

Examiners' report

AS LEVEL

CHEMISTRY B (SALTERS)

**OCR Level 3 Advanced Subsidiary GCE
in Chemistry B (Salters)**

H033

For first teaching in 2015

H033/02 Summer 2025 series

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Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate responses is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the exam paper and the mark scheme can be downloaded from [Teach Cambridge](#).

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Paper 2 series overview

The paper was able to differentiate candidate ability, with a wide spread of results being obtained. The questions asked in the paper were to an appropriate level for the paper and responses required, allowing students to show their understanding and stretch their understanding.

The difficulty of the paper was normal and in line with those of previous years.

There did not seem to be any candidates who ran short of time on the paper and missed answers seemed to be due to a lack of knowledge rather than a lack of time.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• calculated moles • identified alcohol structures • used key terms and ideas in chemistry • used ionisation energy equations • were aware of periodic trends • knew equilibria • K_c expressions and calculating K_c value.	• struggled when applying reagents and conditions required for organic reactions • drew unclear enthalpy profile diagrams and Boltzmann distribution curves or used them incorrectly • could not recall or apply the formula of gases and group 2 hydroxides • found it difficult to apply organic mechanisms to reactions.

Question 1 (a) (i)

- 1 Catalytic converters on cars use metals such as platinum as heterogeneous catalysts.

Catalytic converters turn exhaust emissions such as carbon monoxide and nitrogen monoxide into less hazardous products.

(a)

- (i) Explain the meaning of the term **heterogeneous** here.

.....
..... [1]

This was a good start to the paper for candidates and a large portion were able to correctly describe the term. However, a number of candidates used 'it' when describing the catalyst. Candidates should always make sure the language they use in answers is unambiguous so that credit can be given.

Question 1 (a) (ii)

- (ii) Why is carbon monoxide hazardous?

.....
..... [1]

A number of candidates focused on the idea that carbon monoxide binds to red blood cells and the effect this has on oxygen transport. Few candidates were able to interpret the question as carbon monoxide being toxic.

Question 1 (a) (iii)

- (iii) Write an equation for the reaction of carbon monoxide with nitrogen monoxide to give less hazardous products.

[1]

Understanding formula for gases

A large portion of candidates, when writing the balanced equation, wrote nitrogen as N rather than N₂. This caused candidates to mis-balance the equation and subsequently lose the mark.

Question 1 (a) (iv)

(iv) A simple model to explain the function of a heterogeneous catalyst involves four steps.

Complete **Step 2** and **Step 3** in the sequence below.

Step 1 Reactants are adsorbed onto the surface of the catalyst.

Step 2

Step 3

Step 4 Products are desorbed from the surface of the catalyst.

[1]

Misconception



When describing the steps involved in a catalyst, candidates often referred to intermolecular forces rather than bonds. Others referred to bonds being weakened but not breaking. Although the steps are clearly understood, they are not always clearly described.

Question 1 (b)*

- (b)* Explain how a catalyst increases the rate of a reaction.
Draw an energy profile and a Boltzmann distribution.

.....

.....

.....

.....

.....

..... [6]

Assessment for learning



Although the question states that an energy profile and a Boltzmann distribution curve are both required, a large portion of candidates drew one or the other.

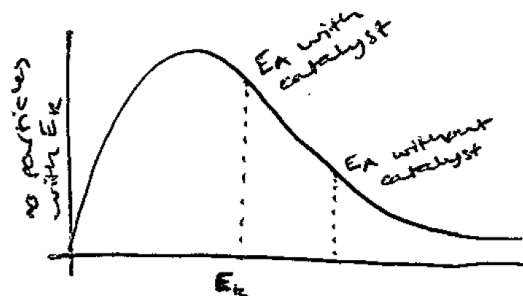
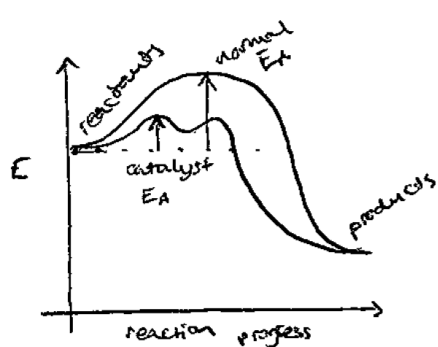
There is a clear understanding showing that candidates know what the two diagrams are, but a number of mistakes can be seen in the graphs.

A common mistake seen is where candidates drew the Boltzmann distribution curve, but rather than showing the presence of a catalyst line to the left of the activation energy, they drew a second curve (showing a change in temperature) and label this as the activation energy. This shows that candidates are merging the two ideas and trying to combine the idea of a different pathway from the enthalpy profile diagram as a Boltzmann distribution curve.

Another common error occurred in the enthalpy profile diagrams. Candidates showed an understanding of the energy curve in the diagram but did not always show two of these.

Practice drawing both graphs and how they relate to changes in the rate of reaction should be focused on in teaching, with students recalling the labels for the diagrams, the shape of them and the changes that occur with catalysts.

Exemplar 1



A catalyst provides an alternative reaction pathway to lower the activation energy for the reaction. It remains chemically unchanged afterwards.

Lower E_a means that more particles have energy $> E_a$, $\therefore$ more particles able to react.

The area under the Boltzmann distribution shows no. particles. The catalyst increases the proportion of particles with $E > E_a$.

This overall means more particles react in a shorter amount of time, leading to increased rate of reaction.

This candidate response is considered a Level 3 response and received 6 marks. Although the graphs are small, they show the correct information regarding the question. They have a clear understanding of the role of catalysts, and this is also shown in the clear communication when explaining the role of catalysts in a reaction and their relation to the two graphs.

Question 2 (a)

2 Ethanol is an important alcohol that is made industrially by the hydration of ethene.

(a) Give the conditions required for this industrial process.

.....

.....

..... [2]

Assessment for learning



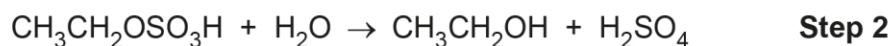
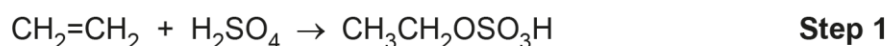
Candidates seem to have gaps in their knowledge regarding reagents and conditions for organic reactions. Candidates were able to remember one of the conditions (stating high temperature and pressure or quoting the correct catalyst of H_3PO_4) but only a few were able to recall both.

Some candidates misread the question, quoting the reagents and conditions required for hydrogenation of an alkene rather than hydration.

More practice at the different reagents and conditions required for organic reactions would help candidates see how these can apply to different reactions.

Question 2 (b)

(b) Ethanol can also be made in the laboratory by a two-step process as shown:



Write the overall equation for this two-step process.

[1]

This was a well answered question with most candidates correctly writing the overall equation. A few candidates did not remove H_2SO_4 and the intermediate and did not score on the question.

Question 2 (c) (i)

- (c) A student does the two-step process in part (b) using an alkene that is a liquid at room temperature. The reaction is exothermic.
- (i) The alkene has a boiling point of 30 °C and is highly flammable.

Suggest a practical arrangement that the student should use to avoid loss of the alkene as a vapour.

.....
..... [1]

Misconception



Many candidates did not identify a suitable practical arrangement for this question. There was an understanding that the reaction is exothermic, but candidate suggestions for this reaction included the use of lids on the reaction chamber to reduce the loss of reactant or stating the reaction should be heated under reflux. Candidates appeared to be using knowledge they have of other organic reactions and how they proceed, rather than considering the steps taken before the reaction equipment is set-up.

A small portion of candidates were able to identify that the reaction should take place in ice or cold-water baths.

Question 2 (c) (ii)

- (ii) When the student has carried out both steps, a mixture is left. This mixture contains an alcohol.

The student finds that drops of this mixture turn bromine water from brown to colourless.

Suggest what this colour change tells the student about the conversion of the alkene into alcohol.

.....
..... [1]

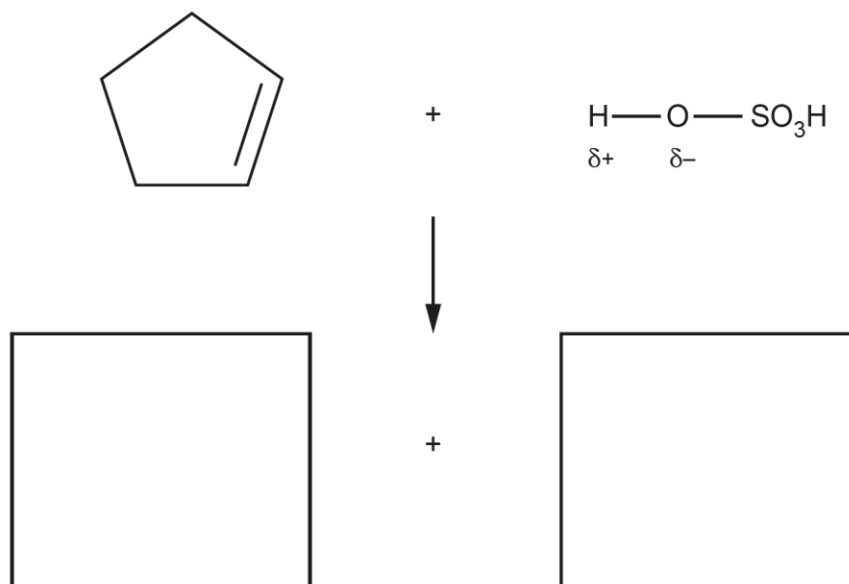
An underlying understanding of the observation of bromine water becoming colourless is shown in the question, but candidates did not always use this to draw the correct conclusions. Some candidates drew the conclusion that the alcohol must have contained a C=C double bond or that the alcohol functional group reacts with the bromine rather than the idea that the reaction was incomplete.

Question 2 (d)

(d) Cyclopentene can be made into cyclopentanol using sulfuric acid.

Complete the first part of **step 1** of the mechanism for the addition of sulfuric acid to form a carbocation.

Show 'curly arrows' and charges.



[4]

Reaction Mechanisms

It is shown in the question that a number of candidates did not understand the organic mechanisms assessed here well. The movement of arrows is not clear, with some candidates drawing arrows on the cyclopentane from a carbon rather than the double bond, from the hydrogen on the $\text{H}-\text{O}-\text{SO}_3\text{H}$ to the cyclopentene double bond or from the H in the $\text{H}-\text{O}-\text{SO}_3\text{H}$ to the oxygen.

Further errors occurred in the intermediates being drawn, with candidates drawing a δ^- charge on $\text{O}-\text{SO}_3\text{H}$, or failing to show the charge on the carbocation intermediate.

This is an opportunity for centres to practice mechanisms for cyclic alkenes as well as those for straight chained alkenes.

Question 2 (e)

(e) Cyclopentene reacts with hydrogen in the presence of a catalyst.

Name a catalyst that allows this hydrogenation to occur at room temperature and pressure.

..... [1]

This, as with Question 2 (a), shows gaps in some candidates' knowledge regarding reagents and conditions. A number of candidates quoted aluminium or aluminium oxide, rather than the correct catalyst of platinum.

Question 2 (f) (i)

- (f) The student then looks at the isomers with the molecular formula C_5H_{10} .
- (i) There are two **unbranched** stereoisomers that are unsaturated with the molecular formula C_5H_{10} .

Draw **skeletal** formulae for these two stereoisomers and give the systematic name of each one, using the *E/Z* nomenclature.

Explain why this type of stereoisomerism arises.

Skeletal formula		
Name		

Explanation

.....

.....

[3]

Assessment for learning



Some candidates have confused *E/Z* isomerism with structural isomerism, showing the structure and name of pent-1-ene and pent-2-ene.

Those that understood the presence of the *E* and *Z* isomer did not always draw these correctly as skeletal formulae was required for the question. Some candidates in attempting to draw these as skeletal formulae sometimes drew the same structure but represented in a different way.

Candidates understood the formation of *E/Z* isomers through the restricted rotation of the $C=C$ bond, but did not always combine this with the idea of there being different groups on each carbon.

Extra practice in the drawing of isomers as skeletal as well as displayed formulae would help candidates to picture these in other formats.

Question 2 (f) (ii)

- (ii) There are other **branched** unsaturated isomers of molecular formula C_5H_{10} .

Give the **name** of **one** of these isomers.

State the **type** of isomerism by which this isomer is related to the stereoisomers in part (f)(i).

Name of isomer

Type of isomerism

[2]

Most candidates were able to identify the isomerism as structural and name the isomer, but some misread the question quoting Z as the type of isomerism.

Question 3 (a) (i)

- 3 A student investigates the reactions of some of the elements and compounds of Group 2.

(a) The student begins by comparing the reactivities of the metals with water.

(i) Write an equation for the reaction of calcium with water.

[1]

Assessment for learning



Candidates could not compose the correct formula for calcium hydroxide, stating this as CaOH rather than $Ca(OH)_2$. This then had a follow-on effect where the candidates misbalanced the equation.

Some others formed calcium oxide in the reaction, mistaking this with the reaction of calcium with oxygen.

Extra practice should be completed when learning the group 2 reactions to make sure candidates understand the balancing of group 2 hydroxides and their formation in water.

Question 3 (a) (ii)

- (ii) The relative reactivities of the Group 2 elements are related to their ionisation enthalpies.

Write an equation for the **first** ionisation enthalpy of calcium.

Show state symbols.

[2]

Most candidates could compose the equation for the first ionisation of calcium. However, the idea that calcium is a solid in its natural state caused candidates to use (s) in the state symbols as opposed to using (g).

Question 3 (a) (iii)

- (iii) Describe and explain, in terms of electrons, the difference between the reactivities of calcium and barium.

.....

.....

.....

.....

.....

..... [4]

Candidates understand their periodic trends. A common error in this question occurred when the candidates referred to calcium as being an atom that can draw in electrons easier than barium, rather than understanding the question regards the loss of electrons between calcium and barium and their relative reactivities.

Question 3 (b)

(b) A student makes a pure sample of hydrated magnesium sulfate using magnesium carbonate.

Describe and explain the method the student should use.

.....

.....

.....

.....

.....

..... [4]

Misconception



A number of candidates on this question mistook the practical for the formation of a hydrated salt with the practical for determining waters of crystallisation. Some candidates also mistook the practical with that for recrystallisation and making a standard solution.

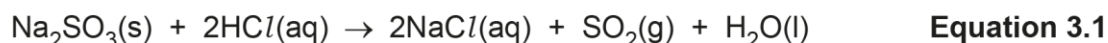
When preparing the solution, some candidates quoted that an excess of acid was required rather than an excess of the carbonate but then stated you would need to filter the remaining solid, losing the first 2 marking points.

Marking point 4 was not well scored for some candidates. This point referred to the need to dry the crystals. Some candidates did not include the need to refilter to remove any extra liquid.

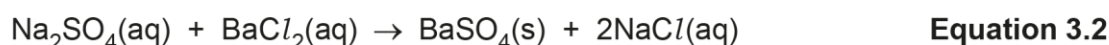
Question 3 (c)*

- (c)* A batch of Na_2SO_3 has partially oxidised to Na_2SO_4 .
Two students each have a 1.00 g sample of this partially oxidised batch.

Each student dissolves their sample in dilute hydrochloric acid.
Only the Na_2SO_3 reacts, as shown in **Equation 3.1**.



Student 1 then adds an excess of barium chloride solution to the resulting solution.
The reaction shown in **Equation 3.2** occurs.



Student 1 washes and dries the precipitate and obtains 0.33 g of dry BaSO_4 ($M_r = 233.4$).

Student 2 repeats the method but uses a volume of barium chloride solution that is **not** an excess.

Use the result from **Student 1** to calculate the percentage by mass of the Na_2SO_3 in the 1.00 g sample.

Explain the effect that the mistakes made by **Student 2** would have on the percentages they calculated.

[6]

A number of candidates, when completing the calculation, mistook the requirement of the task. They successfully determined the mass of Na_2SO_4 using the data given, but did not remove this from the original mass to determine the mass of Na_2SO_3 remaining, and from this calculate percentage by mass. From this the common incorrect answer came out at 20%.

Another common error was the miscalculation of the M_r , with candidates using 126.1 (the M_r for Na_2SO_3) rather than 142.1 (the M_r for Na_2SO_4).

Another common error was seen when candidates discussed the effect of the mistake by Student 2. Although candidates came to the conclusion that BaCl_2 not being in excess would form less precipitate, this caused them to conclude that the percentage by mass would be lower rather than higher.

Exemplar 2

$$\frac{\text{mass}}{n \text{ / } M_r} \quad n(\text{BaSO}_4) = \frac{0.33}{233.4} = 1.414 \times 10^{-3} \text{ mol} = n(\text{Na}_2\text{SO}_4)$$

$$\text{mass}(\text{Na}_2\text{SO}_4) = 1.414 \times 10^{-3} \times 142.1 = 0.2009 \text{ g}$$

$$1 - 0.2009 = 0.7991 \times 100 = 79.91\%$$

$$\% \text{ mass}(\text{Na}_2\text{SO}_3) = 79.91\%$$

Not having BaCl_2 in excess would reduce the yield of

BaSO_4 . Though calculation this would lead to mass of Na_2SO_4

being ^{less} ~~greater~~ than it actually was, $\therefore$ leading to a ~~precise~~

calculated $\% \text{ mass}(\text{Na}_2\text{SO}_3) > 79.91\%$

Fewer $n(\text{BaSO}_4) = \text{fewer } n(\text{Na}_2\text{SO}_4)$

This candidate response is considered a Level 3 response and received 6 marks. The candidate has clearly understood the question and the calculation process required, with them calculating the % mass of Na_2SO_3 rather than mistakenly calculating Na_2SO_4 . This is followed up with a clear understanding of the effect of the mistakes caused by Student 2.

Question 3 (d) (i)

- (d) Five students each do experiments to find the value of x in the formula of the hydrated salt $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$.

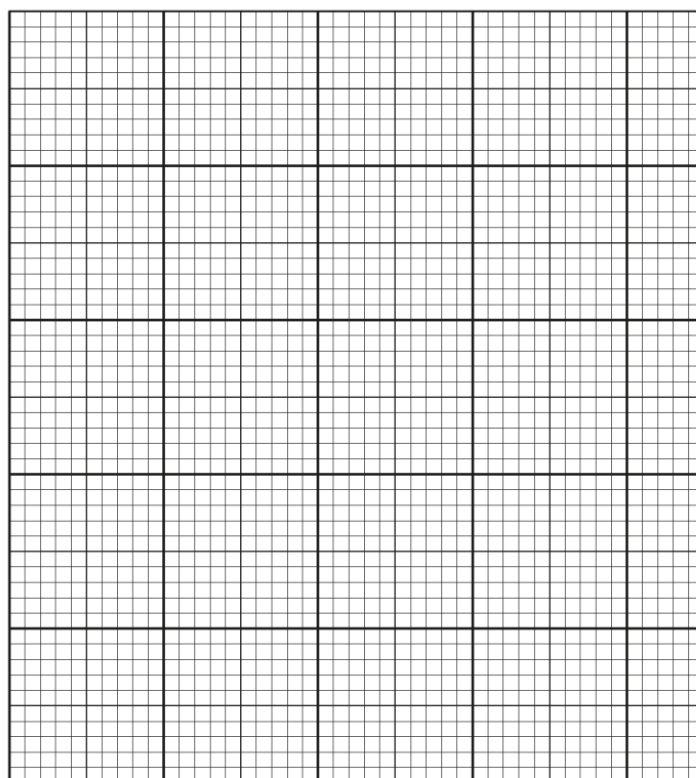
The students heat samples of the hydrated salt to constant mass.
Their results are shown in the table.

	Student				
	A	B	C	D	E
Mass of hydrated salt/g	1.51	1.89	2.50	2.92	3.30
Mass contents after heating/g	0.74	0.92	1.22	1.62	1.61
Mass of water/g	0.77	0.97	1.28	1.30	1.69

- (i) Plot a graph of mass of water against mass of hydrated salt on the graph paper below.

Include the origin.

Draw a line of best fit.



[3]

Candidates made a number of errors in this question.

One error was in the drawing of the axes. Some candidates drew these the wrong way around, with water on the x axis and mass of hydrated salt on the y axis. Another error in the axis was the scale, with some candidates failing to take this back to the 0 origin.

Candidates plotted the points well, but then when drawing the line of best fit did not always make sure it passed through the origin or missed out the anomalous result.

Question 3 (d) (ii)

(ii) Identify the anomalous point and suggest what caused this anomaly.

Anomalous point

Suggested cause of anomaly

[1]

Misconception

Although candidates were confident in their ability to identify the anomalous result, there was a misconception as to why this had occurred.

Candidates often cited the error was due to a miscalibration of the balance, or not weighing enough of the solid, rather than a practical error.

Question 3 (d) (iii)

(iii) Calculate the value of x in the formula $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$. Use the results from **Student C**.

$x =$ [3]

Candidates were able to determine the moles of water, but they often did not determine the mass of anhydrous salt, using a mass of 2.5 rather than 1.22. This led to an error in the calculation with the value of x being determined incorrectly.

Question 3 (e)

- (e) Magnesium exists as three isotopes: magnesium-24, 78.60%, magnesium-25, 10.11% and magnesium-26, 11.29%.

Calculate a value for the A_r of magnesium.

Give your answer to **2** decimal places.

$A_r =$ [2]

The calculation here was generally well done by candidates, with the main error being that candidates did not give an answer to 2 decimal places as required by the question.

Question 4 (a) (i)

- 4 Esters are used as solvents.

- (a) A student reacts propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$, with propan-2-ol, $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$ to prepare an ester.
- (i) Classify propan-2-ol as primary, secondary, or tertiary, explaining your reasoning.

Classification

Reasoning

.....

[2]

This was a well answered question with most candidates correctly identifying the alcohol as secondary. Some candidates did not correctly reason why the alcohol was secondary, but this was the exception rather than a common mistake.

Question 4 (a) (ii)

(ii) Give the reaction conditions that the student should use for this esterification reaction.

.....
..... [1]

As with earlier questions, many candidates again forgot the reaction conditions for this reaction. A large portion of candidates stated that reflux was required but missed the idea that an acid catalyst was required.

Question 4 (a) (iii)

(iii) Write a structural formula for the ester produced in this reaction.

[1]

Assessment for learning



Although candidates understood the formula for the ester, they did not see that the alcohol group was on the second carbon rather than the first. From this, candidates drew the ester as a straight chain, as opposed to adding a branch.

More practice on drawing unusual esters from secondary and tertiary alcohols should be practised in this topic to help students to see the different forms these compounds can take.

Question 4 (b)

- (b) Another student wants to measure the equilibrium constant for the reaction between ethanoic acid, CH_3COOH , and ethanol, $\text{CH}_3\text{CH}_2\text{OH}$.



The student says that at equilibrium the forward and backward reactions have stopped and the composition of the mixture remains constant.

Comment on what the student says, giving the correct chemistry where necessary.

.....

.....

.....

..... [2]

A clear understanding of dynamic equilibrium has been shown by candidates on this question. However, some candidates quoted that the reaction occurs at equal rate but did not mention that the composition remains constant or vice versa.

Question 4 (c) (i)

- (c) The student mixes 20.0 cm^3 ethanoic acid with 20.0 cm^3 ethanol and leaves the mixture to stand for one week at 25°C after which it has reached equilibrium.
- (i) The density of ethanol is 0.790 g cm^{-3} . Calculate the amount (in mol) of ethanol in the 20.0 cm^3 used.

Amount of ethanol = mol [2]

This was a well answered calculation with few candidates failing to score. The most common error from candidates was the incorrect rearrangement of the equation to determine mass from volume and density.

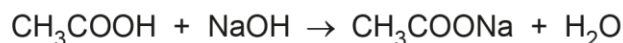
Question 4 (c) (ii)

- (ii) The student then uses a 1.00 cm^3 volumetric pipette to transfer 1.00 cm^3 of the mixture to a conical flask containing 100 cm^3 of ice-cold water.

The student titrates the contents of the conical flask with 0.100 mol dm^{-3} sodium hydroxide.

The mean titre is 29.50 cm^3 .

Ethanoic acid reacts with sodium hydroxide as shown:



Show that the amount of ethanoic acid in the 40.0 cm^3 of the equilibrium mixture is 0.118 mol .

[2]

Candidates were able to calculate the initial moles for the reaction, but having the final answer already forced some candidates to calculate this the wrong way, adjusting their calculation to make sure they could get the correct answer. Many candidates converted the moles to mol dm^{-3} with a further adjustment to dm^3 .

Question 4 (d) (i)

- (d) The student uses further calculations to work out the amounts and concentrations of the four components of the 40.0 cm³ of equilibrium mixture.
- (i) Complete the table by calculating the equilibrium concentration of ethanoic acid.

Component	Equilibrium amount in 40 cm ³ equilibrium mixture /mol	Equilibrium concentration in 40 cm ³ equilibrium mixture /mol dm ⁻³
CH ₃ COOH	0.118	
CH ₃ CH ₂ OH	0.111	2.78
CH ₃ COOCH ₂ CH ₃	0.232	5.80
H ₂ O	0.232	5.80

[1]

This was a well answered question with few candidates calculating the incorrect concentration.

Question 4 (d) (ii)

- (ii) Write the expression for the equilibrium constant for the reaction in **Equation 4.1**.



$$K_c =$$

[1]

It is clear that candidates understand how a K_c expression is constructed.

Question 4 (d) (iii)

(iii) Calculate the numerical value for this equilibrium constant.

Give your answer to an **appropriate** number of significant figures.

Numerical value of equilibrium constant = [2]

Another well answered question with candidates using the values from the table to determine the value for K_c . The main error here appeared where candidates did not give an answer to three significant figures.

Question 4 (e)

(e) Suggest why the student uses a 1.00 cm^3 volumetric pipette and not a small measuring cylinder for transferring 1.00 cm^3 of the equilibrium mixture for the titration.

.....
..... [1]

Candidates understood the principle of the volumetric pipette being more accurate than the measuring cylinder and could therefore score well on this question.

Question 4 (f)

(f) Suggest why the student adds the sample of equilibrium mixture to 100 cm^3 of ice-cold water before carrying out the titration.

.....
.....
..... [1]

Misconception



Many candidates did not score on this question. There is a clear misconception as to why the reaction sample was diluted, with candidates stating this stopped equilibrium rather than preventing it from shifting.

Question 4 (g)

(g) The student is given some values of the equilibrium constant at various temperatures.

As temperature increases, the numerical value of the equilibrium constant decreases.

Explain what the student can deduce about the enthalpy change of the forward reaction in **Equation 4.1** from this information.

.....

.....

.....

.....

.....

..... [3]

Candidates were confident in their determination of the enthalpy change and direction of equilibrium with heat, with a large portion of candidates scoring 2 marks.

However, candidates did not relate this change to Le Chatelier's principle.

Some candidates mistook the information in the question, stating that the change in the value of K_c resulted in the forward reaction being endothermic and therefore more products being made.

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