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Detailed mark scheme

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Level: CIE A & AS Level Chemistry (9701)

Subject: Chemistry

Topic: A & AS Chemistry

Type: Topic Question

2002

XVIII

1583

Chemistry CIE A & AS Level
To be used for all exam preparation for 2025+

CHEMISTRY

A & AS

Key skills

Question 1.

(a) This question is about carboxylic acids.

State the general formula of a carboxylic acid

(1 mark)

(b) Name the carboxylic acid shown in Fig. 1.1.



Fig. 1.1

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(1 mark)

(c) i) Write a balanced symbol equation to show the dissociation of the acid from part (b).

[1]

ii) State where the position of the equilibrium lies and what this says about the strength of the acid.

[2]



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(3 marks)

- (d) Write a balanced symbol equation, including state symbols, for the reaction of propanoic acid with sodium hydrogen carbonate powder to form the soluble sodium propanoate salt and two other products.

(3 marks)

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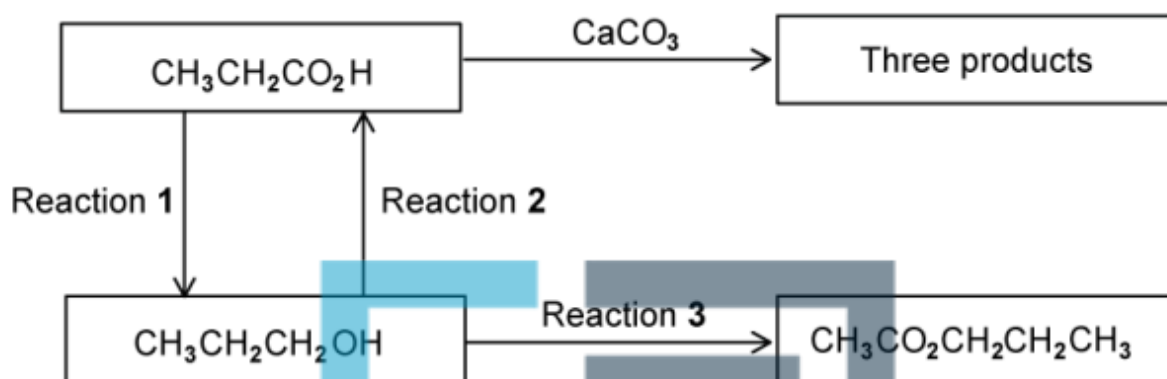
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Question 2.

(a) A series of reactions based on propanoic acid is shown.



Write an equation for reaction 1, using [H] to represent the reducing agent.

(2 marks)

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(b) i) What type of reaction is reaction 2?

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[1]

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ii) Suggest a suitable reagent and conditions for reaction 2.

[2]

(3 marks)

(c) Write an equation for the reaction of propanoic acid with calcium carbonate, CaCO_3 .



(2 marks)

(d) i) Suggest a suitable reagent and conditions for reaction 3.

[2]

ii) Identify the other product of reaction 3.

[1]

(3 marks)

Question 3.

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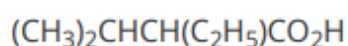
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- (a) Fermentation of sugars by bacteria or moulds produces many different organic compounds.

One compound present in fermented molasses is 2-ethyl-3-methylbutanoic acid which gives a distinctive aroma to rum.



2-ethyl-3-methylbutanoic acid

- i) What is the molecular formula of 2-ethyl-3-methylbutanoic acid? [1]
- ii) How many chiral carbon atoms are present in a molecule of 2-ethyl-3-methylbutanoic acid? If none write 'none'. [1]

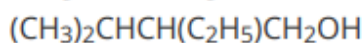
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- (b) A sample of 2-ethyl-3-methylbutanoic acid may be prepared in a school or college laboratory by the oxidation of:

2-ethyl-3-methylbutan-1-ol



- i) State the reagent(s) that would be used for this oxidation.

Describe what colour change would be seen.

reagent(s)
colour change from to

[3]

- ii) This reaction is carried out by heating the reacting chemicals together.
What could be the main organic impurity present in the sample of the acid?
Explain your answer.

[2]

- iii) State whether a distillation apparatus or a reflux apparatus should be used.
Explain your answer.

[1]

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(6 marks)



- (c) A structural isomer of 2-ethyl-3-methylbutan-1-ol is 2-ethyl-3-methylbutan-2-ol, $(\text{CH}_3)_2\text{CHC}(\text{OH})(\text{C}_2\text{H}_5)\text{CH}_3$.

What colour change would be seen if this were heated with the reagents you have given in part (b)(i)?

Explain your answer as clearly as you can.

(3 marks)

- (d) An isomer of 2-ethyl-3-methylbutanoic acid which is an ethyl ester is a very strong smelling compound which is found in some wines. This ethyl ester contains a branched hydrocarbon chain and is chiral.

Draw the displayed formula of this ethyl ester.

Identify the chiral carbon atom with an asterisk (*).

(3 marks)



Question 4.

(a) Propan-1-ol can be oxidised to propanoic acid using acidified potassium dichromate(VI).

Name the intermediate formed during this oxidation.

(1 mark)

(b) i) State the colour of the chromium species after the potassium dichromate(VI) has reacted.

[1]

ii) Identify the conditions to ensure that propanoic acid is obtained in a high yield.

[2]

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(3 marks)

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(c) Describe a chemical test and observation which confirms the presence of a carboxyl functional group.

(2 marks)

Question 5.

- (a) LiAlH_4 is a reducing agent.

LiAlH_4 cannot be used in aqueous solution because it reacts with water to produce $\text{LiOH}(\text{aq})$, $\text{H}_2(\text{g})$ and a white precipitate which is soluble in excess sodium hydroxide.

Identify the white precipitate.

(1 mark)

- (b) Two students try to prepare 2-hydroxybutanoic acid in the laboratory as shown in Fig. 1.1

Both students oxidise butane-1,2-diol to form **P** in reaction 1.

One student then reduces **P** using LiAlH_4 . **Q** is formed.

The other student reduces **P** using NaBH_4 . **R** is formed.

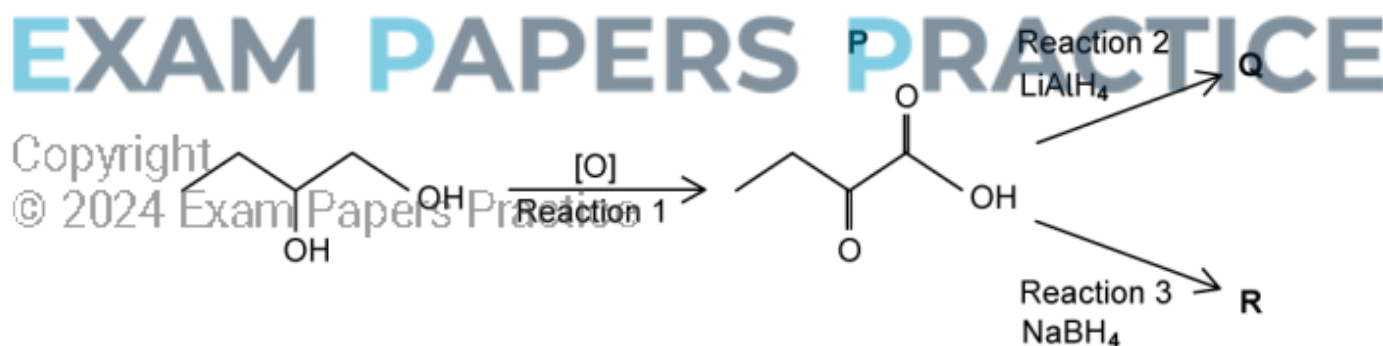


Fig. 1.1

- i) State the reagents and conditions required for reaction 1.

Only one of the students successfully prepares 2-hydroxybutanoic acid.

[2]

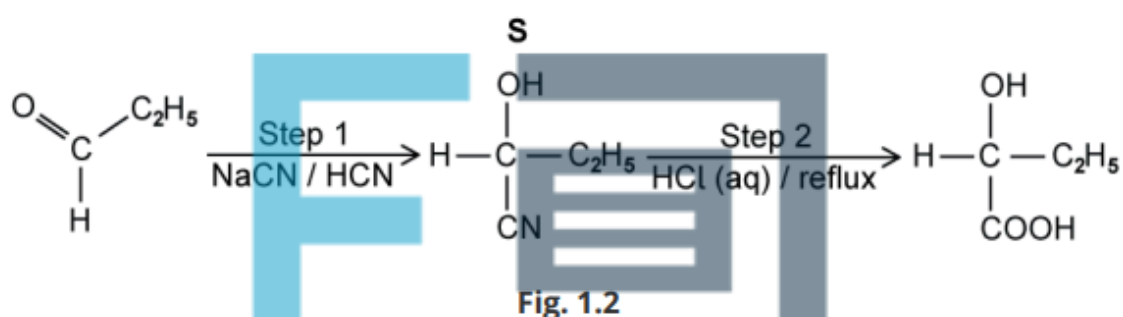
- ii) Identify which of **Q** or **R** is 2-hydroxybutanoic acid and explain the difference between reactions 2 and 3.

[2]



(4 marks)

- (c) A third student prepares 2-hydroxybutanoic acid using propanal as the starting material as shown in Fig. 1.2. In step 1 the student reacts propanal with a mixture of NaCN and HCN.



Draw the mechanism for the reaction of propanal with the mixture of NaCN and HCN to form S.

- Identify the ion that reacts with propanal.
- Draw the structure of the intermediate of the reaction.
- Include all charges, partial charges, lone pairs and curly arrows.

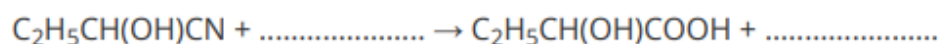
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(4 marks)



- (d) Complete the equation for the reaction in step 2, when **S** is heated under reflux with HCl (aq).



(1 mark)

Question 6.

- (a) Lactic acid, 2-hydroxypropanoic acid, $\text{CH}_3\text{CH}(\text{OH})\text{COOH}$ occurs naturally in sour milk and in our muscles when we take hard exercise.

Lactic acid is chiral and shows stereoisomerism.

Draw fully displayed structures of the two optical isomers of lactic acid.

Circle the chiral carbon atom in the lactic acid molecule.

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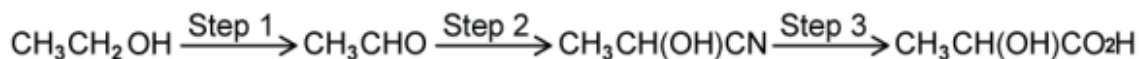
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(1 mark)



(b) Lactic acid may be synthesised from ethanol by the following route.

Give the reagent(s) and essential condition(s) for each step.



step 1

reagent(s)

conditions

step 2

reagent(s)

condition(s)

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step 3

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reagent(s)

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condition(s)



(6 marks)

(c) Lactic acid, $\text{CH}_3\text{CH}(\text{OH})\text{COOH}$ can be reduced by LiAlH_4 .

i) Write an equation to show this reaction using $[\text{H}]$ to represent an atom of hydrogen from the reducing agent.

[1]

ii) Name the organic produced formed in this reaction.

[1]

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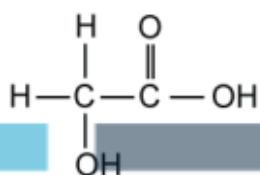
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(2 marks)

Question 7.

(a) Glycolic acid is commonly used in skin care products.

The structure is shown in Fig. 3.1.



Glycolic acid

Fig 3.1

Glycolic acid is added separately to each of the three reagents below.

Complete the table to show what you would observe.

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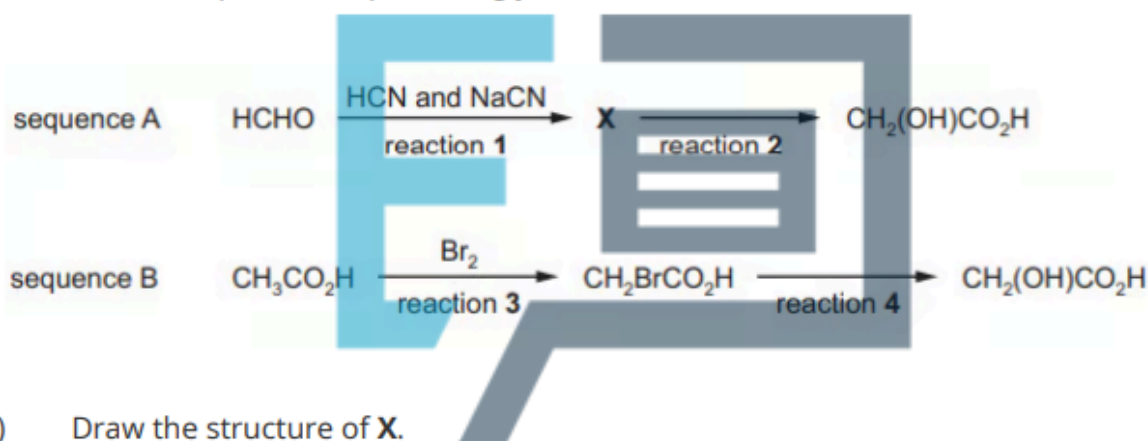
© 2024 Exam Papers Practice. If a reaction occurs, state the functional group of glycolic acid that is responsible for the reaction.

reagent	observation with glycolic acid	does a reaction occur?	functional group
Na_2CO_3			
2,4-DNPH			
acidified $\text{Cr}_2\text{O}_7^{2-}$			



(4 marks)

(b) Two reaction sequences to produce glycolic acid are shown.



i) Draw the structure of X.

[1]

ii) Name the reagent used for reaction 2.

[1]

iii) Name the mechanism for reaction 3.

[1]

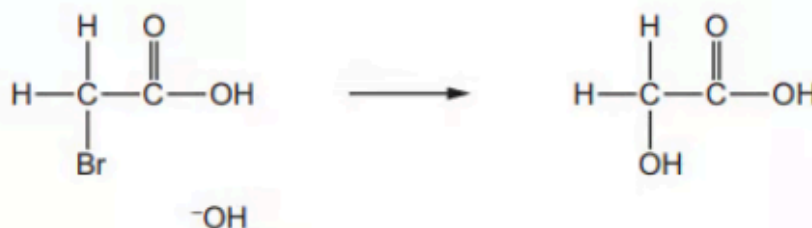
iv) Suggest the essential condition for reaction 3.

[1]

v) Reaction 4 occurs via an $\text{S}_{\text{N}}2$ mechanism.

Complete the diagram for the mechanism for reaction 4.

Include all relevant charges, partial charges, curly arrows and lone pairs.



[2]



(6 marks)

(c) Glycolic acid can also be made by reacting glyoxylic acid with NaBH_4 .

i) State the role of NaBH_4 in this reaction. [1]

ii) Write an equation for this reaction using molecular formulae.
Use [H] to represent NaBH_4 . [2]

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(3 marks)