

Structured Questions: Paper 2

20.3 Stereoisomerism

Easy (5 questions)	/28
Medium (5 questions)	/41
Hard (5 questions)	/31
Total Marks	/100

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Easy Questions

1 (a) Define the term *stereoisomers*.

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.....
(1 mark)

(b) State the conditions needed for a compound to show cis-trans isomerism.

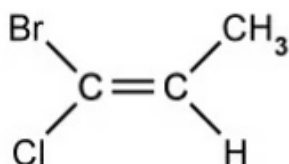
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.....
(2 marks)

(c) Draw the structural formulae for the *E* and *Z* stereoisomers of pent-2-ene.

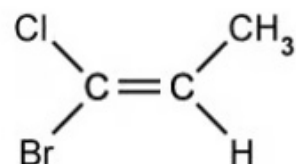
.....
.....
(2 marks)

(d) 2-bromo-1-chloropropene is a colourless, odourless liquid.

A student drew the two stereoisomers of 2-bromo-1-chloropropene below.



E-2-bromo-1-chloropropene



Z-2-bromo-1-chloropropene

State what is incorrect with their diagrams of these two stereoisomers.

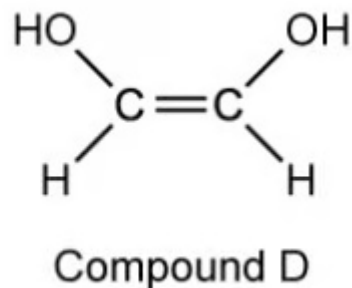
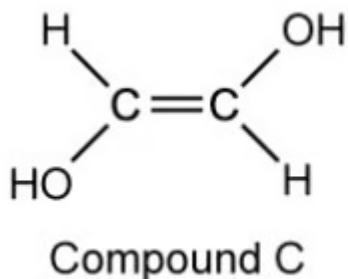
(2 marks)

2 (a) Draw the *E* and *Z* stereoisomers for 2,3-dichlorobut-2-ene.

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..... (2 marks)

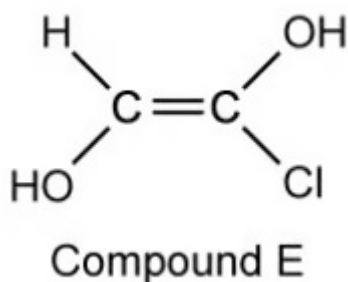
(b) Name compounds **C** and **D** using the *E* / *Z* naming system.



.....

..... (2 marks)

(c) Compound **E** is a derivative of compound **C**.



Suggest why the cis/trans naming system fails with compound **E**.

..... (1 mark)

(d) Describe the difference between conformational and configurational stereoisomers.

.....

.....

(2 marks)

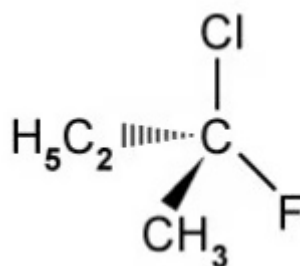
- 3 (a) The chemical and physical properties of optical isomers are identical. However, there are some other differences that can be used to distinguish isomers from each other. In terms of properties, state one difference between optical isomers.

(1 mark)

- (b) Describe how you can detect optical activity in a sample.

(2 marks)

- (c) The structure of one optical isomer of a chlorofluorocarbon is shown below.



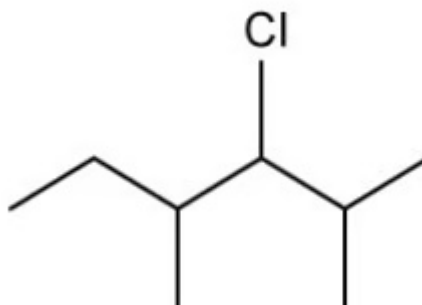
Draw the structure of the other enantiomer.

(1 mark)

4 (a) State what is meant by the term a chiral carbon.

.....
.....
(1 mark)

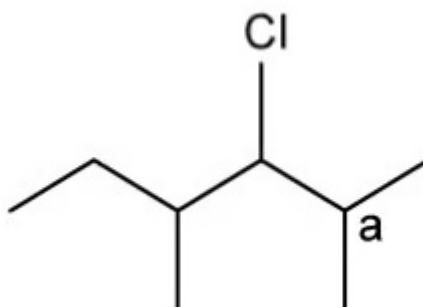
(b) The skeletal structure of an organic compound is shown below.



Identify the chiral carbons.

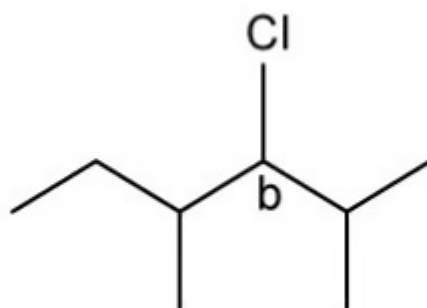
.....
.....
(2 marks)

(c) Explain why carbon **a** cannot be a chiral carbon.

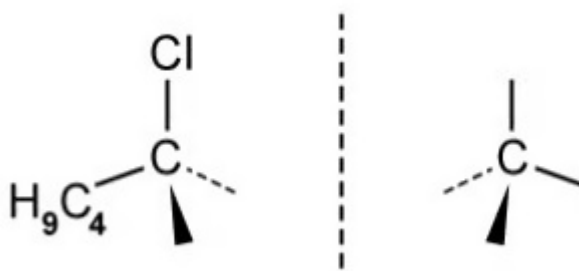


.....
(1 mark)

(d) The figure below identifies a different carbon, **b**, in the organic compounds structure.



Complete the figure below to show the 3D representations of the optical isomers formed at carbon **b**.



(2 marks)

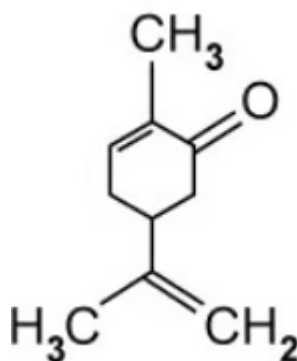
5 (a) Define the term racemic mixture.

.....
(1 mark)

(b) Describe the composition of enantiomers when a reaction mixture is optically active.

.....
(1 mark)

(c) Carvone is an optically active molecule which is found widely in plants, mostly in caraway seeds and spearmint leaves. The structure is shown below.



Mark on the diagram using an asterisk (*) the chiral carbon which causes this structure to exhibit optical isomerism.

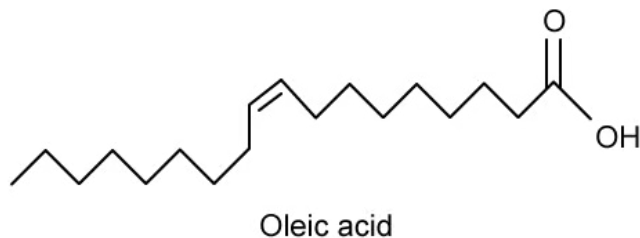
.....
(1 mark)

(d) Draw the structure of the other optical isomer formed by carvone shown in part (c).

.....
(1 mark)

Medium Questions

1 (a) A molecule of oleic acid is shown.



Oleic acid is a fatty acid which occurs naturally in different animals and plants.

Oleic acid exhibits *stereoisomerism*. Explain the meaning of this term and identify why oleic acid has stereoisomers.

(2 marks)

(b) Crotonic acid is another fatty acid which has a similar structure to oleic acid. The molecular formula of crotonic acid is $C_4H_6O_2$.

- State the empirical formula of crotonic acid.
- Crotonic acid has a carboxylic acid functional group. Draw the displayed formula of the positional and branch-chain isomers of crotonic acid.
- Identify which of the isomers you have drawn shows E / Z isomerism..

(4 marks)

(c) Give the IUPAC names of the E / Z isomers of crotonic acid.

.....
(1 mark)

(d) Draw the structure of the Z-isomer of crotonic acid and mark the C-C=C bond angle

.....
.....
(2 marks)

2 (a) A chemist is analysing a collection of organic compounds. The structural formulae of these compounds are shown.

Compound	Structural Formula	IUPAC Name
1	$ \begin{array}{ccccc} & \text{H} & \text{H} & \text{H} & \\ & & & & \\ \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{Br} \\ & & & & \\ & \text{OH} & \text{CH}_3 & \text{H} & \end{array} $	
2	$ \begin{array}{ccccc} & \text{O} & \text{H} & \text{H} & \\ & & & & \\ \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{H} \\ & & & & \\ & & \text{Cl} & \text{H} & \end{array} $	
3	$ \begin{array}{c} \text{H} \qquad \text{CH}_2\text{OH} \\ \diagdown \quad / \\ \text{C} = \text{C} \\ / \quad \diagdown \\ \text{CH}_3 \quad \text{Cl} \end{array} $	
4	$ \begin{array}{ccccccc} & \text{H} & & & \text{O} & & \\ & & & & // & & \\ \text{H} & - \text{C} & - \text{C} & = \text{C} & - \text{C} & & \\ & & & & \backslash & & \\ & \text{H} & \text{CH}_3 & \text{H} & \text{OH} & & \end{array} $	

Give the IUPAC name for the compounds to complete the table.

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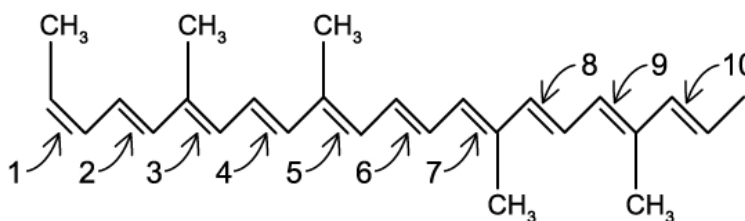
(4 marks)

(b) This question refers to the compounds in the table in part (a)

- (i) Identify the compounds which have chain isomers and draw their isomers.
- (ii) State the empirical formula of compound **3**.
- (iii) Does compound 4 exhibit stereoisomerism? Explain your answer.

(5 marks)

(c) Which of the bond(s) shown in the following structure is/are in the Z configuration?



(1 mark)

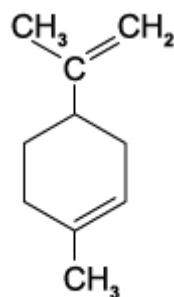
(d) Explain why the reaction between E-but-2-ene and bromine produces the same product as Z-but-2-ene with bromine.

(2 marks)

3 (a) Draw and label the cis / trans isomers of 1,2-dichlorocyclohexane. Explain why this molecule has cis / trans isomers

(2 marks)

(b) Mark the location of any chiral centres in limonene.



Limonene

(1 mark)

(c) Two unsaturated isomers of C₄H₅N, display stereoisomerism.

Draw and name the isomers.

(2 marks)

(d) Draw an isomer of C₄H₅N that does **not** exhibit stereoisomerism.

(1 mark)

- 4 (a) 2-methylbut-2-ene can be converted into 2-methylbutan-2-ol, a liquid that smells of camphor.

State the reagents needed to convert 2-methylbut-2-ene into 2-methylbutan-2-ol.

.....

.....

(2 marks)

- (b) The reaction in part (a) produces a small amount of an isomeric co-product, **X**, which is optically active.

- i) State the meaning of *optical activity*.
- ii) Draw the structure of **X**.

.....

.....

(2 marks)

- (c) What does optical activity indicate about the structure of **X**?

.....

(1 mark)

- (d) Explain how optical activity can be detected using a polarimeter

.....

.....

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(3 marks)

5 (a) Dichloroethene exists as two stereoisomers. Draw the structures of these isomers.

.....
(1 mark)

(b) Explain why dichloroethene has stereoisomers.

.....
(1 mark)

(c) Draw the structures of the stereoisomers of 1-bromo-1-chloroethane, C_2H_4BrCl , and show the relationship between them.

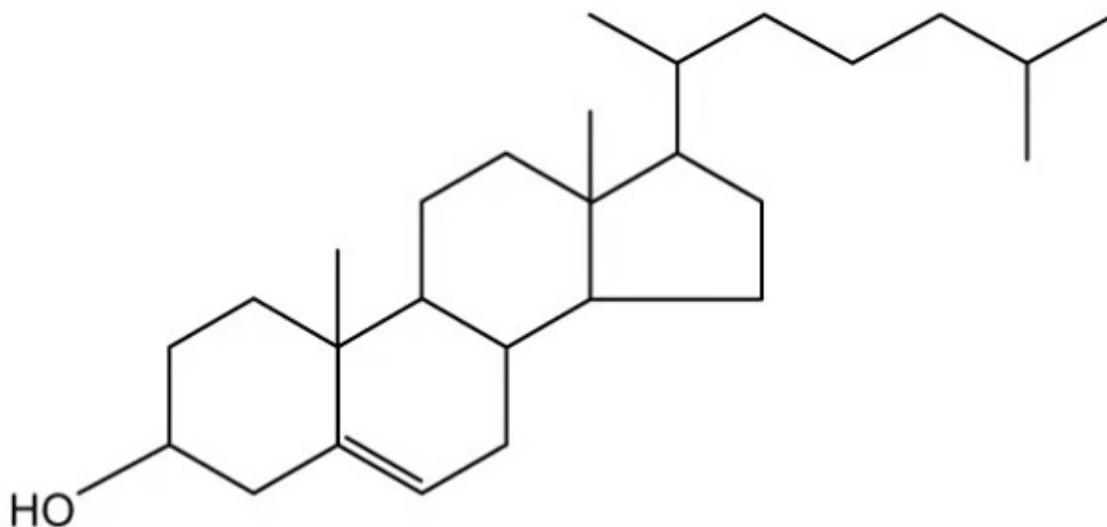
.....
(1 mark)

(d) Explain the differences in chemical and physical properties between the isomers of C_2H_4BrCl

.....
.....
.....
(3 marks)

Hard Questions

1 (a) Cholesterol, shown below, is a fatty chemical used by the body to build healthy cells.



State the number of chiral carbons in the cholesterol structure.

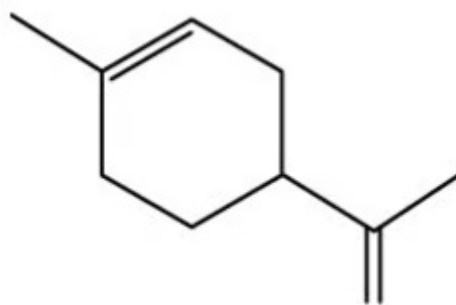
(1 mark)

(b) A student suggested that cholesterol could be tested with plane polarised light to show that it contains chiral centres.

Is the student correct? Justify your answer.

(1 mark)

(c) Limonene, shown below, is a naturally occurring hydrocarbon with the molecular formula $C_{10}H_{16}$ and is commonly found in the rinds of citrus fruits such as grapefruit, lemon, lime and oranges.



Limonene exists as a pair of enantiomers; one enantiomer is responsible for a strong orange smell while the other is thought to smell like lemons.

Draw 3D representations of the two enantiomers of limonene.

(2 marks)

- 2 (a) 1,1,1,2-tetrafluoro-but-2-ene is a compound containing hydrogen, carbon and fluorine atoms.

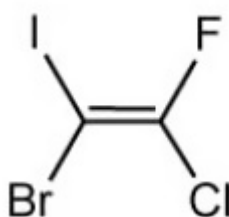
State the meaning of the term 'stereoisomers' and explain why 1,1,1,2-tetrafluoro-but-2-ene displays stereoisomerism.

(5 marks)

- (b) Draw the *E* and *Z* isomers of 1,1,1,2-tetrafluoro-but-2-ene.

(2 marks)

- (c) State the limitation of the cis-trans naming rules when it comes to the molecule shown below.



(1 mark)

- (d) State the name of the molecule shown in part (c).

(1 mark)

- 3 (a) Butenedioic acid is $\text{HOOCCH}=\text{CHCOOH}$. It has two stereoisomers, commonly known as malic acid and fumaric acid. Both acids are responsible for the sour taste in fruit.

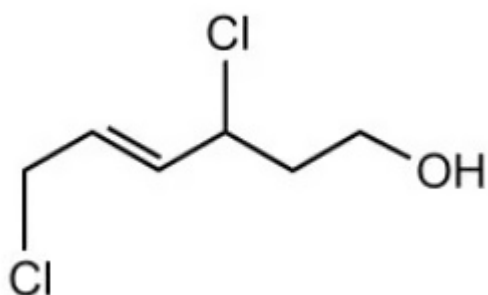
Draw the two *E-Z* isomers of butenedioic acid in **skeletal formulae** and label them as *E*-butenedioic acid and *Z*-butenedioic acid.

.....

.....

(2 marks)

- (b) A student named the alcohol molecule shown below *Z*-1,4-dichlorohex-2-ene-6-ol.



State the errors the student has made in naming the molecule and give the correct IUPAC name.

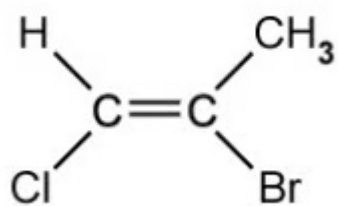
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(3 marks)

- (c) Compounds with a carbon-carbon double bond are unsaturated. The figure below shows an unsaturated hydrocarbon.



i) Name the isomer shown.

[1]

ii) Justify the CIP naming rule for this isomer.

[1]

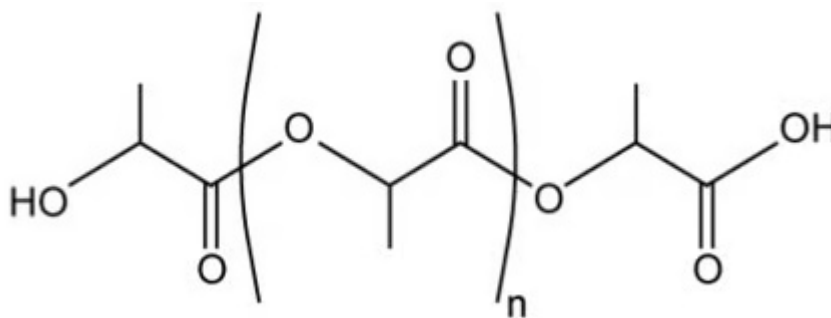
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(2 marks)

- 4 (a) Lactic acid has the molecular formula of $C_3H_6O_3$, and the structural formula of $CH_3CHOHCOOH$.

Illustrate the types of isomerism shown by $C_3H_6O_3$.

(4 marks)

- (b) The general structure of polylactic acid is shown below:



Draw **two** possible structures formed from two repeating units.

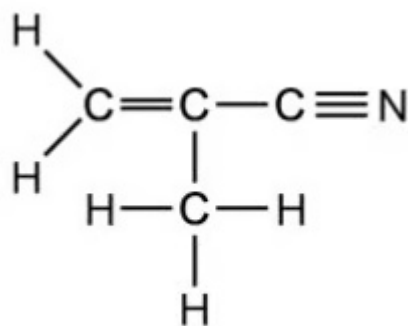
Your answer should keep the main polymer chain in the same plane but show the 3D representation of the chiral carbons.

(2 marks)

- (c) State, why the polymer formed from the uncontrolled condensation polymerisation of lactic acid, is not a racemate.

(1 mark)

5 (a) Two isomers of 2-methylprop-2-enenitrile, C_4H_5N , display E/Z isomerism.



Draw and name the isomers.

.....
.....
(2 marks)

(b) Draw one repeating unit of the polymer formed by addition polymerisation of (*E*)-but-2-ene.

.....
(1 mark)

(c) Explain why the polymer formed by (*E*)-but-2-ene is the same as the polymer formed by (*Z*)-but-2-ene.

.....
(1 mark)