Halogenoalkanes

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Halogen Derivatives
Sub-Topic	Halogenoalkanes
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: **75 minutes**

Score: **/62**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** Organohalogen compounds can undergo hydrolysis.

$$R\text{–}Cl + H_2O \rightarrow R\text{–}OH + HCl$$

State the relative rates of hydrolysis of the following compounds.

$CH_3CH_2CH_2Cl$ CH_3CH_2COCl C_6H_5Cl

Explain your answer.

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.....

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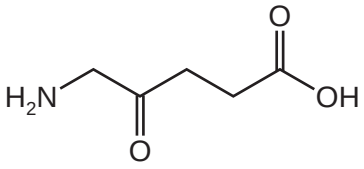
.....

.....

..... [3]

(b) Aminolaevulinic acid is involved in the synthesis of haemoglobin and chlorophyll.



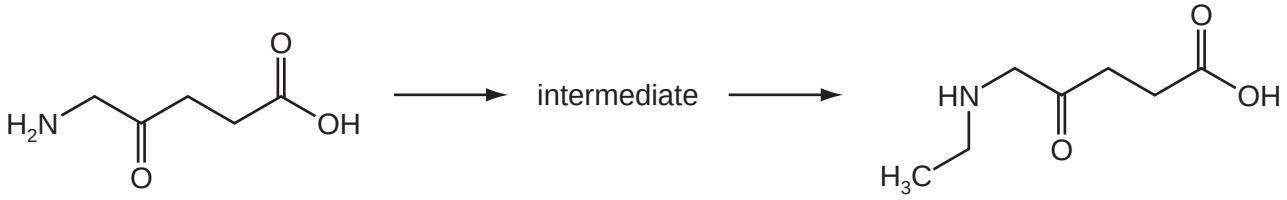
aminolaevulinic acid

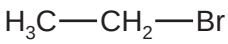
Name the **three** functional groups in aminolaevulinic acid.

..... [2]

(c) Aminolaevulinic acid reacts readily with bromoethane.

(i) Show the mechanism of the **first step** of this reaction on the diagram. Include all necessary curly arrows, lone pairs and relevant dipoles.





(ii) Name the mechanism in **(c)(i)**.

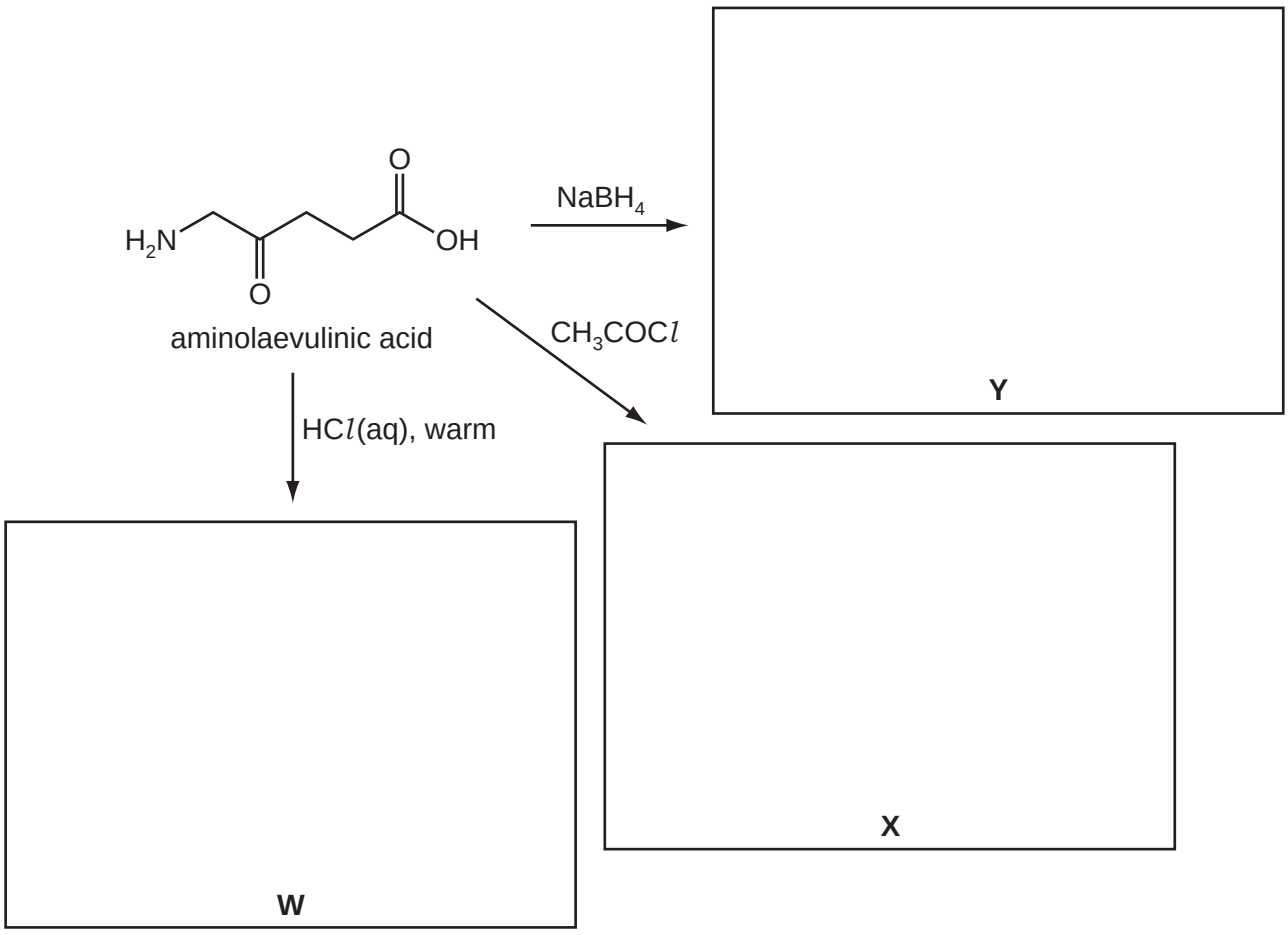
.....

(iii) Identify the non-organic product formed in this reaction.

.....

[5]

(d) Three reactions of aminolaevulinic acid are shown. Draw the structures of the products **W**, **X** and **Y** in the boxes below.



[3]

(e) Aminolaevulinic acid can undergo polymerisation.

Draw the structure of the polymer showing **two** repeat units. The linkages between the monomer units should be shown fully displayed.

[2]

[Total: 15]

2 A bromoalkane, R–Br, is hydrolysed by aqueous sodium hydroxide.

(a) (i) Write a balanced equation for this reaction.

.....

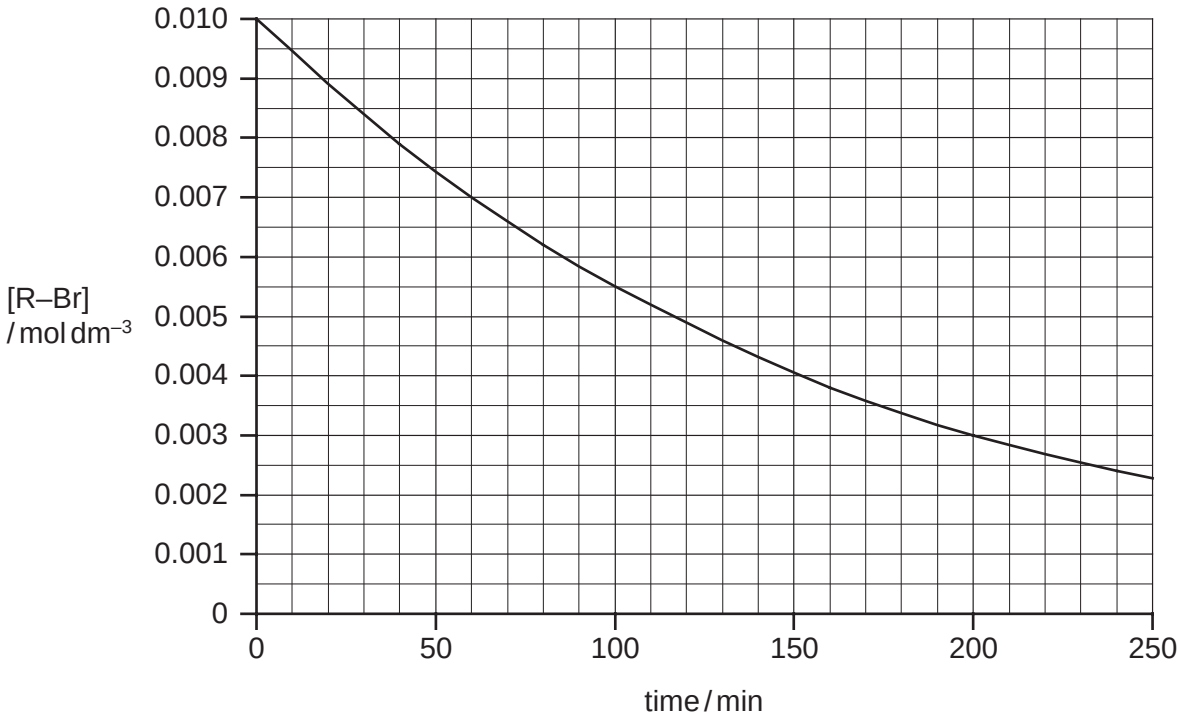
(ii) What *type of reaction* is this?

.....

[2]

(b) The concentration of bromoalkane was determined at regular time intervals as the reaction progressed.

Two separate experiments were carried out, with different NaOH concentrations.
The graph below shows the results of an experiment using [NaOH] = 0.10 mol dm^{-3}.



When the experiment was repeated using [NaOH] = 0.15 mol dm^{-3}, the following results were obtained.

time / min	[R–Br] / mol dm^{-3}
0	0.0100
40	0.0070
80	0.0049
120	0.0034
160	0.0024
200	0.0017
240	0.0012

(i) Plot these data on the axes above, and draw a line of best fit.

(ii) Use one of the graphs to confirm that the reaction is first order with respect to R–Br. Show all your working, and show clearly any construction lines you draw.

(iii) Use the graphs to calculate the order of reaction with respect to NaOH. Show all your working, and show clearly any construction lines you draw on the graphs.

(iv) Write the rate equation for this reaction, and calculate the value of the rate constant.

rate =

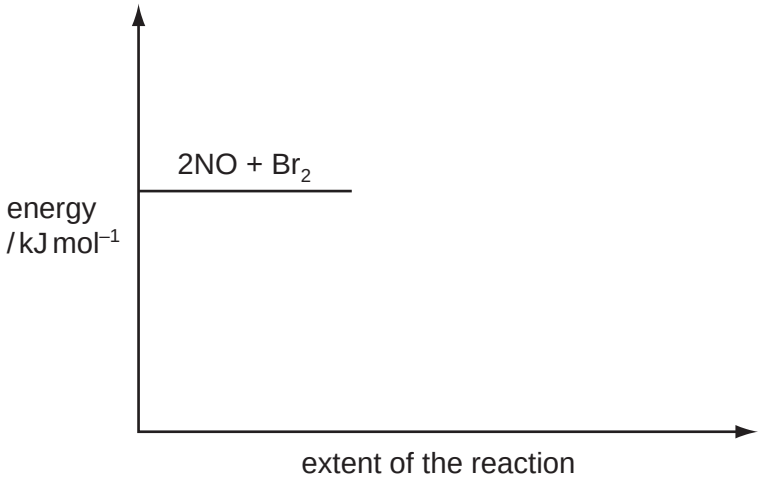
[7]

(c) Nitric oxide, NO, and bromine vapour react together according to the following equation.

$$2NO(g) + Br_2(g) \rightarrow 2NOBr(g) \qquad \Delta H = -23\,kJ\,mol^{-1}$$

The reaction has an activation energy of $+5.4\,kJ\,mol^{-1}$.

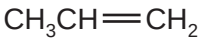
Use the following axes to sketch a fully-labelled reaction pathway diagram for this reaction.
Include all numerical data on your diagram.



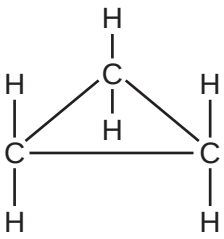
[2]

[Total: 11]

3 The molecular formula C_3H_6 represents the compounds propene and cyclopropane.



propene



cyclopropane

(a) What is the H–C–H bond angle at the terminal $=CH_2$ group in propene?

.....

[1]

(b) Under suitable conditions, propene and cyclopropane each react with chlorine.

(i) With propene, 1,2-dichloropropane, $CH_3CHCl CH_2Cl$ is formed.

State fully what type of reaction this is.

..... [1]

(ii) When cyclopropane reacts with chlorine, three different compounds with the molecular formula $C_3H_4Cl_2$ can be formed.

Draw displayed structures of **each** of these three compounds.

[3]

[Total: 5]

4 **(a)** Explain what is meant by the term *bond energy*.

.....

.....

[2]

(b) Describe and explain the trend in bond energies of the C–X bond in halogenoalkanes, where X = F, C*l*, Br or I.

.....

.....

(ii) Describe the relationship between the reactivity of halogenoalkanes, RX, and the bond energies of the C–X bond.

.....

.....

[3]

(c) Use the *Data Booklet* to suggest an explanation as to why CFCs such as CF_2Cl_2 are much more harmful to the ozone layer than fluorocarbons such as CF_4 or hydrocarbons such as butane, C_4H_{10}.

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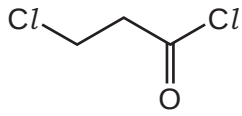
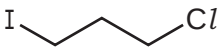
[3]

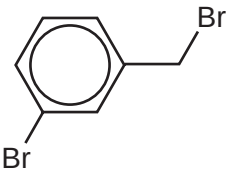
(d) Predict the products of the following reactions and draw their structures in the boxes below. The molecular formula of each product is given, where X = C*l*, Br or I.

H_2O + 

→ $C_3H_5O_2X$

H_2O + 

→ C_3H_7OX

H_2O + 

→ C_7H_7OX

[3]

(e) Ethane reacts with chlorine according to the following equation.

$$C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$$

(i) State the conditions needed for this reaction.

.....

(ii) State the *type of reaction* occurring here.

.....

One of the steps during this reaction is the following process.

$$Cl^{\bullet} + CH_3CH_3 \rightarrow HCl + CH_3CH_2^{\bullet}$$

(iii) Use the *Data Booklet* to calculate the enthalpy change, ΔH, of this step.

ΔH = ... kJ mol^{-1}

(iv) Use the *Data Booklet* to calculate the enthalpy change, ΔH, of the similar reaction:

$$I^{\bullet} + CH_3CH_3 \rightarrow HI + CH_3CH_2^{\bullet}$$

ΔH = ... kJ mol^{-1}

(v) Hence suggest why it is **not** possible to make iodoethane by reacting together iodine and ethane.

.....

(vi) Complete the following equations of some possible steps in the formation of chloroethane.

$Cl_2 \rightarrow$ .....

$Cl^{\bullet} + CH_3CH_3 \rightarrow HCl + CH_3CH_2^{\bullet}$

$CH_3CH_2^{\bullet}$ + ... → ..... + ...

..... + ... → CH_3CH_2Cl

[8]

[Total: 19]

5 Halogenoalkanes have been widely used as aerosol propellants, refrigerants and solvents for many years.

Fluoroethane, CH_3CH_2F, has been used as a refrigerant. It may be made by reacting ethene with hydrogen fluoride.

You are to calculate a value for the C–F bond energy in fluoroethane.

(a) Use relevant bond energies from the *Data Booklet*, and the equation below to calculate a value for the bond energy of the C–F bond.

$CH_2 = CH_2(g) \quad + \quad \rightarrow \quad CH_3CH_2F(g) \quad \Delta H^{\ominus} = -73\,kJ\,mol^{-1}$

C–F bond energy = ... $kJ\,mol^{-1}$ [4]

(b) Another halogenoalkane which was used as a refrigerant, and also as an aerosol propellant, is dichlorodifluoromethane, CCl_2F_2.

State **two** reasons why compounds such as CH_3CH_2F and CCl_2F_2 have been used as aerosol propellants and refrigerants.

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..... [2]

CCl_2F_2 is one of many chlorofluorocarbon compounds responsible for damage to the ozone layer in the stratosphere.

(c) By using relevant data from the *Data Booklet*, and your answer to **(a)** suggest why CCl_2F_2 is responsible for damage to the ozone layer in the stratosphere whereas CH_3CH_2F is not.

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..... [2]

Both CH_3CH_2F and CCl_2F_2 are greenhouse gases.

The 'enhanced greenhouse effect' is of great concern to the international community.

(d) **(i)** What is meant by the term *enhanced greenhouse effect*?

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.....

.....

(ii) Water vapour is the most abundant greenhouse gas.

What is the second most abundant greenhouse gas?

..... [3]

A greenhouse gas which is present in very small amounts in the atmosphere is sulfur hexafluoride, SF_6, which is used in high voltage electrical switchgear.

(e) What shape is the SF_6 molecule?

..... [1]

[Total: 12]