



Oxford Cambridge and RSA

A Level Chemistry B (Salters)

H433/03 Practical skills in chemistry

Tuesday 27 June 2017 – Morning

Time allowed: 1 hour 30 minutes



You must have:

- the Insert (inserted)
- the Data Sheet for Chemistry B (Salters) (sent with general stationery)

You may use:

- a scientific or graphical calculator



First name

Last name

StemUp Model Solution

Centre
number

Candidate
number

INSTRUCTIONS

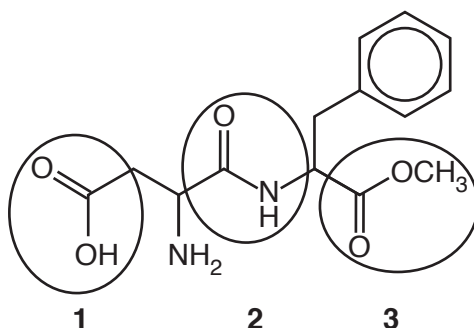
- The Insert will be found inside this document.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- The practical insert is needed with this paper.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION

- The total mark for this paper is **60**.
- The marks for each question are shown in brackets [].
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **16** pages.

Answer **all** the questions.

- 1 A group of students decide to analyse a commercial sweetener. The major component is listed as the dipeptide aspartame.
- (a) The students crush a sweetener tablet and dissolve it in 1 cm^3 of water in a test tube. They add a similar volume of 6.0 mol dm^{-3} hydrochloric acid and some anti-bumping granules. They then cautiously boil the contents for about a minute.
- Suggest the purpose of adding the anti-bumping granules.
- ...To make the liquid boil more gently, with no sudden boiling.....* [1]
- (b) The students expect the aspartame to have been hydrolysed by the hot acid.
- (i) The structure of aspartame is given below with three functional groups (1, 2, 3) ringed.



Name the homologous series for the functional groups 1, 2 and 3.

1*carboxylic acid*.....

2*(secondary) amide*.....

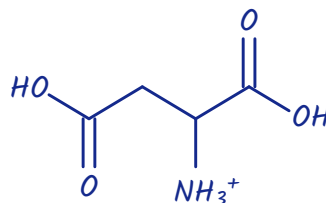
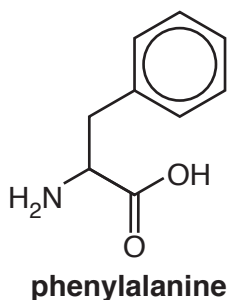
3*ester*.....

[1]

- (ii) Functional group 2 **and** functional group 3 are hydrolysed under the acid conditions to give three products. The products are methanol, and ions formed by the amino acids phenylalanine and aspartic acid.

The structure of the amino acid phenylalanine is given below.

In the box draw the structure of the **ion** formed by **aspartic acid**.

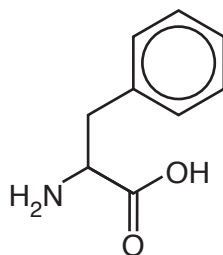


structure of **ion** formed by aspartic acid

[2]

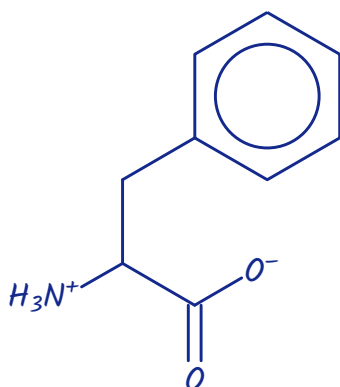
- (iii) Amino acids such as phenylalanine exist as *zwitterions*.

Use the structure of phenylalanine to help explain how amino acids form zwitterions.
Draw the structure of the zwitterion of phenylalanine.



phenylalanine

The acidic COOH group donates H^+ (loses a proton) and the basic NH_2 group accepts H^+ using the lone pair on N: an internal acid to base proton transfer, giving COO^- and NH_3^+ on the same molecule.



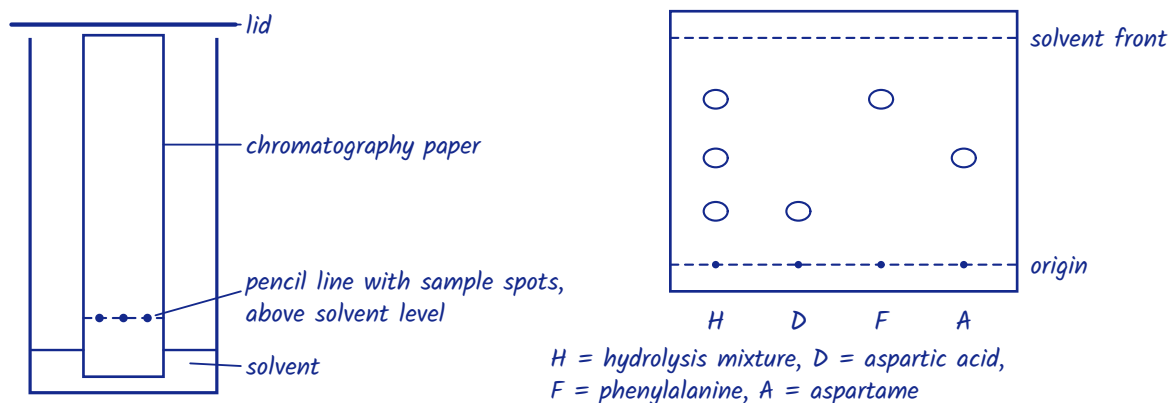
[2]

- (c)* The students wanted to confirm that the aspartame had been hydrolysed to produce the two amino acids, aspartic acid and phenylalanine.

They decided the best way was to use paper chromatography on the solution formed after the hydrolysis reaction.

Describe how the students could carry out the chromatography experiment and explain how they could use their results to show hydrolysis had taken place.

You may include a diagram in your answer.



Draw a pencil line (origin) about 2 cm from the bottom of the paper;
pencil does not dissolve in the solvent.
Using capillary tubes, spot small concentrated samples of the hydrolysis
mixture, pure aspartic acid, pure phenylalanine and aspartame along the line,
evenly spaced.
Stand the paper in a beaker with a little solvent (e.g. butanol, ethanoic
acid and water); the solvent level must be below the pencil line. Cover with
a lid so the air is saturated with solvent vapour.
Remove the paper when the solvent is near the top, mark the solvent front
and dry it. Amino acids are colourless, so spray with a locating agent
(ninhydrin) and warm: purple spots appear.
Results: the hydrolysis mixture gives two spots (three if some aspartame is
left); each pure amino acid gives one spot, at different heights.
The two spots from the hydrolysis mixture are level with the aspartic acid
and phenylalanine spots (same R_f = distance moved by spot $\div$ distance
moved by solvent), so both amino acids are present and hydrolysis has
taken place.

[6]

- (d) The students decided to investigate carbonated drinks such as diet and regular cola. These drinks contain phosphoric acid (to increase the flavour) and aspartame. Regular cola has a lower concentration of acid and keeps for longer than diet cola.

Suggest why regular cola keeps for longer.

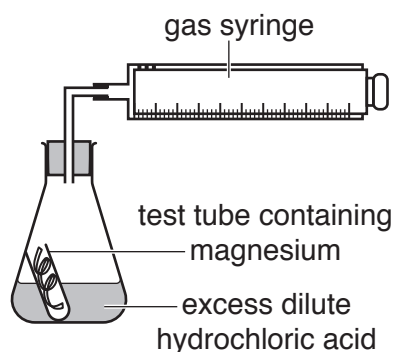
The phosphoric acid catalyses the hydrolysis of aspartame. Regular cola has a lower concentration of acid, so the hydrolysis is slower and the aspartame lasts longer. [2]

- 2 Two students decide to study the reaction of magnesium with dilute hydrochloric acid to find the order of this reaction with respect to the acid.

The equation for the reaction is:



The students use the following apparatus:



- (a) The students run **five** experiments each using a different concentration of hydrochloric acid.

They use the same length of magnesium ribbon each time.

- (i) Why was the length of the magnesium ribbon kept the same?

*So the amount (mass) and surface area of magnesium stay constant
and only the acid concentration affects the rate.* [1]

- (ii) 50 cm³ acid is used each time.
The concentration ranged from 0.1 to 0.5 mol dm⁻³.

Calculate the **maximum** mass of magnesium ribbon that would completely react with the acid in **all** five experiments.

Mg must react completely even at the lowest concentration (0.1 mol dm⁻³):

amount HCl = 0.1 × 50 / 1000 = 0.005 mol

amount Mg = 0.005 / 2 = 0.0025 mol (Mg : HCl = 1 : 2)

mass Mg = 0.0025 × 24.3 = 0.0608 g

mass = ... *0.0608* g [3]

- (iii) Calculate the maximum length of magnesium ribbon needed to completely react with the acid in all the experiments.

The mass per unit length of Mg ribbon = $1.3 \times 10^{-2} \text{ g cm}^{-1}$

$$\text{length} = 0.06075 / 1.3 \times 10^{-2} = 4.67 \text{ cm}$$

$$\text{length} = \dots\dots\dots 4.67 \dots\dots\dots \text{ cm [1]}$$

- (b) The students predict that the reaction will be second order with respect to acid.

Write the rate equation that would be appropriate for this prediction.

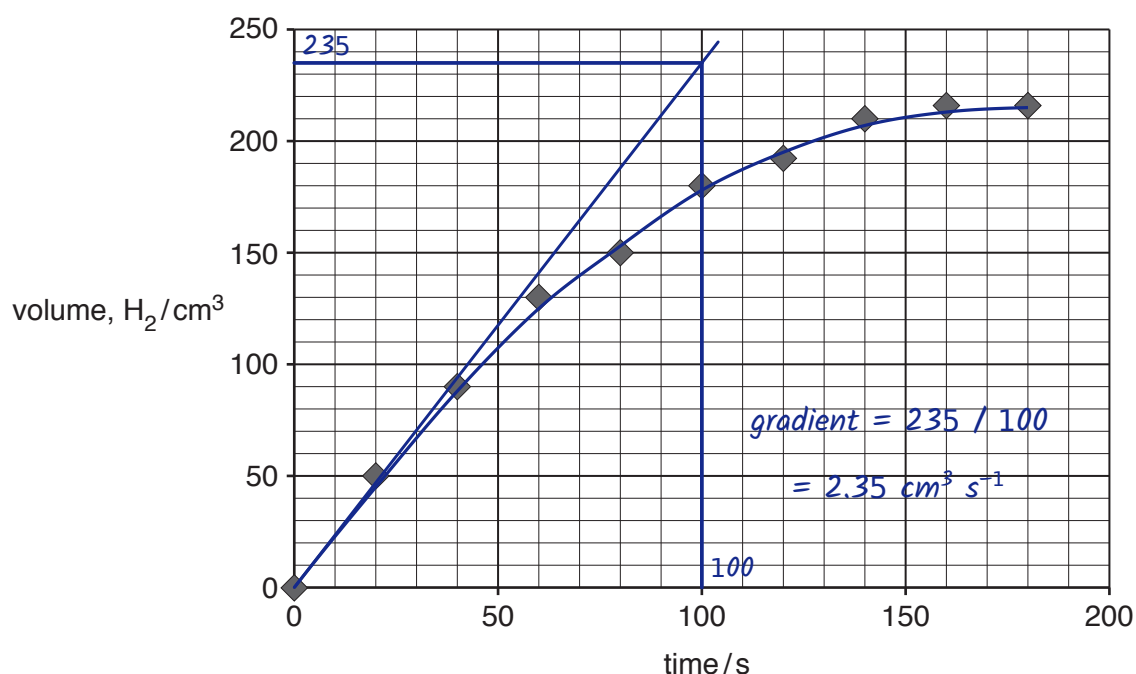
$$\dots\dots\dots \text{rate} = k[\text{HCl}]^2 \dots\dots\dots \text{ [1]}$$

- (c) The students plot a graph of volume of hydrogen against time.
The graph of the results when the concentration of hydrochloric acid is 0.5 mol dm^{-3} is shown below.

Draw a line of best fit on the graph.

Use your line of best fit to calculate the initial rate of reaction at this concentration and give the units.

Show your working on the graph.



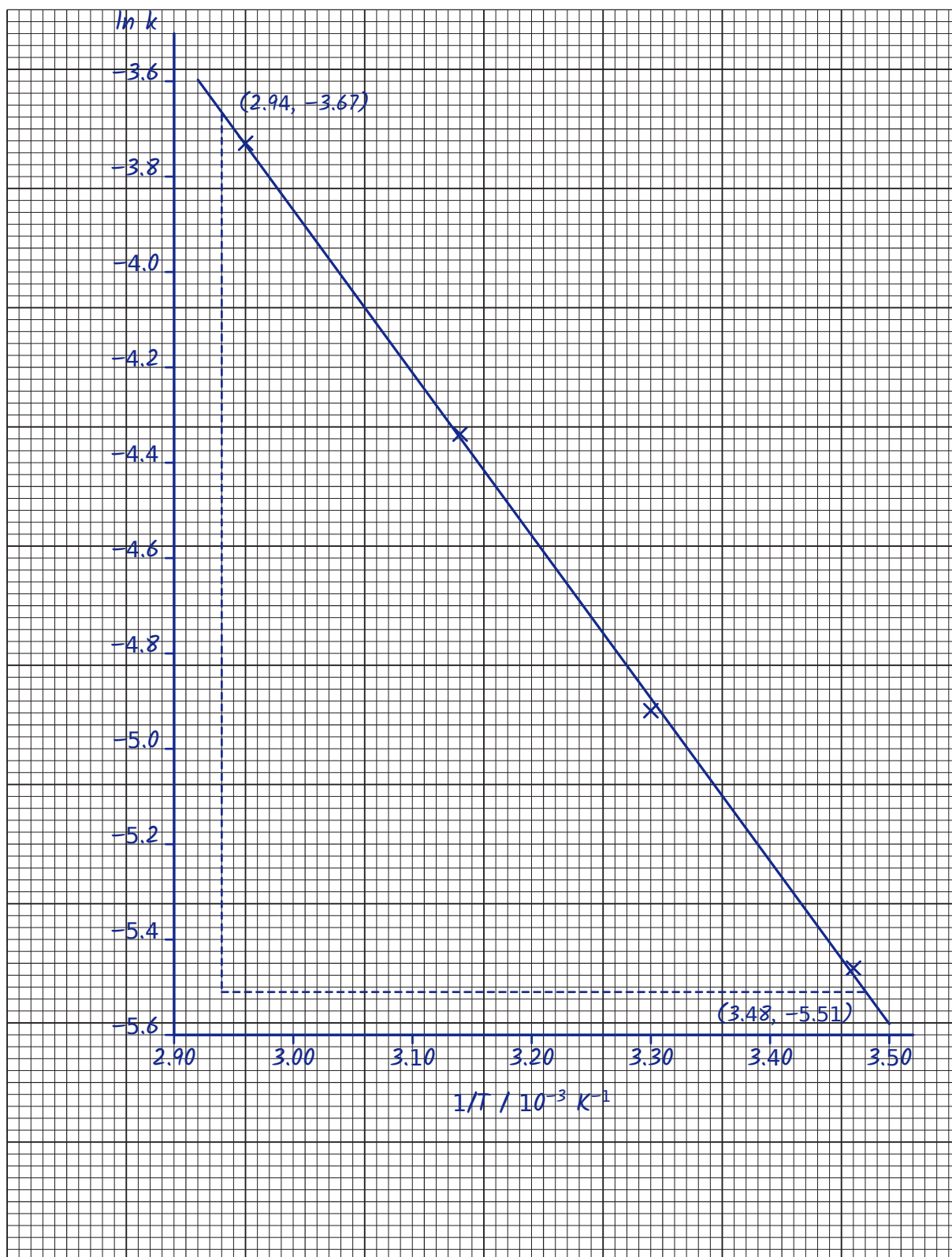
$$\text{initial rate} \dots\dots\dots 2.35 \dots\dots\dots \text{ units } \text{cm}^3 \text{ s}^{-1} \dots\dots\dots \text{ [5]}$$

- (d) The students decide to measure the activation enthalpy for the reaction. They repeat the experiment at different temperatures using a fixed concentration of acid.

The following table shows the data from their experiments.

$\ln k$	Temperature /°C	Temperature, T/K	$1/T/\text{K}^{-1}$ ($\times 10^{-3}$)
-5.46	15.6	288.6	3.47
-4.92	30.3	303.3	3.30
-4.34	45.0	318.0	3.14
-3.73	65.0	338.0	2.96

Use the data to plot a suitable graph on page 9 and work out the activation enthalpy for the reaction.



$$\text{gradient} = \Delta \ln k / \Delta(1/T) = (-5.51 - (-3.67)) / ((3.48 - 2.94) \times 10^{-3}) = -3.41 \times 10^3 \text{ K}$$

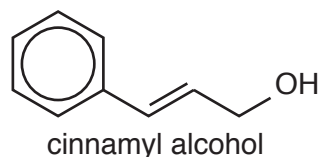
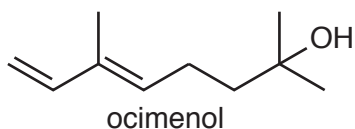
$$\ln k = \ln A - E_a/RT, \text{ so gradient} = -E_a/R$$

$$E_a = 3.41 \times 10^3 \times 8.314 = 2.83 \times 10^4 \text{ J mol}^{-1} = 28 \text{ kJ mol}^{-1}$$

activation enthalpy = ...28..... kJ mol⁻¹ [6]

- 3 A perfume laboratory is investigating the molecules responsible for the smell of some common flowers.

Their investigations suggest that the following two liquid compounds are important in the characteristic smell of hyacinth flowers.



- (a) Acidified dichromate solution can be used to distinguish between these two compounds. Only cinnamyl alcohol can be oxidised using acid dichromate.

Explain why this is so, and describe any colour changes you would expect to see.

Cinnamyl alcohol is a primary alcohol (the C bonded to OH has two H atoms), so it is oxidised by acidified dichromate. Ocimenol is a tertiary alcohol (no H on the C bonded to OH), so it is not oxidised. With cinnamyl alcohol the orange solution turns green; with ocimenol it stays orange.

[2]

- (b) The products of the oxidation of cinnamyl alcohol by acid dichromate differ depending on the conditions. Two experiments are shown below.

Name, in the appropriate boxes below and on page 11:

- the technique used in each set up
- the homologous series of the final product of oxidation

cinnamyl alcohol

oxidising agent

heat

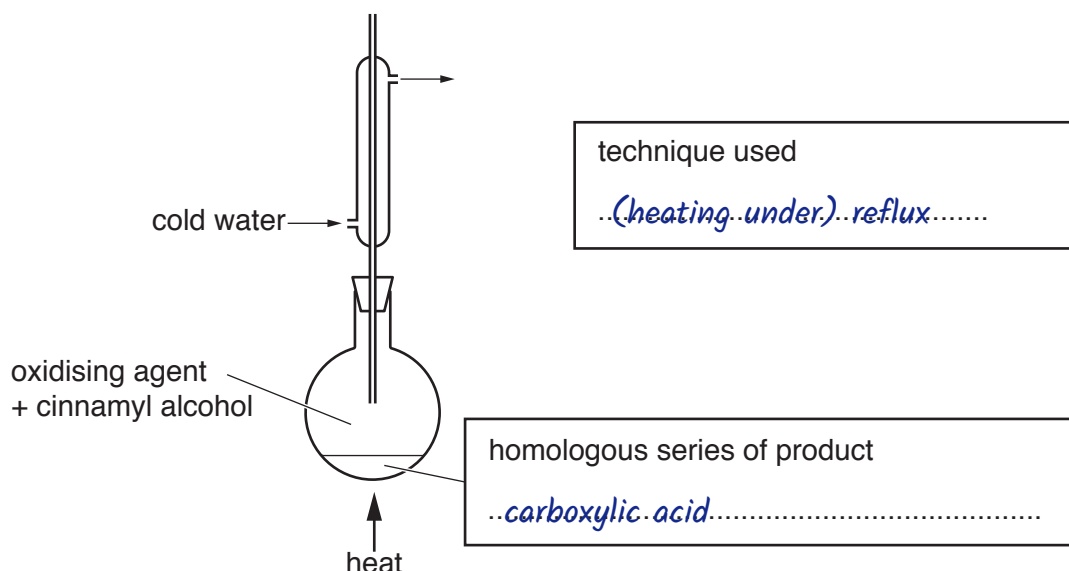
cold water

technique used

distillation

homologous series of product

aldehyde



[4]

(c) Ocimenol and cinnamyl alcohol are both unsaturated molecules.

Explain how you could use a solution of bromine water to show which of the molecules has the greater degree of unsaturation.

Use equal amounts (same number of moles) of ocimenol and of cinnamyl alcohol in separate flasks.

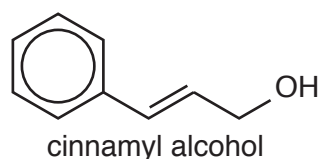
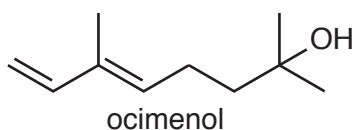
Add bromine water dropwise from a burette to each. The orange bromine is decolourised as it adds across the $C=C$ bonds.

Stop at the first permanent orange/yellow colour and record the volume.

Ocimenol decolourises the greater volume of bromine water, so it has the greater degree of unsaturation (three $C=C$ bonds, compared with one in cinnamyl alcohol).

[4]

(d) Both ocimenol and cinnamyl alcohol molecules show stereoisomerism.

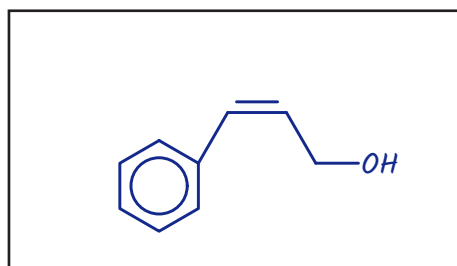
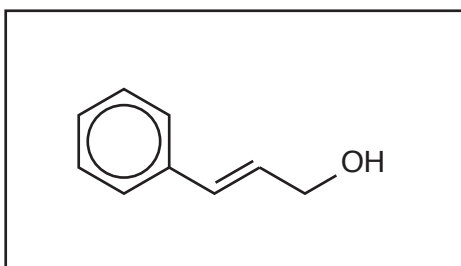


- Name the **type** of stereoisomerism shown by these molecules.
- Explain how this isomerism arises.
- The structure of one of the stereoisomers of cinnamyl alcohol is shown in the left hand box below; draw the structure of the other isomer in the right hand box.

Type of stereoisomerism *E/Z (geometric)*.....

Explanation

There is restricted rotation (no free rotation) about the C=C double bond, and each carbon of the C=C has two different groups attached. So the groups can be arranged in two different ways in space (on the same side, Z, or on opposite sides, E), giving two different isomers.



[3]

(e) Mass spectrometry can also be used to distinguish between ocimenol and cinnamyl alcohol. The molecular ion peak in a mass spectrum of ocimenol is at an m/z value of 154.

What m/z value would represent the molecular ion peak in a mass spectrum of cinnamyl alcohol?

$$M_r \text{ C}_9\text{H}_{10}\text{O} = (9 \times 12.0) + (10 \times 1.0) + 16.0 = 134$$

m/z for cinnamyl alcohol molecular ion = *134* [1]

This question refers to the *Practical Insert* that is provided as an insert to this paper.

- 4 (a) (i) Name the piece of apparatus which is most suitable for removing the 25.0 cm³ of the Cu²⁺ ion solution.

..(25.0 cm³) volumetric pipette..... [1]

- (ii) Use the student's results in the *Practical Insert* to work out an average titre that the student should use in calculating the amount of Cu²⁺ in the 'coin solution'.

titres: 22.85, 22.60, 22.55, 22.65 cm³ (titration 1 is a rough, not concordant)

mean of concordant titres 2, 3 and 4 = (22.60 + 22.55 + 22.65) / 3 = 22.60 cm³

average titre = ...22.60..... cm³ [1]

- (iii) Use your answer from (a)(ii) to calculate the percentage by mass of copper in the coin. Give your answer to an **appropriate** number of significant figures.

$$\text{amount } S_2O_3^{2-} = 0.200 \times 22.60 / 1000 = 4.52 \times 10^{-3} \text{ mol}$$

$$2Cu^{2+} \equiv I_2 \equiv 2S_2O_3^{2-}, \text{ so } Cu^{2+} : S_2O_3^{2-} = 1 : 1$$

$$\text{amount } Cu^{2+} \text{ in } 25.0 \text{ cm}^3 = 4.52 \times 10^{-3} \text{ mol}$$

$$\text{amount } Cu \text{ in } 250 \text{ cm}^3 = 4.52 \times 10^{-2} \text{ mol}$$

$$\text{mass } Cu = 4.52 \times 10^{-2} \times 63.5 = 2.870 \text{ g}$$

$$\% Cu = 2.870 / 3.56 \times 100 = 80.6\% (3 \text{ s.f.})$$

percentage by mass of copper in coin = ...80.6..... % [4]

- (iv) The student considers the uncertainties of measurement in the experiment.

The percentage measurement uncertainty marked on the apparatus used to transfer the 25 cm³ of the 'copper' solution is $\pm 0.24\%$.

The volumetric flask is marked $\pm 0.08\%$.

Calculate the measurement uncertainties of the other pieces of apparatus used.

Which piece of apparatus contributes most to the measurement uncertainty in this experiment?

burette: $\pm 0.05 \text{ cm}^3$ per reading, two readings so $\pm 0.10 \text{ cm}^3$

% uncertainty = $0.10 / 22.60 \times 100 = \pm 0.44\%$

balance: $\pm 0.005 \text{ g}$

% uncertainty = $0.005 / 3.56 \times 100 = \pm 0.14\%$

The burette contributes most to the measurement uncertainty ($\pm 0.44\%$).

[2]

- (v) Name another method that the student could use to find the concentration of Cu²⁺ ions in the 'coin solution'.

colorimetry (measure the absorbance and use a calibration curve)..... [1]

(b)* The student's method requires a standard solution of sodium thiosulfate for the titration.

Describe the techniques and procedures used to prepare a standard solution of a specific concentration from a solid.

Calculate the mass of sodium thiosulfate needed: $\text{mass} = \text{concentration} \times \text{volume (in dm}^3\text{)} \times M_r$, for the volume of the volumetric flask, e.g. 250 cm^3 .
Weigh a weighing bottle containing approximately this mass of solid on a balance reading to at least 2 decimal places. Tip the solid into a beaker and reweigh the empty bottle; the mass of solute is the difference.
Dissolve the solid in a small volume of distilled (deionised) water in the beaker, stirring with a glass rod.
Transfer the solution through a funnel into a clean volumetric flask rinsed with distilled water. Rinse the beaker, rod and funnel with distilled water and add all the washings to the flask.
Add distilled water, swirling to mix, until close to the mark, then add drop by drop with a dropping pipette until the bottom of the meniscus is on the mark, viewed at eye level.
Stopper the flask and invert it several times to mix thoroughly; calculate the exact concentration from the mass used. [6]

END OF QUESTION PAPER

This image shows a blank sheet of white paper designed for writing. It features a series of evenly spaced horizontal blue lines across its entire width. A single vertical red line runs down the left side, creating a narrow margin. The paper is otherwise completely empty, with no text or markings.

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