Stereochemsitry

Question Paper 1

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Stereochemsitry- Organic Chemistry
Booklet	Question Paper 1

Time Allowed: **72 minutes**

Score: **/60**

Percentage: **/100**

Grade Boundaries:

1. The enantiomers of a compound with a chiral centre are normally described as having identical physical and chemical properties, apart from their effect on the plane of plane polarised light.

In many cases the enantiomers also have different odours. For example, (*R*)-(+)-2-methylbutan-1-ol has a fermented, fatty odour, while (*S*)-(–)-2-methylbutan-1-ol smells fresh.

(a) Explain what is meant by each of the terms *enantiomers* and *chiral centre*.

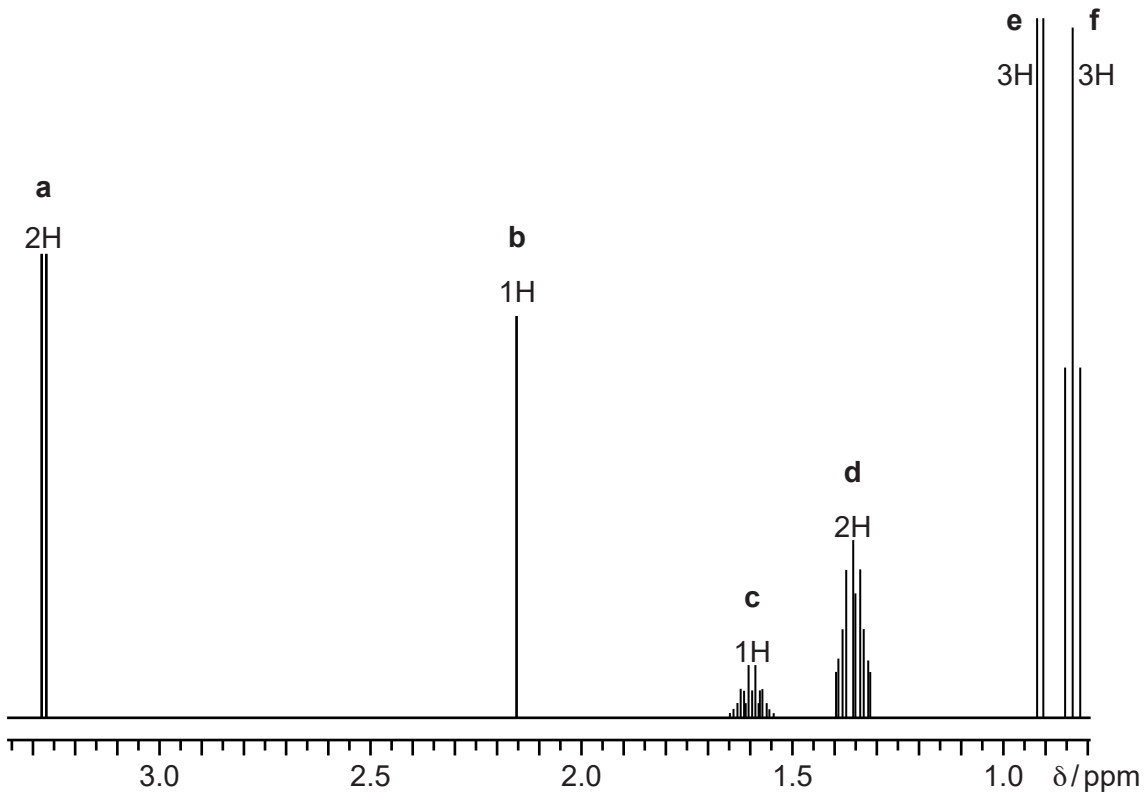
enantiomers .....

.....

chiral centre .....

.....[2]

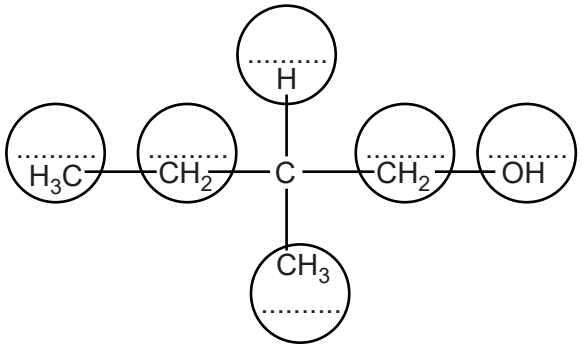
(b) The diagram of the proton NMR spectrum of 2-methylbutan-1-ol has the signals labelled **a–f** for ease of reference, and the signal integrations are given.



(i) Give the relative intensities of the peaks in signal **f**.

.....[1]

(ii) Label the structure of 2-methylbutan-1-ol, with the letters **a–f**, to indicate which protons are responsible for each signal in the spectrum.



[3]

(c) Oxidation of 2-methylbutan-1-ol, by acidified potassium dichromate(VI) with immediate distillation, produces a compound, **P**.

P turns acidified potassium dichromate(VI) from orange to green and produces **Q**.

Q effervesces on addition of sodium carbonate solution.

A pure enantiomer of **P**, when reacted with hydrogen cyanide, produces **R** as a mixture of optical isomers.

R forms **S**, with no change in functional group level, on reaction with dilute hydrochloric acid.

(i) Give the **displayed** formula and name of **P**. Ignore stereochemistry.

name .....[2]

(ii) State the type of reaction involved in the conversion of **P** to **Q**.

.....[1]

(iii) Identify **Q** and write a balanced equation, using molecular formulae, for its reaction with sodium carbonate.

identity of **Q** .....

equation .....[2]

(iv) Give the structural formula of **R**, name the mechanism by which it is formed from **P** and explain why it forms as a mixture of optical isomers.

structural formula

name of mechanism .....

explanation .....

.....[4]

(v) Identify **S** and state the type of reaction involved in its formation from **R**.

identity of **S** .....

type of reaction.....[2]

[Total: 17]

2. Halogenoalkanes react with sodium hydroxide in two different ways depending on the solvent, the temperature and the structure of the halogenoalkane.

(a) Under appropriate conditions (S)-(+)-2-bromobutane was reacted with sodium hydroxide to produce a mixture of three isomeric alkenes.

(i) State the type of reaction taking place.

.....[1]

(ii) State the conditions necessary to bring about this type of reaction.

.....

.....[2]

(iii) Give the displayed formulae and names of the three alkenes formed.

[3]

(b) If (S)-(+)-2-bromobutane is hydrolysed with sodium hydroxide to form an alcohol then the reaction will proceed by a mixture of the S_N1 and S_N2 mechanisms.

(i) State the conditions necessary for the hydrolysis of (S)-(+)-2-bromobutane by sodium hydroxide.

.....

.....[1]

(ii) Complete Fig. 3.1 to show the S_N1 mechanism of hydrolysis of (S)-(+)-2-bromobutane with sodium hydroxide. Include all necessary curly arrows, lone pairs and full or partial charges.

[4]

Fig. 3.1

(iii) Explain fully why one of the two mechanisms, S_N1 or S_N2, gives rise to an optically active product while the other mechanism gives an optically inactive product.

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.....[5]

(iv) Give the full name of the product formed by the S_N2 mechanism.

.....[1]

(c) A structural isomer of (S)-(+)-2-bromobutane undergoes hydrolysis almost exclusively by the S_N1 mechanism.

Identify this isomer and explain why the S_N1 mechanism is preferred over the S_N2 mechanism.

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.....[3]

[Total: 20]

3. Pantothenic acid, vitamin B_5, is a water-soluble vitamin needed to form coenzyme-A (CoA), and it is critical in the metabolism and synthesis of carbohydrates, proteins and fats.

The skeletal formula of pantothenic acid is shown in Fig. 5.1.

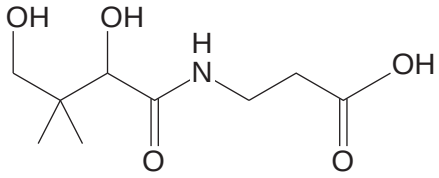

Fig. 5.1

(a) Name fully all the functional groups present in a molecule of pantothenic acid.

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.....

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.....[4]

(b) Give the structures of the organic products that would be formed if pantothenic acid was

(i) hydrolysed by reaction with aqueous acid,

[2]

(ii) reacted with sodium metal.

[2]

(c) Pantothenic acid is a chiral molecule and the full name of the biologically active form includes the prefixes R and (+).

(i) On Fig. 5.1 draw a circle around the chiral carbon in the molecule. [1]

(ii) Explain the meaning of each of the prefixes in the name R-(+)-pantothenic acid.

(+) .....

.....

R .....

.....

.....

..... [3]

(d) The acid dissociation constant, K_a, for pantothenic acid is $3.98 \times 10^{-5}\,\text{mol}\,\text{dm}^{-3}$, whilst that of propanoic acid is $1.32 \times 10^{-5}\,\text{mol}\,\text{dm}^{-3}$.

(i) Calculate the pH of a $0.20\,\text{mol}\,\text{dm}^{-3}$ solution of pantothenic acid.

pH = ... [3]

(ii) The inductive effect can be used to account for the difference in the acid dissociation constants of pantothenic acid and propanoic acid. Explain why.

.....

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..... [3]

(e) A derivative of pantothenic acid, pantothenol, is a more stable form of the vitamin. It is often used in multivitamin supplements as it is converted to pantothenic acid in the body. Its structure is shown in Fig. 5.2.

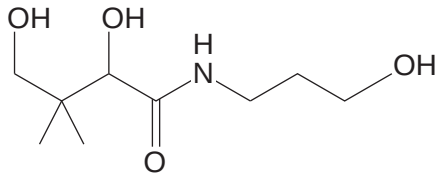

Fig. 5.2

The structural formula of pantothenol is $HOCH_2C(CH_3)_2CHOHCONH(CH_2)_3OH$ and its molecular formula is $C_9H_{19}NO_4$.

(i) With reference to the concept of functional group level, explain what type of reaction is involved in the conversion of pantothenol into pantothenic acid.

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..... [2]

(ii) Give the structural formula of the organic product of the reaction of pantothenol with ethanoyl chloride.

[1]

(iii) Complete and balance the equation below for the reaction of pantothenol with ethanoyl chloride, using **molecular formulae** for the products.

$C_9H_{19}NO_4$ + ... CH_3COCl → ..... + ...

[2]

[Total: 23]