OXFORD

INTERNATIONAL AQA EXAMINATIONS

Please write clearly in block capitals.

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INTERNATIONAL A-LEVEL

CHEMISTRY (9620)

Unit 4: Organic 2 and Physical 2

Friday 7 June 2019 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. Use pencil only for drawing.
- 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.
- All working must be shown.
- 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).
- 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.

Do not write outside the box

0 1 This question is about amines.

0 1 . 1 Write an ionic equation for the reaction between propylamine and hydrochloric acid.

[1 mark]

0 1 . 2 Explain why propylamine is a stronger base than ammonia.

[2 marks]

0 1 . 3 Name and outline a mechanism for the reaction of ammonia with 1-bromopropane to form propylamine.

[5 marks]

Name of mechanism

Mechanism

Do not write outside the box

0 1 . 4 Explain why the reaction in Question **01.3** may give a low yield of propylamine.

[1 mark]

0 1 . 5 Propylamine reacts with bromoethane, under specific conditions, to give a compound with the formula $C_9H_{22}NBr$

Draw the structure of the compound with the formula $C_9H_{22}NBr$
Identify this type of compound.
Give a use for this type of compound.

[3 marks]

Structure

Type of compound _____

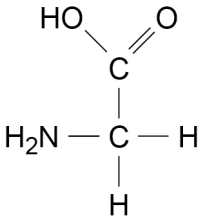
Use _____

12

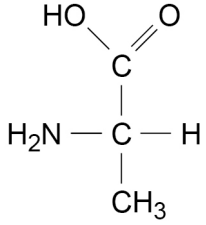
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0 2 This question is about amino acids and peptides.

The structures of two amino acids, glycine and alanine, are shown.



glycine



alanine

0 2 . 1 Use IUPAC rules to name alanine.

[1 mark]

0 2 . 2 State why glycine does **not** show optical activity.

[1 mark]

Do not write outside the box

0 2 . 3 Draw the structure of each of the two dipeptides that are formed when glycine reacts with alanine.

Circle the peptide link in **one** of your structures.

[3 marks]

0 2 . 4 Draw the structure of the zwitterion of alanine.
Explain why alanine has a high melting point.

[2 marks]

Structure

Explanation _____

_____

_____

_____

Turn over ►

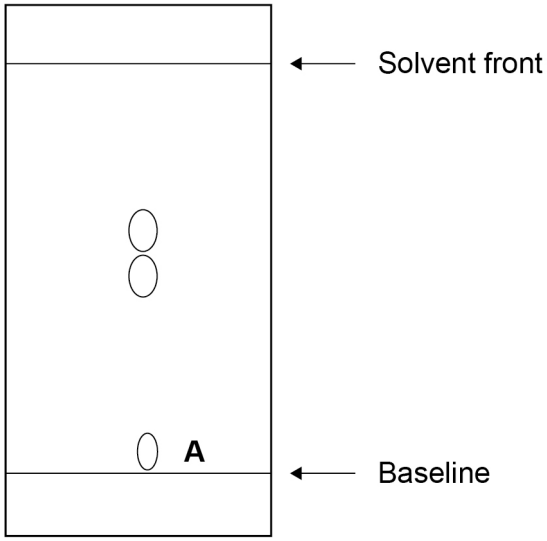
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0 2 . 5 A peptide is known to contain **four** different amino acids.

In an experiment a student heats the peptide with acid to help hydrolyse it.
The student analyses the resulting mixture by thin-layer chromatography (TLC).

Figure 1 shows a diagram of the chromatogram that the student obtains.

Figure 1



The spot just above the baseline, labelled **A**, contains a mixture of substances.
This mixture cannot be separated using this method.

Identify a developing agent that can be used to locate the amino acids on the chromatogram.
Suggest a possible reason why the R_f value of the compounds in spot **A** is low.

[2 marks]

Identity of developing agent _____

Reason for low R_f value _____

_____

0 2 . 6 Suggest **two** reasons why there are only three spots on the chromatogram.

[2 marks]

Reason 1 _____

_____

Reason 2 _____

_____

Do not write outside the box

R_f values of some amino acids are given in **Table 1**

Table 1

Amino acid	glycine	methionine	phenylalanine	serine	tyrosine
R_f value	0.26	0.59	0.75	0.23	0.48

0 2 . 7 Identify the **two** amino acids in the hydrolysed mixture that can be identified from the chromatogram.

Tick (✓) **two** boxes.

[1 mark]

Glycine ☐

Methionine ☐

Phenylalanine ☐

Serine ☐

Tyrosine ☐

0 2 . 8 State why the structure of a peptide **cannot** be determined from a chromatogram, even if the identity of all the amino acids is known.

[1 mark]

_____

_____

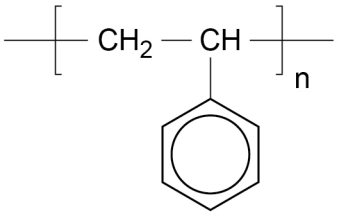
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13

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0 3 This question is about polymers.

The structure of polymer **A** is shown.



0 3 . 1 State the type of polymerisation used to make **A**.

[1 mark]

0 3 . 2 Draw the skeletal formula of the monomer used to make **A**.

[1 mark]

0 3 . 3 Explain why **A** is not biodegradable.

[2 marks]

Do not write outside the box

0 3 . 4 After use, some materials made of polymers can be recycled.

State **one** disadvantage of recycling materials made of polymers.

[1 mark]

0 3 . 5 After use, some materials made of polymers cannot be recycled.
These materials can be disposed of by burning.

State **one** disadvantage of burning as a method of disposing of materials made of polymers.

[1 mark]

6

Turn over for the next question

Do not write outside the box

0 4 This question is about structure determination.

Use Tables **A**, **B** and **C** on the Data Sheet to help answer Questions **04.1** to **04.4**

0 4 . 1 Isomers **P** and **Q** have the molecular formula C_4H_8O

When warmed with Tollens' reagent:
P gives a silver mirror
Q does not give a silver mirror

In their infrared spectra:
P and **Q** both have a strong absorption in the 1700–1725 cm^{-1} region

In their ^{13}C NMR spectra:
P has three peaks
Q has four peaks

Deduce the structure of **P** and the structure of **Q**.

[2 marks]

P **Q**

Do not write outside the box

0 4 . 2 Isomers **R** and **S** have the molecular formula C_3H_9N

In their infrared spectra:
R has absorptions in the 3350–3450 cm^{-1} region
S has no absorptions at wavenumbers greater than 3100 cm^{-1}

In their ^1H NMR spectra:
R has three peaks
S has only one peak

Deduce the structure of **R** and the structure of **S**.

[2 marks]

R **S**

Question 4 continues on the next page

Do not write outside the box

0 4 . 3 Isomers **T** and **U** have the molecular formula C_6H_{12}

In their infrared spectra:
T has an absorption at 1650 cm^{-1}
U has no absorptions between 1500 and 2900 cm^{-1}

In their ^1H NMR spectra:
T and **U** both have only one peak

Deduce the structure of **T** and the structure of **U**.

[2 marks]

T **U**

Do not write outside the box

0 4 . 4 Isomers **V** and **W** have the molecular formula $C_5H_{10}O_2$

In their infrared spectra:
V and **W** both have strong absorptions in the 1700–1750 cm^{-1} region

In their ^1H NMR spectrum:
V has two peaks (both singlets) with integration ratio 9:1
W has four peaks (two triplets and two quartets) with integration ratio 3:3:2:2

With aqueous sodium carbonate:
V effervesces
W does not effervesce

Deduce the structure of **V** and the structure of **W**.

[2 marks]

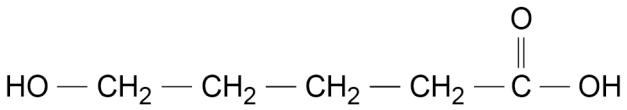
V **W**

8

Turn over for the next question

Do not write outside the box

0 5 The structure of compound **X** is shown.



0 5 . 1 Use IUPAC rules to name **X**.

[1 mark]

0 5 . 2 Draw the structure of the compound formed when **X** is heated under reflux with an excess of acidified potassium dichromate(VI).

[1 mark]

0 5 . 3 When **X** is warmed with a few drops of concentrated sulfuric acid, a cyclic compound with the molecular formula $C_5H_8O_2$ is formed.

Draw the skeletal formula of the compound with molecular formula $C_5H_8O_2$ formed in this reaction.

[1 mark]

Do not write outside the box

0 5 . 4 **X** forms a polymer by reaction with itself, in the presence of a catalyst.

Draw **one** repeating unit of this polymer.

[1 mark]

4

0 6 Alcohols react with acyl chlorides.

Name and outline a mechanism for the reaction of methanol with ethanoyl chloride.

[5 marks]

Name of mechanism _____

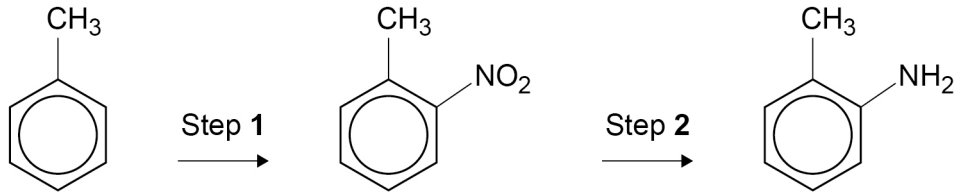
Mechanism

5

Turn over for the next question

Do not write outside the box

0 7 A two-step preparation of 2-aminomethylbenzene starting from methylbenzene is shown.



methylbenzene 2-aminomethylbenzene

0 7 . 1 In Step **1**, methylbenzene undergoes an electrophilic substitution reaction.

Identify the reagents needed for this reaction.
Write an equation to show the formation of the electrophile.
Outline the mechanism for the reaction in Step **1** of methylbenzene with this electrophile.

[6 marks]

Reagents _____

_____

Equation

_____

Mechanism

Do not write outside the box

0 7 . 2 Give the structure of **one other** organic product formed in Step **1**

[1 mark]

0 7 . 3 In this two-step preparation 10.0 cm^3 of methylbenzene (M_r = 92.0) were used.

4.42 g of 2-aminomethylbenzene were obtained.

Calculate the percentage yield in this preparation.

The density of methylbenzene = 0.870 g cm^{-3}

[3 marks]

% yield _____

0 7 . 4 Explain why methylbenzene does **not** react easily with nucleophiles such as ammonia.

[2 marks]

_____

_____

_____

_____

12

Turn over ►

Do not write outside the box

0 8 This question is about acids and bases.

0 8 . 1 State what is meant by a Brønsted–Lowry acid.

[1 mark]

0 8 . 2 Hydrochloric acid is a strong acid.

10.0 cm^3 of 5.00 $mol\,dm^{-3}$ hydrochloric acid are diluted with distilled water to form 250 cm^3 of solution.

Calculate the pH of the solution formed.
Give your answer to 2 decimal places.

[3 marks]

pH _____

0 8 . 3 Water dissociates as shown.

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

Give an expression for the ionic product of water, K_w
State the effect of increasing temperature on the value of K_w
Explain your answer.

[4 marks]

K_w

Effect of increasing temperature _____

Explanation _____

Do not write outside the box

0 8 . 4 Calculate the pH of 0.125 mol dm^{-3} aqueous sodium hydroxide at 298 K
Give your answer to 2 decimal places.

The ionic product of water, $K_w = 1.00 \times 10^{-14}$ $mol^2\ dm^{-6}$ at 298 K

[2 marks]

pH _____

0 8 . 5 Propanoic acid is a weak acid.

An aqueous solution of propanoic acid has a pH of 2.85 at 298 K

Calculate the concentration, in mol dm^{-3}, of this solution.
Give your answer to 3 significant figures.

The acid dissociation constant of propanoic acid, $K_a = 1.35 \times 10^{-5}$ mol dm^{-3} at 298 K

[3 marks]

Concentration _____ mol dm^{-3}

Question 8 continues on the next page

Do not write outside the box

0 8 . 6 A buffer solution is formed when
10.0 cm^3 of 0.210 mol dm^{-3} aqueous sodium hydroxide are added to
25.0 cm^3 of 0.250 mol dm^{-3} aqueous propanoic acid.

Calculate the pH of the buffer solution at 298 K
Give your answer to 2 decimal places.

The acid dissociation constant of propanoic acid, K_a = 1.35 x 10^{-5} mol dm^{-3} at 298 K
[5 marks]

pH _____

0 8 . 7 A small amount of hydrochloric acid is added to the buffer solution in Question **08.6**

Explain why the pH of the buffer solution stays almost constant when the hydrochloric acid is added.

[2 marks]

_____

_____

_____

_____

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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