

Please write clearly in block capitals.

Centre number

Candidate number

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL A-LEVEL CHEMISTRY (9620)

Unit 4: Organic 2 and Physical 2

Thursday 16 January 2025 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	



Answer **all** questions in the spaces provided.

0 1

This question is about carbonyl compounds and optical activity.

0 1 . 1

Pentan-2-one can be reduced to form an alcohol.

Give a reducing agent for this reaction.

Write an equation for this reduction.

Use [H] to represent the reducing agent in this equation.

[2 marks]

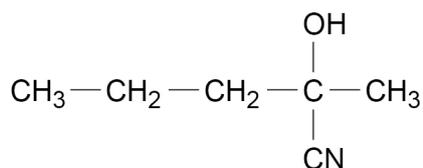
Reducing agent _____

Equation

Potassium cyanide is added to pentan-2-one in aqueous alcohol.

Dilute hydrochloric acid is then added to the mixture.

Compound **P** forms.



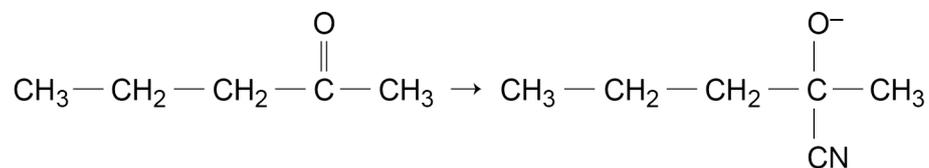
P

0 1 . 2

Complete this stage of the mechanism by adding the species that reacts with pentan-2-one and **two** curly arrows.

Name the mechanism.

[3 marks]



Name of mechanism



0 1 . 3 Use IUPAC rules to name **P**.

[1 mark]

0 1 . 4 **P** is formed as a racemic mixture.

State what is meant by a racemic mixture.

Explain why a racemic mixture is formed in this reaction.

[3 marks]

Racemic mixture _____

Explanation _____

0 1 . 5 Draw the structure of a position isomer of **P** that does **not** show optical activity.

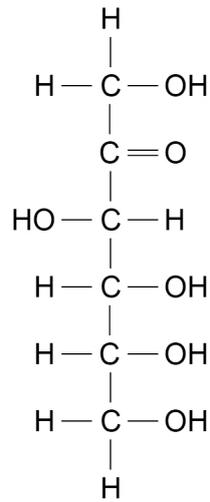
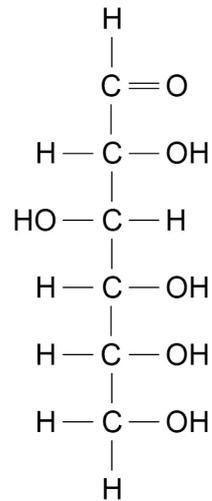
[1 mark]

Question 1 continues on the next page

Turn over ►



Compound **Q** and compound **R** are two sugars.

**Q****R**

0 1 . 6

Suggest a reagent that can be used in a test-tube reaction to distinguish between **Q** and **R**.

State the observation you would expect with each compound.

[3 marks]

Reagent _____

Observation with **Q** _____

Observation with **R** _____



0 2

This question is about the rate of reactions that involve iodide ions.

Iodide ions react with hydrogen peroxide (H_2O_2) in acidic conditions to form iodine and **one** other product.

0 2 . 1

Write an equation for the reaction.

[1 mark]

0 2 . 2

Explain, in terms of the collision theory, why increasing the concentration of iodide ions increases the rate of reaction.

[2 marks]

0 2 . 3

At 25 °C, the rate constant, k , for this reaction is $1.17 \times 10^{-2} \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$

The activation energy (E_a) for the reaction is 56.1 kJ mol^{-1}

The Arrhenius equation is $k = Ae^{\frac{-E_a}{RT}}$

Calculate the value of the Arrhenius constant, A , for this reaction at 25 °C
Give your answer to 3 significant figures.

Give the units of the Arrhenius constant, A .

The gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

[4 marks]

A _____

Units _____



The rate of a reaction between iodide ions and a compound **S** is investigated in a series of experiments at a fixed temperature.

Table 1 shows data from the experiments.

Table 1

Experiment	[I ⁻] / mol dm ⁻³	[S] / mol dm ⁻³	Rate / mol dm ⁻³ s ⁻¹
1	0.02	0.05	8.80×10^{-3}
2	0.04	0.05	1.76×10^{-2}
3	0.10	0.15	1.32×10^{-1}

0 2 . 4

Show how the data in **Table 1** can be used to deduce the rate equation for the reaction between iodide ions and **S**.

[3 marks]

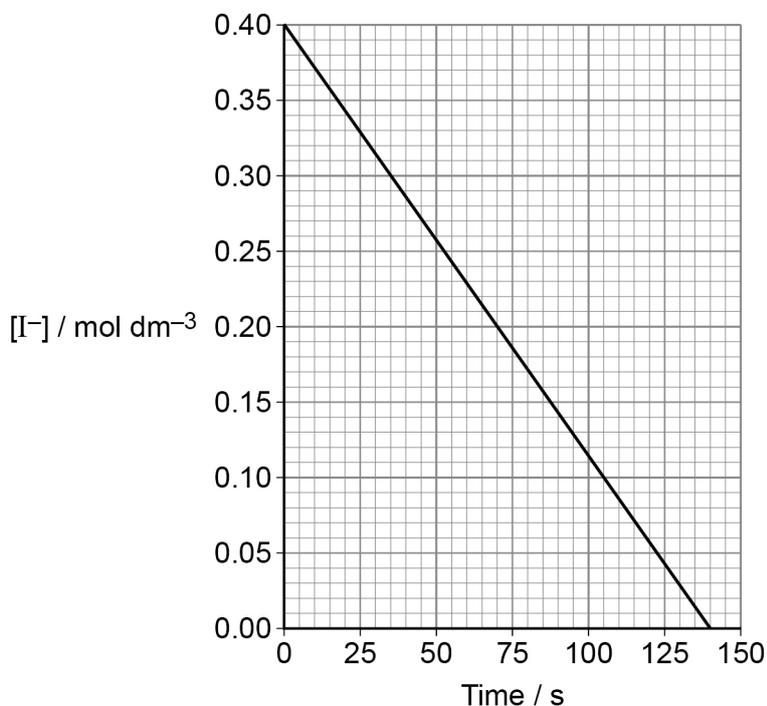
Rate equation _____



The rate of a reaction between iodide ions and a large excess of a compound **T** is investigated in a series of experiments.

A graph of the results is shown in **Figure 1**.

Figure 1



0 2 . 5 Use **Figure 1** to deduce the order of the reaction with respect to I⁻

Justify your answer.

[2 marks]

Order with respect to I⁻ _____

Justification _____

0 2 . 6 The percentage uncertainty of the clock used to measure time at 25 s is 0.8 %

Calculate the uncertainty in reading the clock at 25 s

[1 mark]

Uncertainty = ± _____ s

13

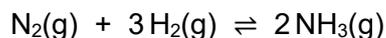
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0 3

This question is about equilibria involving hydrogen gas.

Ammonia is manufactured in an equilibrium reaction.



Iron is used as a catalyst for the reaction. The catalyst has no effect on the equilibrium yield of ammonia.

0 3 . 1

Explain why the use of a catalyst has no effect on the yield of ammonia.

[1 mark]

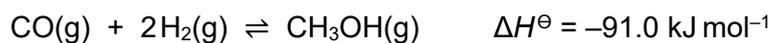
0 3 . 2

The yield of ammonia increases as the pressure is increased.

Suggest **one** reason why a very high pressure is **not** used.

[1 mark]

Methanol is manufactured in an equilibrium reaction.



0 3 . 3

Tick (✓) **one** box to show how the yield of methanol changes for this equilibrium when the temperature is increased.

[1 mark]

Decreases	Stays the same	Increases



0 3 . 4 Write an expression for the equilibrium constant (K_p) for this equilibrium.

Give the units of K_p

[2 marks]

K_p

Units _____

0 3 . 5 Tick (✓) **one** box to show how the value of K_p changes for this equilibrium when the total pressure is increased.

[1 mark]

Decreases	Stays the same	Increases

0 3 . 6 0.343 mol of carbon monoxide is added to 0.604 mol of hydrogen in a sealed container and the mixture allowed to reach equilibrium at temperature T .

At equilibrium, the mixture contains 0.382 mol of hydrogen.

The total pressure of the mixture is 2.55×10^5 kPa

Calculate the partial pressure, in kPa, of methanol in the equilibrium mixture.

[4 marks]

Partial pressure of methanol _____ kPa

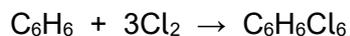
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Turn over ►



Benzene and methylbenzene both react with chlorine in the presence of ultraviolet light.

0 4 . 3 The reaction between benzene and chlorine in the presence of ultraviolet light forms the product $C_6H_6Cl_6$



Suggest the name of the mechanism for this reaction.

Give the structure of the product $C_6H_6Cl_6$

[2 marks]

Name of mechanism _____

Structure of product $C_6H_6Cl_6$

0 4 . 4 One product of the reaction between methylbenzene and chlorine in the presence of ultraviolet light has the molecular formula C_7H_7Cl and has four peaks in its 1H NMR spectrum.

Give the structure of this product.

[1 mark]

7

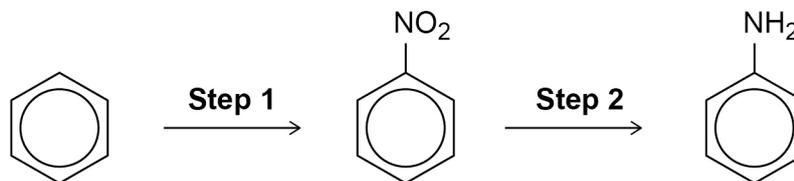
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0 5

This question is about amines and organic synthesis.

Phenylamine can be formed from benzene in two steps.



0 5 . 1

State the reagent(s) needed for **Step 1**.

[1 mark]

0 5 . 2

Name the type of reaction shown in **Step 2**.

Give reagent(s) for **Step 2**.

[2 marks]

Type of reaction _____

Reagent(s) _____

0 5 . 3

State the number of peaks in the ^{13}C NMR spectrum of phenylamine.

[1 mark]

0 5 . 4

Give a use of aromatic amines.

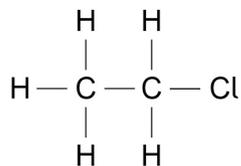
[1 mark]



Methylamine can react with chloroethane and also with ethanoyl chloride.

0 5 . 5 Outline a mechanism for the reaction between methylamine and chloroethane.

[3 marks]



0 5 . 6 Draw the structure of the organic molecule formed in the reaction between methylamine and ethanoyl chloride.

Name the mechanism for this reaction.

[2 marks]

Structure

Name of mechanism _____

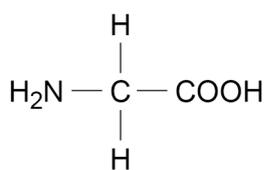
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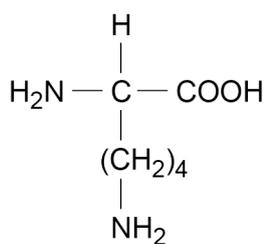


0 6

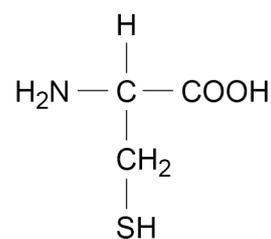
Three amino acids are shown.



glycine



lysine



cysteine

0 6 . 1

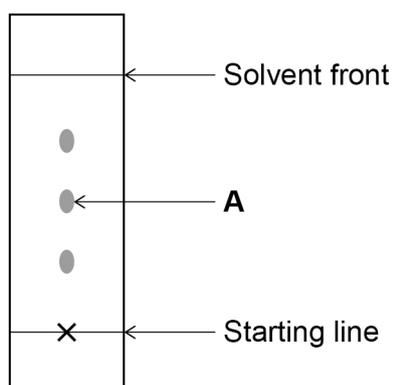
Draw the structure of the zwitterion of glycine.

[1 mark]

A mixture of these three amino acids is separated using thin-layer chromatography.

Figure 2 shows the chromatogram produced. One of the amino acids is labelled **A**.

Figure 2



0 6 . 2

State how the amino acids can be made visible on a chromatogram.

[1 mark]



0 6 . 3 Use **Figure 2** to calculate the R_f value of **A**.

[1 mark]

R_f _____

0 6 . 4 Amino acids can join to form peptides.
The sequence of amino acids in the peptide can be shown using the first three letters
of each amino acid. The amino acids are written in the order that they are joined.

Draw the structure of the peptide with the sequence lys-cys-gly

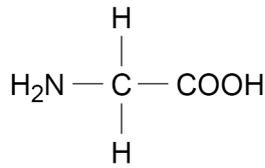
[1 mark]

Question 6 continues on the next page

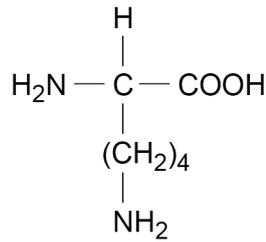
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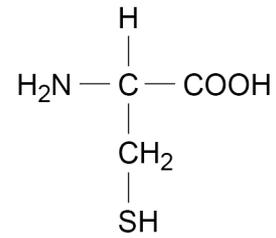
The structures of the three amino acids are repeated here.



glycine



lysine

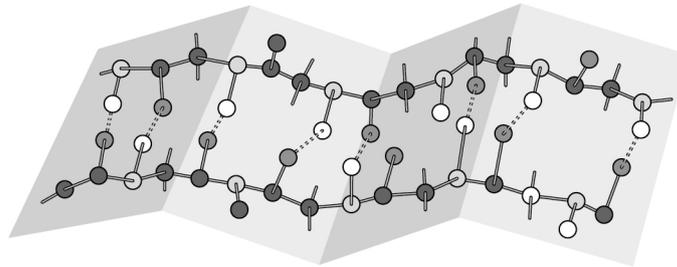


cysteine

A protein is formed from many amino acids, including glycine, lysine and cysteine.

Figure 3 shows part of this protein structure.

Figure 3



0 6 . 5

Identify the highest level of protein structure (primary, secondary or tertiary) shown in **Figure 3**.

Name the interaction that maintains this protein structure.

[2 marks]

Structure _____

Interaction _____



0 6 . 6

The protein in **Figure 3** is hydrolysed in acidic conditions.
The mixture produced is analysed by column chromatography.
The column is packed with a resin that acts as a polar stationary phase.
A non-polar solvent is used.

Explain why lysine leaves the column after glycine.

[2 marks]

8

Turn over for the next question

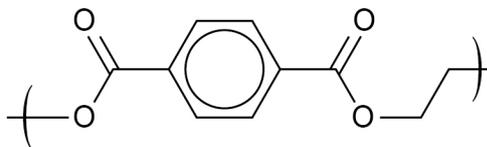
Turn over ►



07

This question is about the condensation polymer Terylene.

The repeating unit of Terylene is shown.



07.1

Draw the structures of the **two** monomers used to make Terylene.

[2 marks]

Monomer 1

Monomer 2

07.2

Terylene is biodegradable.

Other polymers, including poly(propene), are not biodegradable.

Explain why Terylene is biodegradable but poly(propene) is not biodegradable.

[3 marks]

5



0 8

This question is about carboxylic acids and their derivatives.

0 8 . 1

Propanoic acid can be made from propan-1-ol.

Give the reagent (or combination of reagents) for this reaction.

Give the practical condition needed to produce a good yield of propanoic acid in this reaction.

[2 marks]

Reagent(s) _____

Condition _____

0 8 . 2

Propanoic acid can also be made by the reaction between propanoyl chloride and water.

Outline a mechanism for this reaction.

Identify the other product formed.

[4 marks]

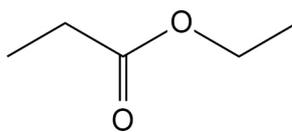
Mechanism

Identity of other product _____

Question 8 continues on the next page

Turn over ►

Compound **X** is an isomer of pentanoic acid.



X

0 8 . 3 Use IUPAC rules to name **X**.

[1 mark]

0 8 . 4 Write an equation for the reaction of **X** with aqueous sodium hydroxide.

[1 mark]

0 8 . 5 Infrared spectroscopy can be used to distinguish between pentanoic acid and **X**.

Give **two** differences between the infrared spectrum of pentanoic acid and the infrared spectrum of **X**.

Use data from **Table A** on the Chemistry Data Sheet.

[2 marks]

Difference 1 _____

Difference 2 _____



0 8 . 6 The ^1H NMR spectrum of **X** contains only four peaks.

Complete **Table 2** to give the integration values and splitting patterns of these peaks.

[2 marks]

Table 2

Chemical shift δ / ppm	1.1	1.2	2.4	3.9
Integration value				
Splitting pattern				

0 8 . 7 **Y** and **Z** are two other isomers of pentanoic acid.
Y and **Z** have only two singlet peaks in their ^1H NMR spectra.

Y reacts with sodium hydrogen carbonate.

Z does not react with sodium hydrogen carbonate.

Give the structures of **Y** and **Z**.

[2 marks]

Y

Z

END OF QUESTIONS



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ANSWER IN THE SPACES PROVIDED**



