Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

1410U34-1

MONDAY, 10 JUNE 2025 – MORNING

CHEMISTRY – A2 unit 3,4
Physical and Organic Chemistry

1 hour 45 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**1**	
	2.	**18**	
	3.	**17**	
Section B	**4.**	**9**	
	5.	**13**	
	6.	**12**	
	Total	**70**	

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ADDITIONAL MATERIALS

- A calculator, pencil and ruler
- **Data Booklet** supplied by WJEC

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 70.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q2**(b)(iii).

1 Ethanedioic acid, $(COOH)_2$, can be oxidised by acidified manganate(VII) ions.

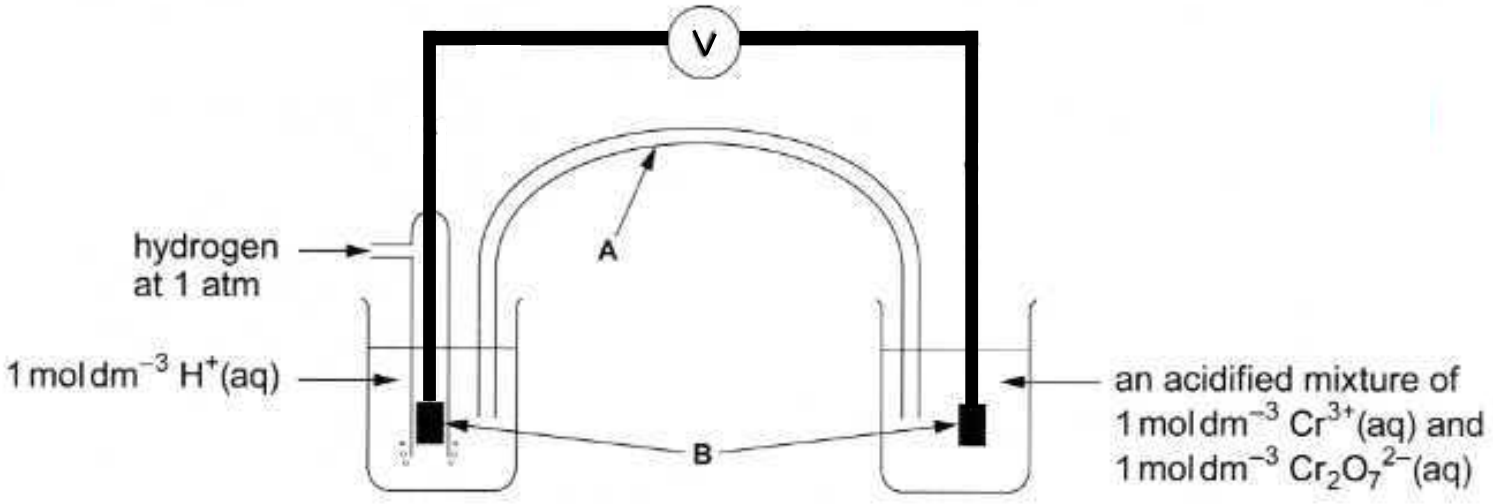
Use the half-equations below to write the ionic equation for the reaction. [1]

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

$$(COOH)_2 \longrightarrow 2CO_2 + 2H^+ + 2e^-$$

2 (b) The diagram shows the apparatus used to measure the standard electrode potential for the half-equation:

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O \qquad E^\theta = +1.33\,V$$



(i) Name parts **A** and **B**. [1]

A .....

B .....

(ii) **Label the diagram** to show the direction of flow of electrons in the wire. [1]

(b) Reaction 2 produces a mixture of the weak acid CH_3COOH and the strong acid HI.

(i) Suggest what effect the presence of HI will have on the dissociation of CH_3COOH in this mixture compared to an aqueous solution containing only CH_3COOH. Give your reasoning. [2]

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(ii) Calculate the pH of an aqueous solution of the strong acid HI of concentration $0.250\,mol\,dm^{-3}$. [2]

pH = ...

(iii) A student is given 100 cm^3 of a solution of ethanoic acid of concentration 0.100 mol dm^{-3} and wishes to produce a buffer solution of pH 4.45. He has access to the full range of chemicals in a laboratory.

Describe how the buffer solution could be formed, calculating the amounts of any other substances required. Explain how the buffer solution works to keep the pH of the solution constant.

[6 QER]

Ka for $CH_3COOH = 1.74x10^{-5}$ mol dm^{-3}

(c) The complex $[Ru(CO)_2(P(CH_3)_3)_2CH_3I]$ catalyses the reaction of iodomethane with carbon monoxide. One stage in the process is the reversible reaction below, with five of the ligands shown as L.

$$[RuL_5CH_3] + CO \rightleftharpoons [RuL_5COCH_3]$$

The values of the equilibrium constant for this process at different temperatures in methylbenzene solvent are listed in the table.

Temperature / °C	K_c / mol^{-1} dm^3
34	1220
42	694
49	406
56	290
64	196
74	120

(i) Suggest what information this table allows us to deduce about the energy changes during this reversible reaction. [2]

(ii) A solution containing a mixture of complex $[RuL_5CH_3]$ of concentration 1.25×10^{-3} mol dm^{-3} and carbon monoxide of concentration 7.55×10^{-4} mol dm^{-3} is placed in a sealed tube, heated to a set temperature and the mixture allowed to reach equilibrium. The equilibrium mixture contains 1.37×10^{-4} mol dm^{-3} of $[RuL_5COCH_3]$.

Find the value of K_c and hence suggest the temperature used for the experiment. [4]

K_c = ... mol^{-1} dm^3

Temperature = ... °C

3 Copper is present in a range of alloys, including those listed below.

Alloy	Typical copper content (% by mass)	Other element(s) present
brass	65-95	zinc
cupronickel	60-90	nickel
bronze	85-90	tin
electrum	6-25	gold silver
leaded tin bronze	70-85	tin lead

One method of finding the copper content of an alloy is by treating the alloy with concentrated hydrochloric acid in the presence of air to form a solution containing metal ions and diluting this to a known volume. This solution can then be analysed by titration.

(a) The class teacher notes that this method would not be suitable for analysing electrum or leaded tin bronze.

Suggest how the method could be changed to allow for the analysis of electrum and leaded tin bronze. Give your reasoning. [2]

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(b) Several of the metals added to copper to form these alloys are amphoteric.

Identify **one** amphoteric metal from the table and state what is meant by the term amphoteric. [2]

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(c) A 1.72 g sample of an alloy was used to make 250 cm^3 of an aqueous solution containing copper and other metal ions. Samples of 25.0 cm^3 of the solution were measured out and the copper ions reacted with excess iodide ions to form iodine.

The iodine was titrated using sodium thiosulfate solution of concentration 0.0500 mol dm^{-3}. The mean volume of sodium thiosulfate needed for complete reaction was 33.05 cm^3.

(i) Write the equations for the following reactions:

- $Cu^{2+}(aq)$ with $I^-(aq)$
- $I_2(aq)$ with $S_2O_3^{2-}(aq)$

Hence show that 1 mol of $S_2O_3^{2-}(aq)$ is equivalent to 1 mol of $Cu^{2+}(aq)$ in the titration. [3]

(ii) Find the percentage by mass of copper in the alloy and hence identify which alloy(s) could be present in the sample. [4]

Percentage copper = ... %

(e) The standard electrode potentials for some reactions of copper and thallium ions are given below.

Half-equation	Standard electrode potential, E^{θ}/V
$Tl^{3+} + 2e^- \rightleftharpoons Tl^+$	+1.25
$Cu^+ + e^- \rightleftharpoons Cu$	+0.52
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+0.16
$Tl^+ + e^- \rightleftharpoons Tl$	−0.34

(i) When copper(I) ions are formed in solution, the reaction below occurs.

$$2Cu^+ \longrightarrow Cu^{2+} + Cu$$

Use the standard electrode potential values to explain why this reaction occurs. [2]

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(ii) I. Copper(I) ions can act as a reducing agent. Identify the final thallium containing species formed when copper(I) ions reduce thallium(III) ions.

Use the standard electrode potential values to explain your answer. [2]

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II. A student suggests that the more stable oxidation state of thallium can be predicted from its position in the Periodic Table.

Suggest, giving a reason, which oxidation state of thallium will be more stable. [1]

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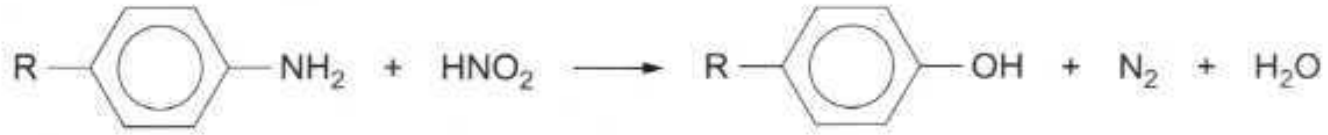
4 (a) (i) A primary aromatic amine, compound **V**, reacts with nitric(III) acid to give the corresponding phenol and nitrogen gas.



compound **V**

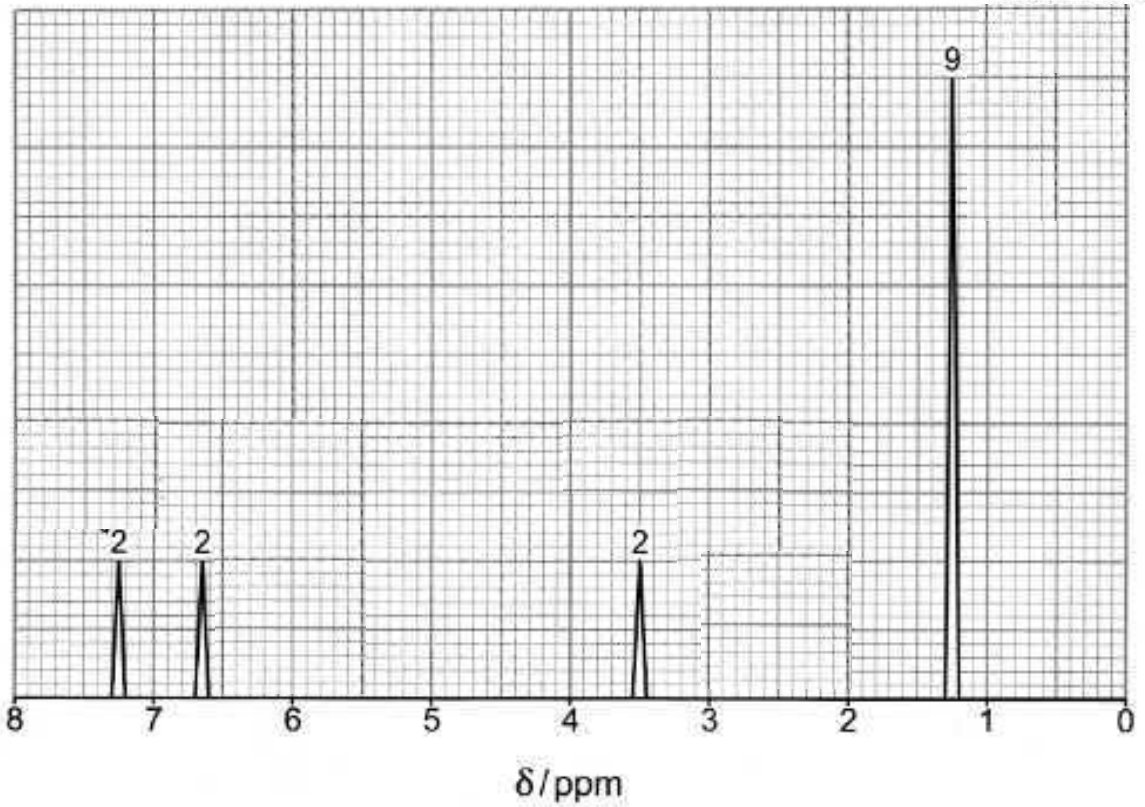
5.00 g of compound **V** gave 823.5 cm^3 of nitrogen gas measured at 298 K and 1 atm pressure.

Use this information to show that the molar mass of compound **V** is 149 g mol^{-1}.

[2]

(ii) The high resolution ^1H NMR spectrum of compound **V** is shown below.

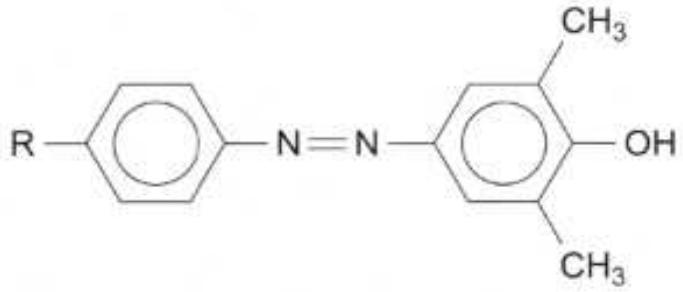
The signal due to the —NH_2 protons is at δ 3.5 ppm.



Use the molar mass from part (i) and this spectrum to deduce the structure of the alkyl group R. Give your reasoning. [3]

R has the structure .....

(iii) At 5 °C compound **V** reacts with nitric(III) acid to give a diazonium compound which then reacts with compound **W** to give the azo dye below.



State the **name** of compound **W**. [1]

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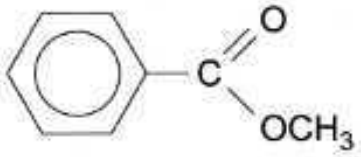
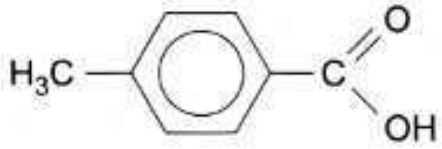
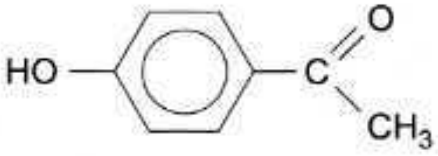
(b) Each of the four compounds whose formulae are shown below are isomers.

Compound	Formula
R	
S	
T	
U	

Select the compound that fits the descriptions below.

Give your reasoning in each case. [3]

Produces carbon dioxide with sodium hydrogencarbonate.

Gives an orange-red solid with 2,4-dinitrophenylhydrazine but does not react with Tollens' reagent.

Produces methanol when heated with sodium hydroxide.

5 (a) A student was asked how she would make 2-aminopropanoic acid (alanine) starting from propenoic acid.

She replied that she would firstly react propenoic acid with hydrogen bromide to give 2-bromopropanoic acid.

$$H_2C{=}CH{-}COOH + HBr \longrightarrow CH_3{-}CHBr{-}COOH$$

(i) State the name of the reaction mechanism for this reaction. [1]

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(ii) She predicted that the main product would be 2-bromopropanoic acid, rather than 3-bromopropanoic acid.

Explain, in terms of carbocations, why 2-bromopropanoic acid should be the main product. [1]

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(iii) 2-Aminopropanoic acid can be obtained by reacting 2-bromopropanoic acid with ammonia in the mole ratio of 1:2 respectively.

Give the equation for this reaction. [1]

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(b) (i) Give the structure of the species predominantly present in an aqueous solution of 2-aminopropanoic acid at pH 4.0. [1]

(ii) 2-Aminopropanoic acid is an α-amino acid.

Write the **general** formula for α-amino acids. [1]

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(iii) 2-Aminopropanoic acid forms a dipeptide with aminoethanoic acid, $H_2C(NH_2)COOH$.

Give the formula of a dipeptide formed from these two amino acids. [1]

(iv) 2-Aminopropanoic acid is one of the many amino acids that contribute to the structure of proteins.

State what is meant by the **secondary** structure of proteins. [1]

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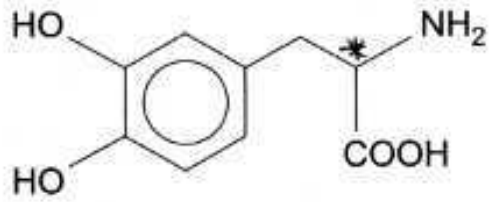
(c) L-dopa is a compound that is used in the treatment of Parkinson's disease.



(i) State the feature present in the molecule of L-dopa that enables it to rotate the plane of plane polarised light. [1]

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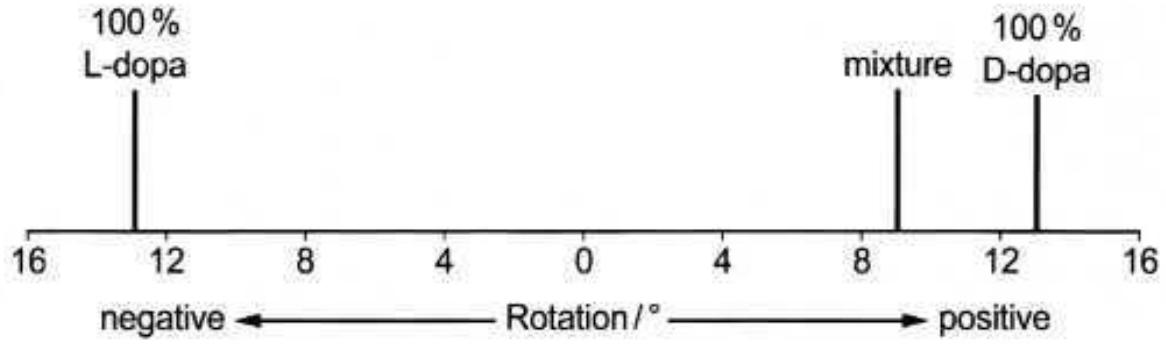
(ii) L-dopa rotates the plane of plane polarised light to the left (–) whereas D-dopa rotates it to the right (+).

At a certain concentration pure forms of the acid rotate the plane of plane polarised light by 13°.

A mixture of the L- and D- forms of dopa gave a rotation of +9°.

This information is shown in the diagram below.



Use the formula below to calculate the percentage of **each** enantiomer present in the mixture, where y is 13 and x is the rotation given by the mixture. [2]

$$\text{percentage of D-dopa} = \frac{100\,(y + x)}{2y}$$

Percentage of D-dopa = ... %

Percentage of L-dopa = ... %

(iii) Although L-dopa is used extensively in many countries in the treatment of Parkinson's disease, it remains too expensive to use in some developing countries.

Scientists have discovered that the beans of the *mucuna pruriens* plant contain useful quantities of L-dopa.

I. State **one** advantage (apart from cost) of using mucuna beans as a source of L-dopa. [1]

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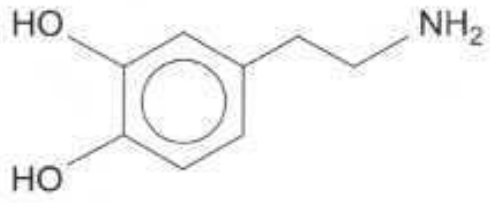
II. A sample of raw mucuna beans was ground and then analysed for L-dopa. This analysis showed that the beans contained 6 % by mass of L-dopa.

Some patients suffering from Parkinson's disease need to take 250 mg of L-dopa **three** times each day.

Use this information to calculate the mass of raw mucuna beans needed to produce the daily dose for one patient. [1]

Mass of beans = ... g

(iv) In the body an enzyme converts L-dopa into dopamine by a decarboxylation reaction.

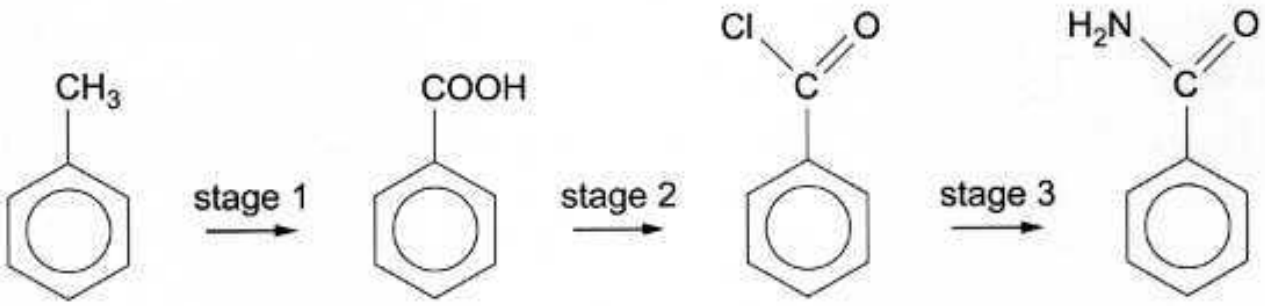


dopamine

Use this information to help you complete the equation for the decarboxylation of phenylethanoic acid using sodium hydroxide. [1]


$CH_2COOH + 2NaOH \longrightarrow$ ..... $+ Na_2CO_3 +$ .....

6 (a) Study the reaction sequence below and answer the questions that follow.



(i) State reagent(s) that can be used for stage 1. [1]

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(ii) State the type of reaction occurring in stage 1. [1]

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(iii) One way of carrying out stage 2 is to react benzoic acid with phosphorus(V) chloride.

Explain why the yield of benzoyl chloride, C_6H_5COCl, will be lower if moisture enters the reaction vessel. [1]

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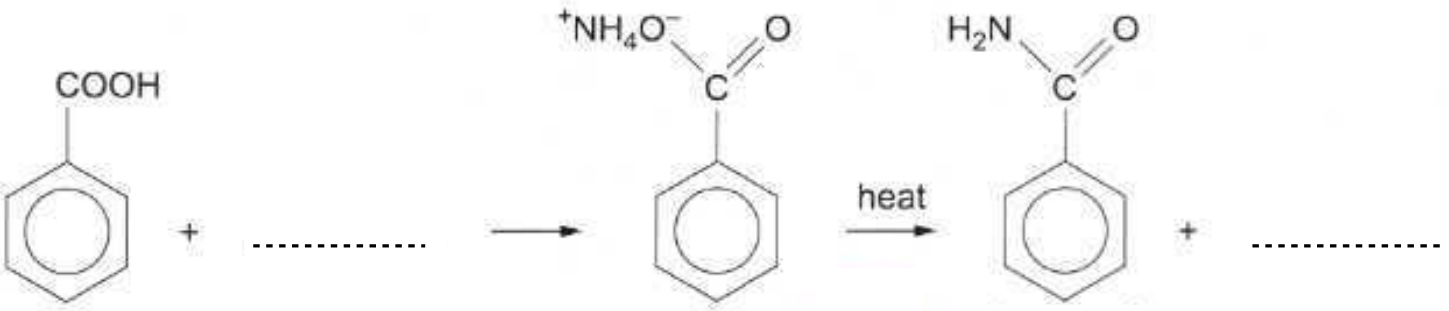
(iv) In stage 3 benzamide is produced from benzoyl chloride by its reaction with ammonia.

Suggest the structure of the compound produced if benzoyl chloride reacts with methylamine, CH_3NH_2, in place of ammonia. [1]

(v) In the reaction sequence opposite, benzamide is made from benzoic acid via the acid chloride, benzoyl chloride. It can be made from benzoic acid by a different route as shown in the sequence below.

Complete this sequence by giving the formulae of the missing compounds. [1]



(vi) Benzamide, $C_6H_5CONH_2$, undergoes the Hofmann degradation reaction.

This reaction produces an organic nitrogen-containing compound **Z**, that contains one carbon atom less per molecule than benzamide.

The mass spectrum of compound **Z** shows a molecular ion peak at m/z 93 and its infrared spectrum does **not** show a characteristic peak at 1661 cm^{-1}.

Use this information to suggest a structure for compound **Z**. Explain your answer. [3]

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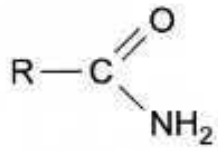
(b) Another amide,  , reacts with alkali to give ammonia as one of the products.

The ammonia produced can then be reacted with sulfuric acid.

In an experiment, 3.50 g of this amide reacted with sodium hydroxide. The ammonia produced required 16.0 cm^3 of sulfuric acid of concentration 1.50 mol dm^{-3} for complete neutralisation.

Use this information to find the formula of the R group present in this amide. [4]

R has the formula .....

END OF PAPER