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Examiners' Report
June 2016

GCE Chemistry 8CH0 02

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June 2016

Publications Code 8CH0_02_1606_ER

Introduction

This is the first examination in the Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry (8CH0) qualification. This is an AS qualification and the marks awarded do not contribute to the Advanced GCE in Chemistry (9CH0) qualification. The marks for paper 8CH0/01 and paper 8CH0/02 will be added together to give a total mark on which the grade is awarded.

The paper is 1 hour 30 minutes with 80 marks. The paper consists of a mixture of multiple-choice, short open, open-response, calculations and extended writing questions. There has to be a minimum of 20% of the marks for mathematics at Level 2 or above and some questions have to assess conceptual and theoretical understanding of experimental methods.

The main differences between this paper and those from the previous specification are:

- fewer multiple-choice questions
- more calculations and the calculations do not have any scaffolding
- more questions based on practical techniques as these are now not assessed as part of practical coursework
- a 6 mark extended writing question.

The overall impression of the examiners was that many candidates coped very well with this first examination and gave excellent answers. However, there were a significant number who did not seem prepared for this new style of paper and they did not perform well on the calculations and/or the questions based on practical work.

More able candidates:

- used correct scientific terminology in their answers
- used a wide-range of practical techniques when carrying out experiments or investigations and could describe these accurately
- could carry out unstructured calculations.

Some answers were of a lower standard. Less able candidates:

- did not read the questions carefully and gave answers that were related to the topic being tested, but did not answer the question
- did not use correct scientific terminology, for example, they interchanged atoms, molecules, ions, radicals, elements and compounds without understanding what the correct word should be
- could not carry out unstructured calculations
- were careless in the way they drew structures of organic molecules
- were unfamiliar with some pieces of apparatus used in a chemistry laboratory, such as a separating funnel or a volumetric flask.

In future, candidates need more practice in answering these new styles of questions, particularly those based on calculations and practicals.

Question 1 (c)

Many candidates found this a challenging item to answer. Although the majority of candidates could draw the skeletal formula for heptane, they found drawing a heptagon for cycloheptane more difficult. However, examiners allowed any cyclic shape with 7 sides. Many candidates did not complete the balanced equation by adding H_2. A few candidates incorrectly showed a double bond in the cyclic product.

(c) Write the equation for reforming heptane into cycloheptane, showing the **skeletal** formulae of the organic molecules.

(2)

ResultsPlus
Examiner Comments

This candidate has not scored any marks as they have shown hexane and cyclohexane in their equation.

ResultsPlus
Examiner Tip

Use the correct reactants and products in any balanced equation.

(c) Write the equation for reforming heptane into cycloheptane, showing the **skeletal** formulae of the organic molecules.

(2)

$C_7H_{16} \longrightarrow C_7H_{14} + H_2$

ResultsPlus
Examiner Comments

=This candidate has the correct skeletal formula for heptane but has drawn methyl cyclohexane instead of cycloheptane. However, the candidate scores 1 mark for balancing the equation with H_2.

ResultsPlus
Examiner Tip

Read the question carefully and use the correct reactants and products in all equations.

(c) Write the equation for reforming heptane into cycloheptane, showing the **skeletal** formulae of the organic molecules.

(2)

C_7H_{16}

ResultsPlus
Examiner Comments

This candidate has drawn the correct skeletal formulae and balanced the equation so scores 2 marks.

ResultsPlus
Examiner Tip

Remember that all equations must be balanced. You may not be given all of the products in the question so you need to work out any that are missing.

Question 1 (d)(ii)

The majority of candidates could write the two propagation steps for the formation of chloroethane. Common errors included omitting the dots to show the radicals and writing termination steps instead of propagation steps.

(ii) Write the propagation steps to show the formation of C_2H_5Cl.

(2)

$C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl^{\bullet}$

$HCl^{\bullet} + C_2H_6 \rightarrow C_2H_5Cl + H_2$

ResultsPlus
Examiner Comments

These equations are incorrect and score 0 marks. HCl does not exist as a radical and H_2 is not formed as a product in this reaction.

ResultsPlus
Examiner Tip

Remember that a radical is a highly reactive species with an unpaired electron.

Learn the propagation steps for the chlorination of methane so that you can apply this to similar reactions.

(ii) Write the propagation steps to show the formation of C_2H_5Cl.

(2)

$Cl^{\bullet} + C_2H_6 \longrightarrow C_2H_5^{\bullet} + HCl$

$C_2H_5^{\bullet} + Cl^{\bullet} \rightarrow C_2H_5Cl$

ResultsPlus
Examiner Comments

The first equation is a correct propagation step but the second equation is a termination step, which is not required here. This answer scores 1 mark.

ResultsPlus
Examiner Tip

Remember that in a propagation step there is no loss of radicals so there should be one radical as a reactant and another radical as a product.

(ii) Write the propagation steps to show the formation of C_2H_5Cl.

(2)

$Cl\cdot + C_2H_6 \rightarrow C_2H_5\cdot + HCl$

$C_2H_5\cdot + Cl_2 \rightarrow C_2H_5Cl + Cl\cdot$

ResultsPlus
Examiner Comments

This candidate has given two correct equations for the propagation steps and scores 2 marks.

ResultsPlus
Examiner Tip

Remember to include the dots to show the free radicals.

It doesn't matter which order you write the propagation steps as they are both taking place at the same time.

Question 1 (d)(iii)

The majority of candidates realised that two ethyl radicals react together to form butane. Common incorrect answers included: the use of ethyl molecules, ethane radicals and the production of hydrogen radicals. Candidates should use the correct terminology for different types of particles. Some candidates attempted to show the mechanism of the reaction using half arrows but that is not needed in this specification. Some candidates did not read the question and they gave one propagation step and one termination step.

(iii) State how some butane, C_4H_{10}, is formed in the reaction.

(1)

when two C_2H_5Cl radicals react they will form C_4H_{10} + Cl_2 in the termination step

ResultsPlus
Examiner Comments

This answer is incorrect and does not score a mark. C_2H_5Cl are molecules not radicals.

ResultsPlus
Examiner Tip

Learn the termination steps for the chlorination of methane so that you can apply them to similar reactions.

(iii) State how some butane, C_4H_{10}, is formed in the reaction.

(1)

the two $\cdot C_2H_5$ radicals react to form C_4H_{10}

ResultsPlus
Examiner Comments

This is a correct answer, scoring 1 mark.

ResultsPlus
Examiner Tip

This candidate has correctly referred to the particles as radicals. Always remember to use the correct terminology for types of particles. The use of atoms, ions or molecules here would have negated the mark.

Question 2 (c)(i)

The majority of candidates worked out that the yield of ethanol decreases as the temperature increases. Some candidates just stated that the equilibrium position shifts to the left without stating the effect on the yield so they did not score the mark. A few candidates contradicted themselves and stated that the yield of ethanol decreases as the equilibrium position shifts to the right so they did not score a mark.

(c) Ethene reacts with steam to form ethanol in a reversible reaction.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \quad \Delta H = -45 \text{ kJ mol}^{-1}$$

At 300°C and a pressure of 65 atm, the equilibrium yield of ethanol is 5%.

(i) State the effect, if any, on the yield of ethanol when the temperature is **increased**.

(1)

Increase, as more product will be produced, causes the equalibrium to shifts towards left

ResultsPlus
Examiner Comments

This candidate has written two contradictory statements. The equilibrium position does shift to the left but the yield of ethanol decreases. This response scores 0.

ResultsPlus
Examiner Tip

Check that you do not write contradictory statements otherwise you will lose the marks.

(c) Ethene reacts with steam to form ethanol in a reversible reaction.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \quad \Delta H = -45 \text{ kJ mol}^{-1}$$

At 300 °C and a pressure of 65 atm, the equilibrium yield of ethanol is 5%.

(i) State the effect, if any, on the yield of ethanol when the temperature is **increased**.

(1)

The yield of ethanol decrease when the temperature is increased.

ResultsPlus
Examiner Comments

This is an example of a correct answer.

ResultsPlus
Examiner Tip

The question just uses the command word 'State' so no explanation is necessary. Some candidates lost the mark by including a contradictory explanation.

Question 2 (c)(ii)

Surprisingly, slightly fewer candidates gave the correct answer to this question than 2(c)(i). Possibly some candidates did not read the question carefully and they assumed that it referred to an increase in pressure. There were fewer contradictory statements here.

(ii) State the effect, if any, on the yield of ethanol when the pressure is **decreased**.

(1)

It will favour the right side since there are less moles so greater yield of ethanol

ResultsPlus
Examiner Comments

This answer is incorrect and scores 0. There are fewer moles on the right side of the equilibrium but a decrease in pressure causes the equilibrium position to move to the side with the greater number of moles.

ResultsPlus
Examiner Tip

Read the question carefully. This is the correct answer to the effect on the yield of ethanol caused by an **increase** in pressure. Important words are shown in bold in the question.

Question 3 (a)(i)

Many candidates found it difficult to write the ionic equation for the hydrolysis of 2-bromobutane and they would benefit from more practice at this skill.

3 This question is about halogenoalkanes and kinetics.

(a) Some halogenoalkanes are hydrolysed by aqueous potassium hydroxide.

(i) Write the **ionic** equation for the hydrolysis of 2-bromobutane showing the **structural** formulae for the organic molecules.

(1)

$C_4H_9Br + KOH \rightarrow C_4H_9OH + KBr$

2-bromobutane

$\Rightarrow$ structural formula = $CH_3CH_2CH_3CHBr + KBr$

ResultsPlus
Examiner Comments

This candidate has written an equation using the molecular formulae for the organic reactant and product. They have then tried to draw the structural formula for the reactant but have shown an incorrect structure of 1-bromobutane instead of 2-bromobutane so scored 0. They have also left in the potassium.

ResultsPlus
Examiner Tip

Check that you are starting with the correct reactant stated in the question.

3 This question is about halogenoalkanes and kinetics.

(a) Some halogenoalkanes are hydrolysed by aqueous potassium hydroxide.

(i) Write the **ionic** equation for the hydrolysis of 2-bromobutane showing the **structural** formulae for the organic molecules.

(1)

$CH_3CHBrCH_2CH_3 + OH^- \longrightarrow CH_3CHOHCH_2CH_3 + Br^-$

ResultsPlus
Examiner Comments

This candidate has written a correct ionic equation.

ResultsPlus
Examiner Tip

If you find ionic equations difficult, start by writing the full equation and then re-write it omitting the potassium ions.

Question 3 (a)(ii)

There was a fairly even spread of marks from 0 to 6 for this item. Those candidates who had carried out a similar Core Practical and revised it carefully scored high marks. Some candidates seemed to be unfamiliar with this experiment and many different reagents were suggested, such as the addition of acidified potassium dichromate(VI) or carrying out a titration with sodium hydroxide. Many candidates omitted to use ethanol as a solvent and some did not mention any controls to make it a fair test. A common error was to add potassium hydroxide as well as silver nitrate solution and candidates did not realise that the water in the silver nitrate solution would hydrolyse the halogenoalkanes and that potassium hydroxide would also react with silver nitrate to form a precipitate. Some candidates did not explain the trend in the rates of reaction clearly enough. Some just discussed the carbon-iodine bond and did not compare it with the carbon-chlorine bond. A few candidates just wrote about bond length and polarity and did not mention the strengths of the bonds.

*(ii) Devise an experiment to compare the rates of hydrolysis of 2-chlorobutane, 2-bromobutane and 2-iodobutane.

State the trend in the rates of reaction. Justify your answer.

(6)

reaction for hydrolysis of 2-iodobutane would be fastest rate of reaction during nucleophilic substitution. this is because iodine has a much larger atomic radius, more shielding and less nuclear charge when bonded to the carbon. The bond is much larger and therefore the london forces holding iodine to carbon weaker and easier to remove iodine. this is why iodine reacts much faster than bromine and chlorine as chlorine would be the slowest.

ResultsPlus
Examiner Comments

This candidate scores 1 mark for the trend in the rates of reaction. The explanation is incorrect as there is a covalent bond between iodine and carbon, not London forces.

ResultsPlus
Examiner Tip

Read the question carefully.

The first part of the question asks for an experiment to compare the rates of hydrolysis of the halogenoalkanes and there is no experimental detail included in this answer.

This question is based on one of the Core Practicals in the specification so you should be familiar with it.

*(ii) Devise an experiment to compare the rates of hydrolysis of 2-chlorobutane, 2-bromobutane and 2-iodobutane.

State the trend in the rates of reaction. Justify your answer.

(6)

2-chlorobutane will react the slowest, with 2-bromobutane in the middle and 2-iodobutane reacting the fastest. This is because the C-I bond has the lowest bond enthalpy, while C-Cl has the highest. This means the reaction for 2-iodobutane has the lowest activation energy, so the fastest rate of reaction. For the experiment you could react each of the organic compounds with the potassium hydroxide, and time how long it takes for a precipitate to form, as Group 1 salts are insoluble. The less time it takes for the KCl, KBr and KI to form, the higher the rate of reaction.

ResultsPlus
Examiner Comments

This response scores 2 marks for the trend in the rates of reaction and the explanation. There is limited experimental detail as the addition of potassium hydroxide is incorrect and there is no mention of adding silver nitrate solution.

ResultsPlus
Examiner Tip

Revise the Core Practicals so you are familiar with the experimental techniques in them.

*(ii) Devise an experiment to compare the rates of hydrolysis of 2-chlorobutane, 2-bromobutane and 2-iodobutane.

State the trend in the rates of reaction. Justify your answer. (6)

To the solution of haloalkane in a boiling tube, ~~The~~ First add, ~~the~~ ~~aqueous potassium~~ aqueous silver nitrate (in ethanol as a solvent) and acidify it. Then add the aqueous potassium hydroxide.

As ~~the~~ each of the halogenoalkanes is hydrolysed, the halogen ion product will react with the silver ions, to form a precipitate - white for ~~silver~~ $AgCl_2$, cream for $AgBr_2$ and yellow for AgI_2.

Time how long it takes for the precipitate to form (perhaps by using a dissapearing cross method to improve accuracy).

The faster the precipitate forms, the faster the halogenoalkane has been hydrolysised

The trend is, the rate of hydrolysis increases down the group as the carbon-halogen bond gets weaker, so is more easily broken.

ResultsPlus
Examiner Comments

This is quite a good answer that is awarded 4 marks. The candidate has some of the experimental detail correct – use of ethanol, silver nitrate and time for a precipitate to form. However, they have added potassium hydroxide solution, which is incorrect, and there is no indication of trying to make this a fair test. The explanation is good.

There are 5 indicative marking points which gives 3 marks. Only 1 mark was added for structure of answer and sustained lines of reasoning due to the error in adding the potassium hydroxide.

A total of 4 marks is awarded.

ResultsPlus
Examiner Tip

Potassium hydroxide would react with silver nitrate to form a precipitate so it would not be possible to find the time taken to form precipitates of the silver halides. The water in the silver nitrate solution hydrolyses the halogenoalkanes.

*(ii) Devise an experiment to compare the rates of hydrolysis of 2-chlorobutane, 2-bromobutane and 2-iodobutane.

State the trend in the rates of reaction. Justify your answer.

(6)

Place an equal amount of each of the organic substance in ~~at least~~ separate test tubes, and place these 3 test tubes in a water bath, and leave for several minutes. To each test tube add a ~~few drops of~~ small amount of ethanol and then a few drops of silver nitrate solution. Using a stopwatch (in each tube) measure and record the time taken for a precipitate to form. The faster the time, the quicker the rate of hydrolysis. The ~~2-iodobutane will be~~ rate of the reaction with 2-iodobutane will be fastest, followed by the 2-bromobutane and then the 2-chlorobutane. The reason for this is that the ~~C-I bond enthalpy~~ C-I bond (C-I bond enthalpy is lower than C-Br and C-Cl since the bond length is the largest. This means that less energy is required to break it so the water ~~will attack~~ molecules will break the bond quicker, resulting in the production of I^- ions the fastest, and so the AgI precipitate will form first, followed by AgBr and then AgCl

ResultsPlus
Examiner Comments

=This is an excellent answer that includes all the essential practical information to carry out this experiment. The trend in the rates of reaction is clearly stated as is the reason for this trend. This answer scores 4 marks for the indicative marking points and 2 marks for the structure of the answer and sustained lines of reasoning.

ResultsPlus
Examiner Tip

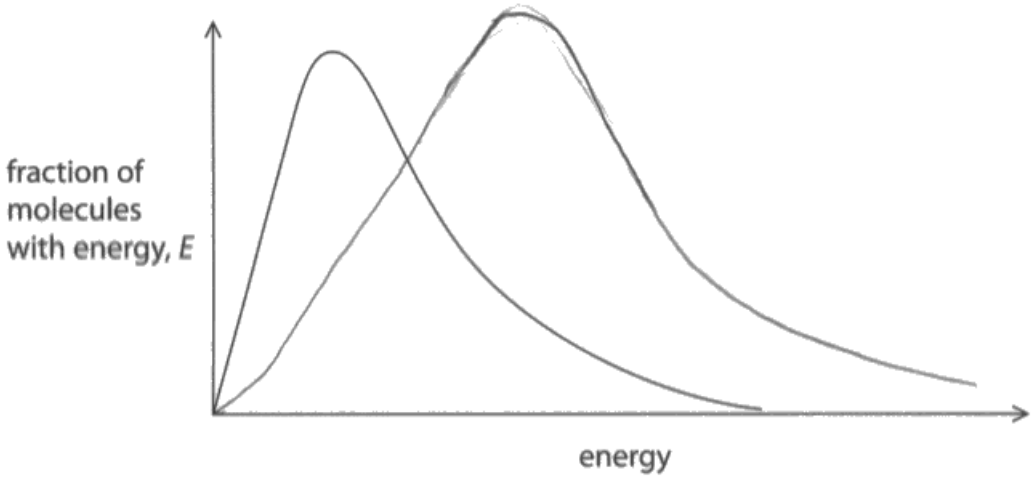
Try to write detailed answers to the 6 mark questions.

Question 3 (b)

The majority of candidates added an acceptable curve to the graph in (i) to show the Maxwell-Boltzmann distribution at a higher temperature. Some candidates lost the mark as the peak of their curve was too high or the end of the curve crossed the x axis or curled up at the end. Lines should be drawn approaching the x axis but not meeting it or levelling out far above it. Candidates should draw their curves as accurately as possible to avoid these careless errors.

Many candidates gave a clear explanation about the increase in rate or reaction when the temperature increases although they did not all include all three points from the mark scheme. Although the question asked candidates to use the graph, very few of them showed the activation energy on it. This was not essential to score the mark but may have helped some candidates who found it difficult to express their ideas clearly in words.

(b) The graph shows the Maxwell-Boltzmann distribution of molecular energies of a gaseous system.



(i) On the graph, draw the Maxwell-Boltzmann distribution for the same system at a higher temperature.

(1)

(ii) Use the graph to explain why a small increase in temperature results in a large increase in the rate of a gaseous reaction.

(3)

As the temperature is increased, particles gain more kinetic energy and so they move faster which results in more frequent collisions. So, more collisions make the particles react more.

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Examiner Comments

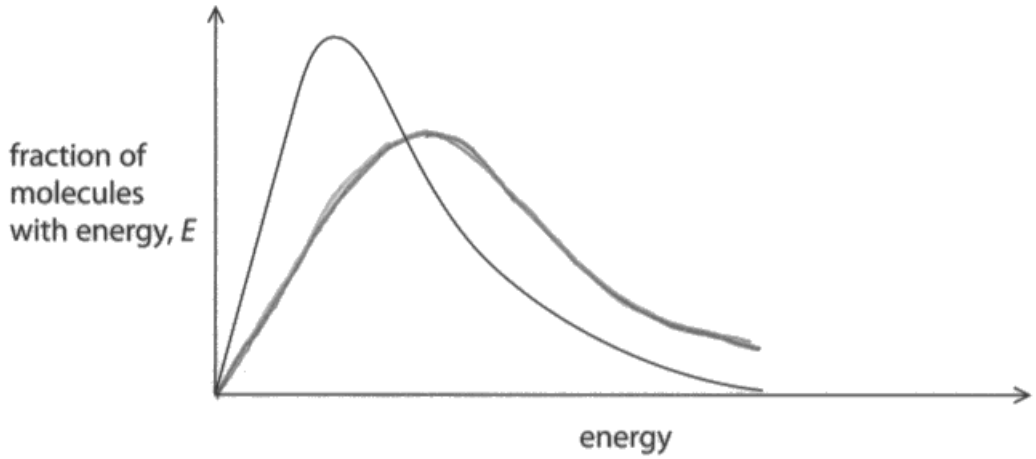
This candidate is not awarded the mark for (i). The peak of the curve that the candidate has drawn has moved to the right, but it should be at a lower height than the original curve.

In (ii) the candidate was awarded a mark for the idea of particles gaining kinetic energy. There is no mention of activation energy or successful collisions so the other marks could not be awarded.

ResultsPlus
Examiner Tip

Revise the reasons why the rate of a reaction changes when the temperature changes.

(b) The graph shows the Maxwell-Boltzmann distribution of molecular energies of a gaseous system.



(i) On the graph, draw the Maxwell-Boltzmann distribution for the same system at a higher temperature.

(1)

(ii) Use the graph to explain why a small increase in temperature results in a large increase in the rate of a gaseous reaction.

(3)

A small increase in temperature results in a large increase in the rate of reaction because more molecules will have the sufficient activation energy to start the reaction. This will increase the rate of reaction because there will be a higher frequency of successful collisions

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Examiner Comments

This candidate scores 1 mark for (i) and 2 marks for (ii). They omit the fact that at a higher temperature the molecules will have more kinetic energy.

ResultsPlus
Examiner Tip

Include as much detail as possible for questions that require an explanation.

Question 4 (a)

The majority of candidates scored 2 marks for this question. Some candidates did not convert the 55.2 kg into g before calculating the number of moles of ethanol while others divided it by 1000 instead of multiplying it by 1000. A small number of candidates worked out an incorrect molar mass for ethanol, even though the formula was given.

4 Ethanol, C_2H_5OH, is a member of the homologous series of alcohols.

(a) Calculate the number of molecules in 55.2 kg of ethanol.

[Avogadro Constant = 6.02×10^{23} mol^{-1}]

(2)

$6.02 \times 10^{23} \times 9 = 5.418 \times 10^{24}$

$5.418 \times 10^{24} \times 55.2\,kg = 2.991 \times 10^{26}$

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Examiner Comments

This candidate has multiplied the Avogadro Constant by 9 as there are 9 atoms in a molecule of ethanol and then they have multiplied this by the mass in kg. Both of these steps are incorrect so this answer scores 0.

ResultsPlus
Examiner Tip

Convert masses into moles by dividing the mass in grams by the molar mass of the substance. If you are given a mass in any other unit, convert it to grams first.

4 Ethanol, C_2H_5OH, is a member of the homologous series of alcohols.

(a) Calculate the number of molecules in 55.2 kg of ethanol.

[Avogadro Constant = 6.02×10^{23} mol^{-1}]

(2)

no of molecules = moles x 6.02×10^{23}

= $1.2 \times 6.02 \times 10^{23}$ = 7.224×10^{23}

moles of C_2H_5OH = mr : 46 $\frac{55.2}{46}$ = 1.2

ResultsPlus

Examiner Comments

This candidate did not convert 55.2 kg into moles before calculating the number of moles of ethanol. However, they scored 1 mark for correctly multiplying the number of moles they calculated by the Avogadro Constant.

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Examiner Tip

Always show your working for all calculations as you may be able to receive some credit for correct working even if the final answer is incorrect.

Remember to convert a mass in kg into g before dividing by the molar mass to find the number of moles.

4 Ethanol, C_2H_5OH, is a member of the homologous series of alcohols.

(a) Calculate the number of molecules in 55.2 kg of ethanol.

[Avogadro Constant = 6.02×10^{23} mol^{-1}]

(2)

$55.2 \times 1000 = 55200\ g$

$\frac{55200}{12\times2+6+16} = \frac{55200}{46} = 1200$ moles of ethanol

$1\ mol = 6.02 \times 10^{23}$ particles ~~molecules~~

$1200\ mol = 7.224 \times 10^{26}$ particles

~~there~~ are 9 atoms in ethanol

$7.224 \times 10^{26} \div 9 = 8.03 \times 10^{25}$ molecules (2.dp)

ResultsPlus
Examiner Comments

This candidate calculated the correct answer but then continued to divide it by 9 as there are 9 atoms in ethanol. This is incorrect so only 1 mark could be awarded. The question asked for the number of molecules of ethanol not atoms. If the number of atoms had been required, the candidate would need to multiply the answer by 9.

ResultsPlus
Examiner Tip

Make sure you understand the difference between atoms and molecules.

Question 4 (b)

It was surprising that only about one third of candidates scored both marks for writing the balanced equation for the standard enthalpy change of formation of ethanol. Some candidates didn't understand what is meant by the standard enthalpy change of formation so they wrote other equations involving ethanol, such as the hydration of ethene or combustion of ethanol. Those that did realise that they need to start with the elements gave incorrect formulae, for example 6H instead of $3H_2$, doubled the balancing numbers to produce 2 moles of ethanol instead of one mole or gave an incorrect state symbol. (aq) was a common incorrect state symbol for ethanol. A minority of candidates attempted to draw a Hess cycle.

(b) Write the equation to represent the standard enthalpy change of formation of ethanol. Include state symbols.

(2)

$$C_{(s\text{-graphite})} + H_{2(g)} + O_{2(g)} \longrightarrow C_2H_5OH_{(aq)}$$

ResultsPlus
Examiner Comments

This equation has all the correct species but it is not balanced. The state symbol for ethanol is incorrect so no marks are awarded.

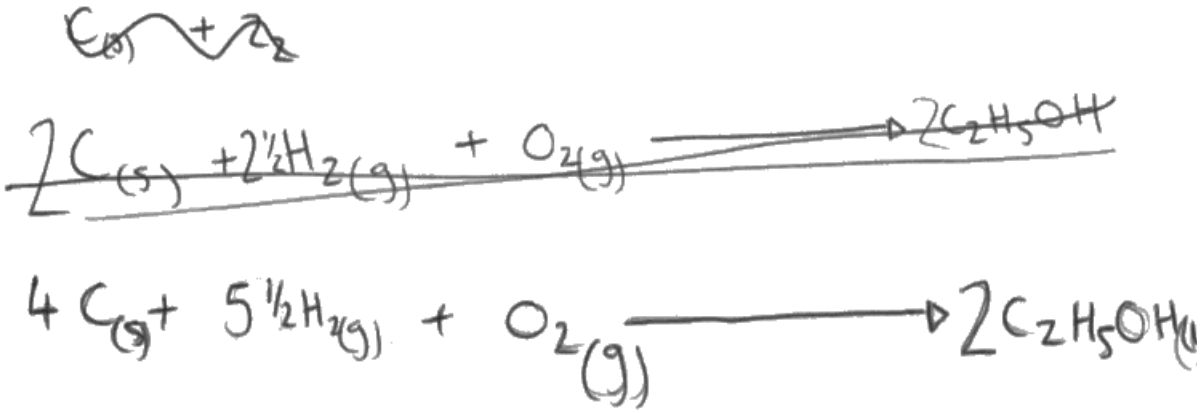
ResultsPlus
Examiner Tip

All equations must be balanced.

Make sure you understand the meaning of the four different state symbols (s), (g), (l) and (aq).

(b) Write the equation to represent the standard enthalpy change of formation of ethanol. Include state symbols.

(2)



ResultsPlus
Examiner Comments

This candidate has all of the correct species in the equation but the equation is not balanced, probably because they have forgotten to include the two H from the OH groups. Even if the equation had been correctly balanced with $6H_2$, it would still not score a mark as 2 moles of ethanol are formed. However, the state symbols are correct, so 1 mark is awarded.

ResultsPlus
Examiner Tip

Make sure that you understand the meaning of standard enthalpy change of formation and can apply it when writing equations. It must involve the formation of **1 mole** of a compound.

Question 4 (c)(iii)

This question was very poorly answered by the majority of candidates. It asked for the main reason for the difference between the enthalpy change of combustion of ethanol calculated from mean bond enthalpies and the value in a data book. Many candidates wrote irrelevant information about heat loss to the surroundings, incomplete combustion etc. Most candidates just stated it was due to using mean bond enthalpies instead of values specific to ethanol. This will cause some difference between the values but it is not the main difference. A small minority thought about the calculation they had done and realised that mean bond enthalpies relate to gases but ethanol and water will be in the liquid state for the standard enthalpy change of combustion in the data booklet.

(iii) A data book value for the standard enthalpy change of combustion of ethanol is $-1367.3\ kJ\ mol^{-1}$.

Give the **main** reason why the value you calculated in (b)(i) is different from this data book value.

(1)

– The value in (b)(i) was obtained using mean bond enthalpy. The bond enthalpies of any given bond in the reaction is different so an average gives a less accurate value

ResultsPlus
Examiner Comments

This is an example of many answers seen where the use of mean bond enthalpy data is mentioned. However, this cannot score a mark as it is not the main reason for the difference between the values.

ResultsPlus
Examiner Tip

Think carefully about any answers where you are asked to give a difference between experimental and calculated values.

(iii) A data book value for the standard enthalpy change of combustion of ethanol is $-1367.3\ kJ\ mol^{-1}$.

Give the **main** reason why the value you calculated in (b)(i) is different from this data book value.

(1)

Mean bond enthalpies are for bonds in the gaseous state. The H_2O produced in the reaction is a liquid not a gas. A Energy is required to change the state of water from a liquid to a gas. Hence why my value is less negative.

(Total for Question 4 = 10 marks)

ResultsPlus
Examiner Comments

This is an example of an excellent answer where the candidate has thought carefully about the question and gives the main reason for the difference between the values. They could also have mentioned the difference in state for ethanol but only water or ethanol was required for the mark.

ResultsPlus
Examiner Tip

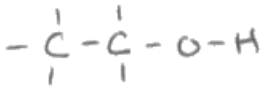
Remember that mean bond enthalpy data relates to gases.

Question 4 (c)(i–ii)

Many candidates were able to calculate the enthalpy change for the complete combustion of ethanol using the mean bond enthalpy data given in (i). Some candidates missed out bonds and others used incorrect values. Candidates would find it helpful to rewrite the equation using displayed formulae first so they can see how many bonds of each type are broken and formed. A few candidates thought that energy is needed to make bonds and released when bonds are broken.

Although many candidates drew clearly labelled, correct reaction profile diagrams, many omitted labels for the arrows, drew arrows pointing in the wrong directions or omitted the activation energy curve. Some candidates who calculated a correct exothermic enthalpy change in (i) drew a reaction profile diagram for an endothermic reaction, showing that they did not understand the meaning of the negative sign.

(c) Ethanol burns completely in excess oxygen.



$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

(i) The table shows some mean bond enthalpy data.

Bond	C—C	C—H	C—O	O—H	O=O	C=O
Mean bond enthalpy / kJ mol^{-1}	347	413	358	464	498	805

Calculate the enthalpy change, in kJ mol^{-1}, for the complete combustion of 1 mol of ethanol.

(3)

$\Delta H = (347 + 5(413) + 358 + 464) + 3(498)$

$= 3234 + 1494$

$= 4728$

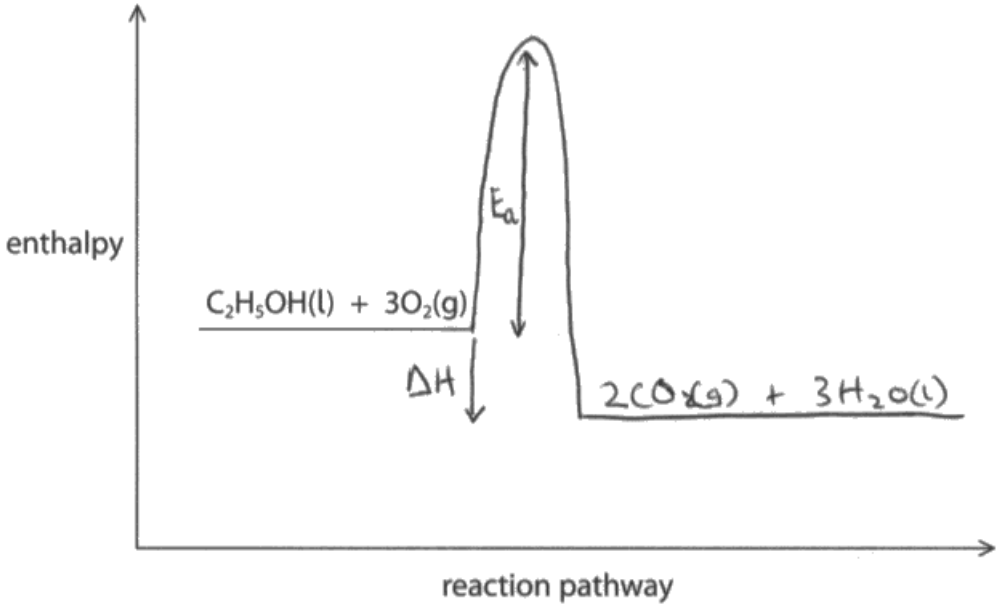
$\Delta H = 4728 - (2(805) + 3(2 \times 464))$

$= 4728 - 4394$

$= -334$ kJ mol^{-1}

(ii) Complete the reaction profile diagram for the combustion of ethanol and fully label the diagram.

(2)



ResultsPlus
Examiner Comments

This candidate has calculated the energy needed to break bonds but the energy released in forming bonds is incorrect as they do not realise that there are 2 C=O bonds in each carbon dioxide molecule so should have multiplied 805 by 4 instead of 2. They have shown a subtraction of 4728 - 4394, which is correct, but the answer to that should be +334 not -334. Only 1 mark is awarded for (i).

(ii) This is a good example of a reaction profile diagram based on the exothermic value the candidate thinks they have calculated and is awarded 2 marks.

ResultsPlus
Examiner Tip

Draw the equation again using displayed formulae as this will help you to see which bonds are present in the reactants and products.

Check your numerical answers carefully and make sure you include the correct sign for any thermochemical calculations.

(c) Ethanol burns completely in excess oxygen.

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

(i) The table shows some mean bond enthalpy data.

Bond	C—C	C—H	C—O	O—H	O=O	C=O
Mean bond enthalpy / kJ mol^{-1}	347	413	358	464	498	805

Calculate the enthalpy change, in kJ mol^{-1}, for the complete combustion of 1 mol of ethanol.

(3)

((5 x 413) + 347 + 358 + 464 + (3 x 498))

- ((4 x 805) + (3 x 464))

(2065 + 3 · 1169 + 1494)

- (3220 + 1392)

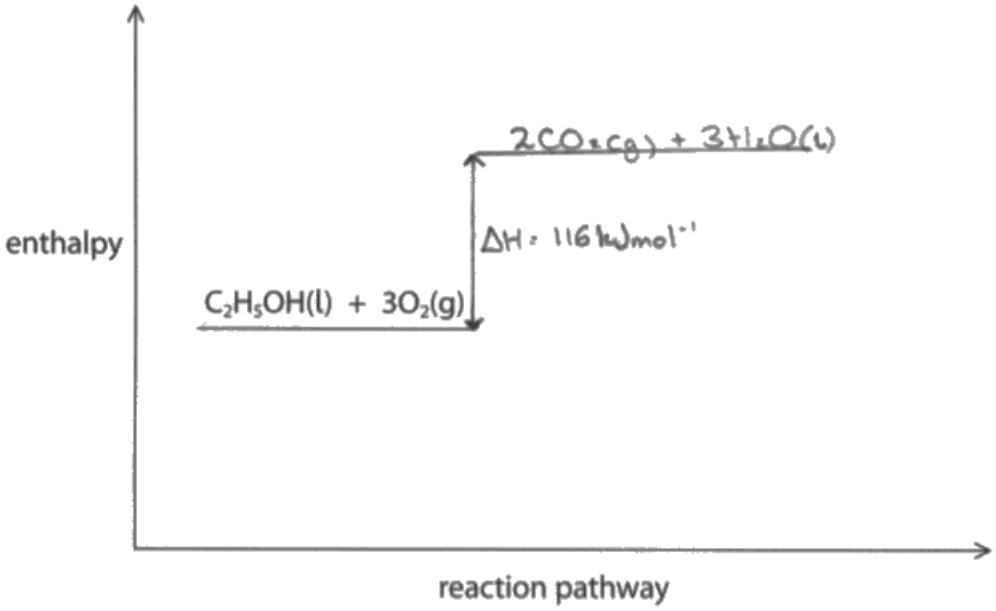
4728

- 4612

ΔH = 116 kJ mol^{-1}

(ii) Complete the reaction profile diagram for the combustion of ethanol and fully label the diagram.

(2)



ResultsPlus
Examiner Comments

This candidate has calculated the energy needed to break bonds but the energy released in forming bonds is incorrect. However, the difference between the values is correct so 2 marks are awarded for (i).

This candidate has drawn an enthalpy level diagram instead of a reaction profile diagram for an endothermic reaction and it is labelled so 1 mark is awarded in (ii).

ResultsPlus
Examiner Tip

Show your working to calculations clearly so that you can receive some credit, even if your final answer is incorrect.

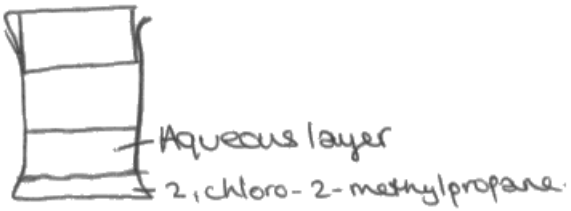
Remember to show activation energy on a reaction profile diagram but not on an enthalpy level diagram.

Question 5 (a)

Many candidates drew clear diagrams of the separating funnel and showed the labelled layers in the correct order. Some diagrams were of a poor quality and looked as if the candidates had not seen this piece of apparatus before. Many diagrams had the tap missing or placed it half-way up the sides of the funnel. A few candidates drew a separating funnel that looked like a burette and this did not receive any credit. Candidates should practise drawing pieces of laboratory equipment.

(a) Draw a diagram of a separating funnel, labelling the aqueous layer and the layer of 2-chloro-2-methylpropane that would be observed at the end of **Step 2**.

(2)



ResultsPlus
Examiner Comments

This candidate has not attempted to draw a funnel and the layers are the wrong way around so this response scores 0.

ResultsPlus
Examiner Tip

You should know that the density of water is 1 g cm^{-3} and you are given the density of 2-chloro-2-methylpropane as 0.84 g cm^{-3} so you should be able to work out that the liquid with the lower density will be on the top.

(a) Draw a diagram of a separating funnel, labelling the aqueous layer and the layer of 2-chloro-2-methylpropane that would be observed at the end of **Step 2**.

(2)

ResultsPlus
Examiner Comments

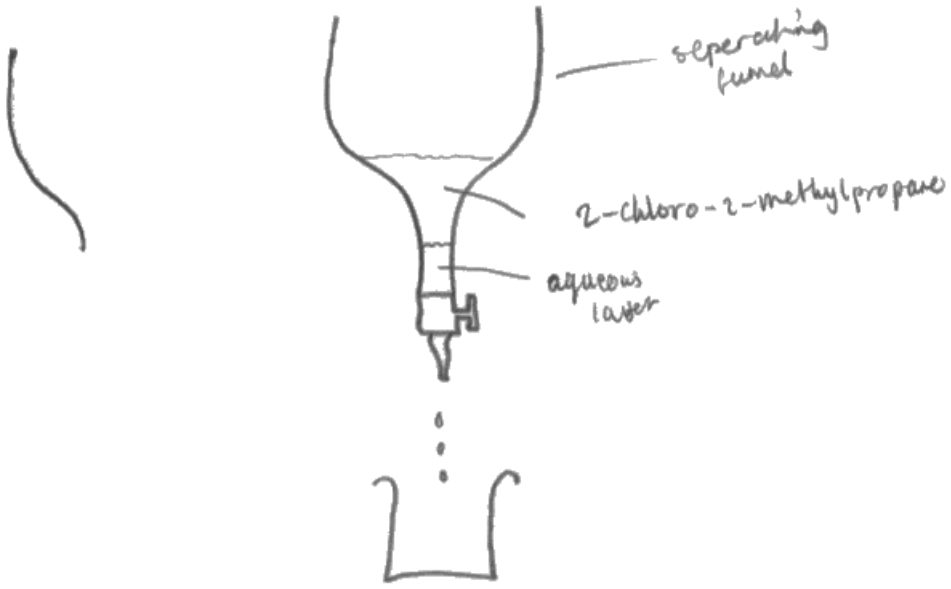
This diagram shows a filter funnel as it is wider at the top than the bottom and there is no tap. However, the layers are in the correct order so this answer scores 1 mark.

ResultsPlus
Examiner Tip

Make sure that you know the names of the pieces of apparatus used in a chemistry laboratory and why they are used. A filter funnel would not be able to separate two liquids.

(a) Draw a diagram of a separating funnel, labelling the aqueous layer and the layer of 2-chloro-2-methylpropane that would be observed at the end of **Step 2**.

(2)



ResultsPlus
Examiner Comments

This was the minimum quality of diagram to score a mark. The funnel has got a tap at the bottom and it does not get wider at the top. However, a better quality of diagram would show the funnel narrowing at the top so that a stopper can be inserted. The layers are in the correct order so this response scores 2 marks.

ResultsPlus
Examiner Tip

Look carefully at the apparatus you use in experiments and make sure that you can draw it accurately.

Question 5 (b)

Candidates who had used a separating funnel and used sodium hydrogen carbonate solution to remove any unreacted acid from a mixture were at an advantage when answering this question. A significant number of candidates did not realise that carbon dioxide is produced and the tap must be opened to relieve the build-up of pressure. A few candidates thought that hydrogen would be produced and they were not awarded the mark. Candidates who were not familiar with this technique just thought that sodium hydrogen carbonate removes impurities and the tap is opened to remove the aqueous layer. Candidates would benefit from using pieces of apparatus, such as separating funnels, so that they understand how they work and why they are used.

(b) Give the reason why sodium hydrogencarbonate solution is added to the organic layer in **Step 4** and why it is important to open the tap after adding this solution.

(2)

to ensure that the any aqueous layer is poured out. to separate any aqueous layers from the organic layer and prevent them from mixing again.

ResultsPlus
Examiner Comments

This candidate has not understood the reason for adding sodium hydrogen carbonate so scores 0.

ResultsPlus
Examiner Tip

Sodium hydrogen carbonate solution is alkaline, like sodium carbonate solution, so it reacts with acids.

(b) Give the reason why sodium hydrogencarbonate solution is added to the organic layer in **Step 4** and why it is important to open the tap after adding this solution.

(2)

The sodium hydrogencarbonate solution removes acidic and water soluble impurities in the organic layer. The tap is open after adding the $NaHCO_3$ to decant the new aqueous layer formed.

ResultsPlus
Examiner Comments

This answer scores 1 mark. The candidate has given a reason why the sodium hydrogen carbonate solution is added but does not realise that this reaction produces a gas.

ResultsPlus
Examiner Tip

Revise the steps involved in purifying an organic liquid.

(b) Give the reason why sodium hydrogencarbonate solution is added to the organic layer in **Step 4** and why it is important to open the tap after adding this solution.

(2)

This neutralises any hydrochloric acid in the organic layer. The tap must be opened to relieve the pressure caused by the CO_2 gas evolving as the $NaHCO_3$ and HCl react.

ResultsPlus
Examiner Comments

This is an excellent answer, scoring 2 marks. This candidate has clearly explained why the sodium hydrogen carbonate solution is used and why the tap is opened

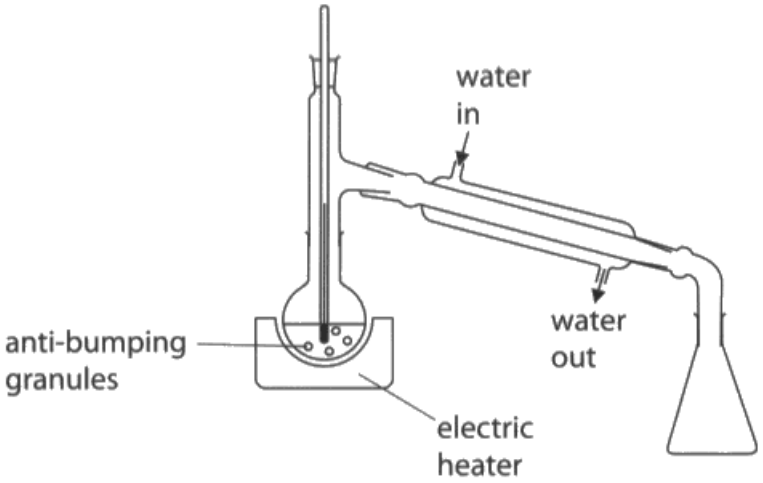
ResultsPlus
Examiner Tip

Try to give clear answers as in this example.

Question 5 (d)(i)

This question discriminated well between candidates. Although there were candidates who noticed all three errors in the apparatus and clearly explained how to modify the apparatus, there were many others who only noticed one or two of these errors and a significant minority who did not notice any. Common incorrect answers included: it would be safer to heat the organic mixture with a Bunsen burner instead of an electric heater, concern over the water in the condenser and the electricity supply and the realisation that the apparatus is sealed and needs an opening somewhere, but suggesting removing the stopper that holds the thermometer. Some candidates gave naive suggestions such as wear safety glasses and make sure that the water goes into a sink.

(d) A student set up this apparatus for distillation in **Step 7** as shown.



(i) Describe **three** ways in which this apparatus must be modified for safe and efficient use. Assume the apparatus is suitably clamped.

(3)

Water must be pumped in at the bottom, so as to ~~keep~~ maintain the flow around the condenser.

ResultsPlus
Examiner Comments

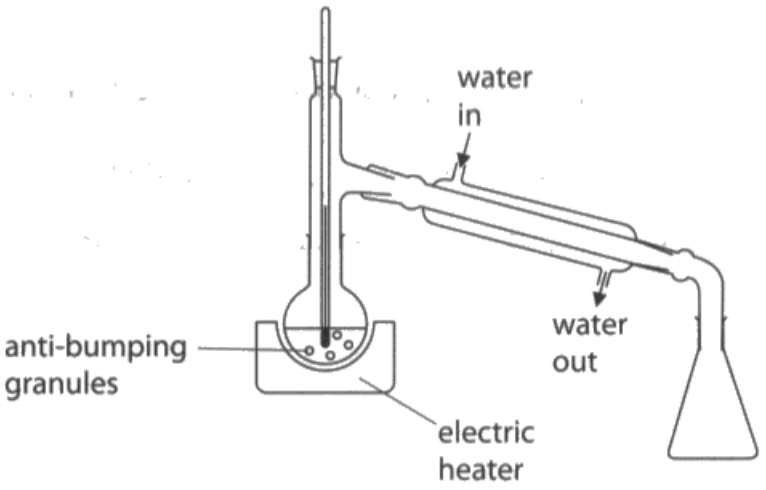
This answer is just sufficient for 1 mark as the candidate has the correct idea of water entering the bottom of the condenser.

ResultsPlus
Examiner Tip

When an answer asks for three modifications you need to write about three changes to achieve 3 marks.

Revise how to set up the apparatus for distillation.

(d) A student set up this apparatus for distillation in **Step 7** as shown.



(i) Describe **three** ways in which this apparatus must be modified for safe and efficient use. Assume the apparatus is suitably clamped.

(3)

- The water should be pumped into the bottom of the distillation arm.
- The thermometer head should be level with the entrance to the delivery arm
- The top of the apparatus should have an opening, to avoid pressure build ups.

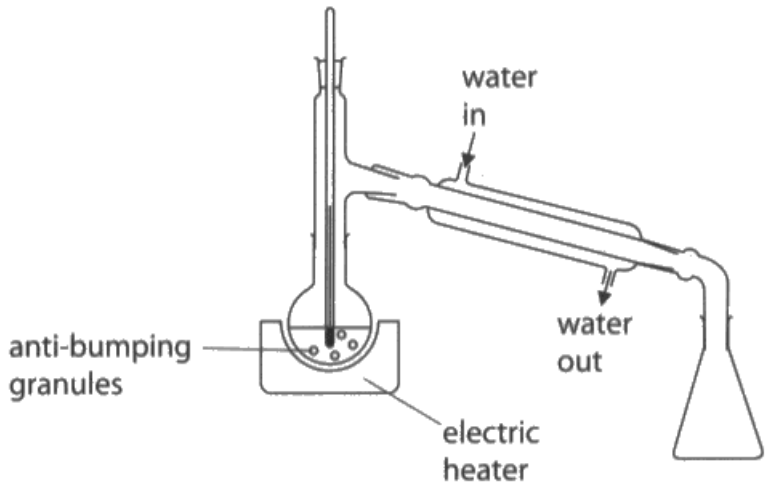
ResultsPlus
Examiner Comments

This response scores 2 marks. The ideas about the water in the condenser and the thermometer are correct. The candidate has realised that there is a problem with pressure build-up as the apparatus is sealed is correct but just stating 'the top of the apparatus should have an opening' is not sufficient. This implies removing the stopper that holds the thermometer and that would allow the organic product to escape.

ResultsPlus
Examiner Tip

The opening should be between the condenser and the conical flask. A vent could be inserted or just leave a gap between them as the organic product will now be a liquid and will drip into the flask.

(d) A student set up this apparatus for distillation in **Step 7** as shown.



(i) Describe **three** ways in which this apparatus must be modified for safe and efficient use. Assume the apparatus is suitably clamped.

(3)

There must be a hole above the conical flask to release gases and prevent the build up of pressure and broken glass. Water in and water out should be swapped to make sure water fills the whole condenser, for more efficient cooling. The thermometer should be out of the liquid so a more accurate reading can be made and to prevent it breaking.

ResultsPlus
Examiner Comments

This is a good answer that scores 3 marks. The errors have been noticed and appropriate modifications have been suggested.

ResultsPlus
Examiner Tip

Imagine yourself carrying out this experiment and how you should set up the apparatus.

Question 5 (d)(ii)

It was disappointing that a very small number of candidates could suggest a suitable temperature range for collecting the 2-chloro-2-methylpropane. They were given the boiling temperature and just expected to suggest a range 1 or 2 C either side of that value. The ranges given were frequently 20°C or more apart and often did not include the boiling temperature of the product.

Question 5 (e)

Some candidates gave clear working to the calculation on the percentage yield, with a correct answer. Many candidates did not know how to convert the volumes of liquids into masses using the densities given so they just treated the volumes as masses and converted them into moles. Candidates would benefit from much more practice at this style of calculation. A few candidates attempted to calculate the atom economy of the reaction instead of the percentage yield.

(e) In the preparation, 15 cm^3 of 2-methylpropan-2-ol produced 6.9 cm^3 of 2-chloro-2-methylpropane.

The equation for the reaction is

$$(CH_3)_3COH + HCl \rightarrow (CH_3)_3CCl + H_2O$$

Calculate the percentage yield of 2-chloro-2-methylpropane, using data from the table.

Data	2-methylpropan-2-ol	2-chloro-2-methylpropane
molar mass / g mol^{-1}	74.0	92.5
boiling temperature / °C	82	51
density / g cm^{-3}	0.79	0.84

$0.79 \times 15 = 11.85$g of $(CH_3)_3COH$

$0.84 \times 6.9 = 5.796$g of $(CH_3)_3CCl$

$\%$ yield $= \frac{5.796}{11.85} \times 100 = 48.9\%$

(3)

ResultsPlus
Examiner Comments

This candidate has converted the volumes into masses so scores 1 mark. However, the masses must be converted into moles before the percentage yield can be calculated.

ResultsPlus
Examiner Tip

Make sure you know how to convert between the mass and volume of a substance using the density.

(e) In the preparation, 15 cm^3 of 2-methylpropan-2-ol produced 6.9 cm^3 of 2-chloro-2-methylpropane.

The equation for the reaction is

$$(CH_3)_3COH + HCl \rightarrow (CH_3)_3CCl + H_2O$$

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Data	2-methylpropan-2-ol	2-chloro-2-methylpropane
molar mass / g mol^{-1}	74.0	92.5
boiling temperature / °C	82	51
density / g cm^{-3}	0.79	0.84

(3)

$m = 6.9 \times 0.84 = 5.8\,g$

$n = \frac{m}{M_r} = \frac{5.8}{92.5} = 0.0627\,moles$

$15 \times 0.79 = 11.85$

$\frac{11.85}{74} = 0.16$ ratio 1:1

not $H_2O = 0.16$

$\frac{0.0627}{0.0627 + 0.16} \times 100$

$= 28\%$

ResultsPlus
Examiner Comments

This candidate has correctly calculated the number of moles of each substance so scores 2 marks. They have just gone wrong at the last stage by adding the two numbers together.

ResultsPlus
Examiner Tip

Revise how to calculate percentage yields.

(e) In the preparation, 15 cm^3 of 2-methylpropan-2-ol produced 6.9 cm^3 of 2-chloro-2-methylpropane.

The equation for the reaction is

$$(CH_3)_3COH + HCl \rightarrow (CH_3)_3CCl + H_2O$$

Calculate the percentage yield of 2-chloro-2-methylpropane, using data from the table.

Data	2-methylpropan-2-ol	2-chloro-2-methylpropane
molar mass / g mol^{-1}	74.0	92.5
boiling temperature / °C	82	51
density / g cm^{-3}	0.79	0.84

$15 \times 0.79 = 11.85$ g 2-methyl propan-2-ol $M_r = 74$ (3)

$6.9 \times 0.84 = 5.796$ g 2-chloro-2-methylpropane $M_r = 92.5$

$\frac{11.85}{74} = 0.160$ mol $\quad \frac{5.796}{92.5} = 0.0627$ mol

1 : 1

∴ should make 0.160 moles of $(CH_3)_3CCl$

$\frac{0.0627}{0.160} \times 100 = 39.1$ %

ResultsPlus
Examiner Comments

This is an example of an excellent answer that scores 3 marks.

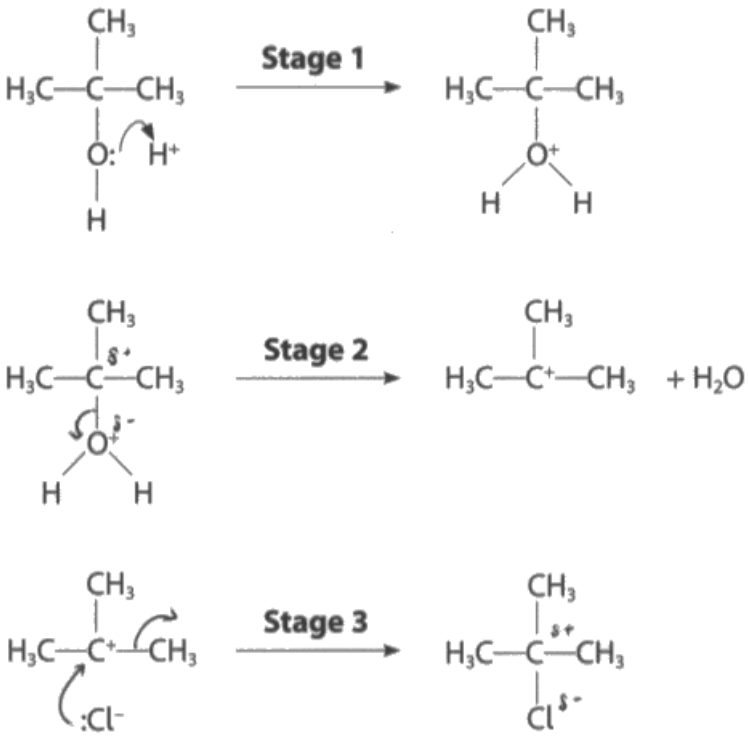
ResultsPlus
Examiner Tip

Set out your calculations like this one, explaining each step in your working. If you were to make a slip you would still receive some credit for the working if the examiner can understand what you have done.

Question 5 (f)

This question involved a mechanism that is not in the specification but the candidates were expected to apply their knowledge of other mechanisms to this new situation. It tested whether they knew that a curly arrow must start from a covalent bond or a lone pair of electrons and where it ends. A far greater proportion of candidates could draw the curly arrow starting at the lone pair of electrons on the chloride ion. The accuracy of the starting and finishing points of the curly arrow from the C-O bond was much poorer, with it starting from an atom, a space or even the wrong atom.

(f) The mechanism for the reaction is in three stages.



Add curly arrows to the reactants in **Stages 2** and **3** to complete the mechanism.

(2)

ResultsPlus
Examiner Comments

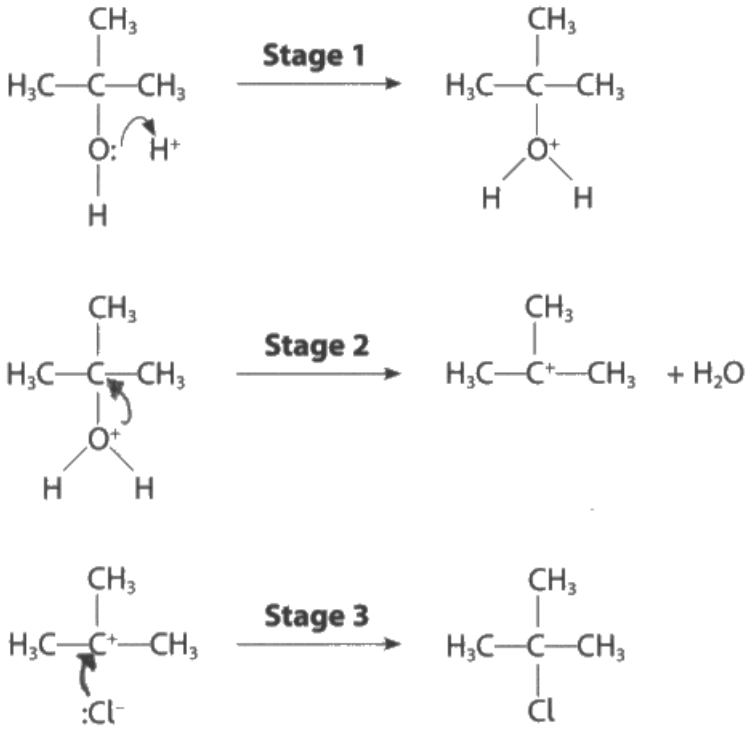
This response has two acceptable curly arrows but the candidate has drawn an additional incorrect curly arrow in Stage 3 from the C-C bond to the CH_3 group. If the pair of electrons moved in this way, the CH_3 group would be lost from the molecule and the product is shown with the methyl group still in place. This additional incorrect curly arrow negates a mark so only 1 mark is awarded.

ResultsPlus
Examiner Tip

Additional incorrect answers will negate a mark.

Try to think about what the curly arrows mean. If a pair of electrons move from a bond to an atom, that bond will break.

(f) The mechanism for the reaction is in three stages.



Add curly arrows to the reactants in **Stages 2** and **3** to complete the mechanism.

(2)

ResultsPlus
Examiner Comments

=The curly arrow in Stage 2 is pointing in the wrong direction and in Stage 3 it is not starting from the lone pair of electrons. This response scores 0.

ResultsPlus
Examiner Tip

Make sure you understand that a curly arrow represents the movement of a pair of electrons so that it must start from a covalent bond or a lone pair of electrons.

Question 6 (a)(b)

It was encouraging to see many candidates who could calculate the enthalpy change of anhydrous sodium carbonate in this unstructured calculation in part (a). Common errors included: using 5.09 g or 55.09 g as the mass of solution, omitting the negative sign to show that it is an exothermic reaction and not giving the final answer to an appropriate number of significant figures. The data in the question was given to three significant figures so the final answer should be given to two or three significant figures. A few candidates added 273 to the temperature change to convert it to Kelvin and a few candidates gave incorrect units.

Candidates found it more difficult to complete the Hess cycle in (b). There were relatively few who realised that $Na_2CO_3(aq)$ should be in the box at the bottom and both arrows should be pointing down towards this box. It was disappointing to see some candidates give an incorrect formula for sodium carbonate, even though this was given in the stem of the question.

6 A student carries out two experiments to determine the enthalpy change that occurs when anhydrous sodium carbonate reacts to form hydrated sodium carbonate.

$$Na_2CO_3(s) + 10H_2O(l) \rightarrow Na_2CO_3.10H_2O(s)$$

(a) In the first experiment, the student determines the enthalpy change of solution for anhydrous sodium carbonate.

50.0 g of distilled water is placed in a polystyrene cup and the temperature is recorded.

A sample of anhydrous sodium carbonate is added to the water, the mixture is stirred and the final temperature recorded.

The results for this experiment are shown in the table.

mass used / g	5.09
initial temperature / °C	27.0
final temperature / °C	32.4

Calculate the enthalpy change of solution, in kJ mol^{-1}, for anhydrous sodium carbonate.
Give your answer to an appropriate number of significant figures and include a sign.

[Use 4.18 J g^{-1} $°C^{-1}$ as the specific heat capacity of water]

$c[H_2O] = 4.18 J g^{-1} °C^{-1}$ $\quad Na_2CO_3(s) + aq \rightarrow Na_2CO_3(aq)$ (4)

$32.4° \rightarrow 305.55$ (+273.15)

$27° \rightarrow 300.15$

ΔT (Temperature change) $= 32.4 - 27 = 5.4 °C$

$\Delta T = 305.55 - 300.15 = 5.4 K$ $\quad Q = mc\Delta T$

mass = 5.09 g

$\Delta H = \frac{m \times c \times \Delta T}{n}$ $\quad Na_2CO_3 + 10H_2O \rightarrow Na_2CO_3 \cdot 10H_2O$

$\Delta H = \frac{Q}{n}$

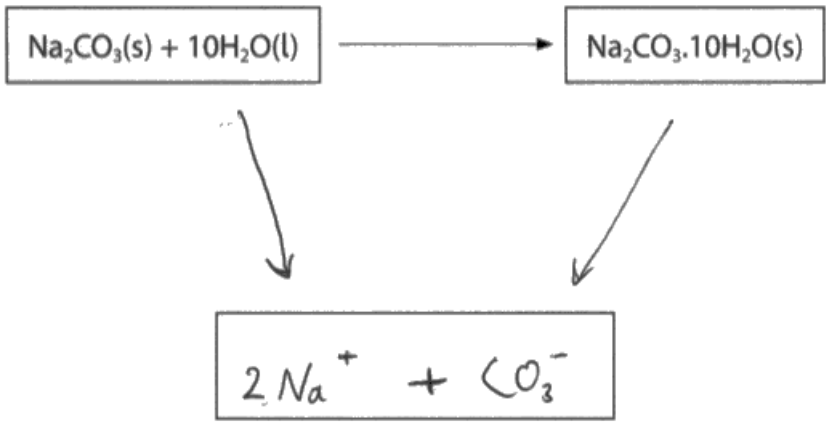
$Q = mc\Delta T$ $\quad Q = 5.09 \times 4.18 \times 5.4 = 114.89148$

(b) In the second experiment, the student determines the enthalpy change of solution for hydrated sodium carbonate.

$$Na_2CO_3.10H_2O(s) + aq \rightarrow Na_2CO_3(aq) \qquad \Delta H = +53.7\,kJ\,mol^{-1}$$

Complete the Hess cycle and, together with your answer to (a) calculate the enthalpy change when anhydrous sodium carbonate reacts to form hydrated sodium carbonate. Include a sign in your answer.

(2)



ResultsPlus
Examiner Comments

This candidate uses 5.09 g as the mass in the calculation in (a) so does not score a mark. If they continued the calculation they could have scored transferred error marks.

The formulae of the carbonate ion is incorrect and there are no state symbols so (b) scores 0.

ResultsPlus
Examiner Tip

Remember to use the mass of the solution when calculating enthalpy changes from experimental data. The density of solutions is assumed to be 1 g cm^{-3} so the mass has the same numerical value as the volume.

Carbonate ions have two negative charges. This could have been worked out from the formula of sodium carbonate, which was given in the question, since sodium ions have one positive charge.

6 A student carries out two experiments to determine the enthalpy change that occurs when anhydrous sodium carbonate reacts to form hydrated sodium carbonate.

$$Na_2CO_3(s) + 10H_2O(l) \rightarrow Na_2CO_3.10H_2O(s)$$

(a) In the first experiment, the student determines the enthalpy change of solution for anhydrous sodium carbonate.

50.0 g of distilled water is placed in a polystyrene cup and the temperature is recorded.

A sample of anhydrous sodium carbonate is added to the water, the mixture is stirred and the final temperature recorded.

The results for this experiment are shown in the table.

mass used / g	5.09
initial temperature / °C	27.0
final temperature / °C	32.4

Calculate the enthalpy change of solution, in kJ mol^{-1}, for anhydrous sodium carbonate.
Give your answer to an appropriate number of significant figures and include a sign.

[Use 4.18 J g^{-1} $°C^{-1}$ as the specific heat capacity of water]

$$Na_2CO_3(s) + aq \rightarrow Na_2CO_3(aq)$$

(4)

$q = mc\Delta\epsilon$

$kJ\,mol^{-1}$ $q = \frac{50}{100^3} \times 4.18 \times 5.4$

$q = 1.1286 \times 10^{-3}$

$M_r\ Na_2CO_3 = 106$

$mol = \frac{5.09}{106} = 0.048$

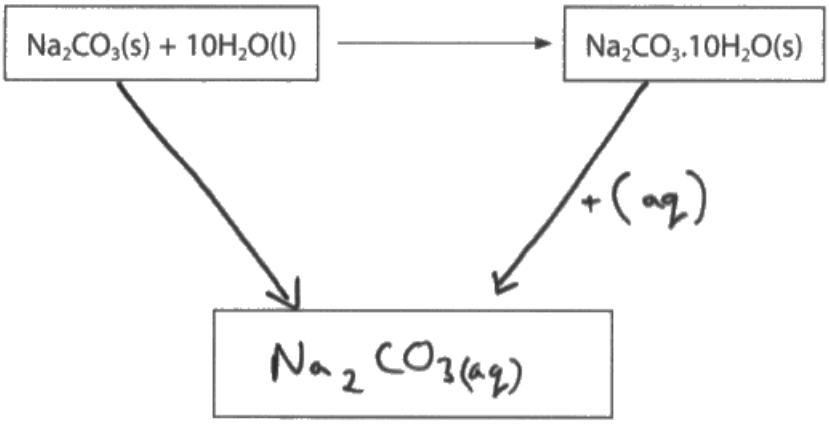
$\frac{0.048}{1.1286 \times 10^{-3}} = 42.53\ kj\,mol^{-1}$

(b) In the second experiment, the student determines the enthalpy change of solution for hydrated sodium carbonate.

$$Na_2CO_3.10H_2O(s) + aq \rightarrow Na_2CO_3(aq) \qquad \Delta H = +53.7\,kJ\,mol^{-1}$$

Complete the Hess cycle and, together with your answer to (a) calculate the enthalpy change when anhydrous sodium carbonate reacts to form hydrated sodium carbonate. Include a sign in your answer.

(2)



ResultsPlus

Examiner Comments

In (a), the candidate has tried to calculate the energy change but has divided the answer by 100^3 instead of by 1000 to convert it to kJ so loses the first mark. The number of moles of sodium carbonate is correct so the second mark is awarded. The candidate has then divided the moles by the energy, which is incorrect so the third mark is not awarded.

In (b), the cycle is completed correcty but there is no calculation so 1 mark is awarded.

ResultsPlus

Examiner Tip

Divide by 1000 to convert an answer in joules to kilojoules.

The final enthalpy change is measured in kJ mol^{-1}. Use the information given in this unit - it means kJ divided by moles. This will help you to do the calculation the correct way.

6 A student carries out two experiments to determine the enthalpy change that occurs when anhydrous sodium carbonate reacts to form hydrated sodium carbonate.

$$Na_2CO_3(s) + 10H_2O(l) \rightarrow Na_2CO_3.10H_2O(s)$$

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Calculate the enthalpy change of solution, in kJ mol^{-1}, for anhydrous sodium carbonate.
Give your answer to an appropriate number of significant figures and include a sign.

[Use 4.18 J g^{-1} $°C^{-1}$ as the specific heat capacity of water]

$$Na_2CO_3(s) + aq \rightarrow Na_2CO_3(aq)$$

(4)

$Q = mc\Delta T$

$Q = 50 \times 4.18 \times 5.4$

$= 1128.6\,J$

$m = 50$

$\Delta T = 5.4$

$n = \frac{5.09}{48}$

$= 0.106$

$\Delta H = \frac{-1128.6}{0.106}$

$= -10647.2\,J\,mol^{-1}$

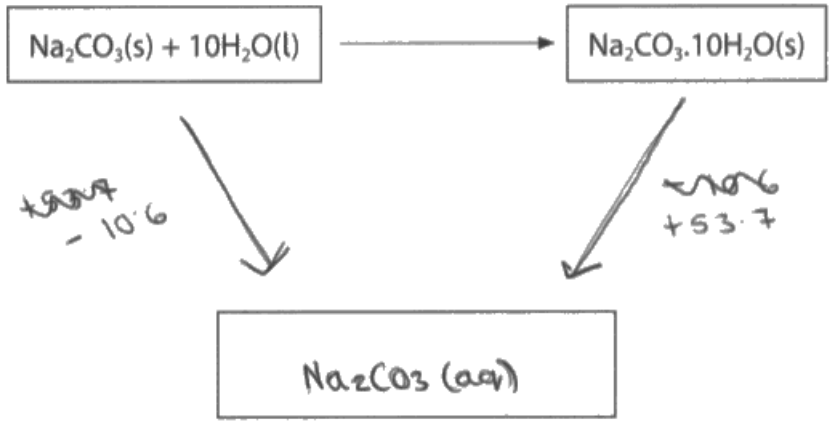
$= -10.6\,kJ\,mol^{-1}$

(b) In the second experiment, the student determines the enthalpy change of solution for hydrated sodium carbonate.

$$Na_2CO_3.10H_2O(s) + aq \rightarrow Na_2CO_3(aq) \qquad \Delta H = +53.7\,kJ\,mol^{-1}$$

Complete the Hess cycle and, together with your answer to (a) calculate the enthalpy change when anhydrous sodium carbonate reacts to form hydrated sodium carbonate. Include a sign in your answer.

(2)



$\Delta H = -10.6 - 53.7$

$= -64.3\ kJmol^{-1}$

ResultsPlus
Examiner Comments

In (a), the candidate has calculated the correct amount of energy given out but has worked out an incorrect molar mass for sodium carbonate. However, they have then used this correctly to calculate the enthalpy change and given the negative sign and an appropriate number of significant figures, so scores 3 marks.

The Hess cycle in (b) is correct and the calculation is correct, using the candidate answer from (a), so both marks are awarded.

ResultsPlus
Examiner Tip

Use the formulae given in the questions to calculate molar masses.

Show your working clearly so that you can be awarded transferred error marks if you make a mistake early on in a calculation.

Question 6 (c)

This question discriminated well between candidates. Candidates had to think carefully about the consequence of using crystals that had lost some water of crystallisation. Many did realise that as there is less water, the enthalpy change will be less endothermic, however, very few were able to explain the reason for this. Some candidates had the idea that there would be fewer bonds to break, but they did not state which bonds need to be broken. Only a very small number of candidates used their answer to (a) to explain that anhydrous sodium carbonate releases energy when it dissolves in water and as there is less water, there will be more sodium carbonate in the sample.

= - 77.2 KJmol

(c) Hydrated sodium carbonate slowly loses some water of crystallisation when left in air.

Explain how the enthalpy change in the second experiment would compare with the data book value if an old sample of hydrated sodium carbonate had been used.

(2)

There will be less water of crystallisation present so the enthalpy change will be less exothermic. Therefore the enthalpy change value will be less negative.

ResultsPlus
Examiner Comments

This candidate states that there will be less water present but this is given in the question so does not score a mark. The dissolving of hydrated sodium carbonate is endothermic so the statement about less exothermic cannot receive any credit. This answer does not score a mark.

ResultsPlus
Examiner Tip

Relate your answers to the information given in the question.

Remember that exothermic reactions have a negative sign for ΔH and endothermic reactions have a positive sign.

(c) Hydrated sodium carbonate slowly loses some water of crystallisation when left in air.

Explain how the enthalpy change in the second experiment would compare with the data book value if an old sample of hydrated sodium carbonate had been used.

(2)

Enthalpy change would be less endothermic, so smaller in magnitude, since there would be less ~~water~~ bonds to break in water molecules, as the sodium carbonate would be hydrated to less water molecules.

ResultsPlus
Examiner Comments

This candidate scores 1 mark for less endothermic. The answer is almost worth a second mark as it mentions less bonds to break. Unfortunately the candidates states the bonds broken are **in** the water molecules whereas the bonds broken are between the water and sodium carbonate.

ResultsPlus
Examiner Tip

When writing about changes to enthalpy changes it is best to write more or less exothermic or endothermic. If you state that it is smaller for a reaction that is exothermic, it is not clear what this actually means and you will not receive any credit.

Question 7 (a)

Most candidates are familiar with one of the methods of calculating a formula so the majority scored the first mark. Some candidates who calculated the empirical formula did not mention the molecular ion peak at 88 gives the relative formula mass so shows that the molecular formula is the same as the empirical formula so they lost the second mark.

7 This question is about the identification of an alcohol, **X**.

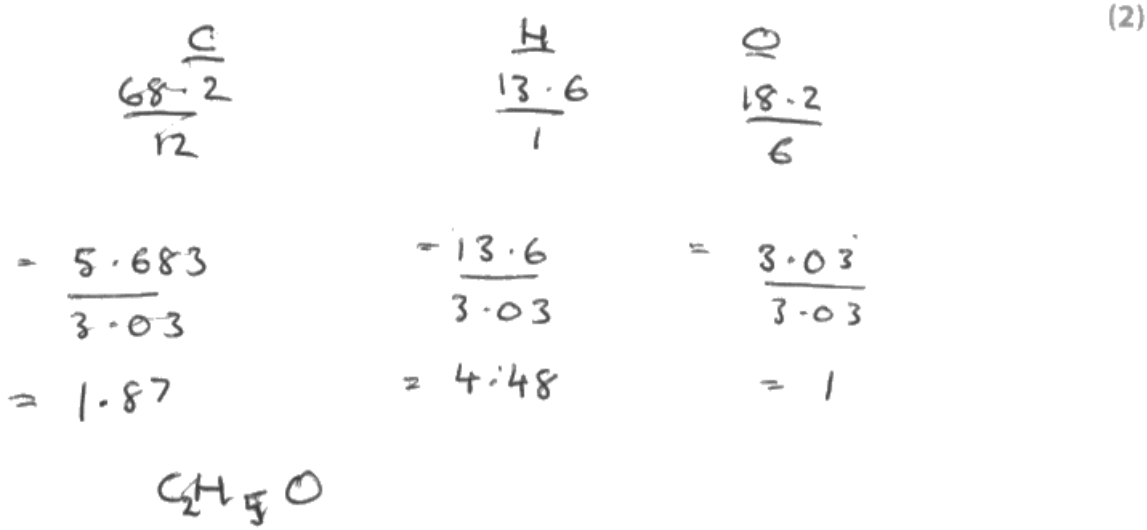
(a) Alcohol **X** has the following percentage composition by mass:

carbon, C = 68.2%
hydrogen, H = 13.6%
oxygen, O = 18.2%

The molecular ion peak in the mass spectrum for alcohol **X** occurs at $m/z = 88$.

Use all of these data to show that the molecular formula for alcohol **X** is $C_5H_{12}O$.
Include your working.

(2)



ResultsPlus
Examiner Comments

This candidate has used 6 for the relative atomic mass of oxygen instead of 16 so has calculated an incorrect empirical formula and scores 0.

ResultsPlus
Examiner Tip

Use the periodic table on the back of the question paper to look up relative atomic masses.

If you are asked to show the molecular formula of a substance given in the question and you get a different answer, check your working as you will have made a mistake somewhere.

7 This question is about the identification of an alcohol, **X**.

(a) Alcohol **X** has the following percentage composition by mass:

carbon, C = 68.2%
hydrogen, H = 13.6%
oxygen, O = 18.2%

The molecular ion peak in the mass spectrum for alcohol **X** occurs at $m/z = 88$.

Use all of these data to show that the molecular formula for alcohol **X** is $C_5H_{12}O$.
Include your working.

(2)

C : H : O

$\frac{68.2}{12} : \frac{13.6}{1} : \frac{18.2}{16}$

5.68 : 13.6 : 1.137

5 : 12 : 1

⇒ the empirical formula is $C_5H_{12}O$.

This corresponds to the molecular ion peak.

So the molecular formula is $C_5H_{12}O$.

$Mr(C_5H_{12}O) = 12\times5 + 12\times1 + 16 = 88$.

ResultsPlus
Examiner Comments

This response scores 2 marks. The candidate has calculated the empirical formula then shows that the M_r of the formula is the same as the m/z value of the molecular ion peak.

ResultsPlus
Examiner Tip

When you are asked to use all of the data given, you will lose a mark if you ignore some of it!

Question 7 (b)

Candidates had to use different pieces of information to identify an alcohol. Many rose to the challenge and worked out that alcohol X was 3-methylbutan-1-ol and explained how they deduced this. Other candidates found this more challenging and floundered before they reached the end. It was surprising that some candidates did not know that primary alcohols are oxidised to carboxylic acids. A few candidates even thought that alcohol X was an aldehyde. Candidates who did state that X was a secondary or even tertiary alcohol could receive consequential marks for the rest of the question but they rarely got much further. Some candidates struggled to draw the displayed formulae of four different primary alcohols and they sometimes drew two that were the same or included a secondary or even a tertiary alcohol. Candidates should take more care when drawing the displayed formulae of alcohols as some showing the H of the OH bond joined to a carbon atom instead of joining through the O and they lost a mark. A significant number of candidates omitted the positive charge from the species giving the peak in the mass spectrum. Quite a few candidates who did deduce the correct structure of the alcohol gave an incorrect name, although they were not penalised on this occasion. Some did not give a full explanation for their choice of alcohol and just stated that it is branched.

(b) (i) When alcohol **X** is oxidised, a carboxylic acid is formed.

State what information this gives about alcohol **X**.

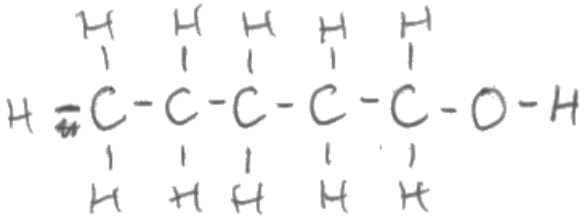
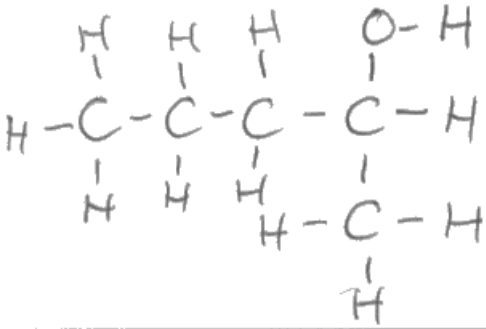
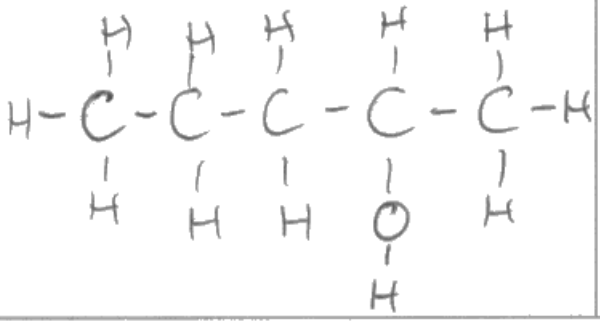
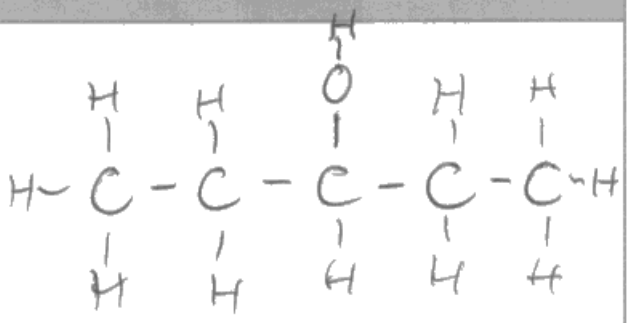
(1)

It is a primary alcohol

$C_5H_{12}O$

(ii) Draw the **displayed** formulae of the four possible structural isomers that could be alcohol **X**.

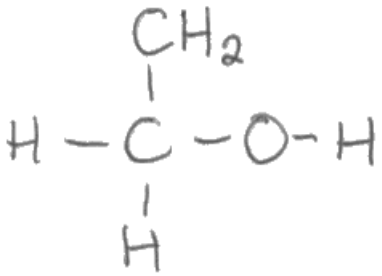
(3)

Alcohol 1	Alcohol 2
	
Alcohol 3	**Alcohol 4**
	

(iii) The mass spectrum of alcohol **X** has a major peak at $m/z = 45$.

Draw the structure of the species that could give this peak.

(1)

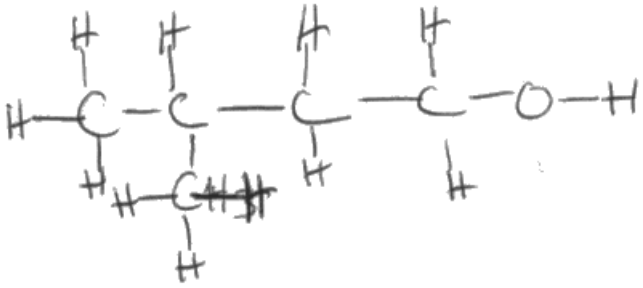


$CH_2CH_2OH^+$

(iv) Alcohol **X** has a branched chain.

Identify alcohol **X**, explaining your reasoning.

(2)



~~Alcohol X is 3-methylbutan-1-ol because if it brea~~

This can break at the bond between the second and third carbon atoms to form the major peak at m/z = 45.

ResultsPlus

Examiner Comments

(i) This is correct and scores 1 mark.

(ii) The Alcohol 1 is a correct primary alcohol but the other three alcohols are secondary and Alcohol 2 and Alcohol 3 are the same. There is no mark awarded for just one correct alcohol.

(iii) The semi-displayed formula of the species doesn't have a positive charge but the structural formula is correct so 1 mark is awarded.

(iv) No mark is awarded as an incorrect alcohol was identified. The question states that the alcohol is branched and pentan-1-ol is a straight chain alcohol.

ResultsPlus

Examiner Tip

Make sure that you know the difference between primary, secondary and tertiary alcohols.

Make sure that you know the difference between straight chain and branched chain molecules.

(b) (i) When alcohol **X** is oxidised, a carboxylic acid is formed.

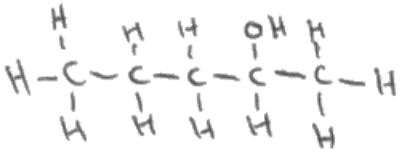
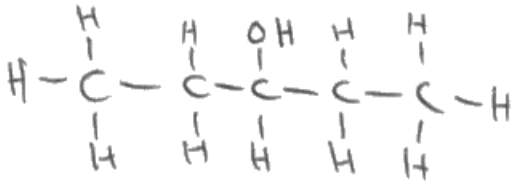
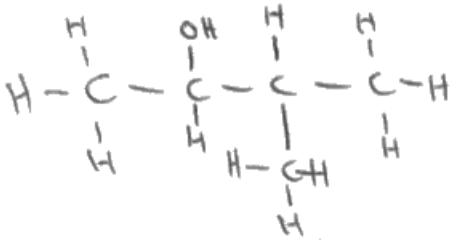
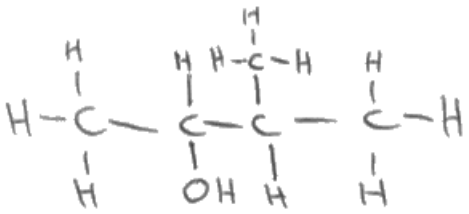
State what information this gives about alcohol **X**.

(1)

The alcohol is Secondary

(ii) Draw the **displayed** formulae of the four possible structural isomers that could be alcohol **X**.

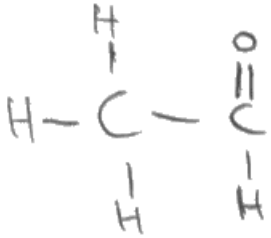
(3)

Alcohol 1	Alcohol 2
	
Alcohol 3	**Alcohol 4**
	

(iii) The mass spectrum of alcohol **X** has a major peak at $m/z = 45$.

Draw the structure of the species that could give this peak.

(1)



(iv) Alcohol **X** has a branched chain.

Identify alcohol **X**, explaining your reasoning.

(2)

3-methyl butane-2-ol because it contains an aldehyde.

ResultsPlus
Examiner Comments

(i) This scores 0 as secondary alcohol is incorrect.

(ii) There are 3 correct secondary alcohols so this scores 2 marks. Alcohols 3 and 4 are the same.

(iii) This is incorrect and scores 0.

(iv) The correct secondary alcohol is identified but the explanation is incorrect so 1 mark is awarded.

ResultsPlus
Examiner Tip

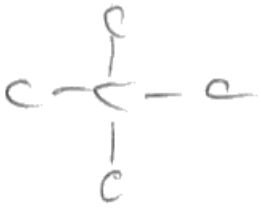
Learn that primary alcohols are oxidised to carboxylic acids, secondary alcohols to ketones and tertiary alcohols are not easily oxidised.

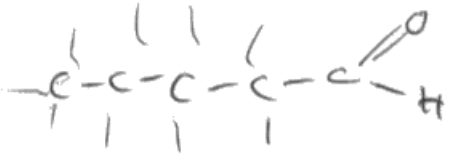
(b) (i) When alcohol **X** is oxidised, a carboxylic acid is formed.

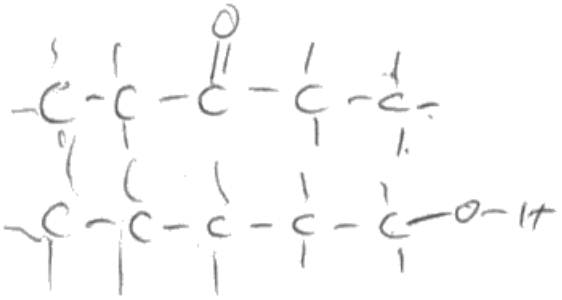
State what information this gives about alcohol **X**.

(1)

Alcohol X could be an aldehyde or a primary alcohol

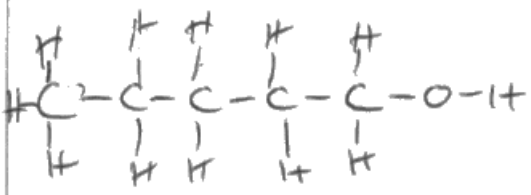
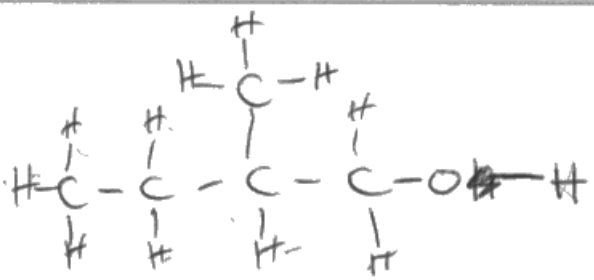
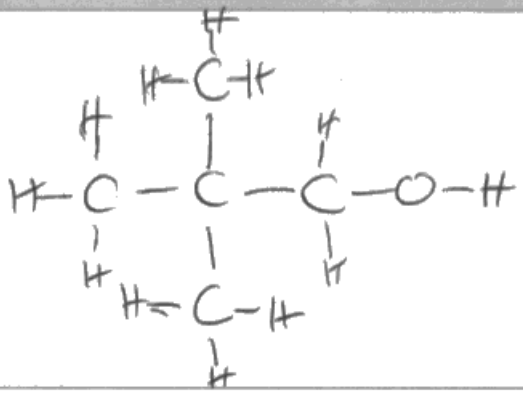
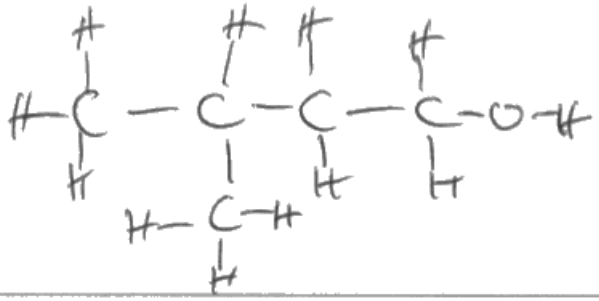






(ii) Draw the **displayed** formulae of the four possible structural isomers that could be alcohol **X**.

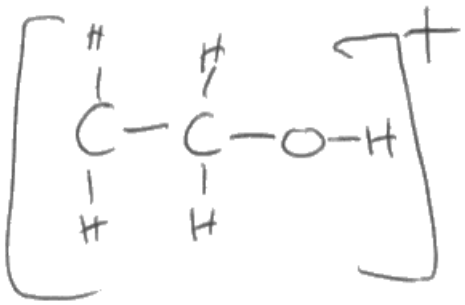
(3)

Alcohol 1	Alcohol 2
	
Alcohol 3	**Alcohol 4**
	

(iii) The mass spectrum of alcohol **X** has a major peak at $m/z = 45$.

Draw the structure of the species that could give this peak.

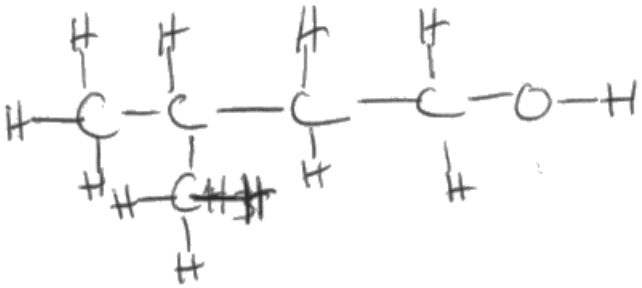
(1)



(iv) Alcohol **X** has a branched chain.

Identify alcohol **X**, explaining your reasoning.

(2)



~~Alcohol X is 3-methylbutan-1-ol because it it brea~~

ResultsPlus
Examiner Comments

(i) A mark cannot be awarded for stating that alcohol X is an aldehyde or a primary alcohol.

(ii) The four correct formulae of four different alcohols scores 3 marks.

(iii) The ion is correct and has a positive charge so scores 1 mark.

(iv) The correct alcohol is identified but there is not enough detail in the reason so scores 1 mark. The candidate has not mentioned that it is the only alcohol that is branched to give a peak at 45.

ResultsPlus
Examiner Tip

Read the question carefully and don't write contradictory statements.

When you explain your reasoning, include as much detail as possible.

Question 8 (a)

Some candidates were able to apply their knowledge of oxidation of ethanol to that of ethane-1,2-diol but many were unable to do this. Candidates should learn the reagents and conditions for the reactions in the specification and be able to apply these to similar reactions. Some candidates gave the name and formula of potassium dichromate or just the formula and they sometimes lost a mark as the formula was incorrect. A few candidates quoted the acid as hydrochloric acid and lost the first mark, although they could still score the second mark for the condition from a nearly correct reagent.

8 Ethanedioic acid has two carboxylic acid groups.

(a) Ethanedioic acid, $H_2C_2O_4$, can be prepared from ethane-1,2-diol.

Give the reagents and condition required for this reaction.

(2)

Reagents ~~Aleho~~ Alcohol

Condition Heated under reflex

ResultsPlus
Examiner Comments

This response scores 0. The alcohol is shown as the organic starting material in the question. The condition is only awarded a mark if the reagent is correct or nearly correct. No additional reagent has been suggested here so no mark is awarded for heated under reflux.

ResultsPlus
Examiner Tip

Learn the reagents and conditions for all the reactions in the specification.

8 Ethanedioic acid has two carboxylic acid groups.

(a) Ethanedioic acid, $H_2C_2O_4$, can be prepared from ethane-1,2-diol.

Give the reagents and condition required for this reaction.

(2)

Reagents Potassium dichromate and dilute sulfuric acid

Condition Heat under reflux

ResultsPlus
Examiner Comments

This response scores 2 marks. The reagent is completely correct with potassium dichromate and sulfuric acid so the condition of heat under reflux can also be awarded a mark.

ResultsPlus
Examiner Tip

Some candidates tried to give the formula of potassium dichromate and made a slip as it is one of the more difficult formulae to remember. This question does not state that you must give the formula so it is safer to give the correct name.

Question 8 (b)(i)

It was disappointing that a significant number of candidates could not describe how to prepare a standard solution. Many of them did not mention to use of a volumetric flask and just added 250cm^3 of water to the crystals in a beaker. Candidates should be given the opportunity to carry out practical techniques such as this as this will help them to answer questions based on these in the examination. There were a lot of excellent answers from candidates who were familiar with this technique but some dropped a mark by not weighing the crystals or forgetting the importance of shaking the volumetric flask at the end.

(i) Describe how the student should prepare the 250.0 cm^3 of ethanedioic acid solution.

(4)

The Student should put the Sodium hydroxide solution in a conical flask and at the indicator. ~~In a bi~~ The ethanedioic acid should be put in a ~~burn~~ burette and should be released drop by drop until the end point is reached. The solution should then be heated until all the

ResultsPlus
Examiner Comments

This response scores 0. The candidate has attempted to describe a titration experiment instead of how to prepare a solution.

ResultsPlus
Examiner Tip

Read the question carefully and make sure that you are familiar with all the practical techniques in the specification.

(i) Describe how the student should prepare the 250.0 cm^3 of ethanedioic acid solution.

(4)

The student should weigh out a known mass of ethanedioic crystals. He should then dissolve these in deionised water in a beaker. He should then ~~transfer~~ transfer this solution into a 250 cm^3 flask. ~~He~~ They should then use the beaker with deionised water into the flask, they should also also wash any other apparatus used. ~~The~~ They should then fill the 250 cm^3 flask up to the mark using ~~deionis~~ deionised water.

ResultsPlus
Examiner Comments

This response scores 2 marks. The candidate has explained how to weigh the crystals and dissolved them in water in a beaker then transferred the solution washings to a flask. However, they have not specified the type of flask to use and they have not mentioned shaking the flask at the end to produce a uniform solution.

ResultsPlus
Examiner Tip

Learn the names of all the apparatus you use in a chemistry laboratory.

(i) Describe how the student should prepare the 250.0 cm^3 of ethanedioic acid solution.

(4)

Dissolve the crystals in a beaker in a small amount of distilled water then add to a volumetric flask. Rinse the beaker with distilled water and add this to the flask. Make the solution up to the 250cm^3 mark on the volumetric flask with distilled water and invert the flask whilst covering the top to ensure that the solution is throughly mixed

ResultsPlus
Examiner Comments

This response scores 3 marks. The candidate has just omitted to mention that the crystals must be weighed to find their exact mass.

ResultsPlus
Examiner Tip

It is important to know the exact mass of a solid used when preparing an accurate solution.

Question 8 (b)(ii)

It was surprising how few candidates were familiar with the colours of phenolphthalein and were then able to work out the correct colour change for this titration. The specification does state that candidates should be familiar with the use of phenolphthalein and methyl orange.

Question 8 (b)(iii)

This was the most difficult calculation on the paper and many candidates failed to get started as there was no scaffolding, as in past papers on the previous specification. Candidates would benefit from much more practice at this style of unstructured titration calculation. Some candidates at least made a start by calculating the amount of sodium hydroxide used then the amount of ethanedioic acid from the mole ratio in the equation. There was a significant minority of candidates who set out their working clearly and achieved full marks.

(iii) Calculate a value of n in the formula $H_2C_2O_4.nH_2O$ from these data. (5)

moles = $\frac{16.2 \times 0.103}{1000}$ = 1.6686 mol

ResultsPlus
Examiner Comments

This response scores 0 but with a little more care, it could have been awarded 1 mark. The candidate has shown the correct working for the number of moles of sodium hydroxide used but they have forgotten to divide by 1000 in their answer.

ResultsPlus
Examiner Tip

Check your answers to calculations carefully.

(iii) Calculate a value of n in the formula $H_2C_2O_4.nH_2O$ from these data.

(5)

mr $H_2C_2O_4$ = 90

$\frac{1}{90}$ mol ~ $\frac{1}{900}$ mol 0.00121 mol

$0.103 \times 0.0162 = 1.67 \times 10^{-3} \div 2 = 8.3 \times 10^{-4}$

$\frac{0.00121}{8.3 \times 10^{-4}} = 0.67g$

1.09 − 0.67 = 0.4

$\frac{0.4}{18} = 0.02$ $\frac{0.02}{0.00121} = 18$

n = 18.

ResultsPlus
Examiner Comments

This response is awarded 2 marks, but only just. There is a jumble of numbers here and no words to explain the working. However, marks are awarded for the number of moles of sodium hydroxide used and the use of the 1:2 mole ratio.

ResultsPlus
Examiner Tip

Use a few words to explain your working as that will help the examiners to give you some credit when your final answer is incorrect.

(iii) Calculate a value of n in the formula $H_2C_2O_4.nH_2O$ from these data.

(5)

$\frac{16.20}{1000} = 0.0162$

$0.0162 \times 0.103 = 1.669 \times 10^{-3}$ mol NaOH

1:2 so 8.343×10^{-4} mol acid in 25 cm^3

8.343×10^{-3} mol acid in 250 cm^3

$\frac{1.09}{8.343 \times 10^{-3}} = 130.6$ g

$H_2C_2O_4 = 90$ g mol^{-1}

$130.6 - 90 = 40.6$ g H_2O

$\frac{40.6}{18} = 2.25$

$n = 2.25$

ResultsPlus
Examiner Comments

This is an example of a response that scores 5 marks.

ResultsPlus
Examiner Tip

Aim to set out your calculations clearly like this one, giving a few words to explain your working.

Question 8 (b)(iv)

This is another question where candidates have to think about the effect a change will make on the results. Some candidates realised that if the crystals were damp they would contain more water so less ethanedoic acid leading to a lower titre and a higher value for n. Others were really not sure how to approach this style of question. Candidates would benefit from evaluating the results they get for the practicals they carry out in the laboratory.

(iv) The student thought that the ethanedioic acid crystals used may have been slightly damp.

Explain the effect of using damp crystals on the titre and on the value of n.

(2)

• Damp crystals would mean more H_2O in them so greater mass of water means less titre would be added (~~the~~ less needed to hydrolyse), greater n. of moles

(Total for Question 8 = 14 marks)

TOTAL FOR PAPER = 80 MARKS

0.5

0.61

ResultsPlus
Examiner Comments

This response scores 1 mark as the candidate has stated the effect of using damp crystals on the titre and the value of n but they have not fully **explained** why they will change in this way. They have explained the change in n but not on the titre.

ResultsPlus
Examiner Tip

The command word 'explain' means that you have to give reasons for any statements that you make.

Paper Summary

In order to improve their performance, candidates are advised to:

- read all of the information in the question carefully and use it to help them to answer the question
- use correct scientific terminology in their answers
- revise all the experiments that they have carried out so they can describe them using the correct names of the apparatus used
- practise evaluating the results of the experiments they carry out
- learn the reagents and conditions for all the reactions in the specification
- practise drawing displayed and skeletal formulae of organic molecules
- practise the different types of calculations in the specification
- learn the meaning of standard enthalpy change of formation
- practise drawing Hess cycles and carrying out calculations related to them
- practise writing full and ionic equations, including state symbols.

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
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with its registered office at 80 Strand, London WC2R 0RL.