Cambridge AS & A Level

CHEMISTRY

Paper 2

Topical Past Paper Questions

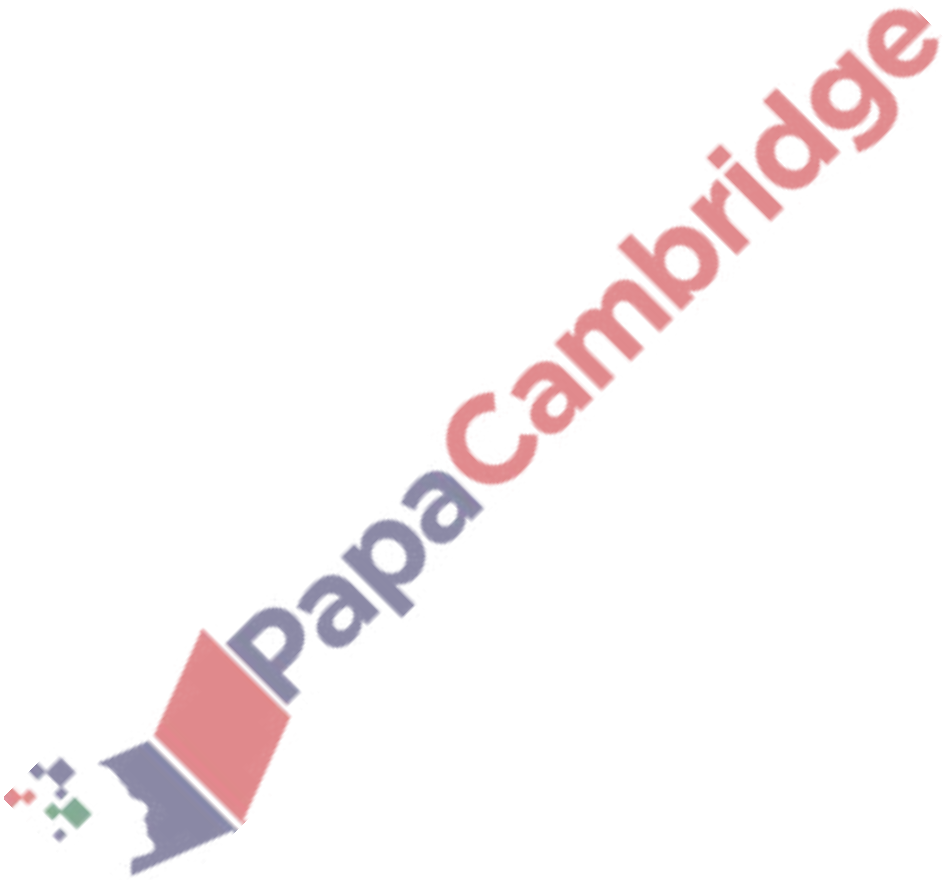
+ Answer Scheme

2015 - 2021

PapaCambridge

Chapter 18

Carboxylic acids and derivatives



18.1 Carboxylic acids

154. 9701_s21_qp_21 Q: 1

Ethanedioic acid, HO_2CCO_2H, has a relative molecular mass of 90.0.

(a) (i) Explain what is meant by the term *relative molecular mass*.

.....

.....

..... [2]

(ii) State the empirical formula of ethanedioic acid.

..... [1]

(iii) Calculate how many atoms of carbon are present in 0.18 g of ethanedioic acid, HO_2CCO_2H.

Show your working.

atoms of carbon present = ... [3]

(b) Solid ethanedioic acid reacts with aqueous calcium ions to make a precipitate of calcium ethanedioate, CaC_2O_4.

CaC_2O_4 breaks down when heated to form calcium oxide, carbon dioxide and carbon monoxide.

(i) Construct an equation to represent the reaction of CaC_2O_4 when heated. Include state symbols.

..... [2]

(ii) Identify the type of reaction which occurs when CaC_2O_4 is heated.

..... [1]

(iii) Identify another compound containing calcium ions which will also produce carbon dioxide and calcium oxide when it is heated.

..... [1]

[Total: 10]

155. 9701_s21_qp_21 Q: 4

Aqueous bromine reacts with methanoic acid to form hydrogen bromide and carbon dioxide gas.

$$Br_2(aq) + HCO_2H(aq) \rightarrow 2HBr(aq) + CO_2(g)$$

The table shows the oxidation numbers of bromine and carbon in the species involved in this reaction.

	Br in Br_2	C in HCO_2H	Br in HBr	C in CO_2
oxidation number	0	+2	–1	+4

(a) Identify the oxidising agent in this reaction. Explain your reasoning with reference to oxidation numbers.

.....

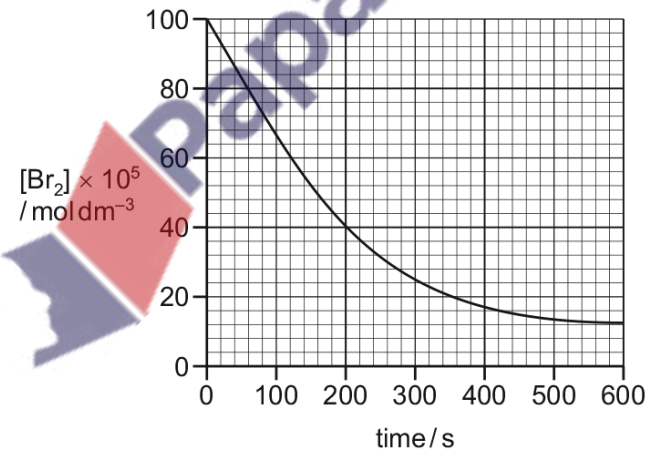
..... [1]

(b) Suggest one change you would observe, ignoring temperature changes, when bromine reacts with methanoic acid.

..... [1]

(c) This reaction can be followed by measuring the concentration of bromine present in the mixture at regular time intervals.

The graph shows the change in concentration of bromine against time in a reaction carried out at 20 °C.



(i) Use the graph to calculate the average rate of reaction at 20 °C during the first 600 s. State the units of this rate of reaction.

average rate of reaction ..... units .....

[2]

The experiment is repeated at a temperature of 40 °C. This relatively small increase in temperature produces a large increase in reaction rate.

(ii) Sketch a graph, on the same axes, to show the expected results when repeating the experiment at 40 °C. [1]

(iii) The rate of reaction increases when the frequency of successful collisions between reactant particles increases.

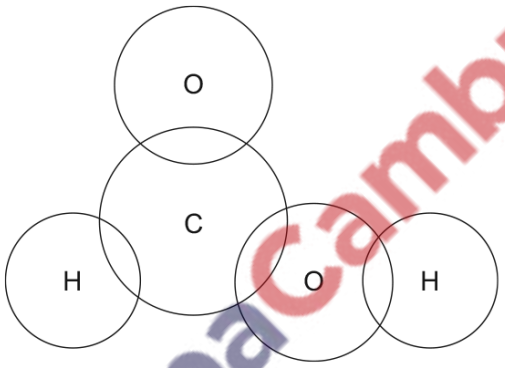
Explain why an increase in temperature produces this effect.

.....

.....

..... [2]

(d) Complete the 'dot-and-cross' diagram, showing outer electrons only, to show the bonding in methanoic acid, HCO_2H.

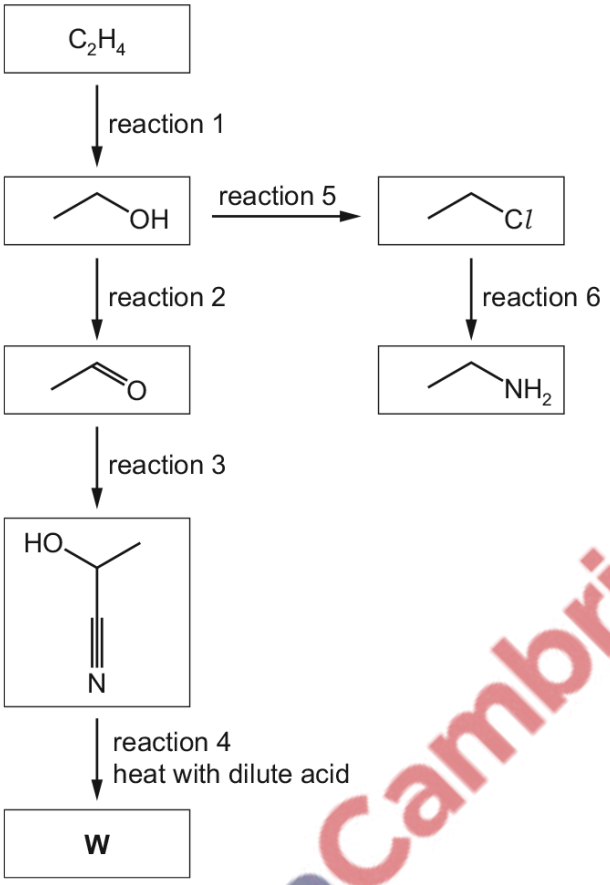


[2]

[Total: 9]

156. 9701_s20_qp_22 Q: 5

The reaction sequence shows how ethene, C_2H_4, can be converted into other organic molecules.



(a) Complete the table to give

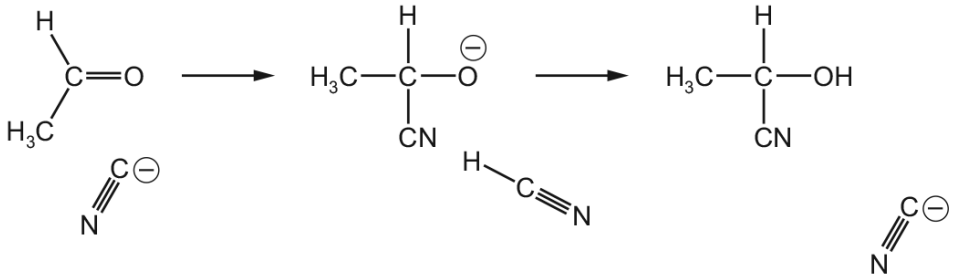
- the name of the reaction mechanisms of reactions 1 and 6
- the reagents and conditions required for reactions 1, 2 and 6.

reaction	name of mechanism	**name** of reagents and conditions
1		
2		
6		

[6]

(b) In reaction 3 the organic molecule reacts with HCN and a KCN catalyst.

(i) Complete the diagram to show the mechanism of the reaction occurring.
Include all relevant dipoles, lone pairs and curly arrows in your answer.



[3]

(ii) Name the functional groups present in the product of reaction 3.

..... [2]

(c) Draw the structure of the organic molecule **W** formed in reaction 4.

[1]

[Total: 12]

157. 9701_w15_qp_22 Q: 4

Halogenoalkanes are useful intermediates in the synthesis of a wide variety of compounds.

(a) 2-bromobutane reacts in two different ways with sodium hydroxide depending on the conditions.

When warmed with aqueous sodium hydroxide, 2-bromobutane produces an alcohol that exists as a pair of optical isomers.

(i) Give the name of the mechanism of the reaction between 2-bromobutane and aqueous sodium hydroxide.

..... [1]

(ii) Explain why the alcohol produced exists as a pair of optical isomers.

.....

..... [1]

(iii) Draw the three-dimensional structure of the two optical isomers of the alcohol produced in **(ii)**.

[2]

Heating 2-bromobutane with ethanolic sodium hydroxide produces a mixture of three alkenes, two of which are a pair of geometrical isomers.

(iv) Give the name of the mechanism of the reaction between 2-bromobutane and ethanolic sodium hydroxide.

..... [1]

(v) Draw and name the structures of the pair of geometrical isomers formed by reaction of 2-bromobutane with ethanolic sodium hydroxide.

name .....

name .....

[2]

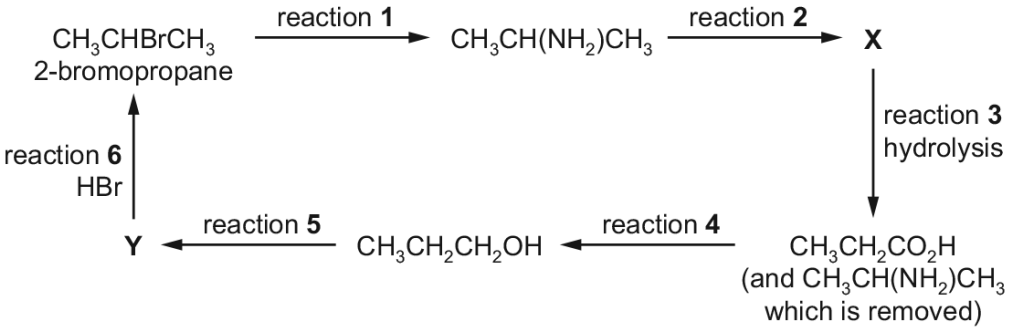
(vi) Name the third alkene produced by reaction of 2-bromobutane with ethanolic sodium hydroxide and explain why it does **not** show geometrical isomerism.

.....

.....

..... [2]

(b) Some reactions involving 2-bromopropane are shown.



(i) State the reagent needed for reaction **1**.

..... [1]

(ii) State the reagent needed for reaction **2**.

..... [1]

(iii) Give the structural formula of **X**.

[1]

(iv) Name the type of reaction involved in reaction **4** and suggest a suitable reagent.

.....

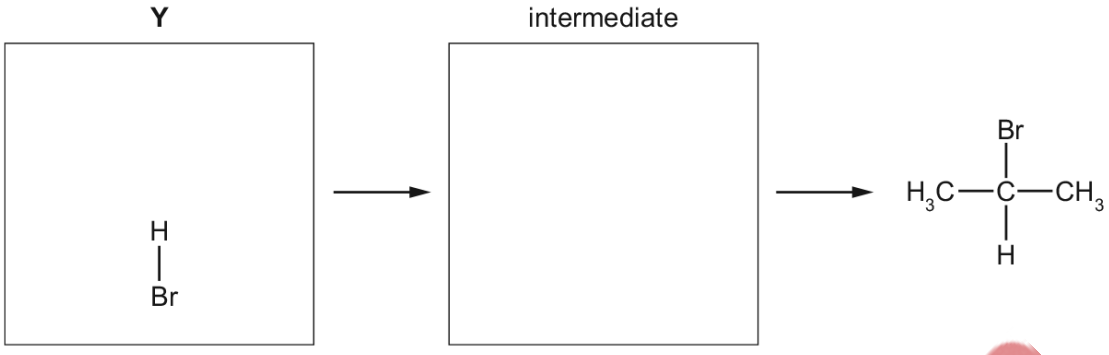
..... [2]

(v) State the name of a solid catalyst for reaction **5**.

..... [1]

(vi) Complete the mechanism for the production of 2-bromopropane from **Y** in reaction **6** shown below.

Include the structure of **Y** and any necessary lone pairs, curly arrows, charges and partial charges.



[4]

(vii) Give the name of the mechanism in **(vi)**.

..... [1]

(viii) 1-bromopropane is a minor product of reaction **6**.

Explain why 2-bromopropane is the major product of reaction **6**.

.....

.....

.....

..... [2]

[Total: 22]

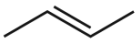
18.2 Esters

158. 9701_s20_qp_23 Q: 5

C, **D** and **E** are isomers of each other.
They are made by passing an alcohol vapour over an aluminium oxide catalyst.

C

D



E

(a) (i) Name the type of reaction occurring.

..... [1]

(ii) Draw the displayed formula of the alcohol used in this reaction.

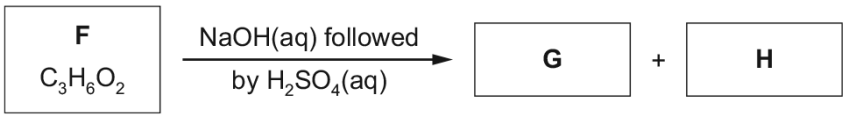
[2]

(iii) Name the isomers **C**, **D** and **E**.

isomer	name
C	
D	
E	

[2]

(b) **F** is an organic molecule which has the molecular formula $C_3H_6O_2$.
When **F** is heated with NaOH(aq) followed by H_2SO_4(aq) the products **G** and **H** are made.



Separate samples of **G** and **H** are added to

- Na_2CO_3(aq)
- sodium metal
- alkaline aqueous iodine.

The observations are described in the table.

reagent(s)	**G**	**H**
Na_2CO_3(aq)	colourless bubbles of gas produced	no visible reaction
Na(s)	colourless bubbles of gas produced	colourless bubbles of gas produced
alkaline aqueous iodine	no visible reaction	yellow precipitate forms

(i) Complete the table to identify the functional groups present in **F**, **G** and **H**.

	functional group
F	
G	
H	

[3]

(ii) Name the yellow precipitate formed when alkaline aqueous iodine reacts with **H**.

..... [1]

(iii) Draw the structures of **G** and **H**.

G	**H**

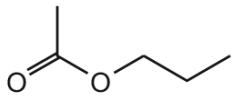
[2]

[Total: 11]

159. 9701_s19_qp_22 Q: 5

Many naturally occurring esters are used as flavourings in food.

(a) The structure of ester **V** is shown.



V

(i) Name **V**.

..... [1]

V reacts with a reagent to form a salt of a carboxylic acid and an alcohol.

(ii) Identify a reagent that could be used in this reaction.

..... [1]

(iii) Draw the displayed formula of the alcohol made during this reaction.

[1]

(iv) State one other possible use for **V**, apart from as a food flavouring.

..... [1]

(b) Ester **W** is made up of 54.5% carbon, 9.1% hydrogen and 36.4% oxygen.

(i) Calculate the empirical formula of **W**.

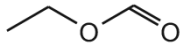
[3]

(ii) State what additional information is required to determine the molecular formula of **W**.

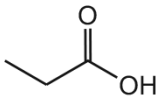
..... [1]

(c) Compounds **X**, **Y** and **Z** are shown. They all have the same molecular formula.

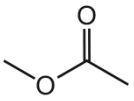
X



Y



Z



(i) Deduce the molecular formula of **X**, **Y** and **Z**.

..... [1]

(ii) In three experiments, sodium is added to separate samples of **X**, **Y** and **Z**.

Complete the table to show the observations for each of these three experiments. Ignore any temperature changes which may occur.

experiment	observations
Na + **X**	
Na + **Y**	
Na + **Z**	

[2]

(d) Sodium carbonate solution reacts with methanoic acid.

Write the equation for this reaction.

..... [1]

[Total: 12]