Gold Paper
A Level only

Question Paper 4

Level	A Level
Subject	Chemistry
Exam Board	OCR
Paper	A Level only
Booklet	Question Paper 4

Time allowed: **73 minutes**

Score: **/54**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

Two students set up the equilibrium system below.

$$CH_3COOC_2H_5(l) + H_2O(l) \rightleftharpoons C_2H_5OH(l) + CH_3COOH(l)$$

The students titrated samples of the equilibrium mixture with sodium hydroxide, NaOH(aq), to determine the concentration of CH_3COOH.

The students used their results to calculate a value for K_c.

The students' values for K_c were different.

Which of the reason(s) below could explain why the calculated values for K_c were different?

1: Each student carried out their experiment at a different temperature.

2: Each student used a different concentration of NaOH(aq) in their titration.

3: Each student titrated a different volume of the equilibrium mixture.

A 1, 2 and 3

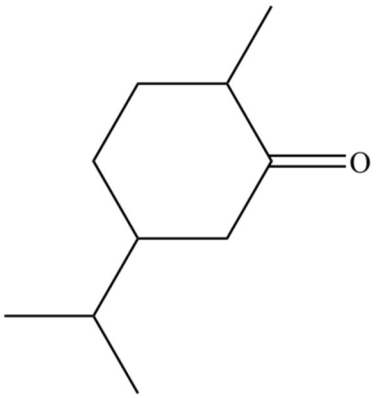
B Only 1 and 2

C Only 2 and 3

D Only 1

[1]

Carbonyl compounds have distinctive smells.
Menthone smells of peppermint.



Menthone

Menthone is reacted in a two-step synthesis shown below.

Step 1: A sample of menthone is added to hot acidified aqueous dichromate(VI) ions.

Step 2: The resulting mixture from **Step 1** is added to $NaBH_4$ in water.

What happens to the smell of the reaction mixture during the process?

	Step 1	Step 2
A	Smell of peppermint remains	Smell of peppermint is lost
B	Smell of peppermint is lost	Smell of peppermint returns
C	Smell of peppermint remains	Smell of peppermint remains
D	Smell of peppermint is lost	Smell of peppermint does not return

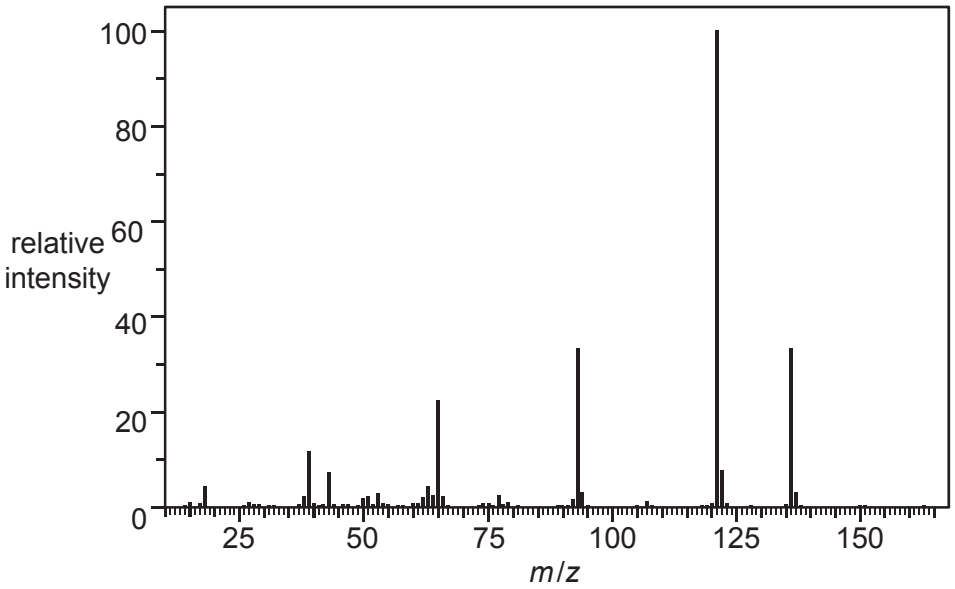
[1]

A chemist analyses a naturally occurring aromatic compound.

(a) The percentage composition and mass spectrum of the compound are shown below.

Percentage composition by mass: C, 70.58%; H, 5.92%; O, 23.50%.

Mass spectrum



Determine the molecular formula of the compound.

Show your working. **[3]**

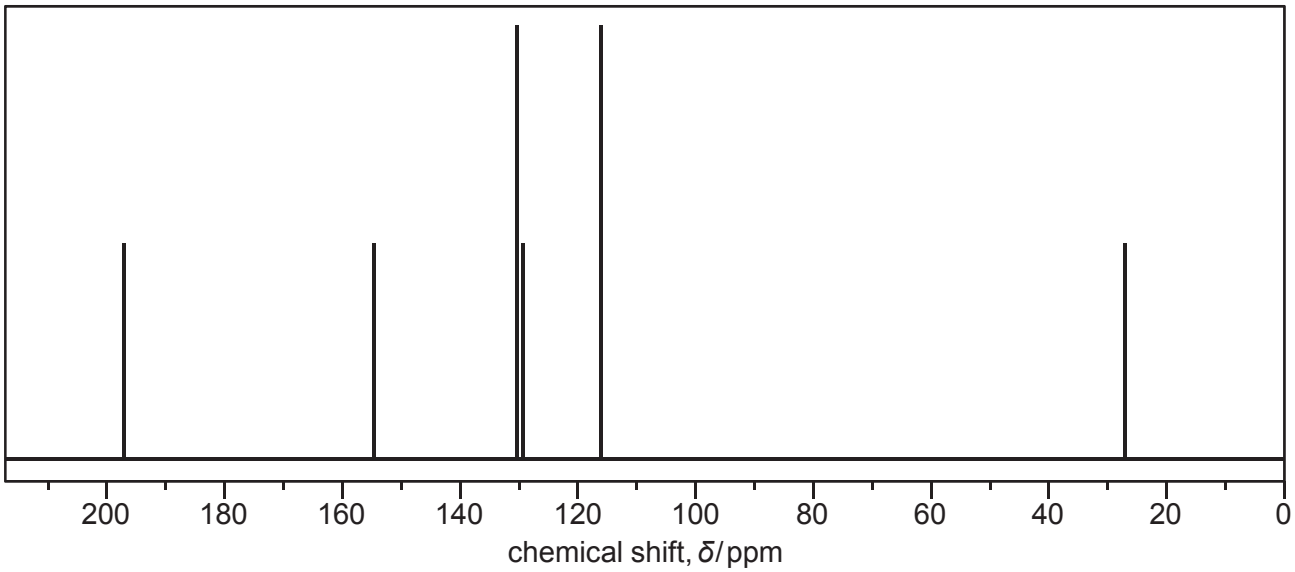
(b) Qualitative tests are carried out on the aromatic compound. The results are shown below.

Test	**Acidity**	**Na_2CO_3(aq)**	**2,4-DNP**	**Tollens' reagent**
Observation	pH = 5	No observable change	Orange precipitate	No observable change

Determine the functional groups in the compound. Explain your reasoning.

[3]

(c) The carbon-13 NMR spectrum of the compound is shown below.



Using the spectrum and the results from **(a)** and **(b)**, determine the structure of the compound. Explain your reasoning.

Structure of compound

[3]

(Total 9 marks)

Some organic compounds contain nitrogen atoms. Examples include condensation polymers and azo dyes.

(a) A section of a condensation polymer is shown below.

$$–CO(CH_2)_4CONH(CH_2)_6NHCO(CH_2)_4CONH(CH_2)_6NH–$$

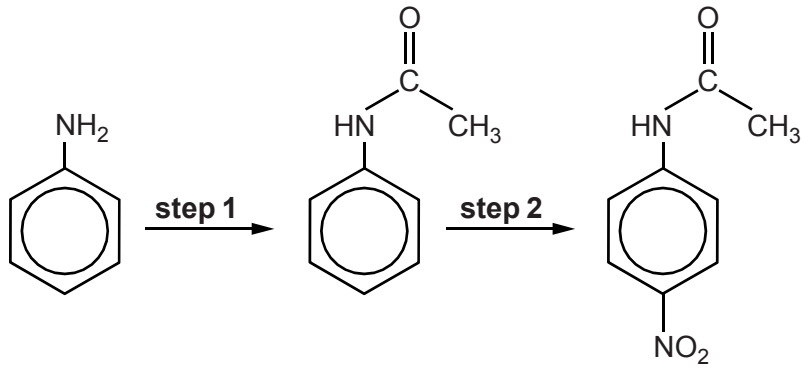
(i) In the boxes below, draw the structures of the two monomers that form this condensation polymer.

[2]

(ii) Name the type of condensation polymer and give a use for this polymer. [1]

(b) A student plans a two-step synthesis starting with phenylamine.

The steps of the synthesis are shown below.



phenylamine **compound A** **compound B**

(i) In **step 1**, phenylamine reacts with ethanoic anhydride to make compound **A** and one other organic product.

Draw the structure of ethanoic anhydride, with the functional group displayed, and suggest the structure of the other organic product formed in **step 1**.

ethanoic anhydride

other organic product

[2]

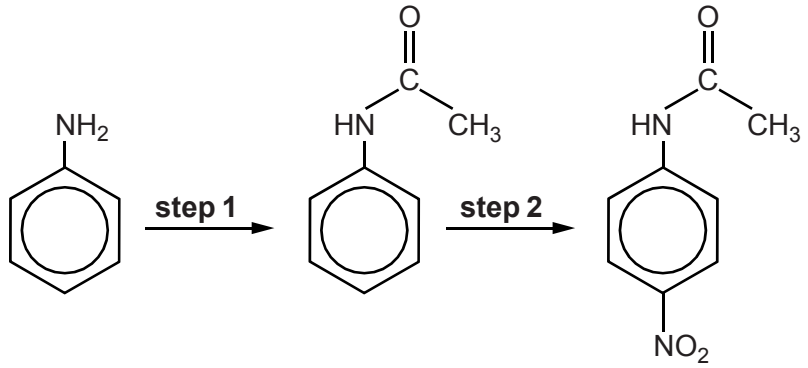
(ii) Calculate the mass of compound **A** that can be synthesised from 3.00 g of phenylamine in **step 1**. The percentage yield of this reaction is 61.0%.

M_r (phenylamine) = 93.0

Give your answer to **three** significant figures.

[3]

The steps of the synthesis are shown again below.



phenylamine **compound A** **compound B**

(iii) In **step 2**, compound **A** is converted into compound **B** using a mixture of concentrated nitric acid and concentrated sulfuric acid.

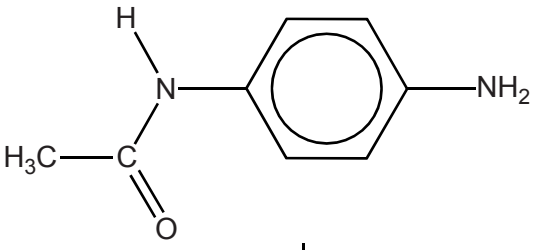
Outline, with the aid of curly arrows, the mechanism for the conversion of compound **A** into compound **B**.

Use equations to explain how sulfuric acid acts as a catalyst in this reaction. [5]

(c) An azo dye is synthesised in two steps. In **step 2** the diazonium ion is reacted with compound **C** to form the azo dye.

Complete the flowchart for this synthesis.

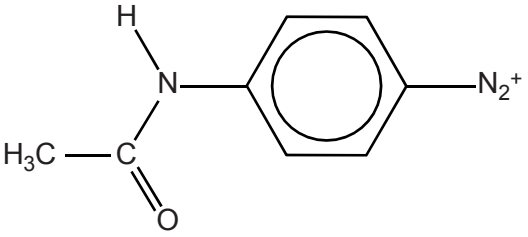
Write your answers in the boxes.



step 1

Reagents.....

Conditions.....

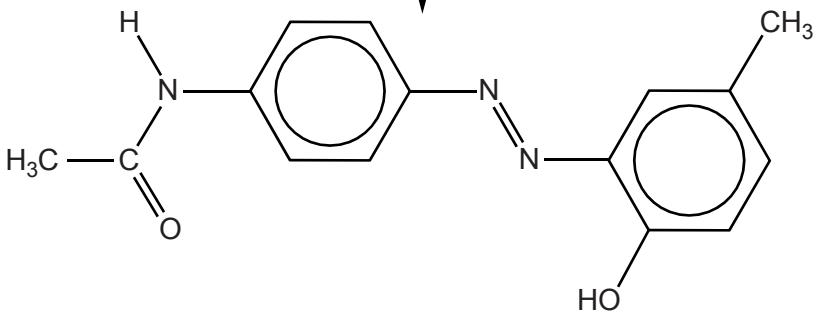


diazonium ion

step 2

Conditions.....

Structure of compound **C**



azo dye

[4]

[Total 17 Marks]

This question looks at two weak acids that are used as food additives to preserve food:

- calcium hydrogensulfate(IV), $Ca(HSO_3)_2$
- a carboxylic acid, **HA**.

(a) $Ca(HSO_3)_2$ can be made by reacting an excess of sulfur dioxide gas with a suspension of calcium carbonate in water.

Write the equation for this reaction. [1]

(b) Calcium hydrogensulfate(IV), $Ca(HSO_3)_2$, dissolves in water forming an aqueous solution containing $Ca^{2+}(aq)$ and $HSO_3^-(aq)$ ions. This solution is weakly acidic.

(i) What is meant by a *weak acid*?

Write an equation to show why this solution is weakly acidic. [2]

(ii) An aqueous solution of $Ca(HSO_3)_2$ oxidises magnesium forming hydrogen gas.

Construct full and ionic equations for the oxidation of magnesium metal by $Ca(HSO_3)_2(aq)$.

[2]

(iii) $HSO_3^-(aq)$ can act as either a Brønsted–Lowry acid or a Brønsted–Lowry base.

Explain this statement.
Include equations for the reaction of $HSO_3^-(aq)$ with $H^+(aq)$ and with $OH^-(aq)$. [4]

(c) A carboxylic acid **HA** is a food additive used as a preservative in cakes.

The K_a value of **HA** is 1.51×10^{-5} mol dm^{-3}.

A student analyses a sample of **HA** using the procedure below.

- A student dissolves 0.7369 g of **HA** in water and makes the solution up to 1.00 dm^3.
- The student measures the pH of the resulting solution as 3.52.

(i) Determine the molar mass of **HA** and suggest a possible formula for **HA**.
HA has one carboxylic acid group and contains C, H and O only.
Show all your working. [6]

(ii) The student had considered analysing the solution of **HA** by carrying out a titration with an alkaline solution of known concentration.

The student rejects this method as being invalid because **HA** is a weak acid and only a small proportion of H^+ ions would be neutralised.

Explain whether the student was correct in rejecting the titration method. [1]

[Total 16 Marks]

Vanadium is a transition element that forms compounds and ions in which vanadium has oxidation states +2, +3, +4 and +5.

(a) Complete the electron configuration of a vanadium ion in the +3 oxidation state:

$1s^2 2s^2 2p^6$ ..... [1]

(b) Suggest why vanadium does **not** form ions in which vanadium has an oxidation state greater than +5. [1]

(c) A student carries out an investigation into the oxidation states of vanadium as outlined below.

Stage 1 A 0.126 g sample of vanadium metal is completely reacted with acid to form a yellow solution. The solution is made up to 50.0 cm^3 in a volumetric flask. This yellow solution contains VO_3^- ions with vanadium in the +5 oxidation state.

Stage 2 The yellow solution is reduced to form a violet solution containing V^{n+} ions. This 50.0 cm^3 violet solution contains vanadium in the +*n* oxidation state.

Stage 3 10.0 cm^3 of the violet solution is titrated with 2.25×10^{-2} mol dm^{-3} $KMnO_4(aq)$. 13.2 cm^3 of $KMnO_4(aq)$ are required to reach the end-point.

In the titration,

- V^{n+} ions are oxidised back to VO_3^- ions.
- MnO_4^- ions are reduced:

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$$

(i) Why is there no clear colour change at the end-point of this titration? [1]

(ii) Analyse the student's results as follows:

- Determine the value of *n* in the V^{n+} ions formed in **Stage 2**
- Construct an equation for the reaction that takes place during the titration.

Show all your working.

n = ...

equation:

[7]

[Total 10 Marks]