Examiners' Report
June 2018

IAL Chemistry WCH06 01

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Introduction

The paper was accessible to most candidates and very few questions were not attempted. The paper did contain some challenging and unfamiliar questions, and these allowed good candidates to show what they could do. The majority of candidates scored well on the first half of question 1 and the calculations. The use of starch indicator in question 2 and the meaning of the hazard signs in question 4 were also well known.

However, many candidates seemed unfamiliar with laboratory procedures such as filtering under reduced pressure, and could not recognise faults in the diagram of a reflux process. The practical details in parts (a) and (b) of question 2 were not well understood and suggested few had carried out a procedure of this nature. Candidates also found it difficult to relate theory about electrode potentials to experimental results for a cell reaction. A simple approach to understanding redox reactions in cells is to remember that electrons move to the positive side of the cell. Discussion about anodes and cathodes leads to confusion with electrolysis.

Question 1

Many candidates scored highly on this question, especially in (a). The test for chloride and carbonate ions was well known, and many recognised the two iron ions. A common error was to think that iron(III) iodide, rather than iodine, formed in (a)(iii), and a failure to describe what was seen in (a)(v). A few candidates named a compound in (a)(ii) where a formula was required. The answers to the second half of this question were less good. Many tried to include ammonia in the formula of the cation in solution **Y**. Some answers also included ammonia in the formula of the brown compound in (b)(ii). A large proportion of candidates failed to balance the charges in the ionic equation, where two moles of each of the iron ions were required.

1 A compound of a d-block element is dissolved in water to form a solution **X**.

A series of tests is carried out on separate 1 cm³ portions of solution **X**.

(a) Complete the table.

Test	Observation	Inference	
(i) Record the colour of solution **X**	Yellow-brown	The **formula** of the cation in solution **X** could be $Fe^{\bullet}$	(1)
(ii) To 1 cm³ of solution **X** in a test tube, add sodium hydroxide solution, drop by drop, until no further change occurs	A brown precipitate forms which remains when sodium hydroxide is in excess	The **formula** of the precipitate is $Fe\,Cl_2$	(1)
(iii) To 1 cm³ of solution **X** in a test tube, add potassium iodide solution	The colour of the mixture in the test tube becomes darker brown	The darker brown colour is due to the formation of $Fe\,I_2$	(1)
(iv) To 1 cm³ of solution **X** in a test tube, add a few drops of nitric acid followed by Addition of Silver Nitrate	A white precipitate forms	Solution **X** contains chloride ions	(1)
(v) To 1 cm³ of solution **X** in a test tube, add sodium carbonate solution	A white precipitate forms	The solution of **X** is acidic	(1)

(b) Sulfur dioxide is passed through a sample of solution **X**. A redox reaction occurs in which the sulfur dioxide forms sulfate ions.

The solution **Y** which forms is no longer yellow-brown.

A series of tests is carried out on solution **Y**.

Complete the table.

Test	Observation	Inference	
(i) To 1 cm³ of solution **Y** in a test tube, add an excess of dilute aqueous ammonia	A precipitate is seen The colour of the precipitate is white	The **formula** of the precipitate is ~~Mg~~ Mno_2 The **formula** of the cation in solution **Y** is Mn	(3)
(ii) Leave the mixture to stand for a few minutes	The surface of the precipitate turns brown	The **formula** of the brown compound is Mn^{2+}	(1)

(c) Complete the ionic equation for the reaction between the **cation** in solution **X** and sulfur dioxide to form solution **Y**. State symbols are not required.

(1)

Mn + SO$_2$ + 2H$_2$O → MnO + SO$_4^{2-}$ + 4 H$^+$

(Total for Question 1 = 10 marks)

SO$_2$ + $c\ddot{u}$ → S + $C\dot{u}o$

In (a) this candidate scored a mark in (iv) only.

A charge is needed as well as the element symbol to identify the cation, and (ii), (iii) and (v) are incorrect.

This candidate was not the only one to give answers about a different element in (a) and (b), and cannot have read the stem of the question which clearly states that solution **Y** is formed in a redox reaction of sulfur dioxide with **X**.

1   A compound of a d-block element is dissolved in water to form a solution **X**.

A series of tests is carried out on separate 1 cm³ portions of solution **X**.

(a) Complete the table.

Test	Observation	Inference	
(i) Record the colour of solution **X**	Yellow-brown	The **formula** of the cation in solution **X** could be Fe^{3+}	(1)
(ii) To 1 cm³ of solution **X** in a test tube, add sodium hydroxide solution, drop by drop, until no further change occurs	A brown precipitate forms which remains when sodium hydroxide is in excess	The **formula** of the precipitate is $Fe(OH)_2^{+}$	(1)
(iii) To 1 cm³ of solution **X** in a test tube, add potassium iodide solution	The colour of the mixture in the test tube becomes darker brown	The darker brown colour is due to the formation of I_2	(1)
(iv) To 1 cm³ of solution **X** in a test tube, add a few drops of nitric acid followed by barium chloride	A white precipitate forms	Solution **X** contains chloride ions	(1)
(v) To 1 cm³ of solution **X** in a test tube, add sodium carbonate solution	Effervescense	The solution of **X** is acidic	(1)

(b) Sulfur dioxide is passed through a sample of solution **X**. A redox reaction occurs in which the sulfur dioxide forms sulfate ions.

The solution **Y** which forms is no longer yellow-brown.

A series of tests is carried out on solution **Y**.

Complete the table.

Test	Observation	Inference
(i) To 1 cm³ of solution **Y** in a test tube, add an excess of dilute aqueous ammonia	A precipitate is seen The colour of the precipitate is _____green_____	The **formula** of the precipitate is _____$Fe(NH_3)_4$_____ The **formula** of the cation in solution **Y** is _____Fe^{2+}_____ (3)
(ii) Leave the mixture to stand for a few minutes	The surface of the precipitate turns brown	The **formula** of the brown compound is _____$Fe\,O$_____ (1)

(c) Complete the ionic equation for the reaction between the **cation** in solution **X** and sulfur dioxide to form solution **Y**. State symbols are not required.

(1)

$$\underline{\quad Fe^{3+} \quad} + SO_2 + 2H_2O \rightarrow \underline{\quad Fe^{5+} \quad} + SO_4^{2-} + \underline{\quad 4 \quad} H^+$$

(Annotations: under SO_2: +4; under SO_4^{2-}: +6 -8)

Remember that ammonia solution has pH greater than 7, so is a source of hydroxide ions.

When writing ionic equations, write down all the species first, and then balance the charges by deciding how many ions react.

Question 2 (a)

A wide variety of answers was seen. Sodium (or potassium) hydrogencarbonate was the expected answer. Sodium (or potassium) carbonate was allowed as an alternative, but strong bases like sodium hydroxide would react with the iodine and the titration could therefore not be carried out.

2   The equation for the acid-catalysed reaction of iodine with propanone is

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + H^+(aq) + I^-(aq)$$

The change of iodine concentration with time was investigated.

Procedure

Step 1 $50.0\,cm^3$ of a solution of $0.0200\,mol\,dm^{-3}$ iodine was measured into a conical flask. The flask was kept in a water bath maintained at room temperature throughout the experiment.

Step 2 $25.0\,cm^3$ of a solution of $1.00\,mol\,dm^{-3}$ propanone and $25.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ sulfuric acid were measured into a second conical flask.

Step 3   The mixture of propanone and acid was added to the iodine, a clock started and the conical flask shaken.

Step 4   After about one minute, a $10.0\,cm^3$ sample of the reaction mixture was removed, using a pipette fitted with a pipette filler. The sample was run into a flask containing a solution which stopped the reaction.

Step 5   At approximately three-minute intervals, the procedure in Step 4 was repeated several times.

Step 6   Each sample of the mixture produced at the end of Step 4 was titrated with sodium thiosulfate solution of concentration $0.0100\,mol\,dm^{-3}$.

(a) Suggest a solution which could be used to stop the reaction in Step 4.

(1)

keep the flask containing the solution in an ice bath.

2 The equation for the acid-catalysed reaction of iodine with propanone is

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + H^+(aq) + I^-(aq)$$

The change of iodine concentration with time was investigated.

Procedure

Step **1** 50.0 cm³ of a solution of 0.0200 mol dm⁻³ iodine was measured into a conical flask. The flask was kept in a water bath maintained at room temperature throughout the experiment.

Step **2** 25.0 cm³ of a solution of 1.00 mol dm⁻³ propanone and 25.0 cm³ of 1.00 mol dm⁻³ sulfuric acid were measured into a second conical flask.

Step **3** The mixture of propanone and acid was added to the iodine, a clock started and the conical flask shaken.

Step **4** After about one minute, a 10.0 cm³ sample of the reaction mixture was removed, using a pipette fitted with a pipette filler. The sample was run into a flask containing a solution which stopped the reaction.

Step **5** At approximately three-minute intervals, the procedure in Step **4** was repeated several times.

Step **6** Each sample of the mixture produced at the end of Step **4** was titrated with sodium thiosulfate solution of concentration 0.0100 mol dm⁻³.

(a) Suggest a solution which could be used to stop the reaction in Step **4**.

(1)

~~Not~~ Sodium HydrogenCarbonate or ~~too~~ NaHCO₃ or NaOH.

Question 2 (b)

Very few candidates realised that it takes time to deliver a sample from a pipette, and therefore the time should be measured at a specific point in the process. The usual procedure is to start timing when half the solution has run out of the pipette. On this occasion a mark was allowed for answers stating that timing should start immediately after all the solution has been transferred.

Answers such as "as soon as the reaction has stopped" were not allowed as there is no way of being certain that this stage has been reached. Common suggestions were to wait for one minute after adding the sample, or to wait for a colour change.

(b) At what point in Step **4** should the time be recorded?

(1)

when the sample was run into the flask, the stop watch should have started and measured the time taken to stop the reaction.

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Answers like this did not score, unless it was clear that the stop watch should be started as soon as the sample was run into the flask.

(b) At what point in Step **4** should the time be recorded?

(1)

When half of the sample removed from the reaction mixture has been poured into the quenching solution.

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Examiner Comments

This is an example of an answer which scored the mark.

Question 2 (c) (i)

This question was surprisingly poorly answered. Many candidates carried out unnecessarily complicated calculations, as very few saw the obvious scale factor. Some merely calculated the number of moles of iodine. Others managed the value of 0.01 and then gave it the wrong units.

(c) (i) Calculate the concentration, in mol dm^{-3} of the iodine solution immediately after mixing with the acidified propanone at the start of the reaction.

(1)

$$\frac{25 \times 1}{1000} = 0.025 \, moles$$

$$0.025 = \frac{50 \times conc}{1000}$$

$$= \boxed{0.5 \, mol \, dm^{-3}}$$

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Examiner Comments

This candidate has calculated the concentration of the propanone after mixing with the sulfuric acid, and has used a complicated method. Writing a few words in the calculation, such as "mol iodine =", instead of writing down numbers, might help avoid an error like this.

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Examiner Tip

Always add a few words to show what you are doing in a calculation.

(c) (i) Calculate the concentration, in $mol\,dm^{-3}$, of the iodine solution immediately after mixing with the acidified propanone at the start of the reaction.

(1)

$0.0200\ mol\ =\ 1000\ cm^3.$

$=\ 50\ cm^3$

$\dfrac{50\ \times\ 0.0200}{1000}\ \ \ \ =\ 0.001\ mol\ dm^{-3}$

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Examiner Comments

This calculation shows the number of mols of iodine in 50cm^3 solution, but not the concentration of iodine after it has been mixed with propanone and acid.

Question 2 (c) (ii)

This was a question which showed clearly whether candidates understood that rate is a measure of change of concentration with time.

The first 2 marks were usually gained even if the candidate could not complete the calculation. For the third mark candidates had to calculate the change in concentration and divide by 70, the number of seconds which had elapsed. The change in concentration should have been based on the answer to (c)(i), and candidates who found that the initial iodine concentration was less than the concentration after 70 seconds should have had another look at their answer to (c)(i). There was some poor rounding e.g. 0.00925 to 0.01. Candidates should look at the number of significant figures given in the data, and give answers to the same degree of accuracy.

(c) (i) Calculate the concentration, in $mol\,dm^{-3}$, of the iodine solution immediately after mixing with the acidified propanone at the start of the reaction.

(1)

$0.025 \times l = 0.025\,mol$

$$\frac{0.025}{0.05} = 0.5\,mol/dm^3$$

(ii) The iodine present in a 10.0 cm³ sample of reaction mixture after reacting for seventy seconds was titrated with 0.0100 mol dm⁻³ sodium thiosulfate solution. The titre was 18.50 cm³.

The equation for the reaction of iodine with thiosulfate ions is

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$
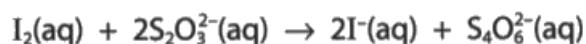
Calculate the concentration of iodine after 70 s.

Hence calculate the mean rate of change of iodine concentration in the first 70 s of the reaction. Include units with your answer.

(4)

$0.0185\,dm^3 \times 0.01 = 1.85 \times 10^{-4}\,mol$

$$2 \quad : \quad 1$$
$$1.85 \times 10^{-4} \quad : \quad 9.25 \times 10^{-5}$$

$$\frac{9.25 \times 10^{-5}}{0.01} = 9.25 \times 10^{-3}\,mol/dm^3$$

.010

$0.01\,dm$

$$0.5 - 9.25 \times 10^{-3} = 0.491\,mol/dm^3$$

(c) (i) Calculate the concentration in $mol\,dm^{-3}$, of the iodine solution immediately after mixing with the acidified propanone at the start of the reaction.

(1)

Moles of propanone = $25 \times 10^{-3} \times 1.00$

= 0.025 moles.

Moles of I_2 used up

Moles of I_2 used = 1×10^{-3} moles.

Moles of I_2 left = Conc = $\dfrac{1 \times 10^{-3}}{(50+25+25) \times 10^{-3}}$ =

= 0.01 mol dm^{-3}

(ii) The iodine present in a 10.0 cm³ sample of reaction mixture after reacting for seventy seconds was titrated with 0.0100 mol dm⁻³ sodium thiosulfate solution. The titre was 18.50 cm³.

The equation for the reaction of iodine with thiosulfate ions is

$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

$\dfrac{1}{2} \times 1.85$

Calculate the concentration of iodine after 70 s.

Hence calculate the mean rate of change of iodine concentration in the first 70 s of the reaction. Include units with your answer.

(4)

Moles of $Na_2S_2O_3$ used = $18.5 \times 10^{-3} \times 0.01$

= 1.85×10^{-4} moles.

Moles of I_2 it reacted with = $(1.85 \times 10^{-4}) \div 2$.

= 9.25×10^{-5} moles was present in 10 cm³ of the solution.

∴ In 100 cm³ amount of I_2 remaining =

$9.25 \times 10^{-5} \to 10\ cm^3$

$x \to 100\ cm$ = 9.25×10^{-4} moles

∴ Concentration of I_2 after 70 s =

$\dfrac{9.25 \times 10^{-4}}{100 \times 10^{-3}} = 9.25 \times 10^{-3}$ mol dm⁻³.

∴ Rate of change = 9.25×10^{-5} $\dfrac{(0.01 - 9.25 \times 10^{-3})}{70s}$

= 1.071×10^{-5} mol dm⁻³ s⁻¹

Question 2 (c) (iii)

This question shows experimental results. The volume of sodium thiosulfate is proportional to the concentration of iodine, so a plot of iodine concentration against time would look the same as the one in the question. As the plot is a straight line, the rate of reaction is constant and not affected by iodine concentration.

The rate equation shows that iodine concentration does not affect the rate, as iodine is zero order. A common error was to think that the sodium thiosulfate was zero order.

Candidates had to make the link between the rate equation and the experimental results to get both marks.

(iii) Further experiments show that the rate equation for the reaction is

$$rate = k[CH_3COCH_3][H^+]$$

The diagram shows typical results of the original experiment. The volume of sodium thiosulfate is proportional to the concentration of iodine in the reaction mixture.
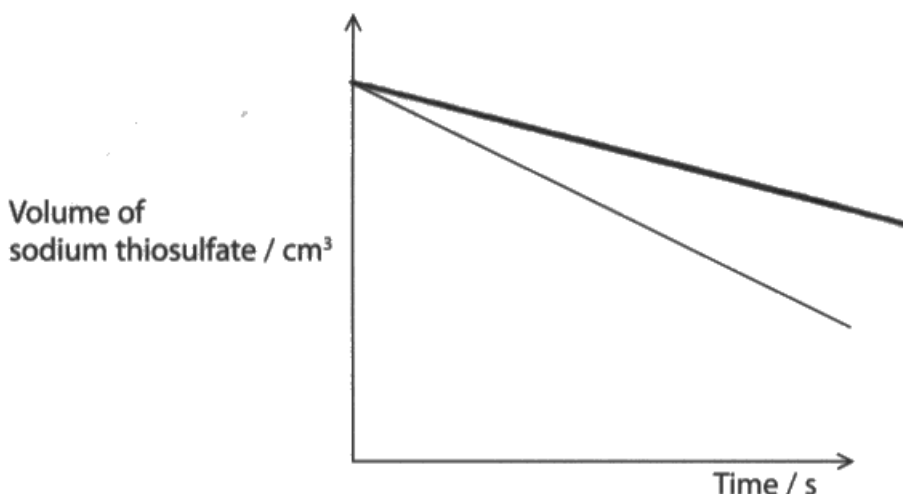
Use the rate equation to explain the appearance of the diagram.

(2)

The rate equation shows the order of both [CH₃COCH₃] and [H⁺] are one, but it also suggests that the order with respect to sodium thiosulfate is zero. As the graph of volume of sodium thiosulfate against time shows a constant gradient, this also tells us that order is zero.

(iii) Further experiments show that the rate equation for the reaction is

$$\text{rate} = k[CH_3COCH_3][H^+]$$

The diagram shows typical results of the original experiment. The volume of sodium thiosulfate is proportional to the concentration of iodine in the reaction mixture.

Volume of
sodium thiosulfate / cm³

Time / s
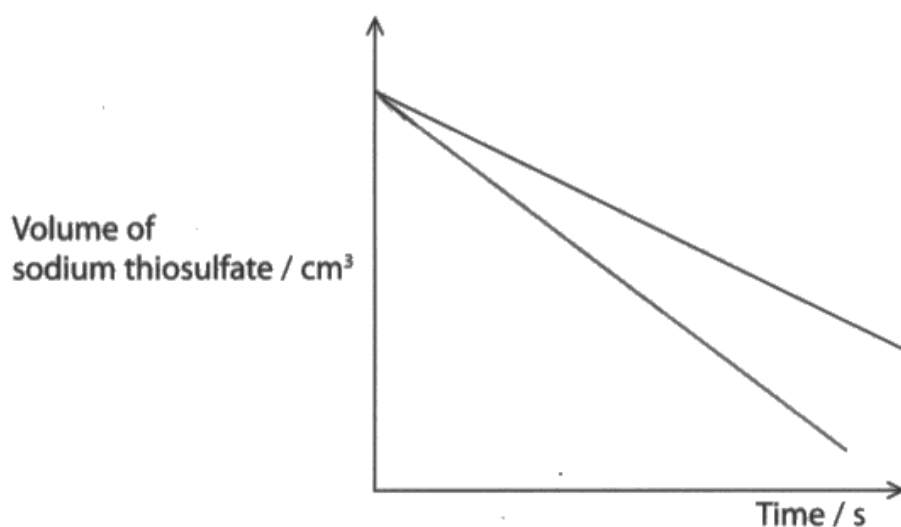
Use the rate equation to explain the appearance of the diagram.

(2)

We can see that iodine isn't present at the rate equation so it's order must be zero. This is showed at the graph as the gradient concentration decreases constantly and the graph shows a negative straight slope.

Question 2 (c) (iv)

Many candidates missed the fact that the concentration of iodine is unchanged in the repeat experiment, so the second line starts from the same point as the first. Its gradient is half as much because the concentration of propanone is halved.

The mark was allowed as long as the gradient was less than in the original experiment, even if not half.

Many candidates stated correctly that the rate in the repeat experiment was lower, but drew a steeper line.
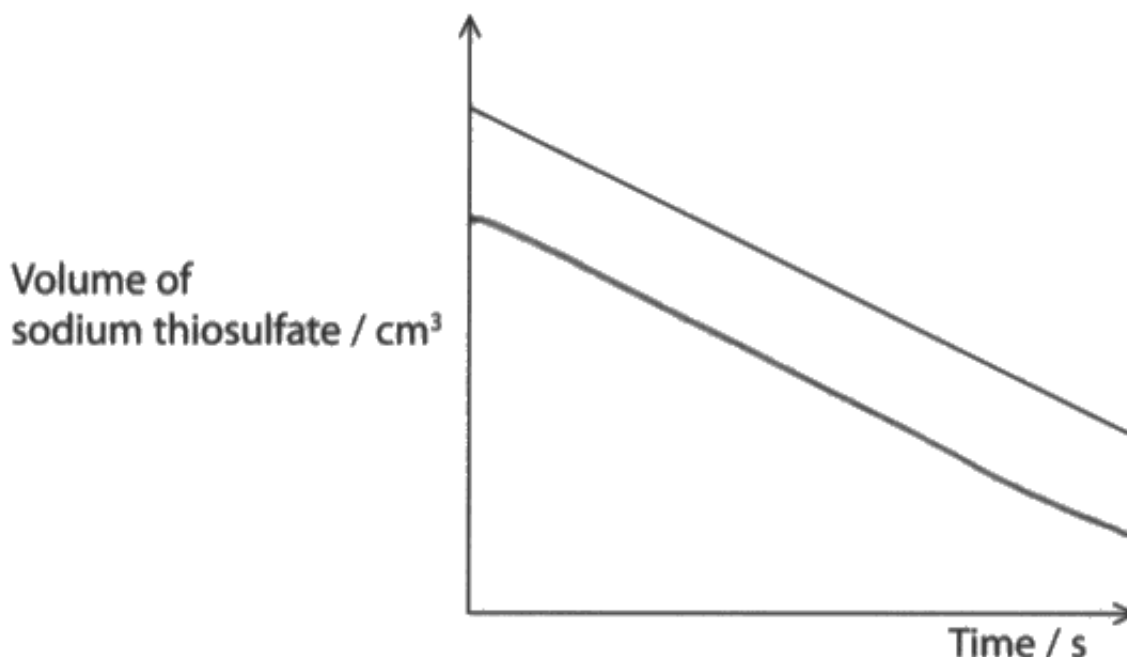
(iv) The experiment was repeated in which the only change was using 25 cm³ of 0.500 mol dm⁻³ propanone in Step **2** instead of 25 cm³ of 1.00 mol dm⁻³ propanone.

Add a line to the diagram in (c)(iii) to show the results which would be obtained in this repeat experiment.

(1)

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This incorrect answer was seen regularly. The parallel lines imply that the repeat experiment goes at the same rate as the original.
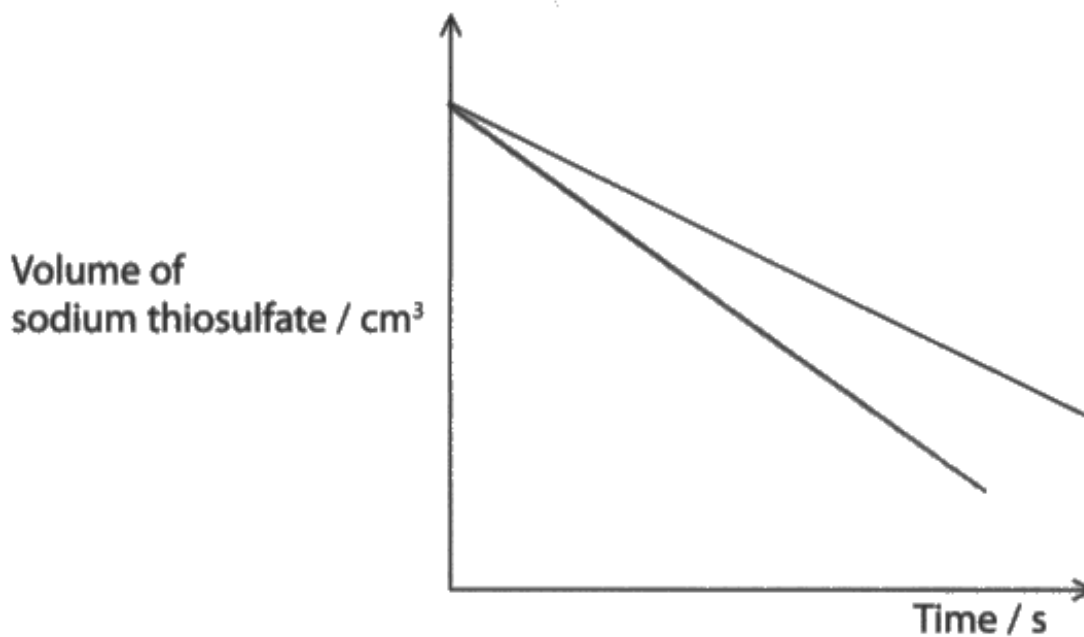
Volume of sodium thiosulfate / cm³

Time / s

(iv) The experiment was repeated in which the only change was using 25 cm³ of 0.500 mol dm⁻³ propanone in Step **2** instead of 25 cm³ of 1.00 mol dm⁻³ propanone.

Add a line to the diagram in (c)(iii) to show the results which would be obtained in this repeat experiment.

(1)

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Examiner Comments

This was a common error. Candidates who said that the rate of the repeat experiment was lower than the original still drew a steeper line.

Question 2 (c) (v)

Most candidates scored a mark for stating that the reaction was first order with respect to propanone. When the concentration of propanone is halved, the rate is also halved, and it was not enough just to say that the rate was reduced.

(v) Explain, using the rate equation, any difference in the results of the repeat experiment.

(2)

As concentration of propanone is lower, the product of Rate constant (k), concentration of propanone cel concentration of H$^+$ would be smaller. So the rate would lower than previous experiment.

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This candidate realises that the rate in the repeat experiment would be lower but does not say it would be half the original, and does not relate the result to the rate equation.

Question 2 (d)

This was a high scoring question. Nearly all answers named starch as the indicator, and gave the correct colour change at the end point. Marks were sometimes lost by saying that starch was added at the end-point, rather than close to it.

(d) The titration was carried out using an indicator. Name the indicator and state when it is added. Give all the colour changes involved.

(3)

When the mixture turns from pale yellow to colourless, a few drops of starch indicator are added, which forms a black solution in presence of any remaining Iodine. It goes colourless upon addition of more thiosulfate which reacts with the remaining Iodine.

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This answer lost the second mark as it is too late to add starch when the mixture has turned colourless.

(d) The titration was carried out using an indicator. Name the indicator and state when it is added. Give all the colour changes involved.

(3)

A freshly prepared starch ~~solooob~~ solution is added as the indicator
The indicator is added when the mixture turns pale yellow. The colour changes from blue-black to colourless.

Question 3 (a) (b)

Many candidates did not score in (a) as they did not realise that an acid is needed for the redox reactions to occur. Hydrochloric acid was not allowed as it can be oxidised by manganate(VII) ions.

Nearly all candidates knew the need for a salt bridge, or piece of filter paper linking the half cells, and many knew that potassium nitrate is the best compound to use in the salt bridge. The chosen compound must be soluble, and must not contain ions which could take part in redox reactions with the other compounds in the cell.

3 A student set up a cell in an attempt to investigate whether potassium manganate(VII) is a stronger oxidising agent than potassium dichromate(VI).
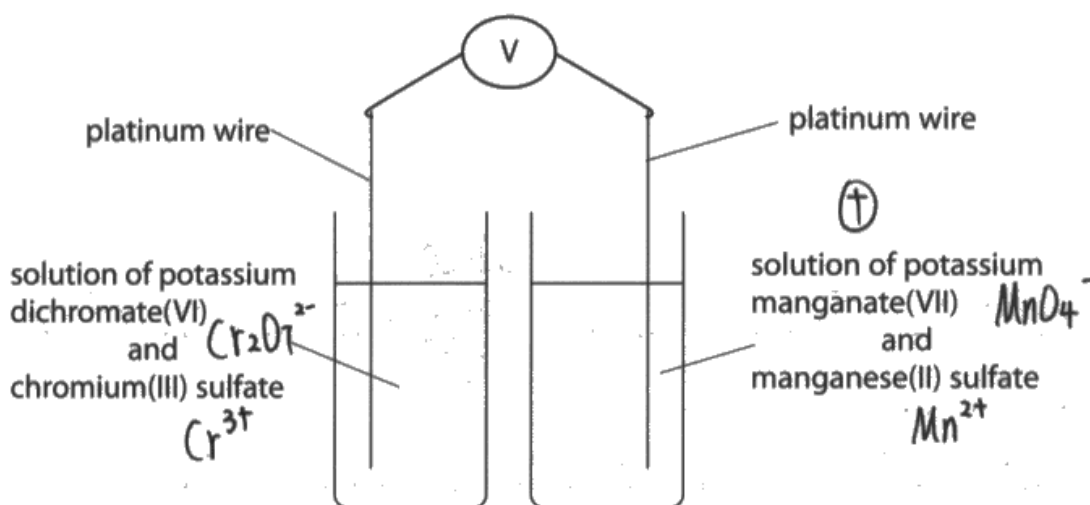
The concentration of each of the solutions was 0.100 mol dm⁻³.

(a) What **compound** must be added to both beakers to allow redox reactions to occur?

(1)

solution that has conductivity ~~KNO₃ solution~~ 'electroylte'

(b) What must be added to the set-up to complete the cell? Name the item and any chemicals which are needed.

(2)

"salt bridge"
filter paper soaked in KNO₃ solution

An electrolyte is needed for the salt bridge, but this is not a correct answer to (a).

In (b) the candidate could have named either a salt bridge or a piece of filter paper. Both terms were not needed.

Question 3 (c) (i)

This was a challenging question that showed whether candidates could use an experimental result to deduce the relative strength of oxidising agents. Answers as to which substance was the stronger oxidising agent were poorly expressed, and candidates struggled to produce coherent answers that did not contradict themselves. Few related the polarities of the electrodes to the direction of electron flow.

Electrons flow to the positive electrode. Manganate(VII) ions accept electrons and become reduced, so potassium permanganate is the stronger oxidising agent.

Candidates sometimes confused the use of the terms of "anode" and "cathode" with their use in electrolysis. In some the change in oxidation numbers (+7 to +2 as opposed to +6 to +3) was suggested as the explanation. Many answers restated the question without relating the voltmeter result to the chemical change.

(c) (i) The voltmeter showed that the right-hand half-cell contained the positive electrode.
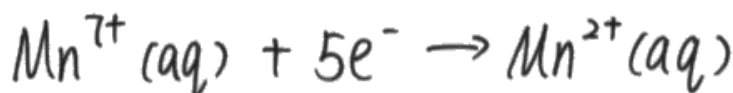
Use this information to deduce whether potassium manganate(VII) is a stronger oxidising agent than potassium dichromate(VI). Explain how you made your deduction.

(2)

Yes, Potassium magne manganate is a stronger oxidisigen oxidising agent compared with potassium dichromate because in right hand cell is gain electron which means it's an oxidising agent.

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The candidate was awarded one mark for identifying potassium manganate as the stronger oxidising agent which gains electrons, but this was not related to the sign of the electrode which was necessary for the second mark.

(c) (i) The voltmeter showed that the right-hand half-cell contained the positive electrode.

Use this information to deduce whether potassium manganate(VII) is a stronger oxidising agent than potassium dichromate(VI). Explain how you made your deduction.

(2)

Because an oxidising agent is reduced that is it gains electron. Since electrons flow from negative terminal to positive terminal, so potassium manganate (VII) gains electron hence it is stronger. If it was not the case then, current will not pass through the cell.

Question 3 (c) (ii)

The reaction which occurs is the reduction of manganate(VII) ions to mangansese(II) ions, but if candidates thought that potassium dichromate(VI) was the stronger oxidising agent they should have written the equation in reverse. The equation should be a very familiar one, but there were many mistakes both in formulae and in balancing.

(c) (i) The voltmeter showed that the right-hand half-cell contained the positive electrode.

Use this information to deduce whether potassium manganate(VII) is a stronger oxidising agent than potassium dichromate(VI). Explain how you made your deduction.

(2)

the electrons of the cell is flowing from left to right.
so $KMnO_4$ is a stronger oxidising agent than $K_2Cr_2O_7$,
it is better at attracting electrons.

(ii) Write the half-equation for the reaction which occurs in the right-hand half-cell when a current flows.

(1)

$MnO_4^-{(aq)} + 5e^- \rightleftharpoons Mn^{2+}{(aq)} + 4H_2O$

$$Mn^{7+}(aq) + 5e^- \rightarrow Mn^{2+}(aq)$$

(c) (i) The voltmeter showed that the right-hand half-cell contained the positive electrode.

Use this information to deduce whether potassium manganate(VII) is a stronger oxidising agent than potassium dichromate(VI). Explain how you made your deduction.

(2)

The more positive the half cell, the higher the tendancy of reduction. That means potassium dichromate (VI) is a stronger oxidizing agent since the left hand side has higher tendancy to get oxidized.

(ii) Write the half-equation for the reaction which occurs in the right-hand half-cell when a current flows.

(1)

$$5e^- + 4H_2O + Mn^{2+} \longrightarrow MnO_4^- + 8H^+$$

Question 3 (d)

Even though most candidates thought that potassium manganate(VII) was a better oxidising agent than potassium dichromate(VI) they gave the well known colour change, familiar in organic reactions, of orange to green.

In the cell, the manganate(VII) ions cause oxidation of the chromium(III) ions, so the green Cr^{3+} ions will turn to orange $Cr_2O_7^{2-}$.

(d) What colour change would be observed in the left-hand half-cell when a current has been flowing for some time?

(1)

green

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The question asked for a colour change, so naming one colour does not get the mark.

(d) What colour change would be observed in the left-hand half-cell when a current has been flowing for some time?

(1)

orange to dark green, to orange

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Dark green was allowed here, so this scored the mark.

Question 3 (e)

Many candidates said that the pressure should be 1 atm. It is a necessary condition when a standard hydrogen electrode is used but it is irrelevant here as there are no gases in the electrodes.

The required answer was the concentrations of the solutions. A few said that potassium manganate(VII) should have concentration 1 mol dm^{-3} and stopped there, implying that the concentration of manganese(II) sulfate did not matter. The mark was not awarded in that case.

(e) What change, other than keeping the temperature at 298 K, would be needed to make the right-hand half-cell standard?

(1)

1 mol dm^{-3} of manganate(VII) ions.

(e.g. 1 mol dm^{-3} KMnO$_4$)

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This answer should refer to the concentration of manganese(II) sulfate as well as the manganate(VII) ions so the mark was not awarded.

(e) What change, other than keeping the temperature at 298 K, would be needed to make the right-hand half-cell standard?

(1)

gas temperat pressure must be kept at standard

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Examiner Comments

This was the most common incorrect answer. Atmospheric pressure is not a factor when there are no gases reacting in the electrode.

Question 3 (f)

This question proved to be surprisingly difficult. In past examinations there have been many questions asking for use of electrode potential data to predict the products of a reaction.

Many answers seemed to be giving the endpoint for a manganate(VII) titration. These answers, like those in 3(d), suggest that candidates are learning specific answers to practical scenarios but do not understand how to use this knowledge when expressed in an alternative situation.

The peroxodisulfate ion is an even stronger oxidising agent than the manganate(VII) ion. However +7 is the highest oxidation state of manganese, so in (i) no reaction will occur. The mixture will remain purple.

In (ii) the manganese(II) ions will be oxidised to manganate(VII) ions and the solution will turn purple. Manganese(II) sulfate is a pale pink solid, but its solution is colourless, so the answer pink to purple was not allowed. However in very dilute solutions the mangante(VII) ions look pink, so colourless to pink scored the mark.

reduction

(f) The standard electrode potential of the right-hand half-cell, measured at 298 K, is +1.51 V.

The standard reduction potential of another system is given.

Electrode reaction	$E^\ominus$/V
$S_2O_8^{2-}(aq) + 2e^- \rightarrow 2SO_4^{2-}(aq)$	+2.01

reduction

Aqueous sodium peroxodisulfate, $Na_2S_2O_8$, is a colourless solution containing $S_2O_8^{2-}(aq)$ ions.

State all the observed colours and any colour changes that would be expected if a solution of sodium peroxodisulfate is added to

(i) potassium manganate(VII) solution.

(1)

Colourless

(ii) manganese(II) sulfate solution.

(1)

Colourless to purple.

Question 4 (a)

A wide variety of tests was suggested here.

Phosphorus(V) chloride, sodium and sodium carbonate were not possible answers as they would react with the carboxylic acid group in both compounds. Sodium hydroxide would also react with both, and there would not be anything to see.

The compound used for a simple chemical test should react quickly and give a clearly observable change. Phenol does not contain a CHOH group, so it is not a secondary alcohol which can be oxidised easily. Oxidation of a phenolic compound involves breakdown of the delocalised electron ring; candidates should realise that this does not happen quickly, so potassium dichromate(VI) is not a suitable compound to use.

Candidates should be familiar with the reaction of phenol with bromine water, and this was the expected answer.

4   Salicylic acid is the original name for a compound which can be obtained from the bark of willow trees. The systematic name for salicylic acid is 2-hydroxybenzoic acid.

(a) Give a simple chemical test which is positive for 2-hydroxybenzoic acid but not for benzoic acid. State the reagent you would use and the expected result with 2-hydroxybenzoic acid.

(2)
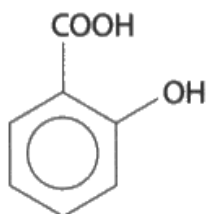
Add   PCl₅ ,   Misty   fumes   will   form .

4 Salicylic acid is the original name for a compound which can be obtained from the bark of willow trees. The systematic name for salicylic acid is 2-hydroxybenzoic acid.
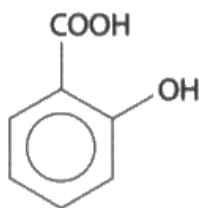
(a) Give a simple chemical test which is positive for 2-hydroxybenzoic acid but not for benzoic acid. State the reagent you would use and the expected result with 2-hydroxybenzoic acid.

(2)

Add sodium, H₂ gas should be given off. makes a 'pop' sound when lit splint is placed near it to confirm H₂ gas.

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Sodium reacts with a carboxylic acid group so would not distinguish the compounds. If the volume of hydrogen per mole was measured for each compound it would differ, but this would not be a simple test.

Question 4 (b) (i)

This was well answered. However the mark was not awarded if a candidate gave two alternative answers, e.g. corrosive and poisonous.

Question 4 (b) (ii)

There were many correct answers here. However some candidates calculated the mass of ethanoic anhydride which was actually used instead of calculating the minimum mass required.

(ii) Calculate the minimum mass, in grams, of ethanoic anhydride needed for the 2.00 g of 2-hydroxybenzoic acid to react completely.

(2)

$$n = \frac{2.00}{138} = \frac{1}{69}.$$

$$m = \frac{1}{69} \cdot 102 = \boxed{1.48g}$$

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Examiner Comments

The final answer is correct so this scored both marks. However candidates should not express values as fractions in final answers.

(ii) Calculate the minimum mass, in grams, of ethanoic anhydride needed for the 2.00 g of 2-hydroxybenzoic acid to react completely.

(2)

$$Moles = \frac{mass}{molar\ mass} \rightarrow$$

$$Moles = CV \rightarrow 0.01$$

$$\frac{2}{138} = \frac{1}{69} = 0.01\ moles$$

$$\therefore 0.01 \times 102 = 1.02g.$$

This is an example of poor rounding of numbers. The number of moles of ethanoic anhydride has been rounded to one significant figure, even though there are three significant figures in the data. This leads to a difference of around 30% in the final answer. The second stage of the calculation was allowed as an error carried forward, but the mark for the first stage was not awarded.

Question 4 (b) (iii)

There were several different ways of doing this calculation. The simplest was to use the density of ethanoic anhydride to calculate the mass of 4.0 cm^3. Many candidates scored this mark.

(iii) Show by calculation that the ethanoic anhydride used in Step **1** was in excess.

(1)

$$\frac{4 \times 1.800}{102} = 0.042 \, mol$$

(iii) Show by calculation that the ethanoic anhydride used in Step **1** was in excess.

(1)

mass = density × volume = 102 × 4 = 1.08 × 4 = 4.32 g. ethanoic anhydride

2hydroxybenzoic acid needs only 2.48, this is more

so it is in excess.

Question 4 (b) (iv)

Again, this calculation was well answered.

Some candidates failed to calculate any mole ratios and thought the percentage was (1.7 x 100)/2. Others calculated the maximum theoretical yield, and compared this with the mass of 2-hydroxybenzoic acid, rather than with the actual yield.

Numbers were often rounded incorrectly in intermediate steps e.g. 65.1669 to 65.16%, 0.014493 to 0.0144. However candidates often left an unrounded number in their calculation and reached the correct final answer, and in that situation incorrect roundings were not penalised.

(iv) A student obtained 1.70 g of aspirin from 2.00 g of 2-hydroxybenzoic acid. Calculate the percentage yield. (2)

Since mol ratio = 1 : 1

$138g = 1mol = 0.01449 mol$
$2g = ?$

0.01449 mol of aspirin produced.

if $180g$ of aspirin = $1mol$
? $\cong 0.01449$

$\dfrac{0.01449 \times 180}{1} = 2.608g$ produced theoretically

Percentage yield $= \dfrac{2}{2.61} \times 100 = 76.7\%$
$= 77\%$

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This scored one mark for calculating the maximum theoretical yield, but this value has not been compared with the actual yield.

(iv) A student obtained 1.70 g of aspirin from 2.00 g of 2-hydroxybenzoic acid. Calculate the percentage yield.

(2)

Theoritical mol of aspirin = 0.0144 mol.

mass of aspirin = $0.0144 \times 180 = 2.608g$.

% Yield $= \dfrac{1.70}{2.608} \times 100 = 65.2\%$

Question 4 (b) (v)

The glaring error in this diagram was that the vertical tube did not have an outer water jacket, so the flask would be flooded with water. A significant number of candidates missed this, and wrote about whether an electric heater should have been used, or whether the water flow was in the correct direction. This may indicate that some candidates have never used a condenser, and do not understand its structure.

A higher proportion of candidates said that the thermometer was in the wrong position. Some wanted to lower it into the reaction mixture rather than making sure the top of the condenser was open. Again, it seems that many candidates lack practical experience in this regard.

(v) A student drew a diagram of the apparatus for the reflux process. The diagram is shown below.
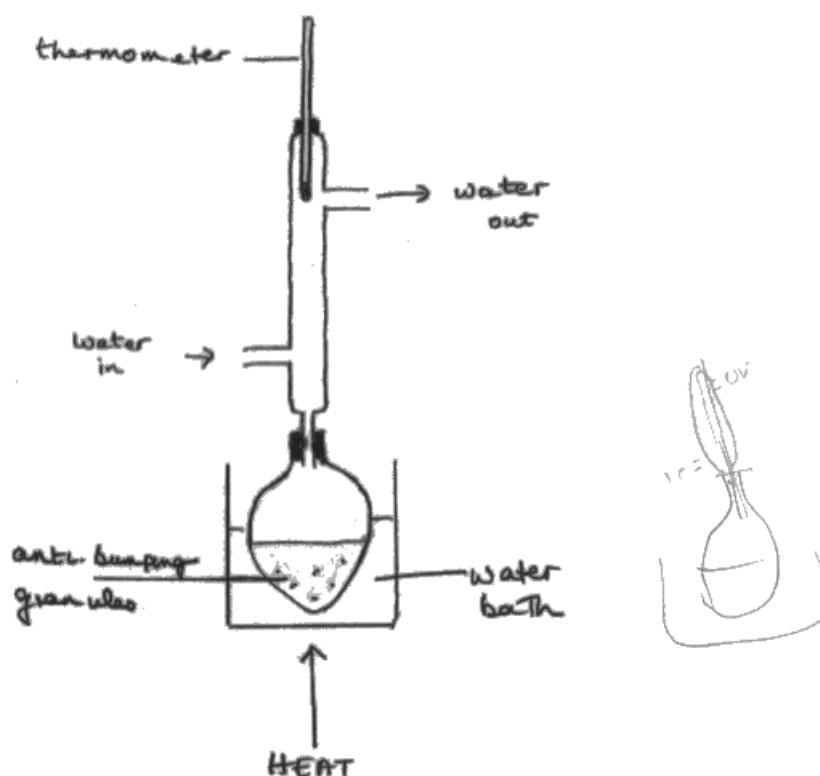
Identify **two** errors in the diagram and state how they should be corrected to make the apparatus workable. Assume that the apparatus is suitably clamped.

(2)

~~The apparatus is complet~~

1. The condenser itself is not present, water will just fall into the mixture being refluxed. Water jacket should be outside the tube with cold water flowing through it.

2. Thermometer is not required. The purpose of this is just to ~~&~~ avoid escape of product/reactant and ensure complete reaction. There is no seperation due to boiling point taking place so no thermometer required. It should just be left open on top.

(v) A student drew a diagram of the apparatus for the reflux process. The diagram is shown below.
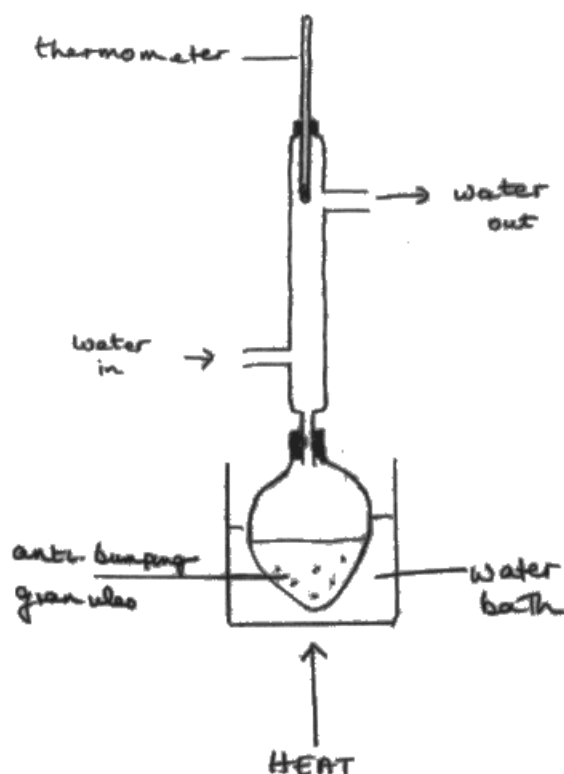
Identify **two** errors in the diagram and state how they should be corrected to make the apparatus workable. Assume that the apparatus is suitably clamped.

(2)

- thermometer must not be placed on top, so remove it
- do not use bung to ... it in reflux system, remove and leave it open.

Question 4 (b) (vi)

The standard of diagrams drawn in this question was poor. Many showed systems which were not sealed. The position of the side arm caused problems – it was drawn on the stem of the funnel or on the neck of the flask. Often the latter meant that the filtrate would go down the side arm into the pump. Some diagrams had dotted lines across the funnel, which usually represent the perforations, but this line was labelled as the filter paper. If a funnel without perforations was shown, but labelled as a Buchner funnel, the first mark was given. There had to be a labelled filter paper and a side-arm flask to gain the second mark; the system had to be sealed and a method of reducing pressure had to be given for the third mark. A small number of answers showed conical funnels labelled Hirsch funnels, and these were given the first mark, but a conical funnel in simple gravity filtration did not score.

This was the only question on the paper where a significant number of answers was left blank, and as question 4(c) was attempted this suggested lack of knowledge of the procedure rather than lack of time.

(vi) Draw a labelled diagram of the funnel and flask used for filtration in Step **5** of the procedure, and state how reduced pressure is achieved.

(3)
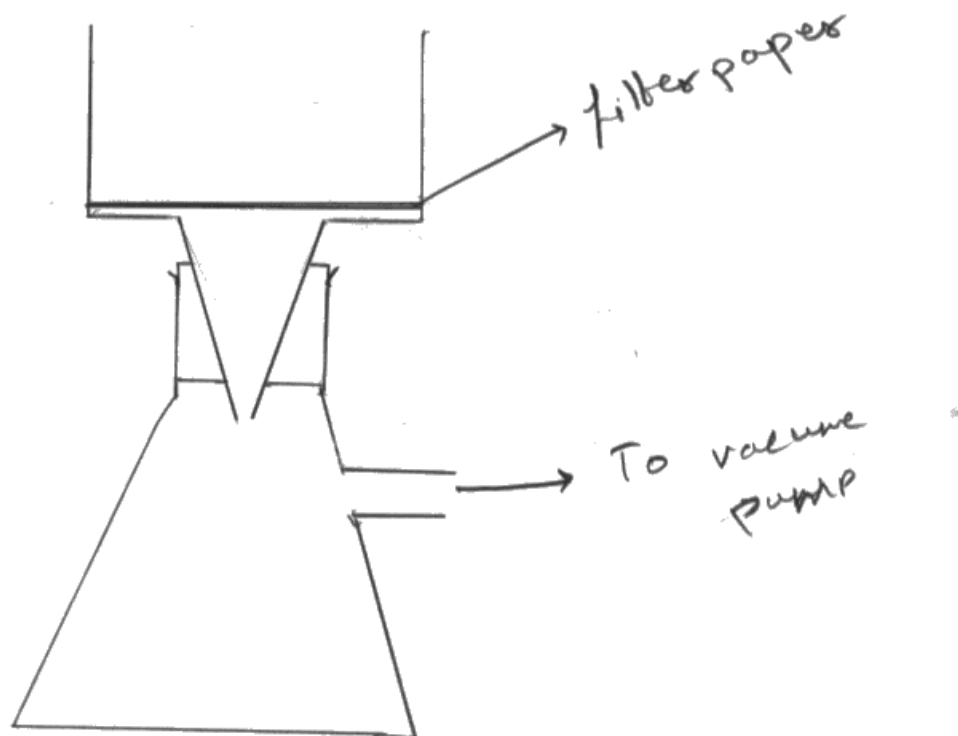
How to achieve reduced pressure: by connecting a pump.

(vi) Draw a labelled diagram of the funnel and flask used for filtration in Step **5** of the procedure, and state how reduced pressure is achieved.

(3)

filter paper

funnel

tube to release gas.

conical flask
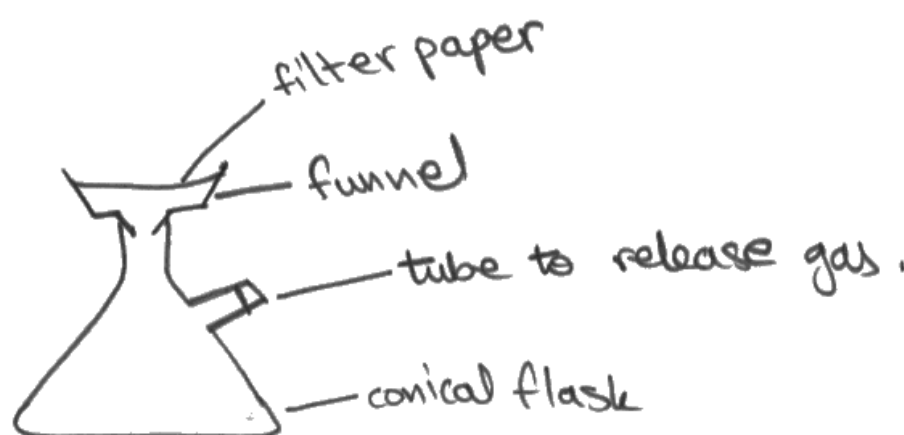
How to achieve reduced pressure: The lid of the tube is opened to releases gases formed.

The shape of this funnel looks like a Buchner funnel, but no perforations are shown and it is not labelled as such. The filter paper and side arm flask are shown correctly. It is probably meant to be a sealed system, though this is not very clear, but the method for achieving reduced pressure is incorrect, so the total score is 1 mark.

Question 4 (c) (i)

The question asked for a molecular formula, not a structural formula, and the fragment suggested had to be one which might reasonably be formed from aspirin. For this reason $C_6H_5CH_3^{(+)}$ or $C_7H_8^{(+)}$ were not allowed. Some candidates drew a benzene ring connected to an oxygen. This answer alone did not score as it would have the molecular formula $C_6H_5O^{(+)}$, and the ring must have only four hydrogen atoms to give the fragment with mass 92. As a general rule, two alternative answers do not score a mark. In this question the mark was allowed if a diagram with a benzene ring was followed by a correct molecular formula, on the assumption that the candidate was working out the structure before giving the final answer.
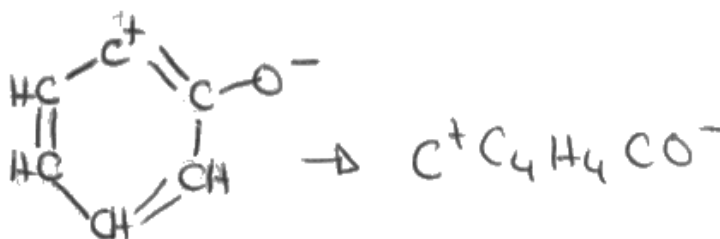
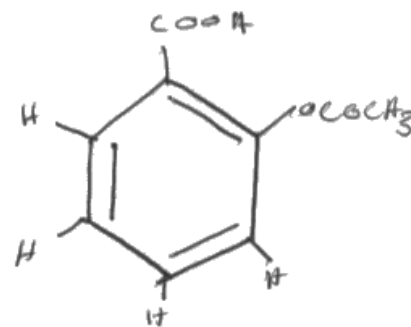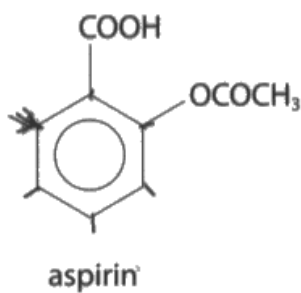(c) (i) The structure of aspirin is given again below.
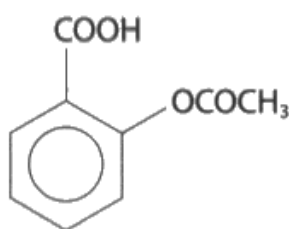
COOH

OCOCH$_3$

aspirin

The mass spectrum of aspirin includes a major peak at $m/e = 92$. Suggest the molecular formula of the fragment which produces this peak.
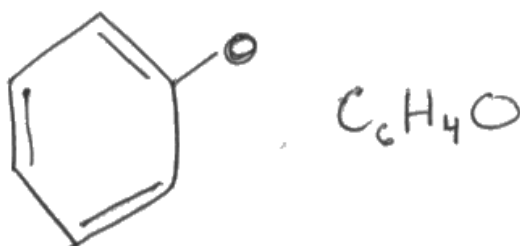
(1)

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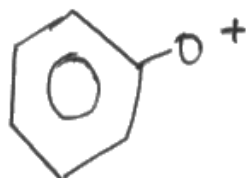
This does not include a molecular formula so does not score.

(c) (i) The structure of aspirin is given again below.
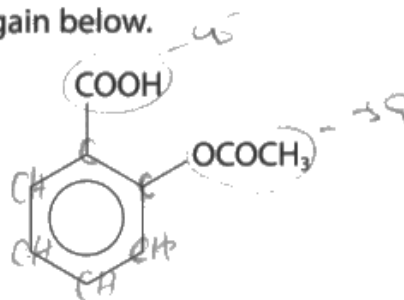
COOH

OCOCH$_3$

aspirin

The mass spectrum of aspirin includes a major peak at $m/e = 92$. Suggest the molecular formula of the fragment which produces this peak.

(1)

$\rightarrow C^+ C_4 H_4 CO^-$

(c) (i) The structure of aspirin is given again below.

COOH

OCOCH$_3$

aspirin

The mass spectrum of aspirin includes a major peak at $m/e = 92$. Suggest the molecular formula of the fragment which produces this peak.

(1)

C_6H_4O

Question 4 (c) (ii)

A variety of answers was seen including many circled carbon atoms. The singlets are produced by the hydrogen atoms on the methyl and hydroxyl groups. However in this paper the mark was allowed if the entire methyl group and entire hydroxyl group were circled.

(ii) The high resolution proton nmr spectrum of aspirin includes two singlet peaks.

On the formula below, which shows the structure of aspirin, circle the atoms which produced these singlet peaks.
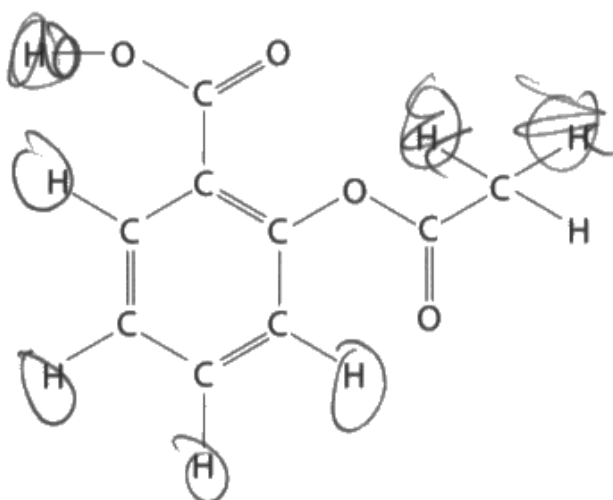
(1)
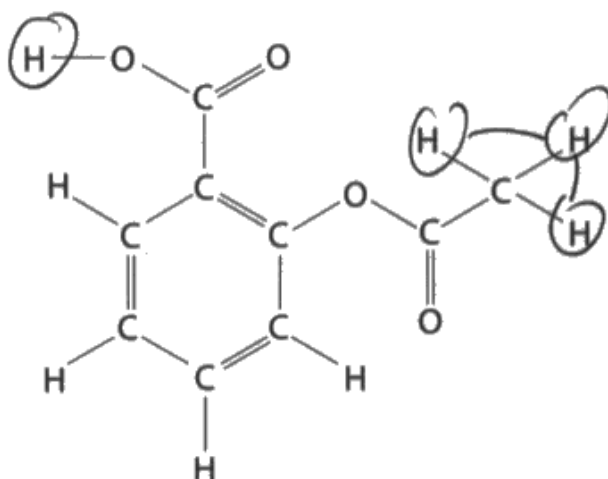
This is an example of a fully correct answer.

(ii) The high resolution proton nmr spectrum of aspirin includes two singlet peaks.

On the formula below, which shows the structure of aspirin, circle the atoms which produced these singlet peaks.

(1)

Paper Summary

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

- Candidates lose marks because they do not read the questions carefully.

- If the formula of a compound is required, it is not enough to give an ion.

- If a molecular formula is required, a structural formula should not be given.

- Giving multiple suggestions in answers will not earn marks if some of the suggestions are wrong.

- Even though calculations are well done, candidates should add a few words to make their methods clear, and not just write down numbers. This might also help them to see what they are doing in a multi-stage calculation.

- Full marks cannot be awarded if numbers are rounded incorrectly, and the incorrect value is used in a later stage.

- If two attempts are made at a calculation, one of them should be crossed out clearly.

- Candidates should take care when writing numbers and symbols so they can be read clearly.

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