

F324: Rings, Polymers and Analysis

4.1.2 Carbonyl Compounds

1. Hydroxyethanal, HOCH_2CHO , is sometimes referred to as the 'first sugar' as it is the simplest possible molecule that contains both an aldehyde group and an alcohol group.

A biochemist investigated some redox reactions of hydroxyethanal and found that several different products were produced.

(a) The biochemist reacted hydroxyethanal with Tollens' reagent.

- (i) State what the biochemist would see when hydroxyethanal reacts with Tollens' reagent.

.....

[1]

- (ii) Write the structural formula of the organic product formed when hydroxyethanal reacts with Tollens' reagent.

[1]

(b) The biochemist also reacted hydroxyethanal with acidified dichromate by heating under reflux.

Write an equation for this oxidation.

Use **[O]** to represent the oxidising agent.

[2]

(c) The biochemist then reduced hydroxyethanal using aqueous NaBH_4 .

- (i) Write the structural formula of the organic product.

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[1]

- (ii) Outline the mechanism for this reduction.

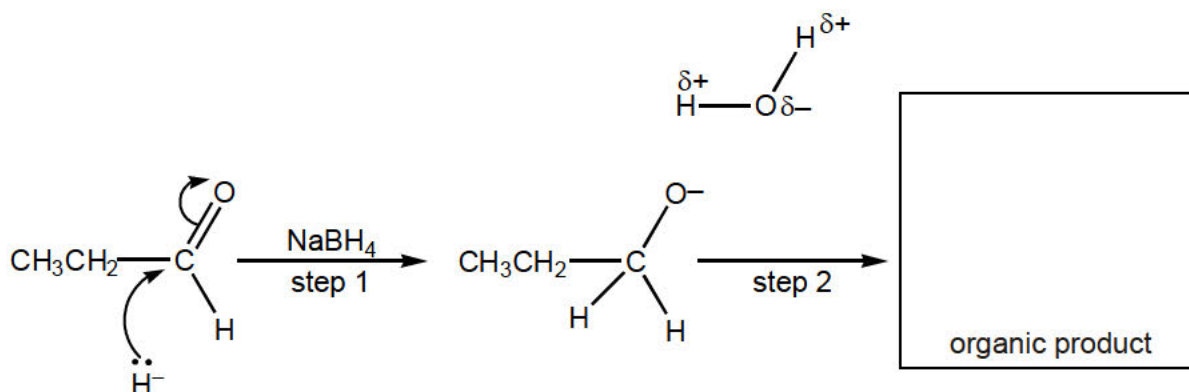
Use curly arrows and show any relevant dipoles.

[4]

[Total 9 marks]

2. Propanal, $\text{CH}_3\text{CH}_2\text{CHO}$, can be used in the synthesis of organic compounds.

$\text{CH}_3\text{CH}_2\text{CHO}$ reacts with NaBH_4 in a nucleophilic addition reaction. The nucleophile can be represented as a hydride ion, H^- . A mechanism for the reaction is shown below.



- (i) Add 'curly arrows' to the mechanism to show how the intermediate reacts with the water molecule in **step 2**.

[2]

- (ii) Draw the structure of the organic product in the box above.

[1]

- (iii) What is meant by the term *nucleophile*?

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[1]

- (iv) Describe, in words, exactly what is happening to the electron pairs and bonds in **step 1** of the mechanism above.

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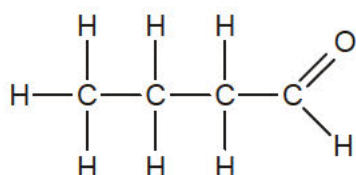
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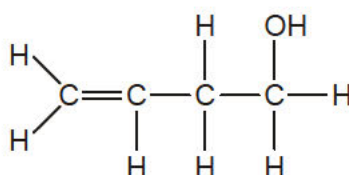
[3]

[Total 7 marks]

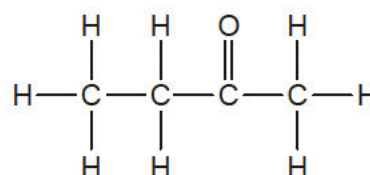
3. An unknown colourless liquid with molecular formula C_4H_8O was thought to be one of butanal, but-3-en-1-ol, or butanone.



butanal



but-3-en-1-ol



butanone

- (a) State a simple chemical test that would positively identify:

- (i) butanal **only**;

reagent

observation

organic product

[3]

(ii) but-3-en-1-ol **only**.

reagent

observation

type of reaction

[3]

(b) Butanal and butanone both react with 2,4-dinitrophenylhydrazine to produce mixtures containing orange precipitates.

Outline how the mixtures containing these orange precipitates can be used to distinguish between butanal and butanone.

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[3]

[Total 9 marks]

4. But-2-enal, $\text{CH}_3\text{CH}=\text{CHCHO}$, is a pale yellow, flammable liquid with an irritating odour.

(a) (i) Describe a simple chemical test that would show that but-2-enal is an aldehyde.

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[2]

- (ii) Explain why this test gives a different result with aldehydes than it does with ketones.

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[1]

- (b) But-2-enal also reacts with sodium borohydride, NaBH_4 .

- (i) Identify the organic compound formed in this reaction.

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[1]

- (ii) State the type of chemical reaction occurring.

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[1]

- (c) Precautions must be taken to prevent but-2-enal catching fire.

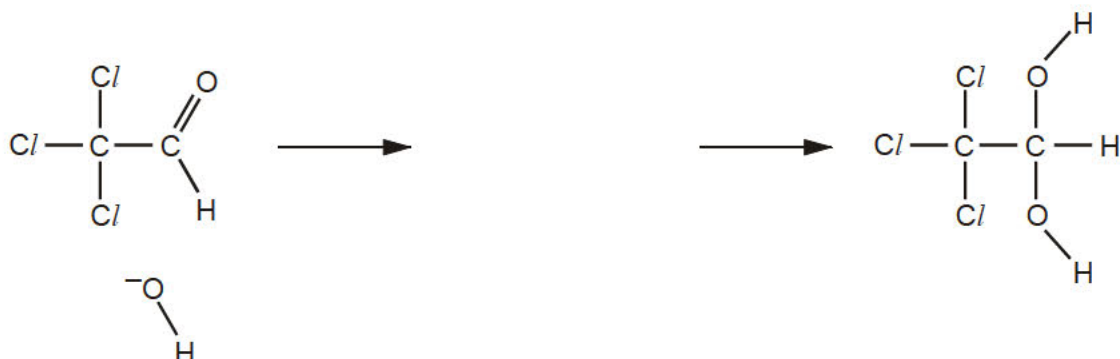
Construct a balanced equation for the complete combustion of but-2-enal, $\text{C}_4\text{H}_6\text{O}$.

[1]

[Total 6 marks]

5. (a) The reaction of trichloroethanal with water is a nucleophilic addition reaction. It can be catalysed by small amounts of hydroxide ions, OH^- .

Complete the diagram below to suggest a mechanism for this reaction. Show all the relevant dipoles and curly arrows.



[5]

- (b) The recommended adult dose of chloral hydrate as a sedative is 250 mg, three times a day.

Calculate the mass of **trichloroethanal** you would need to react with water to make one week's supply of chloral hydrate for an adult, assuming a 60% yield.

M_r : chloral hydrate, 165.5; trichloroethanal, 147.5

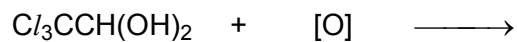
mass of trichloroethanal = ... g

[3]

[Total 8 marks]

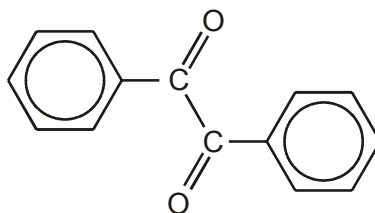
6. Chloral hydrate is broken down in the body after several hours. One reaction is oxidation to trichloroethanoic acid.

Complete the equation for this reaction below.



[Total 1 mark]

7. The reducing agent, NaBH_4 , is used widely in organic chemistry. One example is for the reduction of diphenylethanedione, $\text{C}_{14}\text{H}_{10}\text{O}_2$, shown below.



diphenylethanedione

- (i) Draw a displayed formula to show the structure of the organic product that would be formed by reducing diphenylethanedione with excess NaBH_4 .

[1]

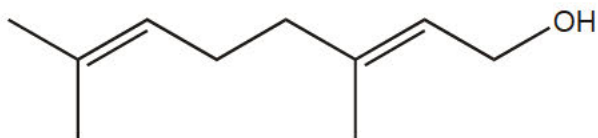
- (ii) Complete and balance the equation for this reaction, using $[\text{H}]$ to represent the reducing agent.



[1]

[Total 2 marks]

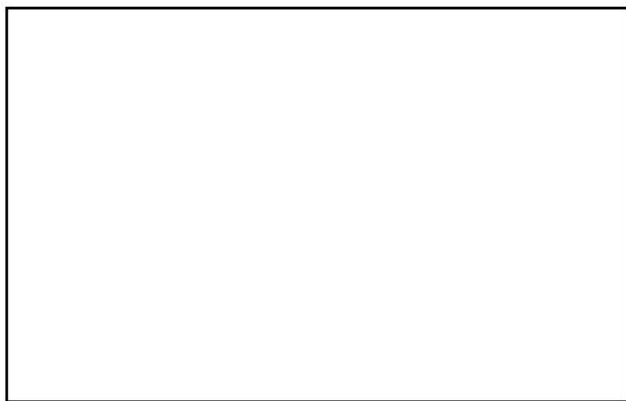
8.



geraniol

Mild oxidation of geraniol gives an aldehyde **Y**.

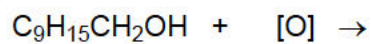
- (i) Draw the skeletal formula of aldehyde **Y** below.



aldehyde Y

[2]

- (ii) Complete the equation for the oxidation of geraniol to aldehyde **Y**.



[2]

[Total 4 marks]

9. Cinnamaldehyde can be reduced using sodium borohydride, NaBH_4 .

- (i) State which functional group reacts with the sodium borohydride.

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[1]

- (ii) Complete and balance the equation for this reaction.



[1]

[Total 2 marks]

10. In this question, one mark is available for spelling, punctuation and grammar.

Tollens' reagent can be used to identify the aldehyde group in cinnamaldehyde.

- Describe how you would make Tollens' reagent and carry out this test in the laboratory.
- Explain what happens to both the Tollens' reagent and the cinnamaldehyde in this reaction. Identify the organic product.

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Quality of Written Communication. [1]

[Total 8 marks]