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June 2018

IAL Chemistry 2 WCH02 01

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Introduction

The paper was similar in difficulty to June 2017. The average score in 2017 was 44.4 and this increased slightly to 44.7 this year. There was no evidence that candidates ran out of time, allowing all candidates to demonstrate their knowledge and understanding. The paper covered a wide range of topics, including practical work and the application of knowledge to novel situations. Candidates from centres that had clearly prioritised time in the laboratory scored well in these areas, emphasising the importance of allowing students to carry out their own experiments and evaluate their results. There was a good spread of marks so the paper managed to differentiate between candidates effectively. However, there were a couple of questions where candidates failed to read and answer the question posed and poor use of technical language was evident in some areas.

The average multiple-choice score was just over 13. The multiple-choice questions where candidates were least successful, with the lowest-scoring question first, were:

18 Mole calculation

13 Ozone

2 Molecular bond angles

Candidates were most successful with these questions, with the highest-scoring first:

4 Bond polarity

7 Group 2 trends

17 Organic oxidation products

Question 21 (a)

The use of silver nitrate followed by ammonia solution was well known by the majority of candidates, but some lost marks by naming the halogen rather than the halide.

However, writing this simple ionic equation proved problematic for many. Errors included using a +2 charge for the silver ion, giving a product of AgI_2 or including the spectator nitrate ion in the equation. State symbols were also often used incorrectly or left out completely. Some candidates confused ionic equations with half equations and gave the formation of the iodide ion from iodine.

21 This question is about the chemistry of Group 7.

(a) Silver nitrate solution is added to an aqueous solution containing two different halide ions. A mixture of two different precipitates, **A** and **B**, is formed. When concentrated ammonia solution is then added, precipitate **A** remains and precipitate **B** dissolves completely.

(i) Identify, by name or formula, the halide ion in **A**. **(1)**

I^-

(ii) Identify, by name or formula, **one** possible halide ion in **B**. **(1)**

Br^-

(iii) Write an **ionic** equation, including state symbols, for the formation of precipitate **A**. **(2)**

$Ag^+ + I^- \longrightarrow AgI_{(s)}$

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Examiner Comments

Part (i) and (ii) are correct for both marks. Part (iii) only scores the correct species mark as the state symbols for the reactants are missing.

ResultsPlus
Examiner Tip

Learn what ionic equations are and practise writing them. Ensure that all state symbols are given if requested. In an ionic equation for a precipitate reaction, the reactants must be aqueous and the products solid.

Question 21 (b)

The first part of the question was answered very well with most candidates giving HCl as the gas. Where candidates correctly chose to remove one proton from the acid to give potassium hydrogen sulphate the equation was usually written correctly. Common errors included giving KSO_4 as a product or incorrect balancing when forming K_2SO_4 . Occasionally P was given as the chemical symbol for potassium.

(b) Concentrated sulfuric acid is added to solid potassium chloride.

H_2SO_4 $KCl_{(s)}$

A reaction occurs in which steamy fumes are formed.

(i) Give the **formula** of the steamy fumes.

(1)

HCl

(ii) Write an equation for this reaction. State symbols are not required.

(1)

$H_2SO_4 + KCl \rightarrow K_2SO_4 + HCl$

ResultsPlus

Examiner Comments

Part (i) is correct, but (ii) does not score as the equation is not balanced.

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Examiner Tip

Take care when writing equations as there is often only one mark available. Here a simple mistake means no mark is scored.

Question 21 (c) (i)

The oxidation numbers of sulfur in these two compounds were well known.

(c) When concentrated sulfuric acid is added to solid potassium bromide, a redox reaction occurs. A mixture of products is formed, including sulfur dioxide as the **only** reduction product.

KBr

$\overset{+2}{H_2}\overset{-8}{SO_4}$ $\overset{+4}{S}\overset{-4}{O_2}$

(i) Give the oxidation number of sulfur in

(2)

sulfuric acid ..... +6 .....

sulfur dioxide ..... +4. .....

ResultsPlus
Examiner Comments

Both oxidation numbers are correct so this scored two marks.

ResultsPlus
Examiner Tip

Here the candidate has done a calculation to work out the correct oxidation numbers. This is a simple but effective method.

(c) When concentrated sulfuric acid is added to solid potassium bromide, a redox reaction occurs. A mixture of products is formed, including sulfur dioxide as the **only** reduction product.

(i) Give the oxidation number of sulfur in

(2)

sulfuric acid ....6........ H_2SO_4 $2 + x + (-2 \times 4) = 0$ $x = 6$

sulfur dioxide ....4........ SO_2 $x + (-2 \times 2) = 0$

ResultsPlus
Examiner Comments

Although the correct numbers are given a lack of charges means only one mark was awarded.

ResultsPlus
Examiner Tip

Oxidation numbers require a number and a charge (unless it is an element that has an oxidation number of zero)

Question 21 (c) (ii)

This question was answered poorly. Despite being told that sulfur dioxide was one of the products a small minority of candidates did not include this. However, the most common mistake was to give HBr instead of Br_2. Where both products were given correctly a common error was to give $4H^+$ ions instead of 2 as the candidate had presumably left out the $2H^+$ from the sulfuric acid.

Here the candidate has only given one correct product (SO_2) so no marks are scored.

(ii) Complete the **ionic** equation for this redox reaction.

State symbols are not required.

(2)

H_2SO_4 + ..6.. H^+ + ..3.. Br^- → SO_2 + 2 HBr + ..4.. H_2O

ResultsPlus
Examiner Comments

The question states that this is a redox reaction. But the candidate has failed to appreciate that the oxidation number of Br is -1 on both sides of the equation.

ResultsPlus
Examiner Tip

When writing redox reactions make sure that both oxidation and reduction takes place. One reactant is oxidised, the other reduced.

Here both bromine and sulfur dioxide are correctly identified as products. However, the equation is not balanced so only one mark is scored.

(ii) Complete the **ionic** equation for this redox reaction. S = 4

State symbols are not required.

(2)

$$H_2SO_4 \quad + \quad 4\,H^+ \quad + \quad 4\,Br^- \rightarrow SO_2 + 2Br_2 + 2\,H_2O$$

ResultsPlus
Examiner Comments

The H^+ are not balanced as the candidate may have overlooked the sulfuric acid protons.

ResultsPlus
Examiner Tip

Writing and balancing equations are important parts of chemistry so practising them is worthwhile.

Question 21 (d)

Many candidates scored full marks here. However, some misunderstood the question and iodine was a frequently seen incorrect response despite the fact that only reduction products were required. Another less common error was to mention sulfur dioxidedespite it being stated in the question.

A fully correct answer.

(d) When concentrated sulfuric acid is added to solid potassium iodide, a redox reaction occurs producing two reduction products other than sulfur dioxide.

Identify these two **reduction** products. In each case, give an observation that indicates the presence of the product.

(4)

First reduction product sulfur

Observation yellow solid

Second reduction product H_2S gas

Observation pungent smell

ResultsPlus
Examiner Comments

The reduction products can be identified by name of formula. Here they have used one of each.

ResultsPlus
Examiner Tip

If both the name and formula are given they both have to be correct.

(d) When concentrated sulfuric acid is added to solid potassium iodide, a redox reaction occurs producing two reduction products other than sulfur dioxide.

Identify these two **reduction** products. In each case, give an observation that indicates the presence of the product.

(4)

First reduction product ......Iodine......

Observation ......black solid......

Second reduction product ......Sulfur......

Observation ......yellow solid.......

ResultsPlus
Examiner Comments

Iodine was a common wrong answer being a product of oxidation not reduction.

ResultsPlus
Examiner Tip

Read the question carefully, paying particular attention to the words in bold. Ensure you can identify oxidation and reduction products.

Question 22 (a)

The majority scored this mark with many giving both scoring options. Although rare, incorrect responses included 'to dissolve easier' or 'make sure all the magnesite reacted'.

22 Hydromagnesite is a mineral containing magnesium carbonate.

A student crushed some hydromagnesite and added a sample of mass 0.936 g to excess dilute hydrochloric acid.

(a) Give a reason why the mineral was crushed before being added to the acid.

(1)

To increase the surface area, to increase the rate of reaction.

ResultsPlus
Examiner Comments

Both scoring options are made so the mark is awarded. However, writing 'just increase surface area' **or** 'increase the rate of reaction' would have been sufficient.

Question 22 (b)

Generally, this question was quite well answered, with candidates often able to correctly identify all reactants and products. However, incorrect state symbols meant many candidates scored 1 mark out of 2. The most common error being $MgCl_2$identified as a solid.

Incorrect formulae also lost marks with MgCl and $Mg(CO_3)_2$ sometimes seen.

(b) Write the equation for the reaction between magnesium carbonate and dilute hydrochloric acid. Include state symbols in your equation.

(2)

~~$2Mg(CO_3)_{2(s)} + 2HCl_{(aq)} \rightarrow 2MgCl_{(aq)} + H_2O_{(aq)} + 2CO_{2(g)}$~~

$MgCO_{3(s)} + HCl_{(aq)} \rightarrow MgCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

ResultsPlus
Examiner Comments

The incorrect formula of magnesium chloride means no marks are scored.

ResultsPlus
Examiner Tip

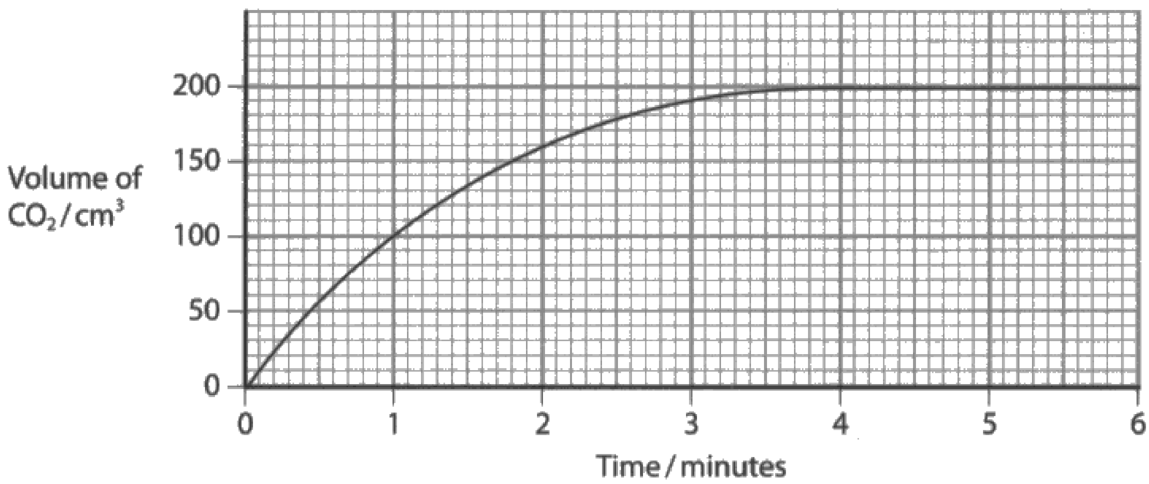
Use the periodic table if you are unsure about the charge on an ion. Magnesium is in group 2 and chlorine in group 7 so the formula of magnesium chloride should be easy to work out.

Question 22 (c)

Candidates may have benefitted from reading the question carefully as they were asked to comment on the rate of reaction, yet some did not mention this in their answer. In many cases candidates did not consider the axis labels carefully enough and incorrectly commented that as the graph was going up the rate was increasing. Although many related collision frequency to the concentration of the reactants, some wrote that the collisions were between molecules so did not score M2.

M3 was rarely gained. Instead of saying that the reaction stopped after 3.5min, a number said that the reaction was constant at this time. Many candidates did not recognise that the carbonate was limiting and stated that the reaction stopped because all the reactants had been used up which did not score M3.

(c) The gas formed in the reaction was collected in a gas syringe.
The volume of gas was measured at regular intervals for 6 minutes.
A graph of the student's results is shown.



Describe the changes in the rate of reaction during the experiment.
Explain these changes in terms of collisions.

(3)

From 0 minutes 3.5 minutes the Volume of CO_2 increases from 0 to 200 means their was a great collisions From 3.6 to 6 minutes the Volume of CO_2 increases is constant no change means that they were no collision happened.

ResultsPlus
Examiner Comments

This is an example of where the candidate has not answered the question. There is no mention of rate of reaction, just a reference to the volume of carbon dioxide. Although they have mentioned collisions, there is no reference to frequency or number. No marks scored.

ResultsPlus
Examiner Tip

Read and answer the question carefully. Use the words in the question as a starting point for the answer. Pay attention to the command word too.

The rate of reaction decreases ~~as~~ during the experiment.

At the beginning, concentration of reactants is high, so more frequent collisions. Rate is high.

Later, concentration decreases, less collisions occur until 3.1 min, all the reactants change into products.

ResultsPlus
Examiner Comments

This scores M1 and M2. The question says that the hydrochloric acid is in excess so to score M3 the candidate has to say that all the magnesium carbonate has reacted. Stating that all reactants have reacted or changed into products is not sufficient.

ResultsPlus
Examiner Tip

When commenting about why a reaction stops, look at the information given in the question and be precise about which of the reagents is limiting.

Rate of reaction increases with an increase in volume and time But at a particular volume the rate of reaction is all the same all through.

ResultsPlus
Examiner Comments

Saying the rate of reaction increases was a common wrong answer. The candidate is incorrectly relating the increase in the volume of carbon dioxide to an increase in rate. No marks awarded.

ResultsPlus
Examiner Tip

When analysing simple volume v time graphs, remember the gradient is an indication of the rate. The steeper the gradient, the faster the rate. When the line is flat and has no gradient the reaction has stopped.

Question 22 (d)

This question was generally answered well.

(d)(i) Almost all candidates read 200 cm^3 from the graph (although 190 cm^3 was seen occasionally) and used the volume correctly to calculate the number of moles. However, a fairly common mistake was to then divide the correct answer by 2.

(d)(ii) Occasionally the Mr of magnesium carbonate was calculated incorrectly. Some candidates only used one significant figure for the mass of magnesium carbonate giving an answer of 0.7 g which did not score the mark.

(d) (i) Use information from the graph to calculate the number of moles of magnesium carbonate that reacted with the dilute hydrochloric acid.

[The molar volume of a gas = 24 000 $cm^3 mol^{-1}$ under the conditions of the experiment.]

(2)

1mol X 24000
?mol 200

$\frac{200}{24000}$ = 8.33×10^{-3} mol HCl

2 : 1 → $\frac{8.33 \times 10^{-3}}{2}$ = ~~4.165×10~~
HCl MgCO3 $= 4.165 \times 10^{-3}$

(ii) Calculate the mass of magnesium carbonate that reacted and hence the percentage by mass of magnesium carbonate in the hydromagnesite.

(2)

1mol $MgCO_3$ → 24.3 + 12 + 3×16 = 84.3

1mol 84.3
4.165×10^{-3} / ?
$4.165 \times 10^{-3} \times 84.3$ = 0.351 g

Mass of magnesium carbonate = 0.35 g

hydromagnesite = 0.936 g
0.936 0.35
100 X ?

$\frac{100 \times 0.35}{0.936}$ = 37.511.

Percentage by mass of magnesium carbonate = 37.5 %

ResultsPlus
Examiner Comments

(d)(i) The candidate has correctly used the volume of carbon dioxide but then divided the answer by 2. Only one mark scored.

(d)(ii) Here transferred error applies. They have correctly calculated and used the Mr of magnesium carbonate so both marks awarded.

ResultsPlus
Examiner Tip

To ensure transferred error marks can be applied it is important to show all your working.

(d) (i) Use information from the graph to calculate the number of moles of magnesium carbonate that reacted with the dilute hydrochloric acid.

[The molar volume of a gas = 24 000 cm^3 mol^{-1} under the conditions of the experiment.]

(2)

$$\frac{200}{24000} = \frac{1}{120} \text{ mol.}$$

(ii) Calculate the mass of magnesium carbonate that reacted and hence the percentage by mass of magnesium carbonate in the hydromagnesite.

(2)

$$\frac{1}{120} \times (24.3 + 12 + 16 \times 3) = 0.7025 \text{ g}$$

Mass of magnesium carbonate = 0.7025 g

$$\frac{0.7025}{0.936} \times 100\%$$

$$\approx 75.1\%$$

Percentage by mass of magnesium carbonate = 75.1 %

ResultsPlus
Examiner Comments

(d)(i) Fractions can be used instead of decimals so this scores both marks.

(d)(ii) Fully correct answer scores both marks.

(d) (i) Use information from the graph to calculate the number of moles of magnesium carbonate that reacted with the dilute hydrochloric acid.

[The molar volume of a gas = 24 000 $cm^3 mol^{-1}$ under the conditions of the experiment.]

(2)

mole (CO_2) = $\frac{200}{24000}$ = 8.3×10^{-3}

mole ($MgCO_3$) = 8.3×10^{-3}

(ii) Calculate the mass of magnesium carbonate that reacted and hence the percentage by mass of magnesium carbonate in the hydromagnesite.

(2)

$8.3 \times 10^{-3} = \frac{mass}{84.3}$ = 0.699 g

Mass of magnesium carbonate = 0.7 g

$\frac{0.7}{0.936} \times 100$ = 74.8 %

Percentage by mass of magnesium carbonate = 74.8 %

ResultsPlus
Examiner Comments

(d)(i) The calculation is correct so both marks are awarded. Although the answer is given to 2 significant figures, this is acceptable.

(d)(ii) The calculation is also correct but the mass of magnesium is only given to 1 significant figure, this is not acceptable so only the mark for the % of magnesium carbonate is scored.

ResultsPlus
Examiner Tip

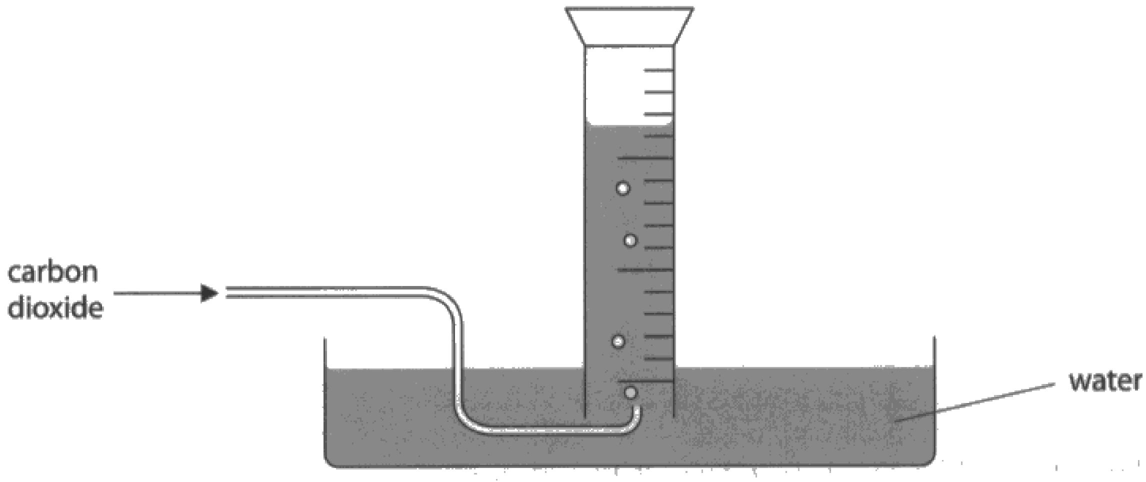
When carrying out calculations think carefully about the number of significant figures you should be giving in your answer. You will often be told how many SF to use but if this is not the case, as a general rule give more than 1. The only exception is when doing a calculation to find the number of water molecules in a sample of hydrated crystals. Here one SF would be appropriate.

Question 22 (e)

Many candidates knew that carbon dioxide was soluble in water so scored M1. The majority were then able to develop their answer and conclude that the volume of carbon dioxide collected would decrease and hence the % mass of magnesium carbonate would be reduced too, scoring M2.

Other reasons candidates gave for a reduced volume of carbon dioxide included: carbon dioxide escaping, evaporation of water, pressure of the water and carbonic acid formation. None of these scored M1, but allowed access to M2.

(e) Another student decided to carry out a similar experiment. This student did not have a gas syringe and therefore collected the carbon dioxide over water in an inverted measuring cylinder, as shown in the diagram.



Explain the effect that collecting the carbon dioxide over water would have on the volume of gas collected and hence on the percentage of magnesium carbonate in hydromagnesite. Assume that the gas syringe and the measuring cylinder can be read to the same accuracy.

(2)

The volume of gas collected will decrease because some of the carbon dioxide will dissolve in water.

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Examiner Comments

The candidate has successfully answered the first part of the question so scores M1. However, they have not commented on the effect the reduced volume of carbon dioxide has on the % of magnesium carbonate. M2 not scored.

ResultsPlus
Examiner Tip

Ensure the question is answered fully.

- Some CO_2 can be dissolved in water.
- So, the measured volume of CO_2 will decrease, thereby decreasing the moles of $MgCO_3$ calculated
- This will reduce the percentage value we get.

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Examiner Comments

This detailed and well linked response scores both marks.

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Examiner Tip

Check that all the details required in the question are given to ensure that all the marks can be achieved.

Question 23 (a)

(i) A large number of candidates demonstrated a good level of understanding of how pressure affects equilibrium. However, many candidates overlooked the first part of the procedure, and therefore did not achieve M1. Some candidates assumed that when the syringe was left standing after being compressed, pressure was released by the plunger moving back to the original position and therefore stated that when left standing the mixture would turn brown again. Hence this resulted in them getting the colour changes the wrong way round. Despite the question being about equilibrium, some candidates also referred to the effect of the increased pressure on the rate of reaction.

(ii) The effect of temperature on equilibrium was generally well understood. However, a number of responses correctly stated the direction of movement but the explanation did not mention either exothermic or endothermic in the answer and so failed to score.

In the following extract, although the candidate has made a comment about the appearance of the mixture, there is no justification and so no marks are awarded in (i). Despite being told the question is about equilibrium, the candidate has wasted time writing about how the rate of reaction would change.

In (ii) the answer given only concerns rate so no mark awarded.

23 This question is about chemical equilibrium.

(a) The gases nitrogen dioxide, NO_2 and dinitrogen tetroxide, N_2O_4 form an equilibrium mixture at room temperature.

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)} \qquad \Delta H = -58\,\text{kJ mol}^{-1}$$

*(i) A gas syringe containing an equilibrium mixture of these gases is compressed by pushing in the plunger and then allowed to stand with the plunger in the new position.

Predict how the **appearance** of the equilibrium mixture would change during this procedure.

Justify your answer.

(3)

The pressure will increase.

The collisions between the particles would increase.
Therefore the rate of reaction would also increase.
So the mixture would a look slightly brown.

(ii) State and explain the effect of an increase in temperature on this equilibrium.

(1)

particles gain kinetic energy, hence the movement of particles increases and the rate of Successful collision increases.

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Examiner Comments

Read the question carefully and try to avoid putting irrelevant information in your answer.

- The mixture will become less brown.
- As pressure is increased, equilibrium will shift towards the right, as there are ~~less~~ fewer moles of molecules on that side.

(ii) State and explain the effect of an increase in temperature on this equilibrium.

(1)

- Equilibrium position moves to the left as reaction is exothermic.

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Examiner Comments

(i) The candidate has stated the correct colour change, the direction the eqm moves and there are fewer moles on the right. This scores M2 and M3. However, they have not stated that the mixture initially gets darker so no M1.

(ii)The mark is awarded for stating the direction of movement and the exothermic nature of the (forward) reaction.

Question 23 (b)

Rather surprisingly, a large number of candidates did not appreciate that the alkali would react with the hydrogen ions and so they were unable to score any marks. Some clearly understood the reaction that was taking place and the need to replace the hydrogen ions, but they did not give a reason so could only score one mark. Some mistakenly thought a redox reaction was taking place.

*(b) When potassium dichromate(VI), $K_2Cr_2O_7$, is dissolved in water, an equilibrium is set up. The position of the equilibrium is well to the left and the solution is an orange colour.

$$\underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O(l) \rightleftharpoons \underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H^+(aq)$$

Aqueous alkali is added and the solution turns a yellow colour.

Explain this observation.

(2)

Because $Cr_2C_7^{2-}$ in the precince of water is a oxidising agent the alkali added is oxidised and the $Cr_2C_7^{2-}$ is reduced to for $2CrO_4^{2-}$ which is yellow in colour and therefore the solution turns yellow.

ResultsPlus
Examiner Comments

This was quite a common incorrect answer relating the colour change to changes in oxidation number of Cr.

This is not a redox reaction as chromium is 6+ on both sides.

*(b) When potassium dichromate(VI), $K_2Cr_2O_7$, is dissolved in water, an equilibrium is set up. The position of the equilibrium is well to the left and the solution is an orange colour.

$$\underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O(l) \rightleftharpoons \underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H^+(aq)$$

Aqueous alkali is added and the solution turns a yellow colour.

Explain this observation.

(2)

- As OH^- ions are introduced the conc. of OH^- increases on left side.
- This causes the equilibrium to shift towards the right, producing more CrO_4^{2-}.

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Examiner Comments

There is no OH^- on the left hand side so there is no reason for the eqm to shift to the right. It may be that the candidate realised that the OH^- would react with the H^+ but as this was not stated no marks were awarded.

ResultsPlus
Examiner Tip

Read the question and make sure that the answer given has sufficient chemical detail.

*(b) When potassium dichromate(VI), $K_2Cr_2O_7$, is dissolved in water, an equilibrium is set up. The position of the equilibrium is well to the left and the solution is an orange colour.

$$\underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O(l) \rightleftharpoons \underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H^+(aq)$$

Aqueous alkali is added and the solution turns a yellow colour.

Explain this observation.

(2)

The alkali reacts with H⁺ ~~ion~~ so the concentration of H⁺ decreases which shifts equilibrivm to the right turning solution to yellow.

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Examiner Comments

This scores both marks for a well-reasoned answer.

Question 24 (a)

(i) Although the majority of candidates knew the correct reagent, very few achieved the conditions mark. Common mistakes included ethanolic KOH, acidified KOH or a lack of heating.

(ii) The majority of mechanisms were of a good standard and many candidates took great care to give the details required in the question. However, marks were lost for omitting the dipoles, missing the charge on the hydroxide ion and the curly arrow not coming from the lone pair. Many candidates who gave a full S_N2 mechanism struggled to score the intermediate mark. Common errors were missing dotted lines to both the OH and Br, lack of charge and the bond going to the H of the OH, not the O. A small minority gave a S_N1 mechanism which allowed a maximum of 3 marks.

24 This question is about the reactions and properties of 1-bromobutane.

(a) 1-bromobutane can be converted into butan-1-ol in a one-step reaction.

(i) State the reagents and conditions required for this reaction.

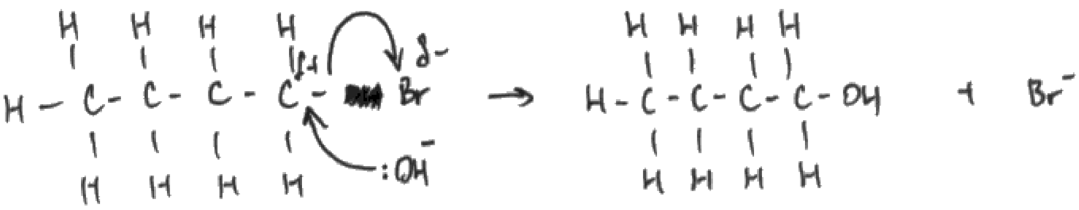
(2)

Reagents: ~~KOH~~ Potassium hydroxide Conditions: Heat under reflux

(ii) Draw the mechanism for this reaction.

Include curly arrows, and relevant dipoles and lone pairs.

(4)



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Examiner Comments

(i) The reagent is correct and it is heated, but aqueous is missing so only one mark was awarded.

(ii) There is no requirement in the specification that detailed knowledge of S_N2 and SN_2 mechanisms are needed until module 4. Therefore, this is the mechanism we were expecting to see, and it scores all 4 marking points.

24 This question is about the reactions and properties of 1-bromobutane.

(a) 1-bromobutane can be converted into butan-1-ol in a one-step reaction.

(i) State the reagents and conditions required for this reaction.

(2)

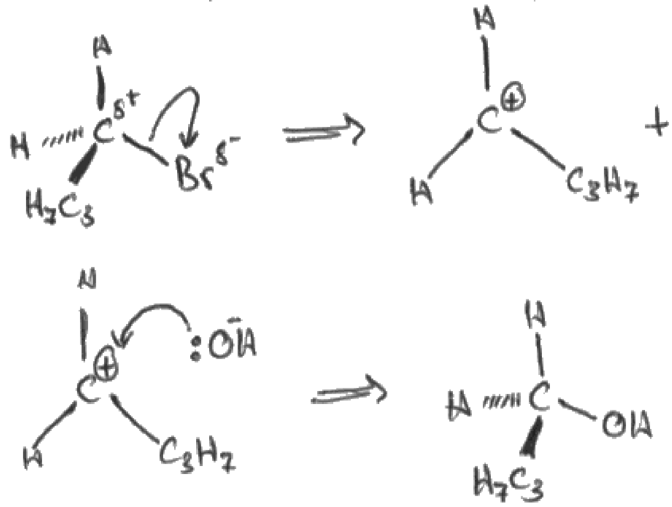
Reagents: H_2O , 1-bromobutane .... Conditions: ....

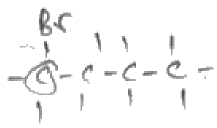
(ii) Draw the mechanism for this reaction.

Include curly arrows, and relevant dipoles and lone pairs.

(4)

S_N2





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Examiner Comments

(i) Although this is a hydrolysis reaction, water is not an acceptable reagent so no marks are scored here.

(ii) This S_N1 mechanism is fully correct, but as 1-bromobutane is a primary halogenoalkane and reacts via S_N2 a maximum of 3 marks is scored.

24 This question is about the reactions and properties of 1-bromobutane.

(a) 1-bromobutane can be converted into butan-1-ol in a one-step reaction.

(i) State the reagents and conditions required for this reaction.

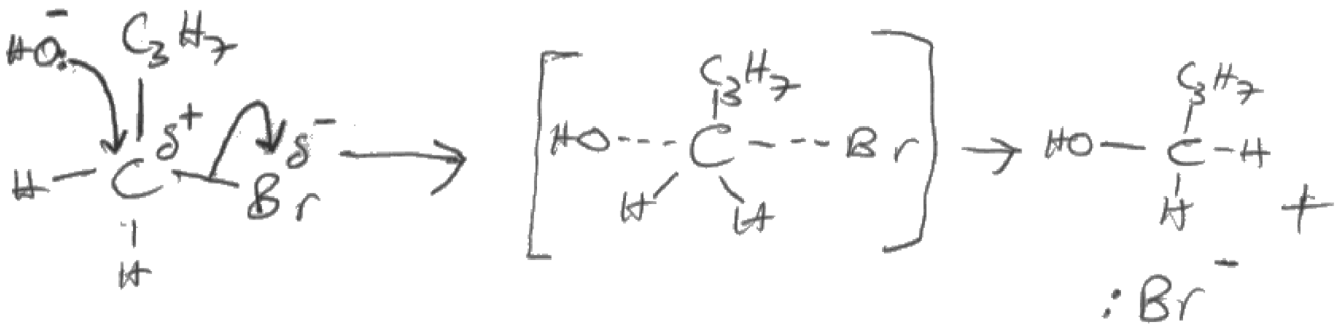
(2)

Reagents: $NaOH_{(aq)}$ Conditions: ~~aqueous~~ heat under reflux

(ii) Draw the mechanism for this reaction.

Include curly arrows, and relevant dipoles and lone pairs.

(4)



ResultsPlus Examiner Comments

(i) The reagents and conditions are fully correct for both marks.

(ii) This is a very good attempt at a full S_N2 mechanism. However, the charge on the intermediate is missing and so only 3 marks were awarded.

ResultsPlus Examiner Tip

When drawing mechanisms, include all the detail the question asks for. Pay particular attention to charges.

Question 24 (b)

This should have been quite a straightforward question comparing the solubility of 1-bromobutane in both water and butan-1-ol. However, the question was misread in many cases and candidates compared the solubility of 1-brombutane and butan-1-ol in water. The mark scheme was adjusted to account for both types of responses. Despite the question stating that a detailed description of the forces involved was not required, a number of candidates did this. Others simply wrote about bond polarity but did not mention by name the intermolecular forces involved so scored no marks. A number of candidates used generalisations such as 'like dissolves like' gaining no credit.

(b) Explain why 1-bromobutane is much less soluble in water than in butan-1-ol.
A detailed description of the forces involved is not required.

(3)

~~1-Bromobutane is a polar solvent~~

Butan-1ol has the ability to forme hydrogen bond with water therefore they dissolve. But 1bromobutane is a non-polar solvent but water is a polar solvent therefore they don't dissolve.

ResultsPlus
Examiner Comments

The candidate is comparing the solubility of 1-bromobutane and butan-1-ol in water. A mark is awarded for stating hydrogen bonds form between butan-1-ol and water. No further marks are scored as the information about bond polarity is too vague.

ResultsPlus
Examiner Tip

When answering questions about solubility state the intermolecular forces present between molecules of the separate liquids. Then explain the intermolecular forces formed between molecules when the liquids have been combined.

(b) Explain why 1-bromobutane is much less soluble in water than in butan-1-ol.
A detailed description of the forces involved is not required.

(3)

This is because 1-bromobutane only contain london forces and dipole- dipole forces while Butan-1-ol contains hydrogen bonds. Butan-1ol contain hydrogen bonds and therefore is able to form hydrogen bonds with the water molecule as its strong enough to break up the water molecule however 1-bromobutane cannot break-up the water molecule that easily hence less soluble in water than butan-1-ol.

ResultsPlus
Examiner Comments

The candidate is comparing the solubility of 1-bromobutane and butan-1-ol in water. A mark is awarded for stating 1-brombutane has London Forces. A mark is awarded for stating butan-1-ol has hydrogen bonds. A mark is awarded for stating hydrogen bonds form between butan-1-ol and water.

(b) Explain why 1-bromobutane is much less soluble in water than in butan-1-ol. A detailed description of the forces involved is not required.

(3)

The hydrogen bond in water is strong.
1- bromobutane forms weak London force with water.
but it forms a significant London force with butan-1-ol.
The weak London force is not able to overcome than strong hydrogen bond in water.

ResultsPlus
Examiner Comments

The candidate is comparing the solubility of 1-bromobutane in both water and butan-1-ol. A mark is awarded for stating London Forces form between 1-bromobutane and butan-1-ol. No further marks are scored.

Question 25 (a)

Although it appeared the interpretation of spectra was quite well understood many responses were too casual and lost marks.

(i) Was well done, but some responses made reference to isotopes of carbon and a few mentioned atomic mass, neither of which scored.

(ii) A number lost marks for missing the charge on the fragment or for giving CH_3O^+. The second mark was sometimes shown with a diagram or explaining which bond was broken. However, many simply wrote generally about fragmentation and so did not score.

(iii) This was very straightforward, although a number of candidates did not include a reference to the OH group with their range.

(a) (i) State what can be deduced about ethanol from the presence of the peak at *m* / *e* = 46 in the mass spectrum.

(1)

It has a molecular formula of C_2H_5OH.

(ii) Identify the species responsible for the peak at *m* / *e* = 31 in the mass spectrum of ethanol, and state how it is formed.

(2)

The species responsible for the peak at m/e = 31 is $^+CH_2OH$.
It is formed when the bond between CH_3 and CH_2OH is broken.

(iii) Identify **one** feature of the infrared spectrum which confirms the functional group in ethanol.

Include the appropriate wavenumber range in your answer.

(1)

A peak at 3750-3200

ResultsPlus
Examiner Comments

Part (i) does not mention the molecular mass or molecular ion so no mark scored. Part (ii) is fully correct so scores both marks, but (iii) is missing the OH so no mark awarded.

ResultsPlus
Examiner Tip

When quoting wavenumber data make sure you include the specific group causing the stretch or vibration.

(a) (i) State what can be deduced about ethanol from the presence of the peak at $m/e = 46$ in the mass spectrum.

(1)

m/e = 46 shows ~~The relative mole~~ the molecular ion peak which is the molecular mass of ethanol.

(ii) Identify the species responsible for the peak at $m/e = 31$ in the mass spectrum of ethanol, and state how it is formed.

(2)

$(CH_3O)^+$ which is responsible for m/e = 31. Ethanol is broken into fragments that is the weaker bonds are broken showing peaks at different positions.

(iii) Identify **one** feature of the infrared spectrum which confirms the functional group in ethanol.

Include the appropriate wavenumber range in your answer.

(1)

There is a broad peak between 3200 – 3750 cm^{-1} corresponding to an O–H bond, in alcohols.

ResultsPlus
Examiner Comments

Parts (i) and (iii) are correct, but the ion produced in (ii) cannot be formed so no mark is awarded. However, if they had written that the C-C bond was broken or a CH_3 is produced the second scoring point would have been awarded.

ResultsPlus
Examiner Tip

When trying to identify fragments use the structural or displayed formulae to ensure correct ions are used and do not forget the charge.

Question 25 (b)

(i) Although the term functional group is used on a regular basis, a large number of candidates struggled with the definition and many scored the first mark by listing examples (such as OH) Likewise, the second mark was often scored by mentioning physical and chemical properties together.

(ii) Despite the reaction being taken directly from the specification fewer than half of the candidates were able to score any marks.

(b) Chemical tests are often used to identify functional groups in organic molecules.

*(i) Explain the meaning of the term **functional group**.

(2)

the group that says about ~~g~~ the molecules chemical and physical properties it determines whether its an alcohol, aldehyde, Ketone, etc.

(ii) The reaction of sodium metal with ethanol can be used to confirm the presence of the functional group in ethanol.

Give the equation for the reaction of sodium with ethanol. State symbols are not required.

(2)

$C_2H_5OH + Na \rightarrow NaOH + C_2H_5,$

ResultsPlus
Examiner Comments

(i)This scores the first mark for mentioning chemical properties.

(ii)The chemical equation is incorrect so no marks are scored.

ResultsPlus
Examiner Tip

Make sure you learn the reactions that are mentioned explicitly in the specification.

(b) Chemical tests are often used to identify functional groups in organic molecules.

*(i) Explain the meaning of the term **functional group**.

(2)

A group of atoms that when joined to an organic molecule, give it certain properties. Each functional group has their own specific properties, which are always the same on every organic compound the bind to. The sequence / position of the functional group atoms never changes.

(ii) The reaction of sodium metal with ethanol can be used to confirm the presence of the functional group in ethanol.

Give the equation for the reaction of sodium with ethanol. State symbols are not required.

(2)

$$2Na_{(s)} + 2C_2H_5OH \rightarrow 2C_2H_5O^-Na^+ + H_{2(g)}$$

ResultsPlus
Examiner Comments

(i)The candidate has identified that a functional group is determined by a specific group of atoms so scores the first mark.However, they do not mention chemical properties or reactions so no second mark.

(ii)The chemical equation is fully correct and scores two marks.

ResultsPlus
Examiner Tip

Ensure that you have an understanding of chemical and physical properties.

Question 25 (c) (i) - (vii)

Parts of this question were quite challenging, but it did allow an opportunity for all candidates to gain some credit and so was an effective discriminator.

(i) Although the calculation was quite straightforward a number simply subtracted one mass from the other (1.79-1.2 = 0.59g) and scored no marks.

(ii) Most candidates found this calculation easier than part (i) and scored a transferred error mark even if they got part (i) incorrect.

(iii) and (vi) Candidates who scored full marks in (i) and (ii) generally scored well here with the correct empirical formula and identification of E. However, using the wrong numbers from (i) and (ii) meant that only one mark could be scored for the empirical formula. Poor rounding in (iii) was seen at times with C=1, H=1.5, O=1 being rounded to CH_2O and some candidates clearly did not understand the definition of empirical formula leaving $CH_{1.5}O$ as the answer.

(v) Most candidates were able to correctly identify the bromine water test with the correct observations, although a few successfully used acidified potassium manganate (vii) instead.

(vi) The structure was answered very well but some candidates struggled with the connectivity of OH group.

(vii) Most candidates recognised there was restricted rotation around the C=C. However, a few incorrectly stated there was free rotation around the C=C. Not as many candidates recognised there were different (functional) groups around each carbon of the double bond. Some missed the point and wrote about different masses or priority groups without explaining the features of the molecule that gave rise to geometric isomerism.

(c) A carboxylic acid **E** was investigated by quantitative and qualitative methods.
E was known to have one of the following structures:

Structure **1** $CH_3CH_2CH{=}CHCOOH$ Molar mass = 100 g mol^{-1}

Structure **2** $HOOCCH_2CH_2COOH$ Molar mass = 118 g mol^{-1}

A sample of 1.20 g of **E** was burned in excess oxygen.
A mass of 1.79 g of carbon dioxide was formed.

(i) Calculate the mass of carbon present in the sample of **E**.

(2)

$1.79 \times \frac{12}{44} =$ ~~0.49~~ (g)
0.4881

Mass of carbon = ~~0.49~~ 0.4881 g

(ii) The mass of hydrogen present in the sample is 0.0610 g.

Deduce the mass of oxygen in the sample.

(1)

1.2 − 0.061 − 0.4881
= ~~0.6509~~ (g)
0.6508

Mass of oxygen = ~~0.6509~~ 0.6508. g

(iii) Use the information from parts (c)(i) and (c)(ii) to calculate the empirical formula of **E**.

(2)

C: $\frac{0.4881}{12} = 0.04$ $0.04 \div 0.04 = 1$

O: $\frac{0.6509}{16} = 0.04$ $0.06 \div 0.04 = 1.5$

H: $\frac{0.0610}{1} = 0.06$ $\times 2$.

CH_2O.

(iv) Deduce the identity of **E**. Give a reason for your answer by referring to the information at the start of (c) and your answer to (c)(iii).

(1)

E is ~~butan-1,1,4~~ butan-1,4-dioic acid.

Because ~~As~~ carbon : oxygen = 1:1. ~~Same~~

~~E is carboxylic acid.~~

(v) Describe a **qualitative** chemical test that would distinguish between Structure **1** and Structure **2**. State the expected results.

(2)

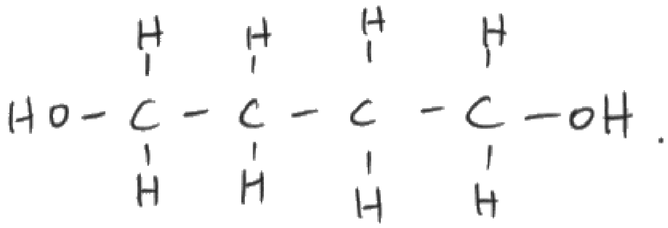
Test: Add bromine water.

Results for Structure **1**: colour change from orange to colourless

Results for Structure **2**: no change.

(vi) Draw the **displayed** formula of a compound that can be oxidised to form Structure **2**.

(1)



*(vii) Explain why a molecule of Structure **1** can show geometric isomerism.

(2)

There's restricted rotation around C=C double bond. And different groups, which are ethyl and -COOH, attach to each end of the C=C.

ResultsPlus
Examiner Comments

Parts (i) and (ii) are fully correct. In part (iii) the mole calculation is correct, but the rounding to get the empirical formula is wrong, so only one mark is scored. The incorrect calculation for the empirical formula means that no mark can be awarded for (iv). Parts (v) and (vi) are correct. In (vii) a mark is awarded for noting the restricted rotation around the double bond.

ResultsPlus
Examiner Tip

Be careful when rounding to produce an empirical formula.

(c) A carboxylic acid **E** was investigated by quantitative and qualitative methods.
E was known to have one of the following structures:

Structure **1**	$CH_3CH_2CH{=}CHCOOH$	Molar mass = 100 g mol^{-1}
Structure **2**	$HOOCCH_2CH_2COOH$	Molar mass = 118 g mol^{-1}

A sample of 1.20 g of **E** was burned in excess oxygen.
A mass of 1.79 g of carbon dioxide was formed.

(i) Calculate the mass of carbon present in the sample of **E**.

(2)

1.79 - 1.20

Mass of carbon = 0.59 g

(ii) The mass of hydrogen present in the sample is 0.0610 g.

Deduce the mass of oxygen in the sample.

(1)

0.59 + 0.0610 = 0.651

1.20 - 0.651

Mass of oxygen = 0.549 g

(iii) Use the information from parts (c)(i) and (c)(ii) to calculate the empirical formula of **E**.

(2)

C H O

$\frac{0.59}{12}$ $\frac{0.0610}{1}$ $\frac{0.549}{16}$

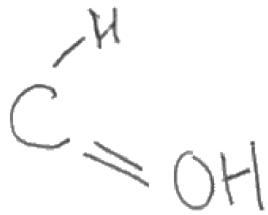
$= \frac{0.0492}{0.0343}$ $= \frac{0.0610}{0.0343}$ $= \frac{0.0343}{0.0343}$

1 : 2 : 1

CH_2O

(iv) Deduce the identity of **E**. Give a reason for your answer by referring to the information at the start of (c) and your answer to (c)(iii).

(1)



(v) Describe a **qualitative** chemical test that would distinguish between Structure **1** and Structure **2**. State the expected results.

(2)

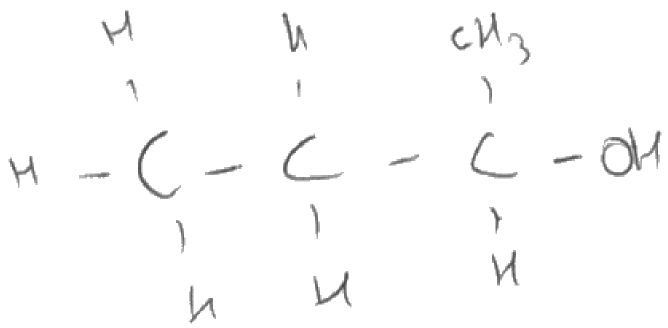
Test: Bromine water

Results for Structure **1**: turns Colourless

Results for Structure **2**: No change (stays orange

(vi) Draw the **displayed** formula of a compound that can be oxidised to form Structure **2**.

(1)



*(vii) Explain why a molecule of Structure **1** can show geometric isomerism.

(2)

because it has a double bond with vith different elements on each carbon

ResultsPlus
Examiner Comments

Part (i) is incorrect but the mark for (ii) is scored as a transferred error. In part (iii) the transferred error mole calculation is correct so one mark is awarded. Part (v) is correct and scores both marks.

ResultsPlus
Examiner Tip

Ensure all working is shown in order to access transferred error marks. Learn the features required for geometric isomerism.

Paper Summary

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

- Read the question carefully underlining key words to make sure that all the scoring points are made.
- Revise and practise writing full and ionic equations.
- Learn practical details of experiments you have carried out and understand how to interpret the results.
- Check calculations thoroughly and show your working. Do not round up too soon and use the appropriate number of significant figures.
- Revise redox reactions carefully and learn to identify the oxidation and reduction products.

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