OXFORD

INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

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Surname _____

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I declare this is my own work.

INTERNATIONAL A-LEVEL

CHEMISTRY (9620)

Unit 4: Organic 2 and Physical 2

Monday 20 January 2020 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.
- 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).
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- 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	
9	
TOTAL	

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

0 1 This question is about rates of reaction.

In acidic conditions, propanone reacts with iodine as shown.

$$CH_3COCH_3 + I_2 \rightarrow CH_3COCH_2I + HI$$

The concentration of iodine is monitored during the reaction using colorimetry.

The rate equation for the reaction is

$$\text{rate} = k\,[CH_3COCH_3][H^+]$$

0 1 . 1 For this reaction, at a given temperature,

the initial concentration of CH_3COCH_3 = 0.10 mol dm^{-3}
the initial concentration of H^+ = 0.20 mol dm^{-3}
the initial rate = 7.6×10^{-7} mol dm^{-3} s^{-1}

Calculate the value of the rate constant, *k*, at this temperature and give its units.

[3 marks]

k _____

Units _____

0 1 . 2 State **one** benefit of using colorimetry to determine the concentration of a solution.

[1 mark]

_____

_____

Do not write outside the box

0 1 . 3 Iodine is a reactant, but does **not** appear in the rate equation.

Explain why the reaction must occur in more than one step.

[2 marks]

0 1 . 4 State the role of hydrogen ions in the reaction.

[1 mark]

7

Turn over for the next question

Do not write outside the box

0 2 Sulfur dioxide reacts with oxygen as shown.

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g) \qquad \Delta H = -196\ kJ\ mol^{-1}$$

In one experiment, 0.40 mol of sulfur dioxide and 0.20 mol of oxygen are mixed and allowed to reach equilibrium.

At equilibrium, 0.30 mol of sulfur trioxide is formed and the total pressure is 180 kPa

0 2 . 1 Calculate the amount, in mol, of sulfur dioxide and of oxygen at equilibrium.

[2 marks]

Amount of sulfur dioxide _____ mol

Amount of oxygen _____ mol

0 2 . 2 Use your answers from **Question 02.1** to calculate the partial pressure, in kPa, of sulfur trioxide in the equilibrium mixture.

Show your working.

(If you were unable to calculate the amounts in **Question 02.1**, you should assume the amount of sulfur dioxide is 0.15 mol and the amount of oxygen is 0.15 mol These are **not** the correct values.)

[2 marks]

Partial pressure _____ kPa

Do not write outside the box

0 2 . 3 Write an expression for the equilibrium constant (K_p) for this equilibrium.

[1 mark]

K_p

0 2 . 4 The experiment is repeated under different conditions.

At equilibrium,

the partial pressure of oxygen = 7.52 kPa
the partial pressure of sulfur trioxide = 90.4 kPa

The value of the equilibrium constant (K_p) for this reaction is 4.19×10^{-3} kPa^{-1}

Calculate the partial pressure, in kPa, of sulfur dioxide in the equilibrium mixture.

[2 marks]

Partial pressure _____ kPa

Do not write outside the box

The equation for the reaction of sulfur dioxide and oxygen is repeated here.

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g) \qquad \Delta H = -196\ kJ\ mol^{-1}$$

0 2 . 5 State and explain the effect, if any, of adding a catalyst on the value of K_p for this reaction.

[2 marks]

Effect of a catalyst _____

Explanation _____

_____

_____

0 2 . 6 State and explain the effect, if any, of increasing the temperature on the value of K_p for this reaction.

[3 marks]

Effect of increasing temperature _____

Explanation _____

_____

_____

_____

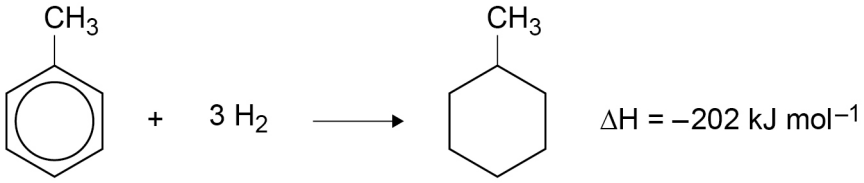
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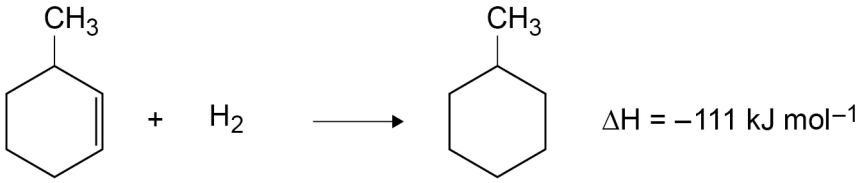
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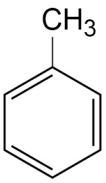
0 3 This question is about methylbenzene.

0 3 . 1 The enthalpies of hydrogenation of two compounds are shown.





The structure of the theoretical molecule methylcyclohexa-1,3,5-triene is shown.



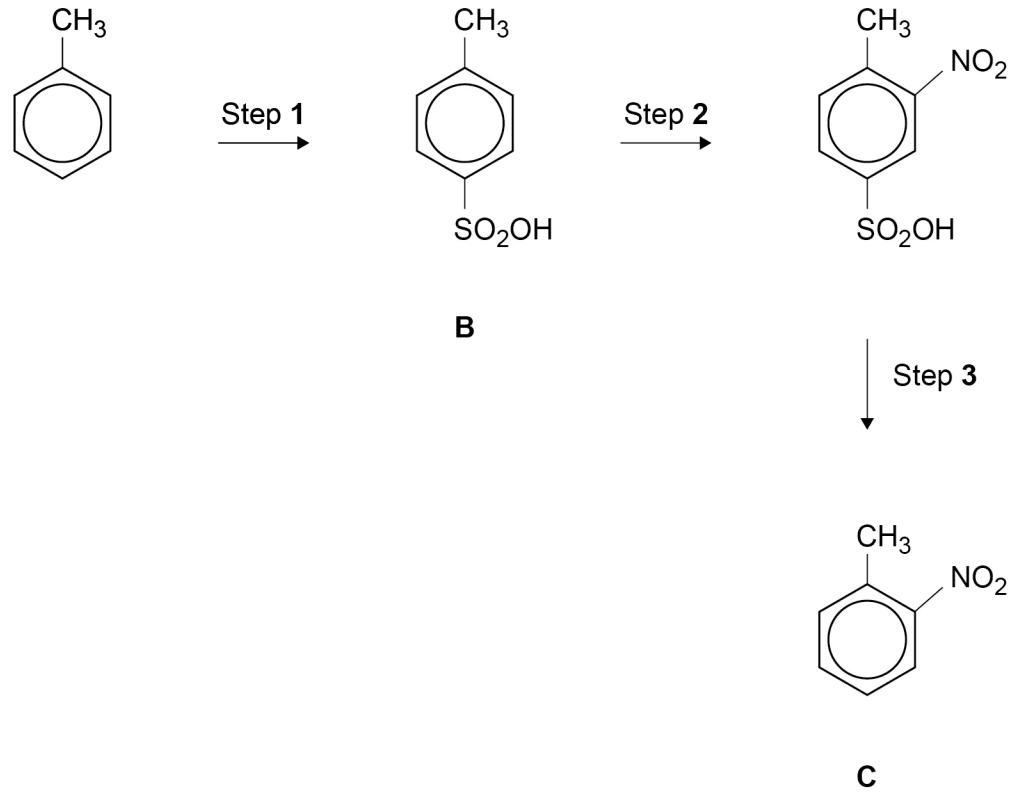
Use the data to calculate the difference in stability, in kJ mol^{-1}, of methylbenzene compared with the theoretical methylcyclohexa-1,3,5-triene.

Explain this difference in stability.

[4 marks]

Do not write outside the box

Compound **C** can be made from methylbenzene in one possible reaction scheme as shown.



0 3 . 2 Give a reagent for Step **1**.

Outline a mechanism for Step **1**.

[5 marks]

Reagent _____

Mechanism

Do not write outside the box

0 3 . 3 Use IUPAC rules to name **B**.

[1 mark]

0 3 . 4 Give a combination of reagents for Step **2**.

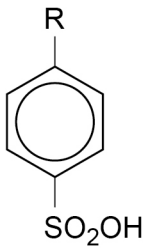
Name the mechanism for Step **2**.

[3 marks]

Reagents

Name of mechanism

0 3 . 5 In the structure shown, R represents a long-chain alkyl group.



State **one** use of this type of compound.

[1 mark]

14

Turn over for the next question

Do not write outside the box

0 4 This question is about carbonyl compounds.

0 4 . 1 State what is meant by the term optical isomers.

[1 mark]

0 4 . 2 Propanone can be reduced by $NaBH_4$ in aqueous solution to form propan-2-ol.

Name and outline the mechanism for this reaction.

[5 marks]

Name of mechanism _____

Mechanism

0 4 . 3 State why propan-2-ol is **not** optically active.

[1 mark]

Do not write outside the box

0 4 . 4 Outline an experiment to show that propan-2-ol is **not** optically active.

[2 marks]

0 4 . 5 Butanone can be reduced by $NaBH_4$ in aqueous solution to form butan-2-ol in a reaction similar to that in **Question 04.2**.

Explain why the butan-2-ol formed in this reaction is not optically active.

[2 marks]

11

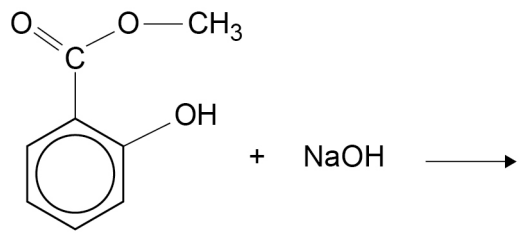
Turn over for the next question

Do not write outside the box

0 5 Methyl salicylate is a naturally-occurring liquid ester that can be used to make salicylic acid.
Salicylic acid is an important compound used to make the drug aspirin.

0 5 . 1 Complete the equation to show the hydrolysis of methyl salicylate in the presence of sodium hydroxide.

[1 mark]



methyl salicylate

A student hydrolyses methyl salicylate using this method.

- Place 20.0 cm^3 of 5.00 mol dm^{-3} sodium hydroxide in a round-bottomed flask.
- Add 6.50 g of methyl salicylate to the flask and swirl the mixture thoroughly.
- Add anti-bumping granules and heat the mixture under reflux for 20 minutes.

0 5 . 2 Calculate the volume, in cm^3, of 6.50 g of methyl salicylate.

The density of methyl salicylate = 1.17 g cm^{-3}

[1 mark]

Volume = _____ cm^3

Do not write outside the box

0 5 . 3 State why anti-bumping granules are added.

[1 mark]

0 5 . 4 After the mixture is heated under reflux, it is allowed to cool.
Sulfuric acid is then added to this mixture until a precipitate of impure salicylic acid forms.

Draw a diagram to show how the impure solid salicylic acid can be separated from the reaction mixture.

[2 marks]

0 5 . 5 Impurities affect the melting point of salicylic acid.
The melting point of pure salicylic acid is 159 °C

Identify **two** ways that the melting point is affected by impurities.

[2 marks]

1

2

Do not write outside the box

0 5 . 6 The impure salicylic acid can be purified by recrystallisation using water.

Outline the method that the student should use to obtain a pure sample of solid salicylic acid.

[6 marks]

Do not write outside the box

0 5 . 7 Salicylic acid reacts with ethanoic anhydride or with ethanoyl chloride to make aspirin.

Give **two** advantages of using ethanoic anhydride instead of ethanoyl chloride to make aspirin.

[2 marks]

Advantage 1 _____

_____

Advantage 2 _____

_____

15

Turn over for the next question

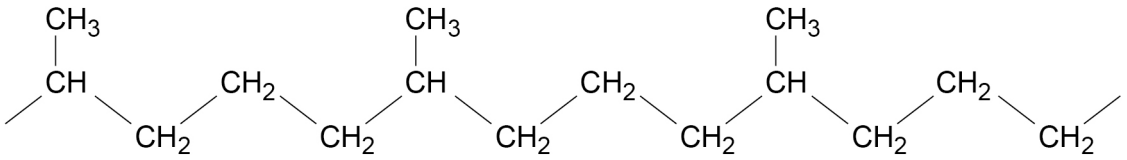
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0 6 This question is about polymers.

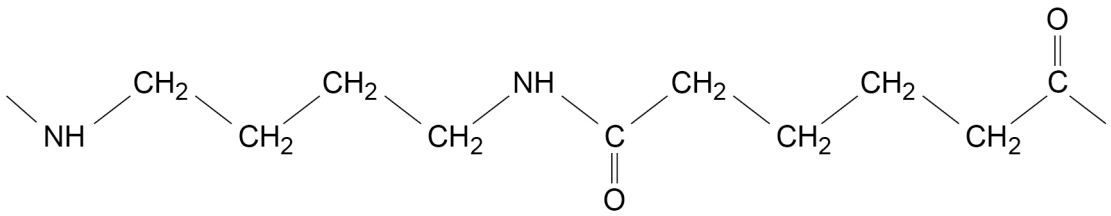
Figure 1 shows the structures of three polymers.

Figure 1

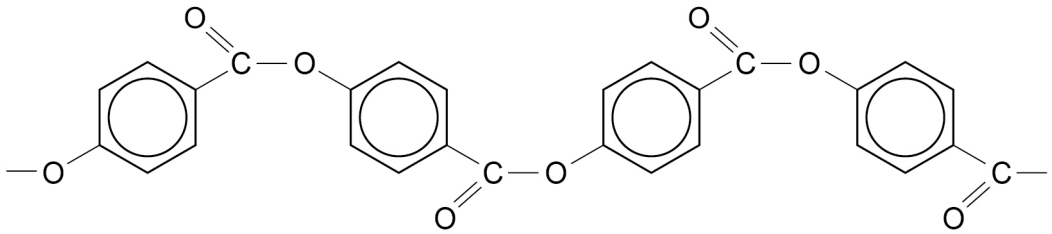
P



Q



R



0 6 . 1 Polymer **P** is an addition polymer made from two different alkene monomers.

Give the structure of each alkene.

[2 marks]

Alkene **1**

Alkene **2**

Do not write outside the box

0 6 . 2 Polymer **Q** is a condensation polymer.

State the type of condensation polymer.

Give the skeletal formula of each monomer used to make polymer **Q**.

[3 marks]

Type of condensation polymer _____

Monomer **1**

Monomer **2**

0 6 . 3 Polymer **R** is made from only one monomer.

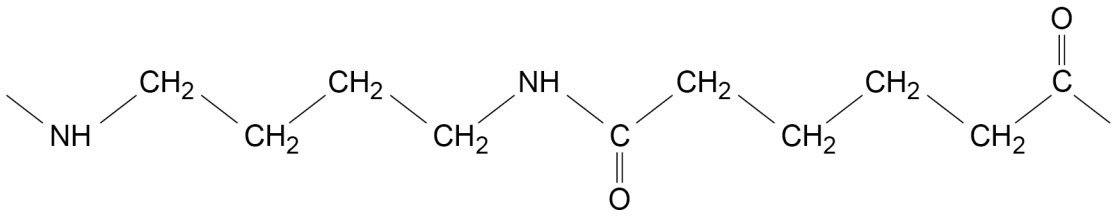
Give the structure of this monomer.

[1 mark]

Turn over ►

Do not write outside the box

The structure of polymer **Q** is repeated here.



0 6 . 4 Explain why polymer **Q** is biodegradable.

[2 marks]

8

Do not write outside the box

0 7 Two amines, **X** and **Y**, have the molecular formula C_3H_9N



X **Y**

0 7 . 1 Draw the structure of a primary amine that is an isomer of **X** and **Y**.

[1 mark]

0 7 . 2 Draw the structure of the compound formed when **X** reacts with propanoyl chloride.

[1 mark]

0 7 . 3 Draw the structure of the compound formed when **Y** reacts with an excess of bromomethane.

[1 mark]

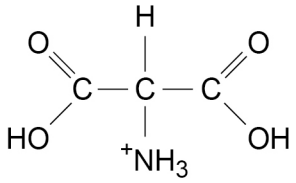
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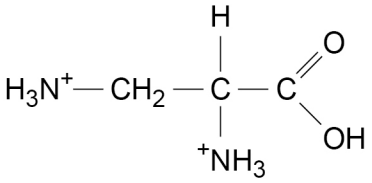
0 8 This question is about peptides and proteins.

0 8 . 1 A dipeptide is hydrolysed by refluxing in acidic conditions.

The structures of the two products formed are shown.



Product 1



Product 2

The mixture of products is analysed using thin-layer chromatography.
The chromatography uses a polar stationary phase and a non-polar mobile phase.

Explain why **Product 2** has the lower R_f value.

[2 marks]

0 8 . 2 The secondary structure of a protein is maintained by hydrogen bonding.

Explain how a hydrogen bond is formed.

[2 marks]

Do not write outside the box

0 8 . 3 The tertiary structure is maintained by interactions between the side chains of amino acids.
Consider the sections of polypeptide chains in **Figure 2** and **Figure 3**.

[2 marks]

Figure 2

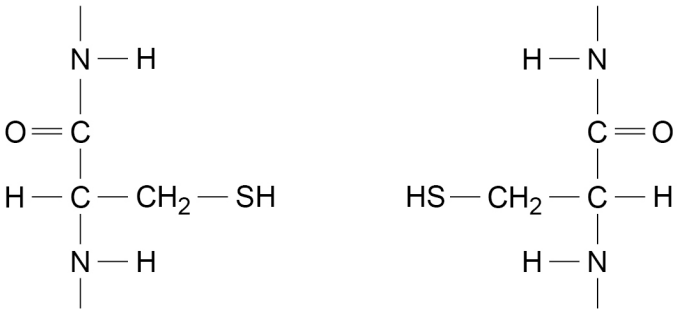
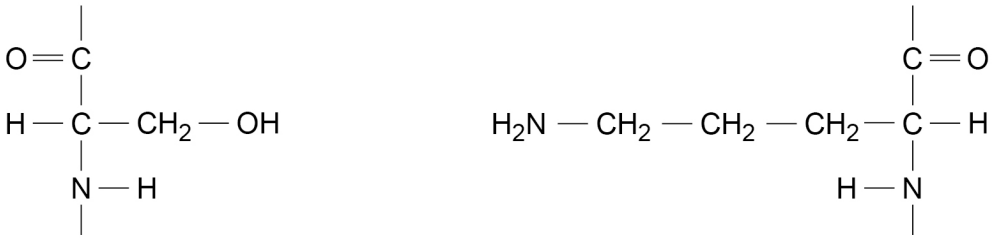


Figure 3



What type of interaction occurs between the two side chains in **Figure 2**?

Tick (✓) **one** box.

Induced dipole-dipole ☐

Hydrogen bonding ☐

Disulfide bridge ☐

What type of interaction occurs between the two side chains in **Figure 3**?

Tick (✓) **one** box.

Induced dipole-dipole ☐

Hydrogen bonding ☐

Disulfide bridge ☐

6

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0 9 This question is about isomers of $C_6H_{12}O_2$

0 9 . 1 Draw the structure of the ester with molecular formula $C_6H_{12}O_2$ that is formed when propan-2-ol reacts with a suitable carboxylic acid.

[1 mark]

0 9 . 2 Draw the structure of an ester with molecular formula $C_6H_{12}O_2$ that has only two peaks in its ^1H NMR spectrum.

[1 mark]

0 9 . 3 Draw the structure of the ester with molecular formula $C_6H_{12}O_2$ that is optically active and has five peaks in its ^{13}C NMR spectrum.

[1 mark]

Do not write outside the box

0 9 . 4 A cyclic compound with molecular formula $C_6H_{12}O_2$ has only two peaks in its ^{13}C NMR spectrum. It has no absorption in the 1680–1750 cm^{-1} range in its infrared spectrum.

Draw the structure of this cyclic compound.

[1 mark]

4

END OF QUESTIONS

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