

Paper Reference(s) 9CH0/02

Pearson Edexcel Level 3 GCE

Chemistry

Advanced

Paper 2: Advanced Organic and Physical Chemistry

Tuesday 11 June 2019 – Afternoon

Time: 1 hour 45 minutes plus your additional time allowance

INSTRUCTIONS TO CANDIDATES

Write your centre number, candidate number, surname, other names and your signature in the boxes below. Check that you have the correct question paper.

Centre No.					
Candidate No.					
Surname					
Other names					
Signature					
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- Use **BLACK** ink or **BLACK** ball-point pen.
- Answer **ALL** questions.
- Answer the questions in the spaces provided – there may be more space than you need.

MATERIALS REQUIRED FOR EXAMINATION

Scientific calculator, Data Booklet, ruler

ITEMS INCLUDED WITH QUESTION PAPERS

Grid for use with question 8(b)(ii), Periodic Table

INFORMATION FOR CANDIDATES

- The total mark for this paper is 90.
- The marks for **EACH** question are shown in brackets – use this as a guide as to how much time to spend on each question.
- For the question marked with an asterisk (*), marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is provided.

ADVICE TO CANDIDATES

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.

(Turn over)

Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question is about some reactions of alcohols.

(a) (i) Which alcohol CANNOT be oxidised by acidified potassium dichromate(VI)? (1 mark)

- ☐ **A hexan-2-ol**
- ☐ **B 2-methylpentan-2-ol**
- ☐ **C hexan-3-ol**
- ☐ **D 2-methylpentan-3-ol**

(ii) Which alcohol reacts with iodine in the presence of alkali to form a yellow solid? (1 mark)

- ☐ **A hexan-2-ol**
- ☐ **B 2-methylpentan-2-ol**
- ☐ **C hexan-3-ol**
- ☐ **D 2-methylpentan-3-ol**

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(b) Which reagent is used with iodine to prepare iodoalkanes from alcohols? (1 mark)

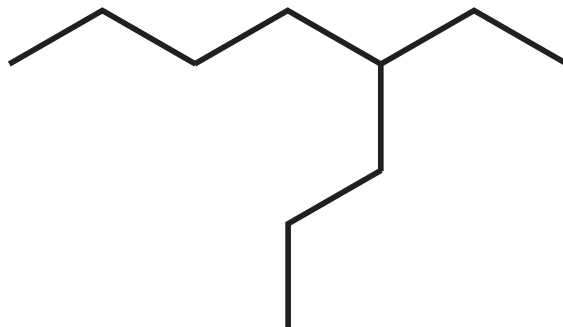
- ☐ **A red phosphorus**
- ☐ **B concentrated phosphoric acid**
- ☐ **C sulfur**
- ☐ **D concentrated sulfuric acid**

(TOTAL FOR QUESTION 1 = 3 MARKS)

(Questions continue on next page)

2 This question is about alkanes and their reactions.

(a) What is the IUPAC name for this alkane? (1 mark)



- ☐ A 4-ethyloctane
- ☐ B 5-ethyloctane
- ☐ C 3-propylheptane
- ☐ D 5-propylheptane

(b) What is the name of the process that could be used to produce propane, C_3H_8 , from decane, $C_{10}H_{22}$? (1 mark)

- ☐ A substitution
- ☐ B reforming
- ☐ C fractional distillation
- ☐ D cracking

(Question continues on next page)

(Turn over)

- (c) A student researched the reaction of propane with bromine and found that the reaction could be used to make 1-bromopropane.



- (i) The first step of the reaction involves (1 mark)

- ☐ A heterolytic bond fission to form free radicals
- ☐ B heterolytic bond fission to form ions
- ☐ C homolytic bond fission to form free radicals
- ☐ D homolytic bond fission to form ions

(Question continues on next page)

(ii) Calculate the atom economy by mass for the formation of 1-bromopropane in the reaction in (c). (2 marks)

(iii) A source from the internet gave the percentage yield for this reaction as 31.0%. The best explanation for the low percentage yield of 1-bromopropane in this reaction is (1 mark)

- ☐ **A bromine is very unreactive**
- ☐ **B a gaseous reactant always gives a low yield**
- ☐ **C the reaction is very slow**
- ☐ **D the reaction produces a mixture of organic products**

(Question continues on next page)

(Turn over)

- (iv) Calculate the volume of propane, in dm^3 , measured at room temperature and pressure, that is needed to produce 14.7 g of 1-bromopropane, assuming a percentage yield of 31.0%.

Give your answer to an appropriate number of significant figures. (3 marks)

[Molar gas volume at r.t.p. = $24.0 \text{ dm}^3 \text{ mol}^{-1}$]

(TOTAL FOR QUESTION 2 = 9 MARKS)

(Questions continue on next page)

(Turn over)

3 This question is about compounds of Group 5 elements.

(a) Phosphorus forms two chlorides with the formulae PCl_3 and PCl_5 .

**(i) Explain the shape of the PCl_3 molecule.
The bond angle is not required. (3 marks)**

(Question continues on next page)

(Turn over)

- (ii) Draw a diagram to show the three-dimensional shape of the PCl_5 molecule in the gas phase.

Include bond angles and the name of the shape.
(3 marks)

(Question continues on next page)

(Turn over)

(iii) Explain why phosphorus forms PCl_5 but nitrogen does not form NCl_5 . (2 marks)

(Question continues on next page)

(b) Nitrogen trichloride, NCl_3 , has a boiling temperature of 344 K, and nitrogen trifluoride, NF_3 , has a boiling temperature of 144 K.

Explain this difference in boiling temperatures, by referring to all the intermolecular forces present. (5 marks)

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(Continue your answer on next page)

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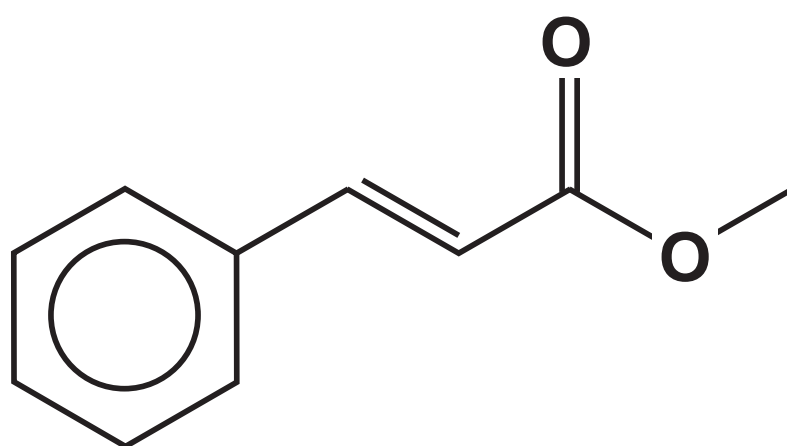
(c) Which of these compounds produces hydrogen chloride when it reacts with PCl_5 ? (1 mark)

- ☐ **A propanal**
- ☐ **B propan-1-ol**
- ☐ **C propanone**
- ☐ **D propyl propanoate**

(TOTAL FOR QUESTION 3 = 14 MARKS)

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- 4 Methyl cinnamate, $\text{C}_{10}\text{H}_{10}\text{O}_2$, is a white crystalline solid used in the perfume industry.



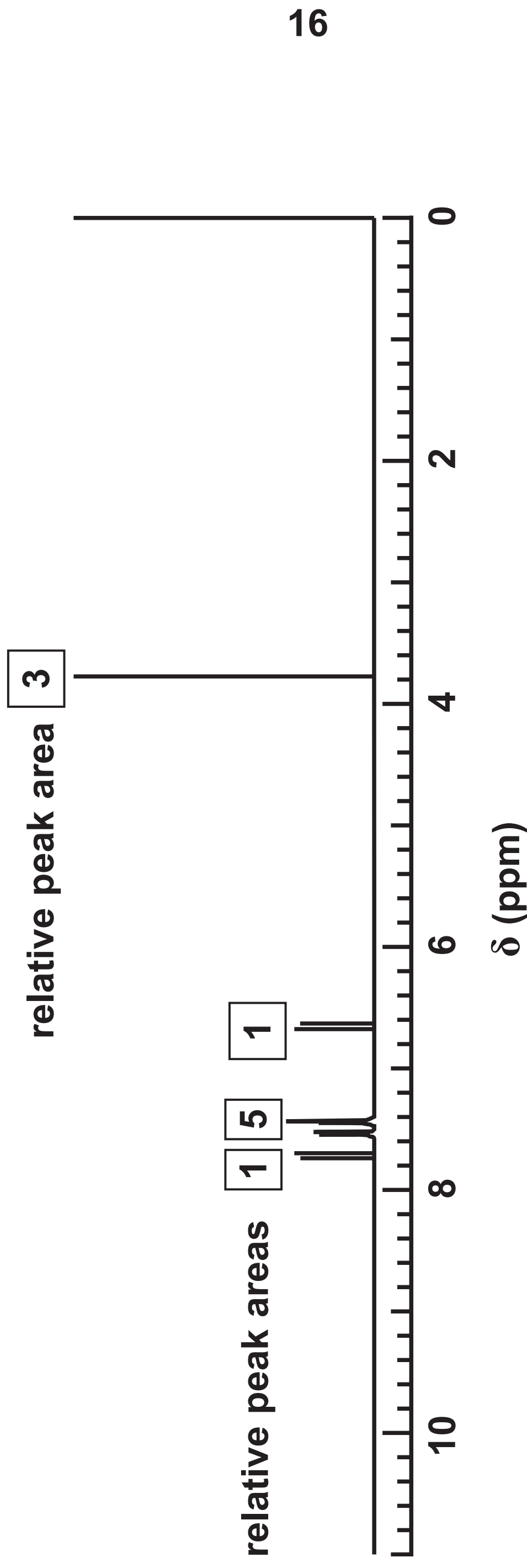
methyl cinnamate

- (a) Calculate the mass of carbon in 2.34 g of methyl cinnamate. (2 marks)

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(b) A sample of methyl cinnamate was analysed by high resolution proton NMR spectroscopy.

A simplified spectrum is shown.



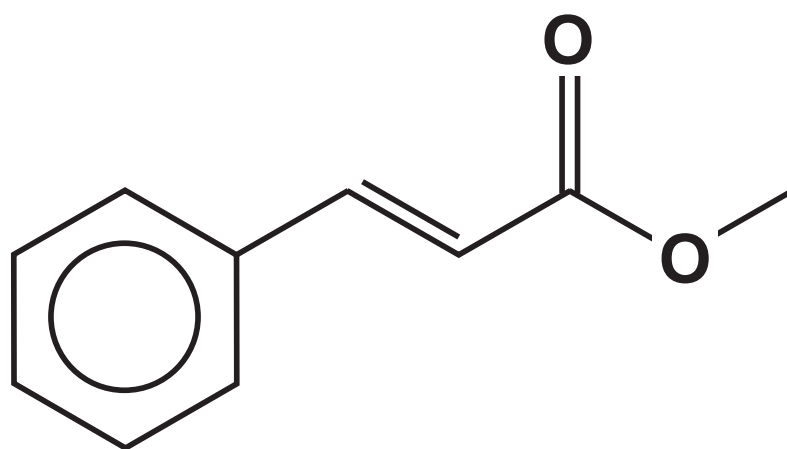
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- (i) Name the compound responsible for the peak at a chemical shift of 0 ppm, stating its purpose. (2 marks)

(Question continues on next page)

- (ii) Identify the proton environment that causes the peak at a chemical shift of 3.8 ppm by circling it on the diagram shown. Fully justify your answer. (3 marks)



(Question continues on next page)

(c) Methyl cinnamate undergoes an addition reaction in the dark with bromine.

- (i) Draw the mechanism for the reaction between methyl cinnamate and bromine, Br₂. Include curly arrows, and relevant lone pairs and dipoles. (4 marks)**

(ii) Deduce the number of optical isomers of the addition product that can exist. (1 mark)

☐ A 2

☐ B 3

☐ C 4

☐ D 8

(iii) When plane-polarised light is passed through an optical isomer, the plane of polarisation is (1 mark)

☐ A diffracted

☐ B reflected

☐ C refracted

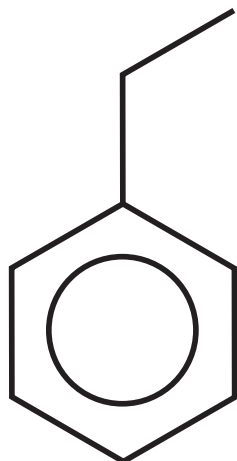
☐ D rotated

(TOTAL FOR QUESTION 4 = 13 MARKS)

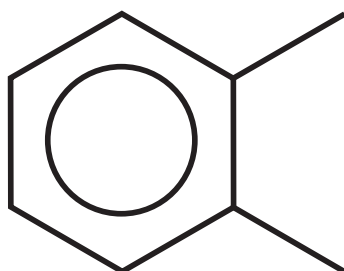
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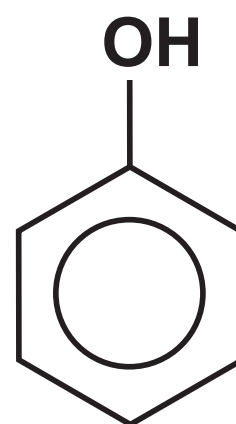
- 5 This question is about the arenes, ethylbenzene, xylene, and phenol, which can be identified in wine samples using gas chromatography.



ethylbenzene



xylene



phenol

- (a) Ethylbenzene can be formed by the reaction of a chloroalkane with benzene, catalysed by aluminium chloride, AlCl_3 .
- (i) Draw the **DISPLAYED** formula of the chloroalkane required for this reaction.
(1 mark)

(Question continues on next page)

(Turn over)

- (ii) Draw the mechanism for this reaction. Include equations showing the role of the catalyst and how it is regenerated. (5 marks)

(iii) Explain whether phenol is likely to be less or more reactive than benzene with the chloroalkane from (a)(i). (3 marks)

(Question continues on next page)

(Turn over)

- (b) A student carried out an experiment to determine the molar mass of xylene.

The student's sample of xylene vapour had a mass of 0.271 g.

At a temperature of 165 °C and a pressure of 118 kPa, this sample had a volume of 70.5 cm³.

Use the Ideal Gas Equation to calculate the molar mass, in g mol⁻¹, of this sample.

Give your answer to an appropriate number of significant figures.

You MUST show your working. (4 marks)

(c) The time taken for a compound to pass through the column in gas chromatography is called the retention time.

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(Turn over)

Explain why different compounds will have different retention times in the same column, under the same conditions. (2 marks)

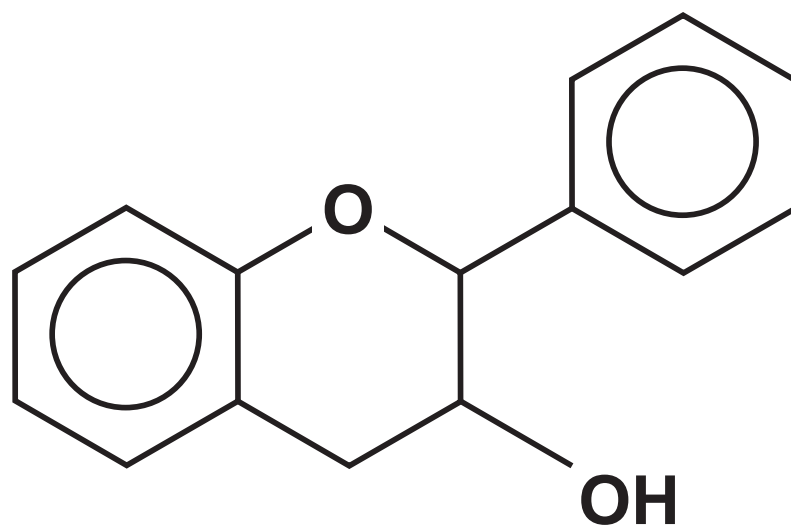
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(TOTAL FOR QUESTION 5 = 15 MARKS)

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(Turn over)

6 The compound flavan-3-ol is found in tea, fruit and wine.



(a) Clearly label all the chiral carbon atoms in flavan-3-ol. (1 mark)

(b) Give the molecular formula for flavan-3-ol. (1 mark)

*(c) A sample of flavan-3-ol extracted from wine contained some ethanol. The sample was left in a flask, open to the air for several days. The contents were then analysed to identify any new compounds formed. Several new compounds were found to be present, including some with a distinctive fruity smell.

(Question continues on next page)

(Turn over)

Identify FOUR new organic compounds that could form under these conditions by considering the chemistry of alcohols. Justify your answers. Include the structure of two compounds formed from flavan-3-ol, one of which has a fruity smell. (6 marks)

(Turn over)

(Turn over)

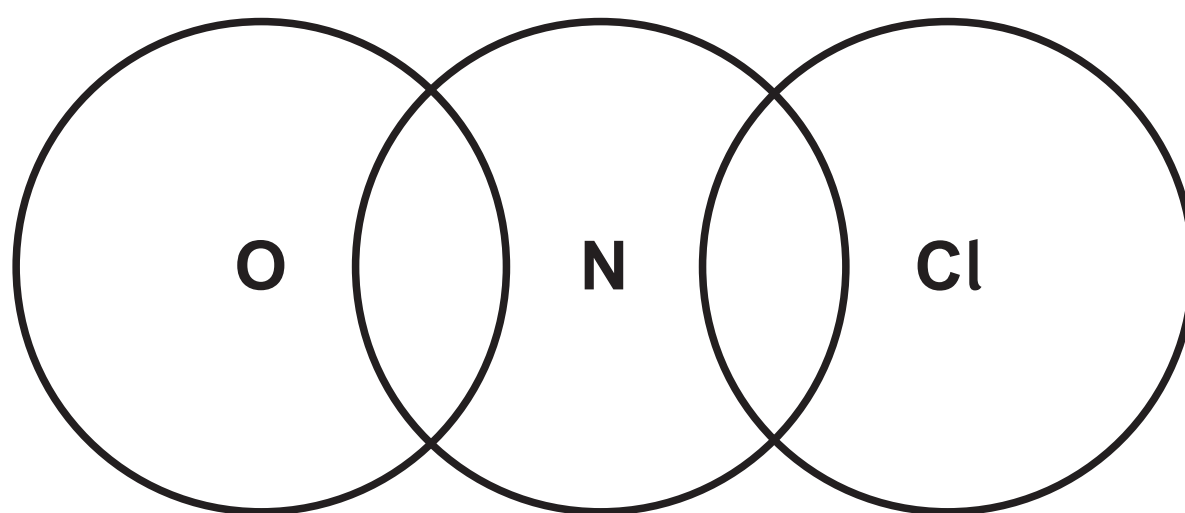
(TOTAL FOR QUESTION 6 = 8 MARKS)

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- 7 Nitrogen monoxide and chlorine react together to form nitrosyl chloride.



- (a) Draw a dot-and-cross diagram for nitrosyl chloride, showing only the outer shell electrons. (2 marks)



(Question continues on next page)

(b) The rate equation for the formation of nitrosyl chloride is



(i) Complete the table by adding the missing values. (2 marks)

Experiment	[NO] / mol dm^{-3}	[Cl ₂] / mol dm^{-3}	Rate / $\text{mol dm}^{-3} \text{s}^{-1}$
1	0.122	0.241	1.09×10^{-2}
2		0.482	8.72×10^{-2}
3	0.366		4.91×10^{-2}

(Question continues on next page)

- (ii) Calculate the rate constant, k , using data from Experiment 1.
Include units with your answer. (3 marks)

(Question continues on next page)

(iii) Explain how using a catalyst increases the rate constant, k . (2 marks)

(iv) The heterogeneous catalyst palladium was suggested for use in this reaction.

Explain how impurities in the gaseous reactants could make the catalyst less effective. (3 marks)

(Continue your answer on next page)

(Turn over)

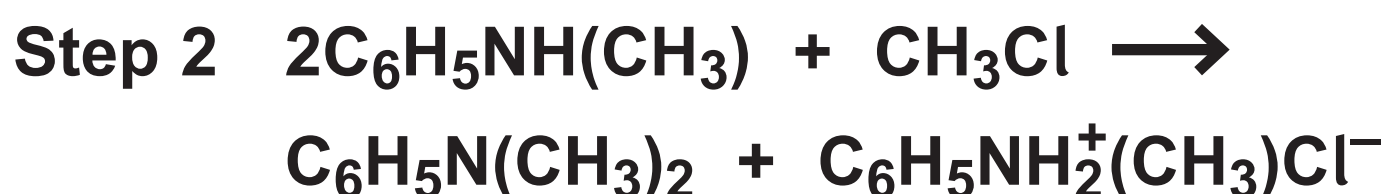
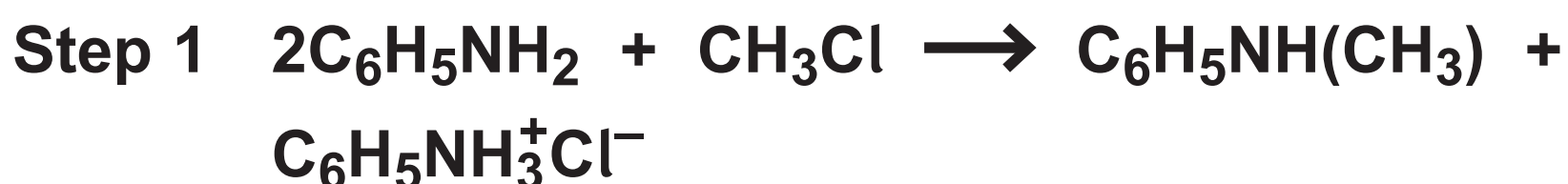
(TOTAL FOR QUESTION 7 = 12 MARKS)

(Questions continue on next page)

- 8 Gentian violet is a purple crystalline solid used as an antifungal treatment.

It can be synthesised from dimethylphenylamine, $\text{C}_6\text{H}_5\text{N}(\text{CH}_3)_2$.

- (a) The dimethylphenylamine used in the synthesis can be made by the stepwise reaction of phenylamine with chloromethane.



The reaction mechanism for Step 1 between phenylamine and chloromethane is the same as that in the reaction between ammonia and chloromethane.

- (i) What is the reaction type and mechanism in Step 1? (1 mark)

- ☐ A electrophilic addition
- ☐ B electrophilic substitution
- ☐ C nucleophilic addition
- ☐ D nucleophilic substitution

- (ii) Draw the mechanism for the reaction in Step 1.
Include curly arrows, and relevant lone pairs and dipoles. (4 marks)

(Question continues on next page)

(Turn over)

(iii) Describe, in outline, how a sample of a solid, such as gentian violet, is purified by recrystallisation.

Specific details of the solvent used are not required. (4 marks)

[illegible]

(Question continues on next page)

(Turn over)

- (b) The rate constant for the reaction between a solution of gentian violet and aqueous sodium hydroxide was determined at different temperatures.

Temperature (T) / K	1 / Temperature (1/T) / K ⁻¹	Rate constant, k / dm ³ mol ⁻¹ s ⁻¹	ln k
283.5	3.53×10^{-3}	2.71×10^{-3}	-5.91
287.5	3.48×10^{-3}	3.55×10^{-3}	
291.5		4.75×10^{-3}	-5.35
295.0	3.39×10^{-3}	6.10×10^{-3}	-5.10
298.5	3.35×10^{-3}	7.60×10^{-3}	-4.88

- (i) Complete the data in the table. (1 mark)

(Question continues on next page)

- (ii) Plot a graph on the separate sheet provided and use it to determine the activation energy for the reaction in kJ mol^{-1} .

You should include the value and units of the gradient of the line.

The Arrhenius equation can be shown as

$$\ln k = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant}$$

(6 marks)

Gradient

Activation energy

(TOTAL FOR QUESTION 8 = 16 MARKS)

TOTAL FOR PAPER = 90 MARKS
END