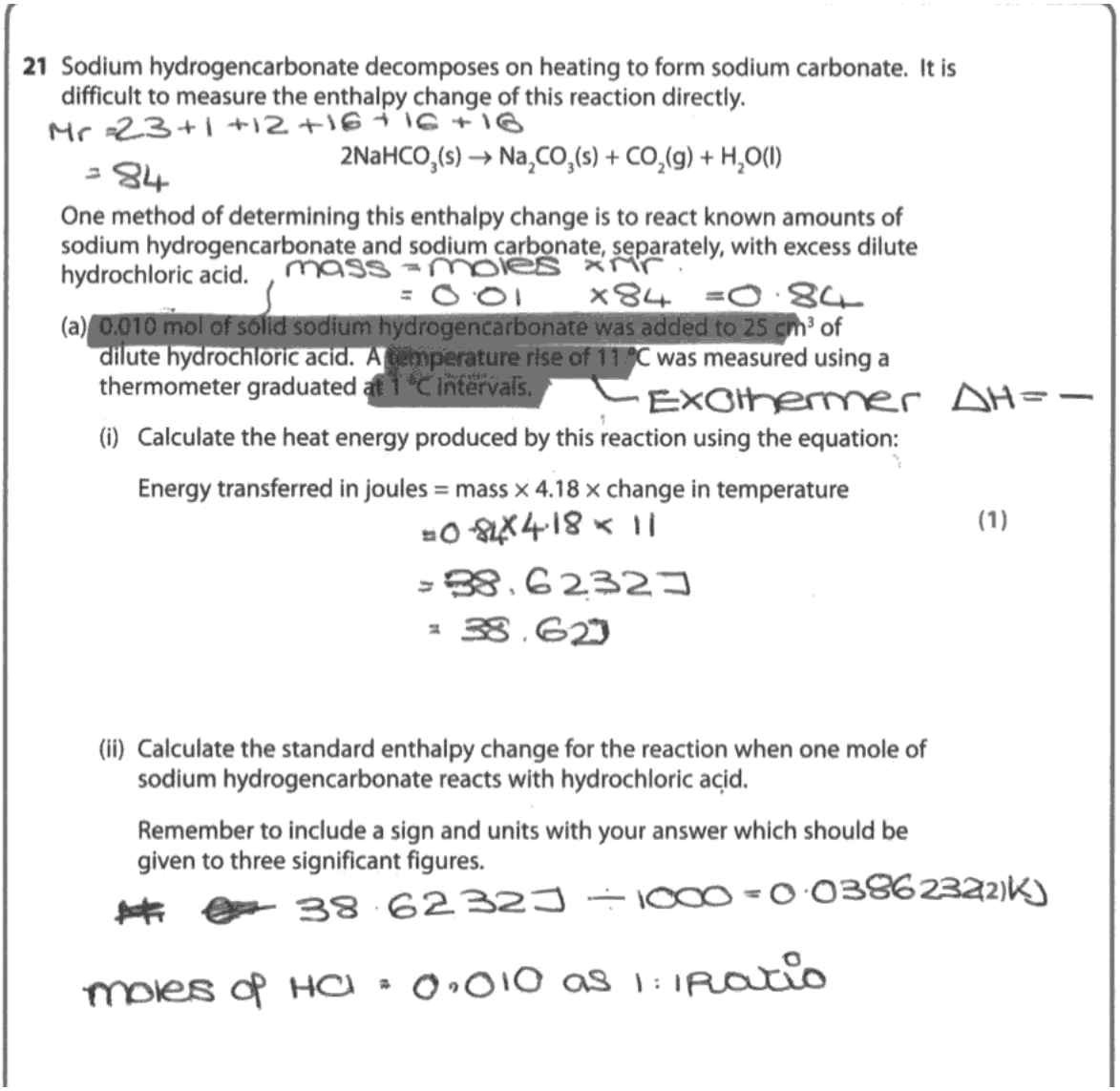
Always try to think of applications of reactions that you see.

Question 21 (a)

The first part was generally fine. Most candidates had no problem in recalling the mass of water is equal to the volume of solution. A few tried to find the mass of sodium hydrogencarbonate.

Candidates found the second part much more difficult. Though the calculation was usually done correctly, the sign was often omitted or given as positive. The number of significant figures was forgotten and the unit omitted or given incorrectly.

It is curious that neither this, nor the mass of hydrochloric acid, should not be included in the calculation with the mass of water. Strictly they should, but then the heat capacity is less, so these two factors more or less cancel out.



21 Sodium hydrogencarbonate decomposes on heating to form sodium carbonate. It is difficult to measure the enthalpy change of this reaction directly.

Mr = 23 + 1 + 12 + 16 + 16 + 16 = 84

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$

One method of determining this enthalpy change is to react known amounts of sodium hydrogencarbonate and sodium carbonate, separately, with excess dilute hydrochloric acid.

mass = moles × Mr = 0·01 × 84 = 0·84

(a) 0.010 mol of solid sodium hydrogencarbonate was added to 25 cm^3 of dilute hydrochloric acid. A temperature rise of 11 °C was measured using a thermometer graduated at 1 °C intervals.

Exothermic ΔH = −

(i) Calculate the heat energy produced by this reaction using the equation:

Energy transferred in joules = mass × 4.18 × change in temperature

= 0·84 × 4·18 × 11 = 38·6232 J = 38·623 J

(1)

(ii) Calculate the standard enthalpy change for the reaction when one mole of sodium hydrogencarbonate reacts with hydrochloric acid.

Remember to include a sign and units with your answer which should be given to three significant figures.

38·6232 J ÷ 1000 = 0·0386232(2) kJ

moles of HCl = 0·010 as 1 : 1 ratio

$$= \frac{0.0386232}{0.01}$$

$$= 3.86232$$

$$= 3.86$$

$$= -3.86 \text{ kJmol}^{-1}$$

ResultsPlus
Examiner Comments

This is an example of a calculation based on the mass of sodium hydrogencarbonate. Notice how the clear working in the answer makes it easy to award the marks for the second part of the question.

ResultsPlus
Examiner Tip

Always show working in calculations clearly.

21 Sodium hydrogencarbonate decomposes on heating to form sodium carbonate. It is difficult to measure the enthalpy change of this reaction directly.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$

One method of determining this enthalpy change is to react known amounts of sodium hydrogencarbonate and sodium carbonate, separately, with excess dilute hydrochloric acid.

(a) 0.010 mol of solid sodium hydrogencarbonate was added to 25 cm^3 of dilute hydrochloric acid. A temperature rise of 11 °C was measured using a thermometer graduated at 1 °C intervals.

(i) Calculate the heat energy produced by this reaction using the equation:

Energy transferred in joules = mass × 4.18 × change in temperature

(1)

$25 \times 4.18 \times 11 = 1149.5 \text{ J}$

(ii) Calculate the standard enthalpy change for the reaction when one mole of sodium hydrogencarbonate reacts with hydrochloric acid.

Remember to include a sign and units with your answer which should be given to three significant figures.

(2)

1149.5 × 100 = 114950

~~114000~~

115000 J

−115 kJ

ResultsPlus
Examiner Comments

This answer is fully correct apart from the incomplete unit.

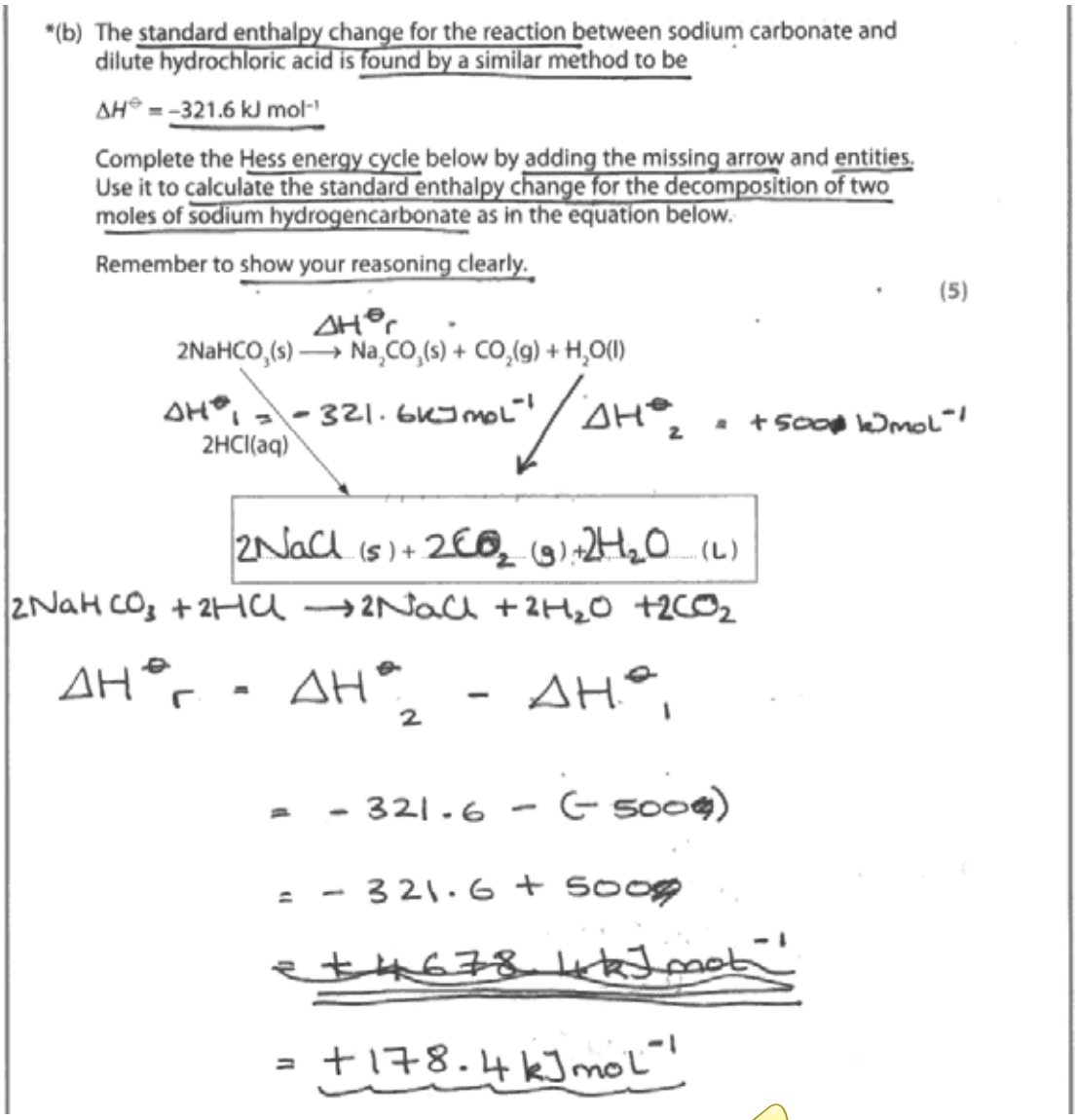
ResultsPlus
Examiner Tip

Always pay careful attention to units.

Question 21 (b)

This was one of the two most challenging parts of the paper. The two marks least regularly awarded were for the completion of the Hess triangle. It seems many just learn a set calculation of energy of formation or combustion, rather than appreciating that Hess can be generally applied to find enthalpy changes for reactions which cannot be carried out directly. Even when correct entities were given, balancing was often missing, and state symbols, especially for sodium chloride were often incorrect.

Working needed to be clearly shown in the calculation, particularly showing the multiple for the enthalpy change for the first reaction. The omission of this multiple was the commonest error for those who managed a calculation. A great many candidates gained no credit at all. Yet many good candidates gained full credit.



*(b) The standard enthalpy change for the reaction between sodium carbonate and dilute hydrochloric acid is found by a similar method to be

$\Delta H^{\ominus} = -321.6 \text{ kJ mol}^{-1}$

Complete the Hess energy cycle below by adding the missing arrow and entities. Use it to calculate the standard enthalpy change for the decomposition of two moles of sodium hydrogencarbonate as in the equation below.

Remember to show your reasoning clearly.

(5)

$\Delta H^{\ominus}_r$

$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$

$\Delta H^{\ominus}_1 = -321.6 \text{ kJ mol}^{-1}$ (2HCl(aq))

$\Delta H^{\ominus}_2 = +500$ kJ mol^{-1}

$2NaCl(s) + 2CO_2(g) + 2H_2O(L)$

$2NaHCO_3 + 2HCl \longrightarrow 2NaCl + 2H_2O + 2CO_2$

$\Delta H^{\ominus}_r = \Delta H^{\ominus}_2 - \Delta H^{\ominus}_1$

$= -321.6 - (-500)$

$= -321.6 + 500$

$= +178.4 \text{ kJ mol}^{-1}$

ResultsPlus
Examiner Comments

There are a number of instructive errors here. First the Hess triangle is nearly fully correct but the wrong state is given for sodium chloride.

Hess's law has been applied to the symbols correctly, but the numbers are the wrong way round and the multiple has been omitted from the calculation.

ResultsPlus
Examiner Tip

Try as many Hess cycles questions involving unfamiliar compounds as you can.

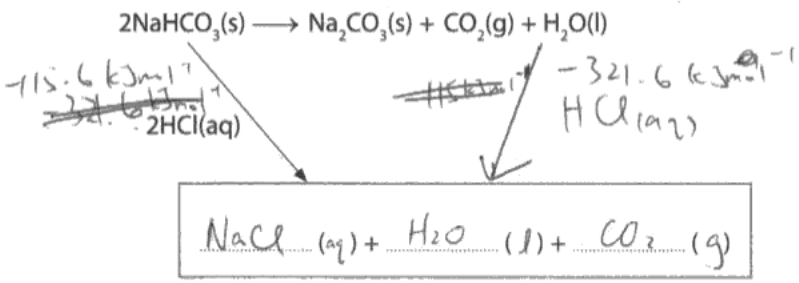
*(b) The standard enthalpy change for the reaction between sodium carbonate and dilute hydrochloric acid is found by a similar method to be

$\Delta H^{\ominus} = -321.6 \text{ kJ mol}^{-1}$

Complete the Hess energy cycle below by adding the missing arrow and entities. Use it to calculate the standard enthalpy change for the decomposition of two moles of sodium hydrogencarbonate as in the equation below.

Remember to show your reasoning clearly.

(5)



$-115 - (-321.6)$

$= +206.6 \text{ kJ mol}^{-1}$

ResultsPlus
Examiner Comments

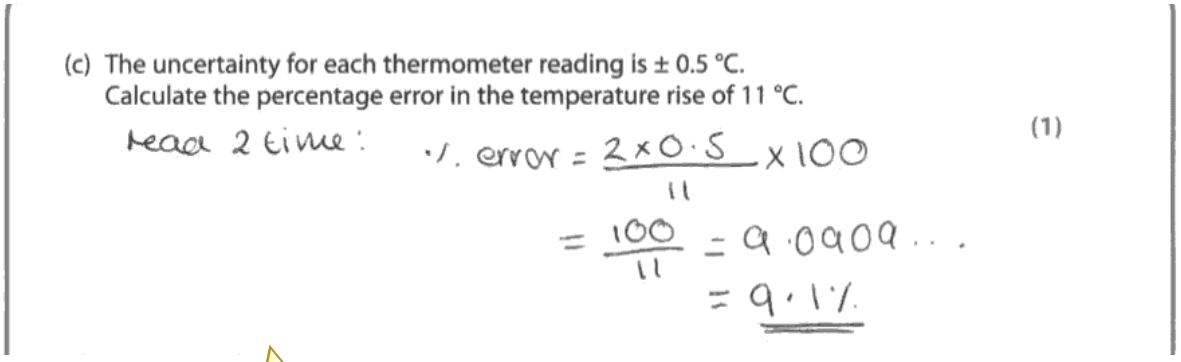
This is a typical response from a reasonably good candidate. There are only two errors. The multiple for the left side reaction has been omitted, as has the balancing of the elements in the formulae.

ResultsPlus
Examiner Tip

Be careful to balance entities in Hess triangles.

Question 21 (c)

Very few candidates realised that in measuring a change in temperature two readings are taken which doubles the uncertainty.



(c) The uncertainty for each thermometer reading is ± 0.5 °C.
Calculate the percentage error in the temperature rise of 11 °C.

(1)

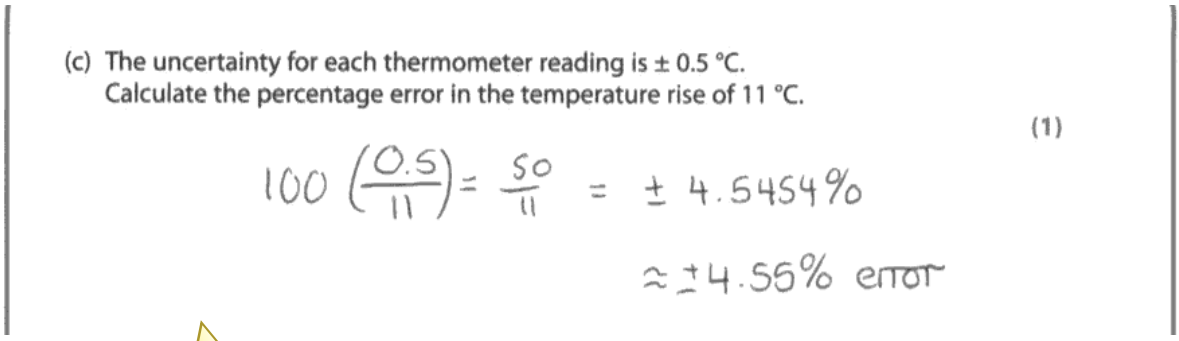
Read 2 time: % error = $\frac{2 \times 0.5}{11} \times 100$

$= \frac{100}{11} = 9.0909\ldots$

$= 9.1\%$

ResultsPlus
Examiner Comments

A perfect, well-reasoned answer with the recurring decimal handled correctly.



(c) The uncertainty for each thermometer reading is ± 0.5 °C.
Calculate the percentage error in the temperature rise of 11 °C.

(1)

$100\left(\frac{0.5}{11}\right) = \frac{50}{11} = \pm 4.5454\%$

$\approx \pm 4.55\%$ error

ResultsPlus
Examiner Comments

The common incorrect answer forgetting that two readings must be taken.

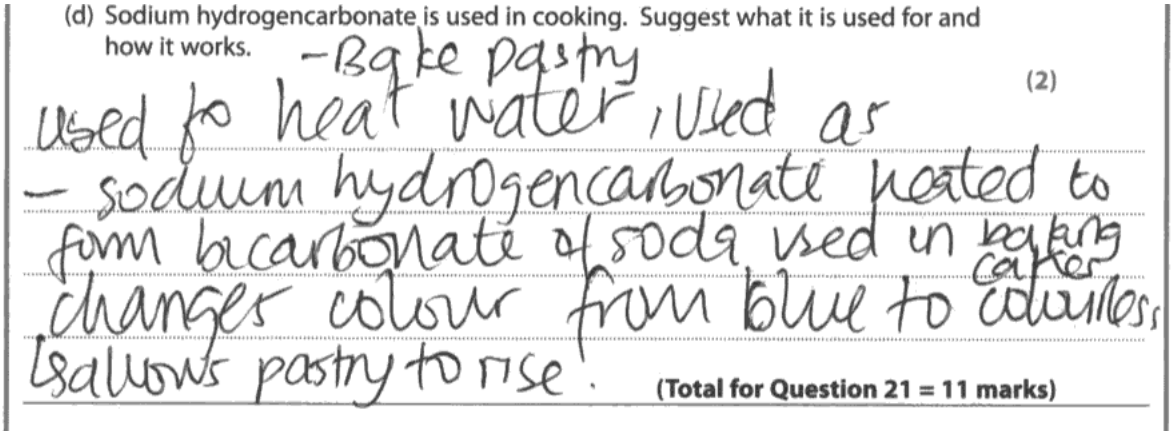
ResultsPlus
Examiner Tip

Remember that the maximum potential error is always found.

Question 21 (d)

The use of sodium hydrogencarbonate as a raising agent was quite well known. Many wrongly suggest its use as a raising agent in bread which though wrong was deemed to be sufficient. Raising agents are not used in pastry so this was not allowed.

The formation of carbon dioxide was needed for the second mark. Gas formation was not enough.



(d) Sodium hydrogencarbonate is used in cooking. Suggest what it is used for and how it works. (2)

– Bake pastry
Used to heat water, Used as
– sodium hydrogencarbonate heated to form bicarbonate of soda used in baking cakes
changes colour from blue to colourless
allows pastry to rise.

(Total for Question 21 = 11 marks)

ResultsPlus
Examiner Comments

This is an example of a range of answers in the hope that one is correct. This is to be discouraged. Such answers are marked as a + for correct and – for incorrect.

Many gave this incorrect first answer about absorbing heat.

ResultsPlus
Examiner Tip

For a one mark question offer one answer.

Question 22 (a) (i)

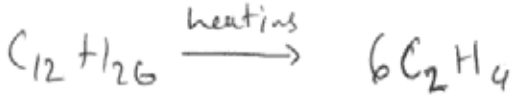
Though most gave the correct equation, many produced ethane or miscounted the hydrogen atoms in the alkane product.

22 This question is about ethene and its reactions.

Ethene is produced in industry by cracking.

(a) (i) Write the equation for the cracking of dodecane, $C_{12}H_{26}$, to produce one mole of ethene as the only alkene product.

(1)



ResultsPlus
Examiner Comments

Though this produces ethene, it omits any other alkane.

ResultsPlus
Examiner Tip

The primary reason for cracking is to make more petrol which is a mixture of alkanes.

22 This question is about ethene and its reactions.

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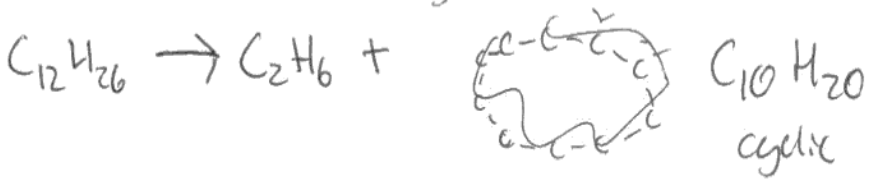
(a) (i) Write the equation for the cracking of dodecane, $C_{12}H_{26}$, to produce one mole of ethene as the only alkene product.

(1)



ResultsPlus
Examiner Comments

It was quite common to see the balanced equation for the formation of ethane like this.

ResultsPlus
Examiner Tip

Cracking produces alkanes like ethane as important by-products.

Question 22 (a) (ii)

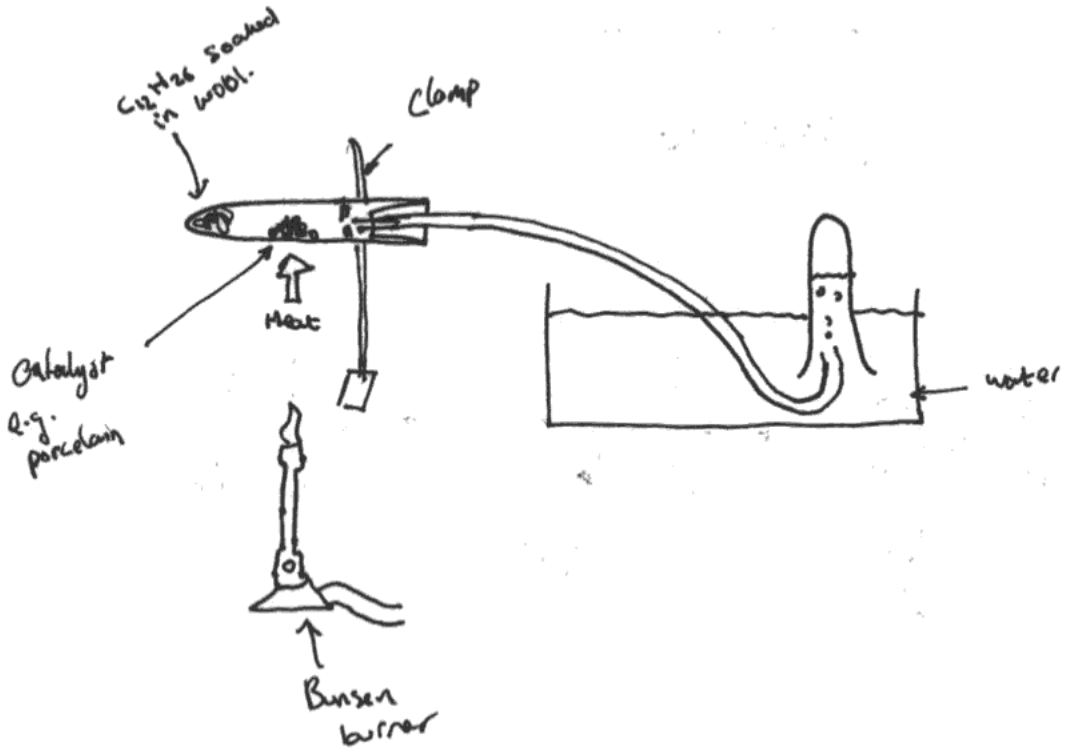
It was clear that many candidates had not done or seen this simple experiment.

All that is needed is a horizontal test tube containing the alkane soaked into ceramic fibre and the vapour passed over heated porcelain chips. The gas given off is collected over water.

The gas collection mark was the limit for most candidates.

(ii) Draw a labelled diagram of the apparatus and materials you would use to crack dodecane and collect a sample of the gaseous alkene in the laboratory.

(4)

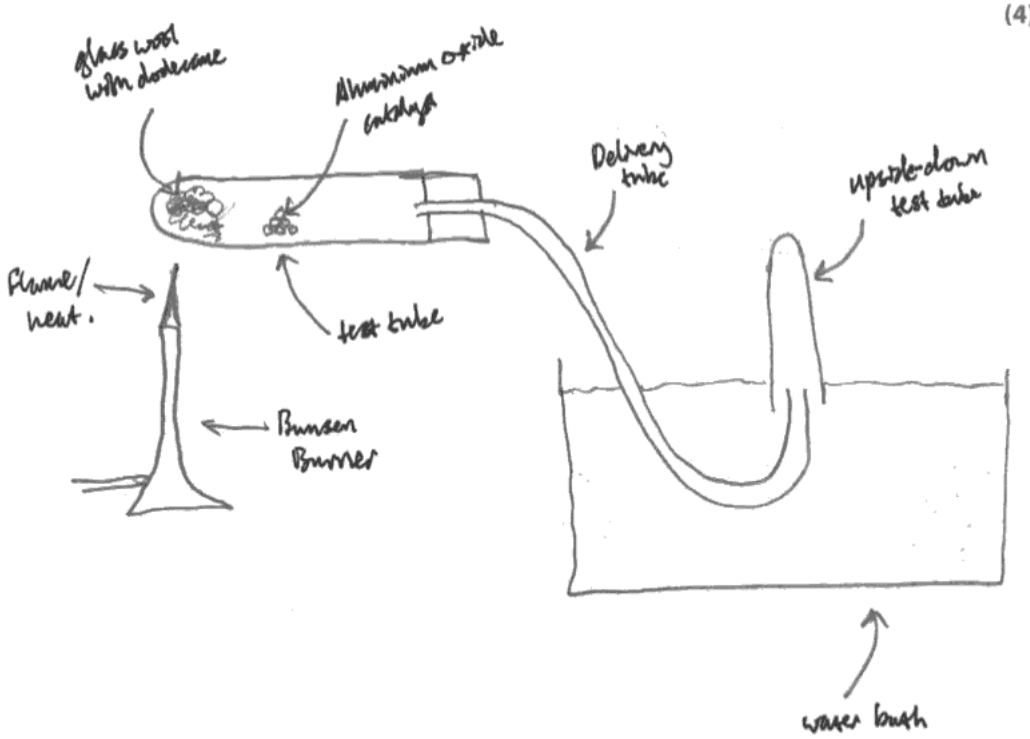


ResultsPlus
Examiner Comments

This is an example of a good answer. 'Wool' to hold the alkane is weak, but it was accepted.

(ii) Draw a labelled diagram of the apparatus and materials you would use to crack dodecane and collect a sample of the gaseous alkene in the laboratory.

(4)



ResultsPlus
Examiner Comments

There are a number faults in this diagram. It is questionable that glass wool would work, but it was allowed as some glass wools would.

The heat is in the wrong place which was penalised.

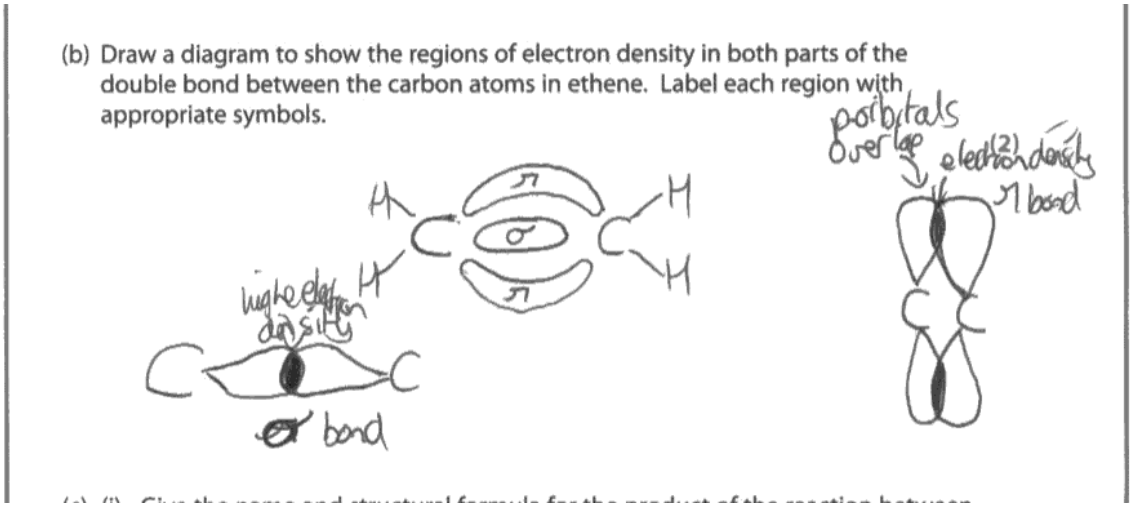
The collecting tube appears to be empty but this could be because it is filled with colourless gas. It would have been safer to show a level of water in the test tube.

ResultsPlus
Examiner Tip

Learn how to draw the apparatus used in organic experiments.

Question 22 (b)

Candidates were not very good at drawing this diagram. Models that show electron distributions within bonds are quite useful to help to understand this. Best answers showed a clearly labelled bond between the atoms with a second bond above and below the first.



ResultsPlus

Examiner Comments

Although the ∏ bonds are shaped incorrectly, this was sufficient. The added information about how the bonds are formed from atomic orbitals is most helpful.

Question 22 (c)

The name was often incomplete in the first part. A number or the prefix 'di' were often omitted.

Though the question asked for the structural formula, a displayed formula was accepted on this occasion. Bromoethane was quite a common product.

The mechanism was quite high scoring. Errors included arrows going the wrong way, like to the double bond or from the carbocation. The charge on the bromide ion is the second step, was often omitted.

(c) (i) Give the name and structural formula for the product of the reaction between ethene and bromine, $Br_2(l)$.

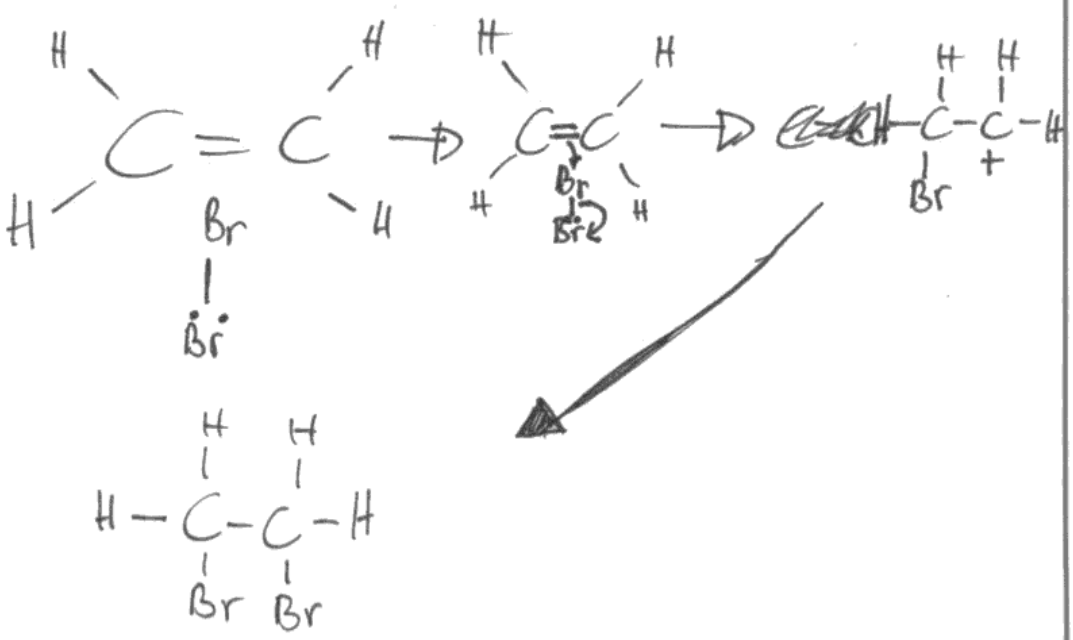
(2)

Name Bromoethene 2bro 1,2 bromoethan

Formula $C_2H_4 + Br_2 \longrightarrow 2C + 2HBr + H_2$

(ii) Give the mechanism for the reaction between ethene and bromine.

(3)



ResultsPlus
Examiner Comments

No marks are awarded in part (i). The name omits the prefix 'di' and there is an 'e' missing at the end. There seems to be some sort of equation rather than a formula.

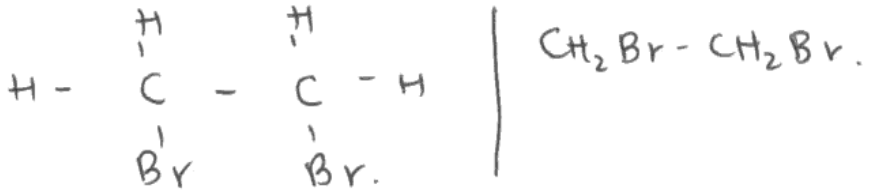
The first step of the mechanism is acceptable, though the polarization of bromine has not been shown. The carbocation is fine but the last step is not shown.

(c) (i) Give the name and structural formula for the product of the reaction between ethene and bromine, $Br_2(l)$.

(2)

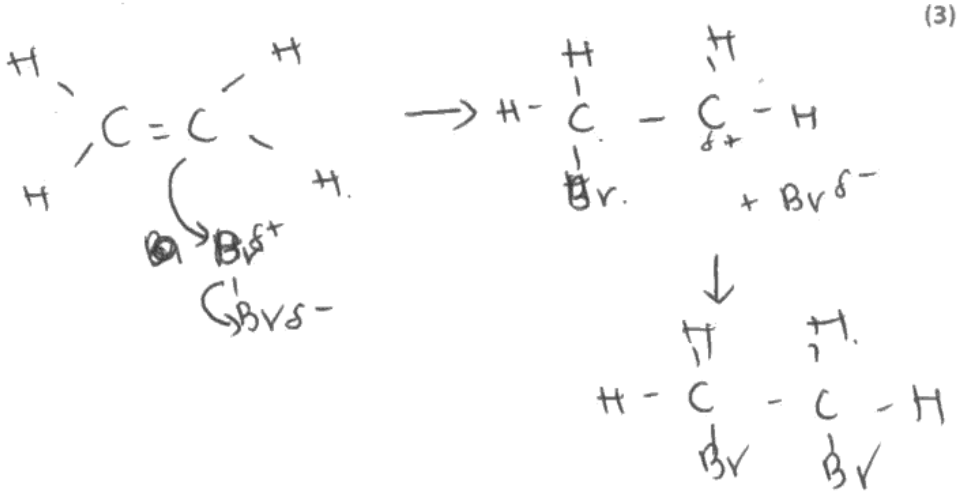
Name 1,2-dibromo ethane.

Formula



(ii) Give the mechanism for the reaction between ethene and bromine.

(3)



ResultsPlus
Examiner Comments

The first part is fine.

In the second part the attacking arrow starts from a carbon and not the double bond. The intermediate and the bromide ion have small δ+ and δ- charges instead of a full, negative charges. There is no movement of electrons shown in the final step.

ResultsPlus
Examiner Tip

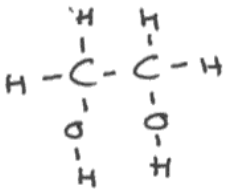
When learning reaction mechanisms the various steps need to be fully understood.

Question 22 (d)

Any recognisable correct product was rewarded on this occasion unless there were clear doubly bonded hydrogen atoms. This leniency was because it was felt that recognition of the correct product was sufficient.

(d) Give the displayed formula for the organic product of the reaction between ethene and acidified potassium manganate(VII). 0'0 1

(1)

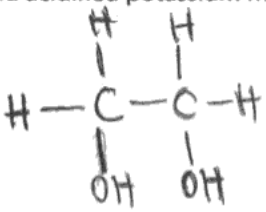


ResultsPlus
Examiner Comments

The perfect answer.

(d) Give the displayed formula for the organic product of the reaction between ethene and acidified potassium manganate(VII).

(1)



ResultsPlus
Examiner Comments

Though the OH bonds were not displayed this was sufficient in this context.

ResultsPlus
Examiner Tip

Check that displayed formulae show all atoms and all bonds.

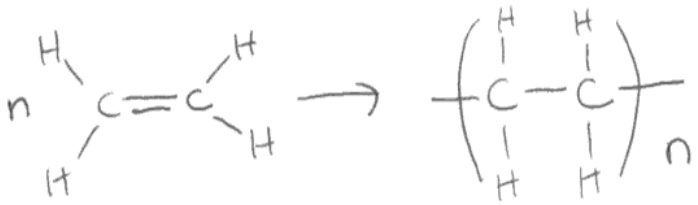
Question 22 (e) (i)

Though a familiar question, both marks were rarely awarded.

While the polymer formula was usually correct the equation was often not balanced.

(e) (i) Write a balanced equation for the formation of poly(ethene) from ethene, showing the structure of the polymer clearly.

(2)

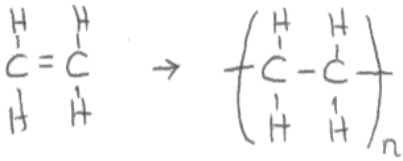


ResultsPlus
Examiner Comments

The fully correct answer.

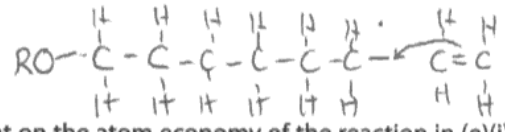
(e) (i) Write a balanced equation for the formation of poly(ethene) from ethene, showing the structure of the polymer clearly.

(2)



with a peroxide radical to initiate this

e.g.



ResultsPlus
Examiner Comments

While there is some correct and useful additional information the left hand side of the equation is not balanced.

ResultsPlus
Examiner Tip

Always check equations are balanced.

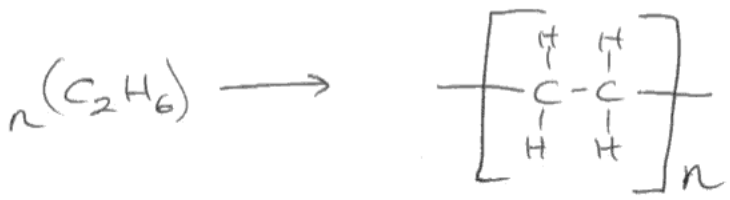
Question 22 (e) (ii)

The precise statement that the atom economy was 100% was needed followed by the comment that there is only one product.

Quite a few hedged their bets - 'The atom economy is high…' - which was insufficient.

(e) (i) Write a balanced equation for the formation of poly(ethene) from ethene, showing the structure of the polymer clearly.

(2)



(ii) Comment on the atom economy of the reaction in (e)(i).

(1)

it has 100% atom economy.

ResultsPlus
Examiner Comments

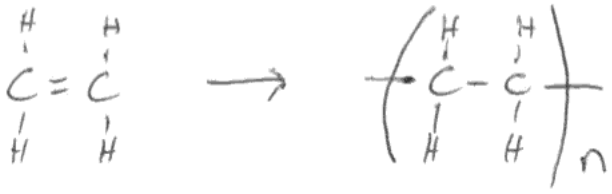
100% is fine but no comment is given.

ResultsPlus
Examiner Tip

Always check the question has been answered.

(e) (i) Write a balanced equation for the formation of poly(ethene) from ethene, showing the structure of the polymer clearly.

(2)



(ii) Comment on the atom economy of the reaction in (e)(i).

(1)

It should be 100% as there is only one product and one reactant

ResultsPlus
Examiner Comments

The correct answer.

Paper summary

On the basis of their performance on this paper candidates are offered the following suggestions for improving their performance:

- Read the question three times, once quickly, once slowly and once after writing the answer to check the question asked has been answered.
- As well as learning practical techniques, think about the reason for each procedure used and how it works.
- Practise Hess calculations on unfamiliar reactions, where the missing entities are not the chemical elements.
- Learn all the organic reactions thoroughly. Learn the names, structural, skeletal and displayed formulae for reactants and products, and the reaction conditions and mechanisms.

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