

Organic Synthesis

Question Paper 1

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|------------|-----------------------|
| Level | International A Level |
| Subject | Chemistry |
| Exam Board | CIE |
| Topic | Organic Synthesis |
| Sub-Topic | |
| Paper Type | Theory |
| Booklet | Question Paper 1 |

Time Allowed: 66 minutes

Score: /55

Percentage: /100

Grade Boundaries:

| A* | A | B | C | D | E | U |
|------|-------|-----|-------|-------|-----|------|
| >85% | 77.5% | 70% | 62.5% | 57.5% | 45% | <45% |

- 1 (a) Analysis of a sample of DNA showed that 33% of the nitrogenous bases present was guanine. Calculate the percentages of the **other** bases in this sample of DNA.

adenine% cytosine% thymine% [2]

- (b) Many drug molecules are chiral, but are often produced as a mixture of optical isomers.

- (i) Suggest why a larger mass of the mixture is required than of a single optical isomer.

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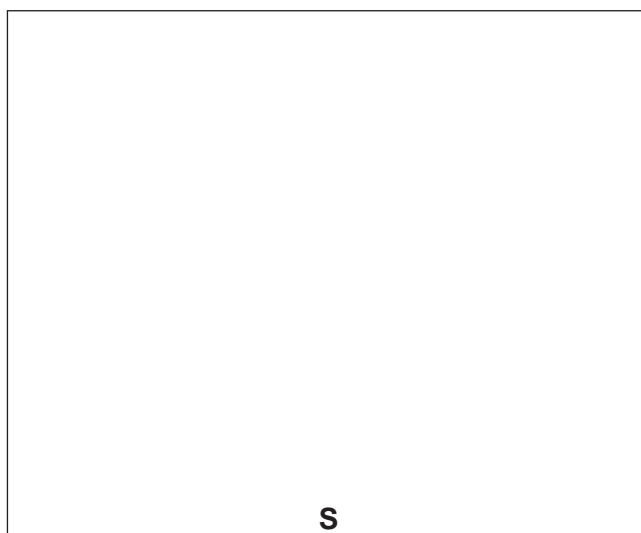
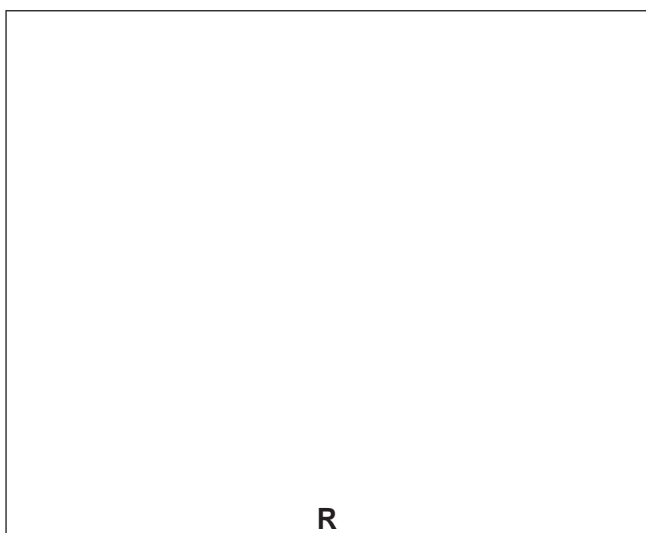
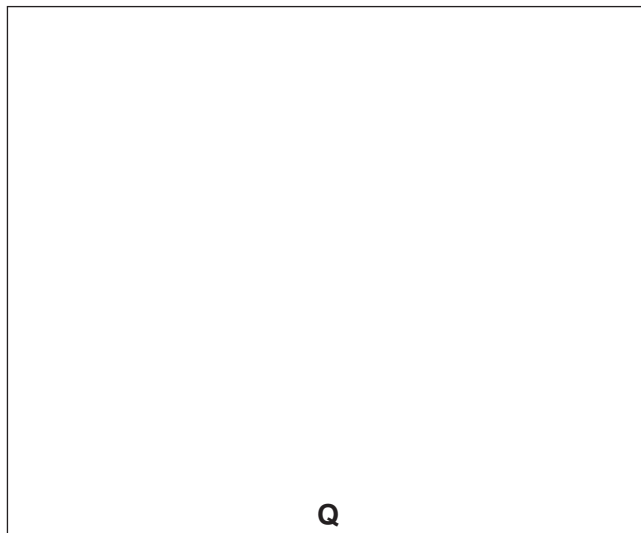
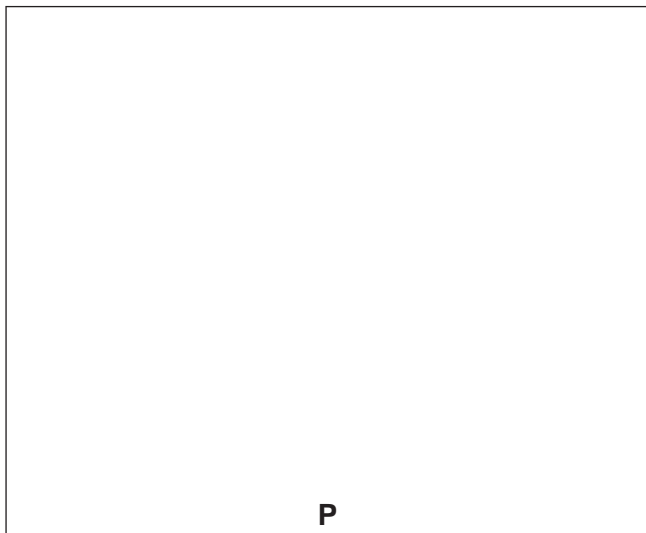
- (ii) Suggest a problem that might arise as a result of taking a mixture of optical isomers.

.....
.....

[2]

(c) There are four structural isomers with the molecular formula $C_5H_{10}O$ that are aldehydes.

(i) Draw the structures of these aldehydes.



(ii) The NMR spectrum of **one** of these isomers contains **four** absorptions. Which isomer **P**, **Q**, **R** or **S** gives this spectrum?

isomer

(iii) Predict the number of absorptions that would be given by each of the other three isomers.

| isomer letter (P , Q , R or S) | number of absorptions |
|--|-----------------------|
| | |
| | |
| | |

[6]

[Total: 10]

2 (a) Enzymes are particular types of proteins that catalyse chemical reactions. The efficiency of enzymes can be reduced by the presence of other substances known as inhibitors.

(i) State **one** example of a substance that can act as a *non-competitive* inhibitor in enzyme reactions.

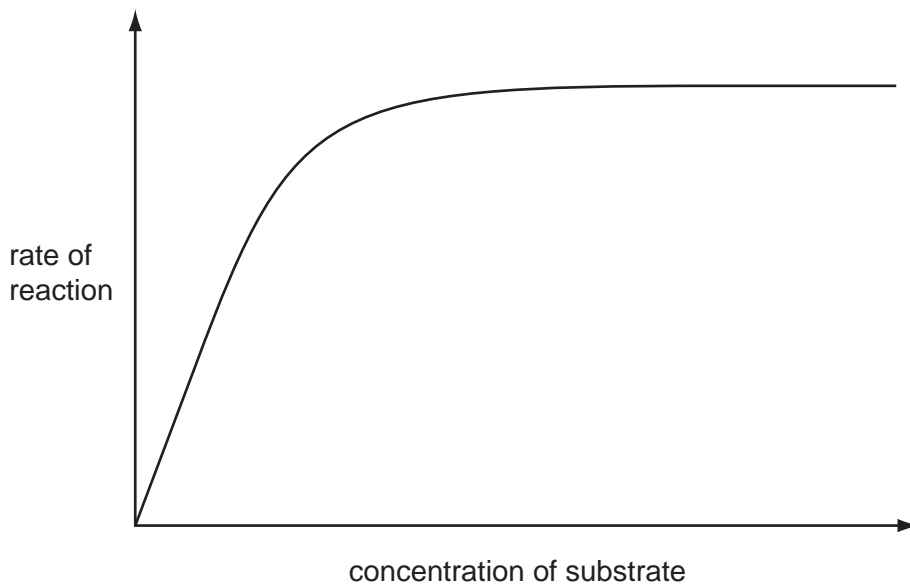
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(ii) For the inhibitor you have identified, explain why it is a non-competitive inhibitor.

.....

.....

(iii) The graph shows the rate of an enzyme-catalysed reaction against the substrate concentration in the absence of an inhibitor.



On the same axes, sketch a graph showing the rate of this reaction if a *competitive inhibitor* was present.

[4]

(b) DNA is responsible for encoding the amino acid sequence to produce proteins.

Ribosome, tRNA and mRNA are all involved in the process of protein synthesis.

(i) Write ribosome, tRNA and mRNA in the boxes below to show the correct sequence in which they are involved.



(ii) Sequences of three bases code for specific amino acids. The code UGA however does not usually code for an amino acid. Suggest its use.

.....
[3]

(c) Much of the energy used in biochemical reactions is provided by the hydrolysis of the molecule ATP.

(i) What are the breakdown products of the hydrolysis of ATP?

.....

(ii) Give **two** uses for the energy released by ATP hydrolysis in cells.

1.

2.

[3]

[Total: 10]

- 3 Organic compounds which contain oxygen may contain alcohol, aldehyde, carboxylic acid, ester or ketone functional groups. The functional groups may be identified by their reactions with specific reagents.

Compound **X** has the empirical formula CH_2O and M_r of 90.

- (a) There is no reaction when **X** is treated with NaHCO_3 .

What functional group does this test show to be **not** present in **X**?

.....

[1]

- (b) When 0.600 g of **X** is reacted with an excess of Na, 160 cm^3 of H_2 , measured at room temperature and pressure, is produced.

- (i) What functional group does this reaction show to be present in **X**?

.....

- (ii) Use the data to calculate the amount, in moles, of hydrogen **atoms** produced from 0.600 g of **X**.

- (iii) Hence, show that each molecule of **X** contains **two** of the functional groups you have given in (i).

[4]

(c) When **X** is warmed with Fehling's reagent, a brick red precipitate is formed.
Treatment of **X** with 2,4-dinitrophenylhydrazine reagent produces an orange solid.

(i) What functional group do these reactions show to be present in **X**?
Draw the displayed formula of this functional group.

(ii) Use your answers to (b)(i), (b)(ii) and (c)(i) to deduce the structural formula of **X**.

(iii) What is the structural formula of the organic product of the reaction of **X** with Fehling's reagent?

[3]

(d) Compound **X** can be both oxidised and reduced.

(i) Give the structural formula of the compound formed when **X** is reacted with NaBH_4 under suitable conditions.

(ii) Give the structural formula of the compound formed when **X** is heated under reflux with acidified $\text{K}_2\text{Cr}_2\text{O}_7$.

[2]

[Total: 10]

4 Oxygen-containing organic compounds may contain a number of different functional groups including alcohol, aldehyde, carboxylic acid, ester or ketone functional groups. These functional groups may be identified by their reactions with specific reagents.

(a) On treating compounds containing each of these functional groups with the reagents below, only five reactions occur. Complete the table by placing a tick (✓) in each box where you believe a reaction will occur. You should place **no more** than five ticks in the table.

| reagent | alcohol R_2CHOH | aldehyde $RCHO$ | carboxylic acid RCO_2H | ester RCO_2R' | ketone $RCOR'$ |
|--------------------|----------------------|--------------------|-----------------------------|--------------------|-------------------|
| $NaHCO_3$ | | | | | |
| Na | | | | | |
| $Cr_2O_7^{2-}/H^+$ | | | | | |

[5]

Compound **G** has the empirical formula CH_2O and M_r of 90.

An aqueous solution of **G** is neutral. There is no reaction when **G** is treated with $NaHCO_3$.

When 0.30 g of pure **G** is reacted with an excess of Na, 80 cm³ of H_2 , measured at room temperature and pressure, is produced.

(b) What functional group do these two reactions show to be present in **G**?

.....

(ii) Use the data to calculate the amount, in moles, of hydrogen **atoms** produced from 0.30 g of **G**.

(iii) Hence, show that each molecule of **G** contains **two** of the functional groups you have given in (i).

[4]

(c) Treatment of **G** with 2,4-dinitrophenylhydrazine reagent produces an orange solid. When **G** is warmed with Fehling's reagent, no reaction occurs.

(i) What functional group do these reactions show to be present in **G**?
Draw the displayed formula of this functional group.

(ii) Use your answers to (b)(i) and (c)(i) to deduce the structural formula of **G**.

[2]

(d) Compound **G** can be both oxidised and reduced.

(i) When **G** is heated under reflux with acidified $K_2Cr_2O_7$, compound **H** is formed.
Give the structural formula of compound **H**.

(ii) When **G** is reacted with $NaBH_4$ under suitable conditions, compound **J** is formed.
Give the structural formula of compound **J**.

[2]

[Total: 13]

- 5 Many naturally occurring organic compounds contain oxygen. Such compounds may contain alcohol, aldehyde, carboxylic acid, ester or ketone functional groups. These functional groups may be identified by their reactions with specific reagents.

Compound **F** is a white solid which has the molecular formula $C_3H_6O_3$.

Compound **F** is soluble in water. Addition of $NaHCO_3$ to this solution produces a colourless gas, **G**, which turns lime water milky.

- (a) What is the identity of the gas **G**?

.....

- (ii) What functional group does this test show to be present in **F**?

.....

[2]

- (b) When **F** is heated with concentrated sulfuric acid, a colourless liquid **H** is produced. When cold dilute acidified $KMnO_4$ is shaken with **H**, the solution becomes colourless.

- (i) What *type of reaction* occurs when **H** is formed from **F**?

.....

- (ii) Use your answers to (a)(ii) and (b)(i) to deduce the structural formula of the colourless liquid **H**.

[4]

(c) Compound **F** will react with sodium.

Calculate the volume of H_2 , measured at room temperature and pressure, which will be produced when 0.600 g of **F** is reacted with an excess of Na.

[4]

(d) There are two structural isomers of **F** that give the reactions described in (a) and (b).

(i) Suggest two structural formulae for these isomers.

| | |
|----------|----------|
| J | K |
|----------|----------|

(ii) Isomers **J** and **K** can both be oxidised.

What will be produced when **each** of the isomers **J** and **K** is heated under reflux with acidified $\text{K}_2\text{Cr}_2\text{O}_7$?

| | |
|-----------------------|-----------------------|
| product from J | product from K |
|-----------------------|-----------------------|

[2]

[Total: 12]