Examiners' Report
June 2016

IAL Chemistry WCH03 01

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications come from Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk.
Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

ResultsPlus

Giving you insight to inform next steps

ResultsPlus is Pearson's free online service giving instant and detailed analysis of your students' exam results.

- See students' scores for every exam question.
- Understand how your students' performance compares with class and national averages.
- Identify potential topics, skills and types of question where students may need to develop their learning further.

For more information on ResultsPlus, or to log in, visit www.edexcel.com/resultsplus.
Your exams officer will be able to set up your ResultsPlus account in minutes via Edexcel Online.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk.

June 2016

Publications Code WCH03_01_1606_ER

Introduction

This paper was a reasonable balance of standard and higher demand questions, the latter often requiring candidates to apply their knowledge and understanding in unfamiliar situations. It was similar in style and standard to previous Unit 3 papers on this specification, and a range of skills and knowledge was assessed. The levels of difficulty allowed good discrimination between the different grades, while allowing well-prepared candidates at all levels to demonstrate their abilities. In the multi-step calculation many candidates rounded intermediate values for use in the subsequent stages of the problem; while this practice is not itself penalised, it leads to inaccurate final values and is a frequent source of transcription error. It was evident that, even at this level, candidates do not take sufficient care in reading questions and context material before framing their responses.

Question 1 (a) (i)

Most candidates were very familiar with the procedure for conducting a flame test and the most common errors were failure to mention a suitable material for the flame test wire and neglecting to state that the wire needed to be placed in the flame. Occasionally, the wrong acid was used or a yellow flame was specified. Candidates should be aware that they can assume that the flame test wire is clean.

(a) Compound **A** gives a lilac colour in a flame test.

(i) Describe how to carry out a flame test.

(3)

Dip a nichrome wire in concentrated hydrochloric acid and then in the powdeed solid that you want to test. After that place the nichrome wire in the hottest part of the bunsen flame, the blue ~~flame~~ part.

ResultsPlus
Examiner Comments

An excellent answer that gets straight to the point.

ResultsPlus
Examiner Tip

There is no need to describe how the wire is cleaned.

(a) Compound **A** gives a lilac colour in a flame test.

(i) Describe how to carry out a flame test.

(3)

~~pt or nichro wire~~

bring pt wire then add HCl on the wire then dip the wire into solution we want to test. ~~Finally~~ put the wire over bunsen burner.

ResultsPlus
Examiner Comments

This is a very typical error omitting to mention the flame.

Question 1 (a) (ii) - (c) (ii)

The potassium ion was correctly identified by almost all candidates, with the lithium ion being the only significant alternative suggestion. The mark was occasionally forfeited by use of the element symbol without a charge. Similarly, carbon dioxide was usually recognised. There were many accurately described tests for water, with only a few candidates ignoring the word 'presence' and opting to measure the boiling point. There was some confusion between the reagent required to test for water and a dehydrating agent, such as calcium chloride. Despite the need for an anhydrous compound that decomposed to form carbon dioxide and water and the subsequent difficulties with the equation, most candidates opted for a carbonate in part (c)(i). Better candidates appreciated that a hydrogencarbonate must be present but few of these realised that the solid product of thermal decomposition would be the carbonate and were able to write the correct equation.

Question 2 (a)

The name of the alcohol was very well known although omission of the locant was surprisingly common.

Question 2 (b)

Most candidates gave phosphorus (v) chloride as the reagent, when the observation mark was almost invariably awarded. A minority suggested the use of sodium, again generally gaining the second mark although irrelevant observations, such as 'dissolving' or 'forming a precipitate' were more frequent in this case. Candidates who suggested using potassium dichromate (VI) often forgot to acidify it.

(b) Give a chemical test and its result that could be used to show the presence of the OH group in **E**.

(2)

Test: Add potassium dichromate (VI)

Result: the colour changes from orange to green.

ResultsPlus
Examiner Comments

This test is unsuitable as compounds such as aldehydes will also give a positive result and carboxylic acids which do have an OH group will show no reaction. The rescue mark was dependent on the need for acid conditions to be stated.

(b) Give a chemical test and its result that could be used to show the presence of the OH group in **E**.

(2)

Test: Add potassium pentachloride to ~~unknown~~ compound E.

Result: White steamy fumes* (~~hydrogen chloride~~) that turns damp blue litmus paper ~~to~~ red are produced.

ResultsPlus
Examiner Comments

This candidate included a further test on the hydrogen chloride produced. Candidates should be aware that such additional information must be correct.

Question 2 (c)

Many candidates scored full marks on this item but those attempting a comprehensive answer, describing alkaline hydrolysis followed by a test for the iodide ion, often failed to realise the necessity for acidification with nitric acid before the addition of silver nitrate. The most common error was to suggest a test for the presence of elemental iodine, usually using starch or a non-polar organic solvent.

(c) Give a chemical test and its result that could be used to show the presence of the iodine atom in **F**.

(2)

Test Add $NaOH_{(aq)}$ and warm for several minutes. After cooling add $HNO_{3(aq)}$ until just acidic to litmus paper followed by silver nitrate soln.

Result yellow precipitate forms.

ResultsPlus

Examiner Comments

An excellent answer concisely expressed and demonstrating good chemical knowledge.

(c) Give a chemical test and its result that could be used to show the presence of the iodine atom in **F**.

(2)

Test Add Starch solution.

Result ~~It tur~~ The solution turns blue-black

ResultsPlus

Examiner Comments

An all too common error.

ResultsPlus

Examiner Tip

Do read the question carefully before framing your answer.

(c) Give a chemical test and its result that could be used to show the presence of the iodine atom in **F**.

(2)

Test: Add $KOH_{(aq)}$ ~~and~~ followed by $AgNO_{3(aq)}$

Result: A yellow precipitate would form.

ResultsPlus

Examiner Comments

The test won't work in alkaline conditions so the test mark is not awarded. There is only one error so the correct observation scores a mark.

Question 2 (d) (i)

The colour change when alkenes react with potassium manganate(VII) proved a straightforward mark; a few candidates reversed the colour change.

Question 2 (d) (ii)

The skeletal formula of the diol product proved highly discriminating. The most common errors were giving seven carbon atoms in the chain, one hydroxyl group and non-adjacent hydroxyl groups. There were also responses showing manganese atoms or sulfate groups attached to the carbon chain.

(ii) Draw the **skeletal** formula of the organic product of this reaction.

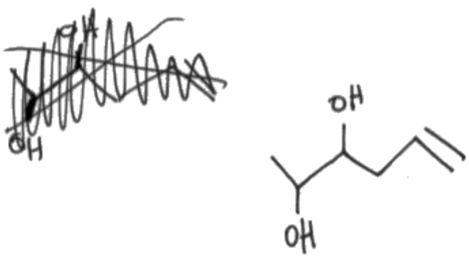
(1)

ResultsPlus
Examiner Comments

One of many incorrect variants of the diol structure. Note that the left-hand OH group clearly shows the hydrogen bonded to the carbon - a further error.

(ii) Draw the **skeletal** formula of the organic product of this reaction.

(1)



ResultsPlus
Examiner Comments

Here the carbon-carbon double bond has not been involved in the reaction at all.

Question 2 (e)

Many different reagents were suggested here but most candidates appreciated that a strong alkali was required. However, far fewer correct conditions were given.

(e) State the reagent and give the essential conditions for the conversion of **F** to **G**.

(2)

Reagent ethanoic NaOH

Conditions ethanol as solvent and to be acidified (by H_2SO_4) and heat.

ResultsPlus

Examiner Comments

Most of this is correct but the addition of acid negates the reagent mark.

(e) State the reagent and give the essential conditions for the conversion of **F** to **G**.

(2)

Reagent Sodium hydroxide

Conditions Ethanol solvent, room temperature

ResultsPlus

Examiner Comments

A near miss. The more usual omission was the ethanol solvent rather than the need to heat.

Question 2 (f) (i)

Candidates generally opted for a displayed formula in answering this question so the length of the carbon chain was rarely an issue. The most common error was to give the major product as 1-iodohexane.

Question 2 (f) (ii)

Despite the phrasing of the question, many candidates referred to Markovnikov's rule, only sometimes going on to explain this in terms of the relative stability of the carbocations. Answers also referred to the primary and secondary molecules.

Question 2 (g) (i)

The water direction was usually labelled correctly but the anti-bumping granules were frequently identified as one of the reactants.

Question 2 (g) (ii)

Reflux was very well known although some candidates negated the mark by adding 'distillation' to their answer.

Question 2 (g) (iii)

The significance of the water passing through the condenser was poorly understood and many candidates discussed liquids being returned to the flask without mentioning the condensation of gases or vapours. The second mark was often awarded for the alternative idea of allowing the reaction to go to completion.

(iii) Explain how the Liebig condenser works and its purpose in the apparatus shown.

(2)

Cold water is Pumped in and moves up the Condenser, surrounding the reflux tube until it leaves through the "water-out" tap. When cold water runs through, it cools the reflux tube so that any gas/vapour escaping the flask would condense and go back to the flask

ResultsPlus

Examiner Comments

A very comprehensive response, clearly expressed.

Question 2 (h) (i)

Once again the majority of responses used displayed formula. The aldehyde group caused more difficulty than the carboxylic acid group, and in the latter the carbonyl oxygen and the hydroxyl group were sometimes placed on different carbon atoms.

Question 2 (h) (ii)

Most candidates realised that a peak or absorption would be observed for the OH group in the carboxylic acid but not the aldehyde although a significant number stated the reverse. Common errors were to refer just to the bonds or wavenumbers. Some discussed the mass spectra rather than the infrared.

Question 2 (i) - (i)

Very few candidates scored the still-head mark and a significant number seemed unaware that the condenser would be used for the distillation as well as the reflux.

Question 2 (i) - (ii)

For the most part the choice of a temperature range was sensible. While few candidates suggested a single temperature, some ranges were so far removed from the boiling temperature that it was difficult to understand how they had been arrived at.

Question 2 (i) - (iii)

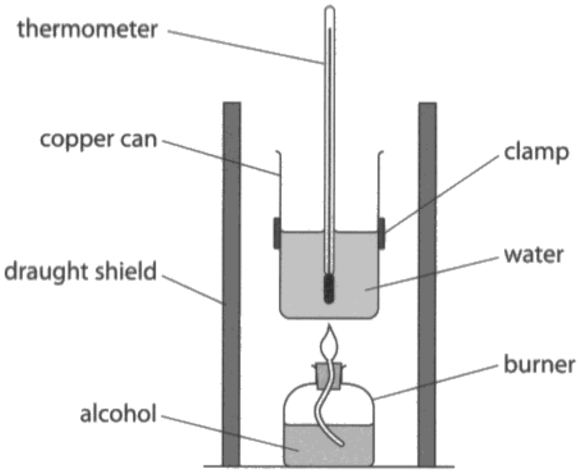
Suitable drying agents were well known and it was encouraging to see many candidates specifying that the suggested compound should be anhydrous.

Question 3 (a)

By far the most common error in the first stage of the calculation was failure to include the copper can term in the temperature multiplication by ignoring the square brackets given in the equation. Occasionally, the mass of fuel was used rather than the mass of water.

The conversion of energy transferred into an enthalpy change was generally well understood, with arithmetical errors the most common source of error. Too many answers were obtained using rounded intermediate values; while this is not penalised it does increase the chance of error. A small but significant number of candidates incorrectly gave the final units as kJ mol- (rather than kJ mol^{-1}).

3 The apparatus below was used in a series of experiments by a group of students to determine the enthalpy change of combustion of some alcohols.



(a) In the experiment to determine the enthalpy change of combustion of CH_3OH, one student obtained the following results.

Measurement	Value
Mass of copper can / g	300.00
Mass of copper can + water / g	700.00
Mass of burner + CH_3OH (start) / g	151.65
Mass of burner + CH_3OH (finish) / g	150.00
Temperature of water (start) / °C	21.5
Temperature of water (finish) / °C	33.5

Data

Specific heat capacity of copper = 0.39 J g^{-1} $°C^{-1}$
Specific heat capacity of water = 4.2 J g^{-1} $°C^{-1}$

(i) Calculate the heat energy transferred. Use the expression

heat energy transferred / J = [(0.39 × mass of copper can) + (4.2 × mass of water)] × temperature rise

(2)

= 0.39 × 300 + 4.2 × 400 × (33.5 − 21.5)

12

= 117 + 1680

= 1797 × 12

= 21564 J

(ii) Use your answer from (a)(i) to calculate the enthalpy change of combustion of CH_3OH.

Give your answer in kJ mol^{-1} and include the appropriate sign.

(3)

151.65 − 150.00 = 1.65 g of CH_3OH

$$\text{moles} = \frac{\text{mass}}{Mr} = \frac{1.65}{32}$$

= 0.0515625 moles of CH_3OH

$$\Delta H = \frac{-Q}{n} \div 1000$$

$$= \frac{-21564}{0.0515625} \div 1000$$

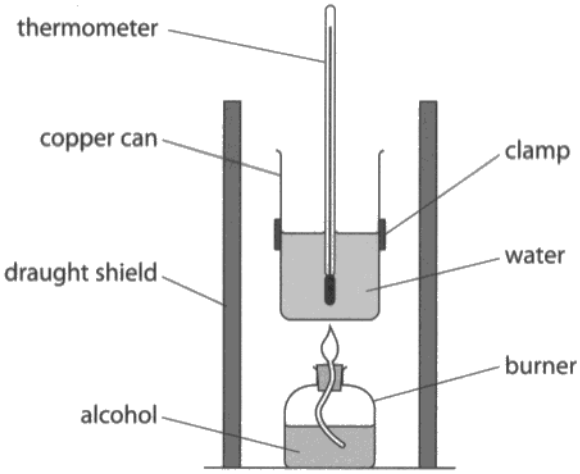
= −418 kJ mol^{-1}

ResultsPlus

Examiner Comments

The top line of the working is algebraically incorrect but the candidate completes the first part of the calculation correctly to score both marks.

3 The apparatus below was used in a series of experiments by a group of students to determine the enthalpy change of combustion of some alcohols.



(a) In the experiment to determine the enthalpy change of combustion of CH_3OH, one student obtained the following results.

Measurement	Value
Mass of copper can / g	300.00
Mass of copper can + water / g	700.00
Mass of burner + CH_3OH (start) / g	151.65
Mass of burner + CH_3OH (finish) / g	150.00
Temperature of water (start) / °C	21.5
Temperature of water (finish) / °C	33.5

Data

Specific heat capacity of copper = 0.39 J g^{-1} °C^{-1}
Specific heat capacity of water = 4.2 J g^{-1} °C^{-1}

(i) Calculate the heat energy transferred. Use the expression

heat energy transferred / J = [(0.39 × mass of copper can) + (4.2 × mass of water)] × temperature rise

(2)

heat energy transferred = {(0.39 × 300) + [4.2 × (700 − 300)]} × (33.5 − 21.5)

heat energy transferred = (117 + 1680) × 12

= 21564 J

(ii) Use your answer from (a)(i) to calculate the enthalpy change of combustion of CH_3OH.

Give your answer in kJ mol^{-1} and include the appropriate sign.

(3)

21564 J = 2.2 kJ

CH_3OH

12+3+16+1 = 32

(151.65 − 150) ÷ 32 = 0.05 mol

~~1.65 g~~

(~~151.65 − 150~~)

2.2 ÷ 0.05 = 42.67 kJ/mol

ResultsPlus
Examiner Comments

Although this candidate understands the principle of the calculation in (a)(ii), several errors are apparent: the rounded value for the heat transferred is a factor of 10 too low; the amount of methanol has been rounded to 1 significant figure; the final sign has been omitted.

ResultsPlus
Examiner Tip

Do not round intermediate numbers; only the final value should be rounded. Retain and use the numbers in your calculator.

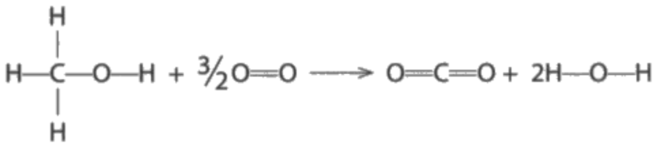
Question 3 (b) (iii)

Full marks were rarely awarded on this item. Even good candidates struggled to articulate the core arguments while many committed elementary errors, notably that bond breaking was exothermic and the trend depended on intermolecular forces.

(iii) By considering the combustion equations for the alcohols, explain the trend shown by the graph in terms of the bond changes.

The equation for the combustion of CH_3OH is given below; you are **not** expected to write any other equations.

(2)



As number of carbon atoms increase, the enthalpy change of combustion increase, because breaking more carbon bonds would need more energy so no. of Carbon atoms is ~~directly~~ proportional with enthalpy change of combustion. As bonds more to break, bonds need moreenergy.

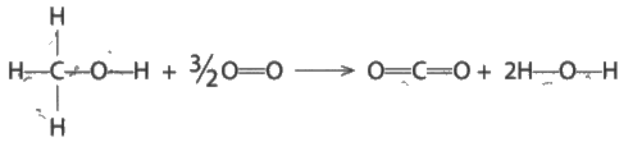
ResultsPlus
Examiner Comments

This candidate is actually working along the right lines but there is no mention of bond formation or of the incremental increase in carbon chain length.

(iii) By considering the combustion equations for the alcohols, explain the trend shown by the graph in terms of the bond changes.

The equation for the combustion of CH_3OH is given below; you are **not** expected to write any other equations.

(2)



With reference to the graph when the no. of carbon atoms increase in the alcohol, the enthalpy change of combustion increases. ~~to~~ ~~It is~~ ~~the~~ It is because, when ~~where~~ there are more atoms in the alcohol, more bonds are brocken and more bonds are formed. in the reaction. ~~How~~ But the ~~no~~ increase in the no. of bonds formed outweighs the increase in the no. of bonds brocken. when the carbon chain length increases. So each time a carbon atom is added to the alcohol, the difference between energy given ~~given~~ out by formation and the energy absorbed ~~for~~ breaking bonds. increases. This increases the overall enthalpy of ~~compu~~ combustion.

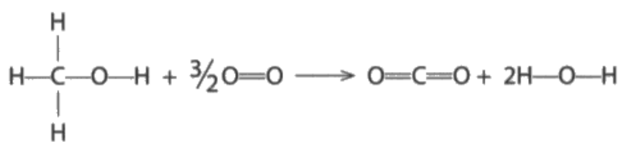
ResultsPlus
Examiner Comments

A rare full marks. The explanation is rather wordy but the main points are clearly there.

(iii) By considering the combustion equations for the alcohols, explain the trend shown by the graph in terms of the bond changes.

The equation for the combustion of CH_3OH is given below; you are **not** expected to write any other equations.

(2)



As the number of carbon atoms ~~increases~~ increase, the number of bonds also increase. More bonds ~~need to be broken so en~~ broken so energy given out increases.

ResultsPlus
Examiner Comments

Stating that bond breaking is exothermic was a surprisingly common error.

Question 3 (b) (i) - (ii)

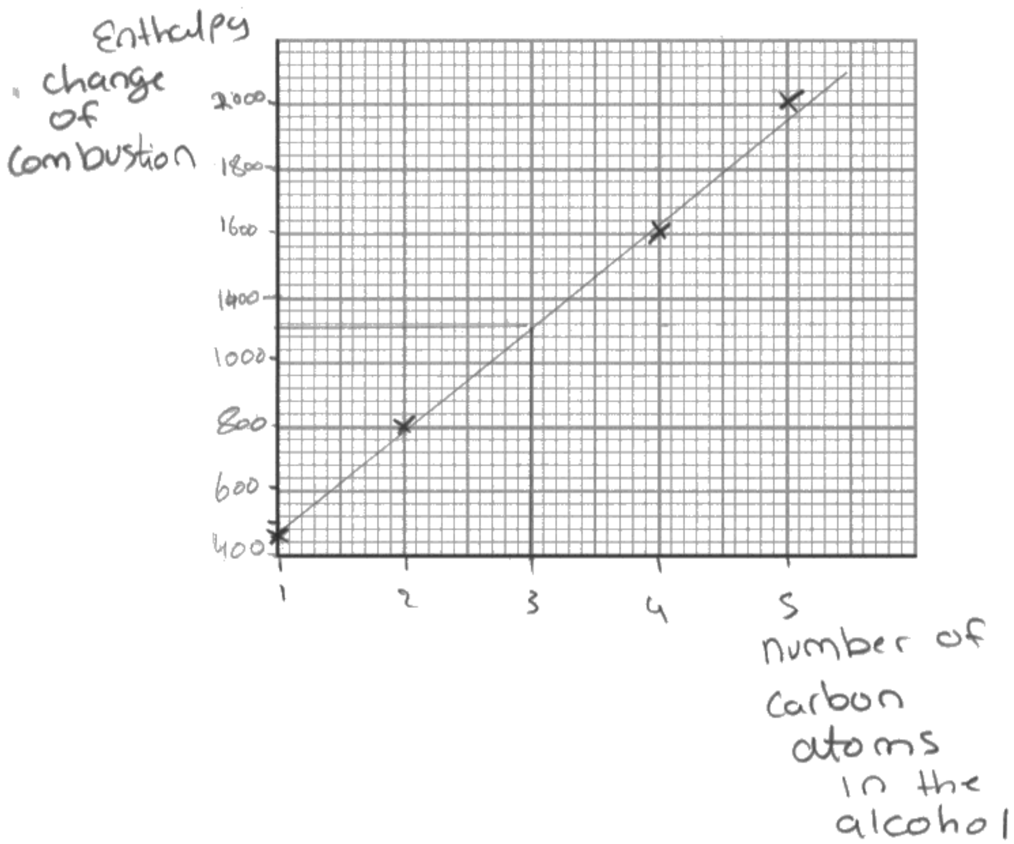
There were many technical errors in drawing this graph: failure to properly utilise the available space; omission of the axis label, incorrect or omitted units; drawing a 'point to point' line rather than a best fit line. In addition non-linear scales and bar charts were far from unusual. Candidates should also ensure that their plotted points are marked by circles or crosses.Most candidates gained the mark for (b)(ii).

(b) The mean values obtained by the students were collected in a table.

Alcohol	(–) Enthalpy change of combustion / kJ mol^{-1}
CH_3OH	450
C_2H_5OH	800
C_3H_7OH	No value obtained
C_4H_9OH	1600
$C_5H_{11}OH$	2000

(i) Label the axes below and plot a graph of (the magnitude of) the enthalpy change of combustion (on the vertical axis) against the number of carbon atoms in the alcohol (on the horizontal axis).

(2)



(ii) Use your graph to estimate the enthalpy change of combustion of C_3H_7OH.

(1)

1200 kJ mol^{-1}

ResultsPlus

Examiner Comments

This response has no value for 1200 kJ mol^{-1} resulting in a non-linear scale. Note also that the y axis label omits units.

ResultsPlus

Examiner Tip

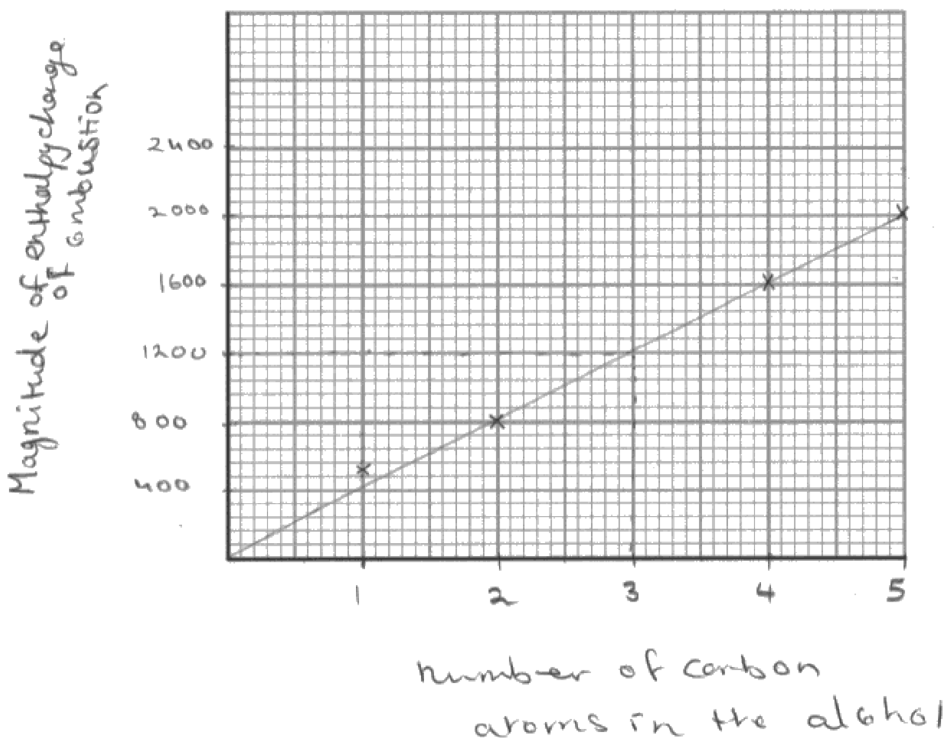
Plotting a graph is a basic skill required for experimental work.
A correct graph has fully labelled axes (including units where appropriate) and a sensible scale which allows easy plotting as well as filling as much of the paper as possible.

(b) The mean values obtained by the students were collected in a table.

Alcohol	(–) Enthalpy change of combustion / kJ mol^{-1}
CH_3OH	450
C_2H_5OH	800
C_3H_7OH	No value obtained
C_4H_9OH	1600
$C_5H_{11}OH$	2000

(i) Label the axes below and plot a graph of (the magnitude of) the enthalpy change of combustion (on the vertical axis) against the number of carbon atoms in the alcohol (on the horizontal axis).

(2)



(ii) Use your graph to estimate the enthalpy change of combustion of C_3H_7OH.

(1)

1200 kJ mol^{-1}

ResultsPlus

Examiner Comments

This graph does not use enough of the graph paper and omits the units on the y axis.

Question 3 (c)

The most usual response to 3(c)(i) was obtained by calculating the value given in the table as a percentage of the Data Booklet value (i.e. 100 x 800/1367.3). Many who used the correct method rounded their answer to 42%, often explicitly via 41.49 and then 41.5.

There were some excellent answers to 3(c)(ii) but these were a definite minority. Some candidates struggled to grasp the idea of 'evaluating validity' and defaulted to responses based on the more familiar 'sources of error' type of question. The core of the question was an understanding of the relative magnitude of the experimental errors and uncertainties and relating these to the percentage error calculated in 3(c)(i).

(c) The students then compared their results to the values in the Data Booklet. They found that the magnitudes were consistently much smaller; for example, the Data Booklet value for C_2H_5OH is -1367.3 kJ mol^{-1}.

The students suggested a number of possible explanations for the discrepancy:

I uncertainties in the measurement of mass and temperature

II the values used for the specific heat capacities of copper (0.39 J g^{-1} K^{-1}) and water (4.2 J g^{-1} K^{-1}) are rounded (from 0.385 and 4.18 J g^{-1} K^{-1})

III heat losses to the surroundings

IV incomplete combustion of the alcohols

(i) Calculate the percentage error in the students' mean value for the enthalpy change for combustion of C_2H_5OH compared with the Data Booklet value. Give your answer to **two** significant figures.

(2)

~~$\frac{800}{-1367.3} \times 100 = -58.5094..$~~

~~$= 58.5\%$~~

$800 - 1367.3 = -567.3$

$\frac{-567.3}{-1367.3} \times 100 = 41.49\%$

(ii) By considering your answer to (c)(i), evaluate the validity of each of the four reasons that the students put forward to explain the discrepancies between their values and those in the Data Booklet.

(4)

Suggestion I valid. Data from the book have really accurate readings while humans can make readings really inaccurate because of parallax error. This would have changed the results. However the readings could have been larger or smaller, not necessarily smaller

Suggestion II valid. Rounding number would make the total answer bigger than the answer you would reach if not rounded numbers were used (Data Book didn't use rounded numbers)

Suggestion III valid. Heat loss to the surroundings will make the enthalpy change of combustion less exothermic. Data Booklet assumes there's no heat loss involved.

Suggestion IV valid. Incomplete combustion is less exothermic due to the fact that the making of C=O bonds in ... less exothermic than the making of the bonds in O=C=O.

ResultsPlus

Examiner Comments

The error calculation is fully correct but the final answer has been given to two decimal places rather than two significant figures.

The suggestion I mark was awarded for the final sentence.
The suggestion II mark and a mark for realising that suggestions III and IV would produce a value that was less exothermic than the Data Booklet value were awarded.

ResultsPlus

Examiner Tip

In dealing with thermodynamic quantities, like enthalpy and entropy, use phrases like 'greater in magnitude' and 'more exothermic' rather than 'larger'.

(c) The students then compared their results to the values in the Data Booklet. They found that the magnitudes were consistently much smaller; for example, the Data Booklet value for C_2H_5OH is -1367.3 kJ mol^{-1}.

The students suggested a number of possible explanations for the discrepancy:

I uncertainties in the measurement of mass and temperature

II the values used for the specific heat capacities of copper (0.39 J g^{-1} K^{-1}) and water (4.2 J g^{-1} K^{-1}) are rounded (from 0.385 and 4.18 J g^{-1} K^{-1})

III heat losses to the surroundings

IV incomplete combustion of the alcohols

(i) Calculate the percentage error in the students' mean value for the enthalpy change for combustion of C_2H_5OH compared with the Data Booklet value. Give your answer to **two** significant figures.

(2)

$$\frac{1367.3 - 800}{1367.3} \times 100 = 41\%$$

(ii) By considering your answer to (c)(i), evaluate the validity of each of the four reasons that the students put forward to explain the discrepancies between their values and those in the Data Booklet.

(4)

Suggestion I uncertainties for mass and temperature are both very small and will not have contributed greatly. Mass was ±0.05g and temperature was ±0.5°C, both of which are very small

Suggestion II For the specific heat capacity of the copper can, 0.005Jg⁻¹K⁻¹ would not have mattered much. 0.02 Jg⁻¹K⁻¹ in the specific heat capacity of water would not have mattered much either. Both are very small uncertainties.

Suggestion III It is possible that some heat was lost to the surroundings, but with the ~~draught~~ draught shield, it would not be a great amount.

Suggestion IV This is the most likely cause of the low results for the enthalpy change. if not enough oxygen is supplied to the flame, there will be incomplete combustion and the flame will not be as hot.

ResultsPlus
Examiner Comments

A good answer for 3(c)(ii) which was awarded marking points 1, 2 and 3.

Paper Summary

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

- Read the questions carefully
- Check that your answers match the requirements of the questions
- Practise retaining intermediate values in your calculator when carrying out calculations.
- Try to ensure that you understand the meaning of the terms error and uncertainty.

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

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

Rewarding Learning

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London WC2R 0RL.