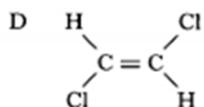
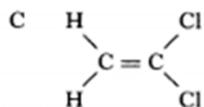
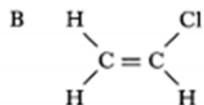
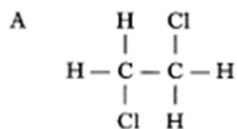
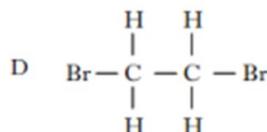
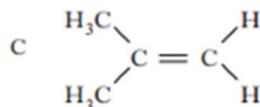
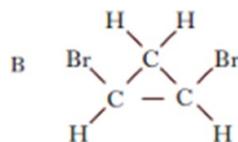
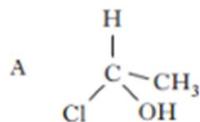


Stereoisomers

1. Which of the following compounds has a geometric isomer?



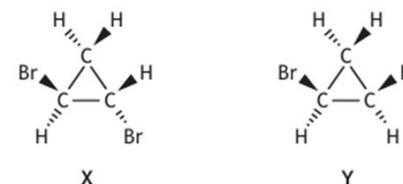
3. Which of the following has a geometric isomer?



2. Geometric isomers

- A are mirror images of each other
- B always contain a carbon-carbon double bond
- C have the same physical and chemical properties
- D have two different groups attached to each of the carbon atoms of the bond with restricted rotation.

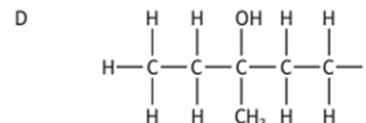
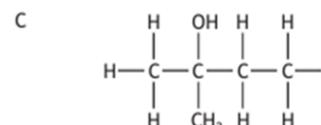
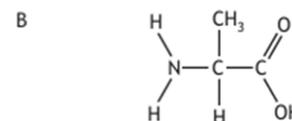
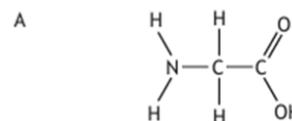
4. X and Y are isomers.



Which line in the table shows the correct names for X and Y?

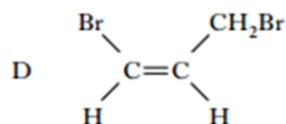
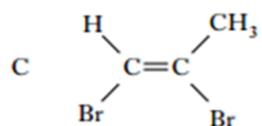
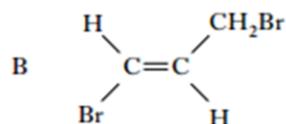
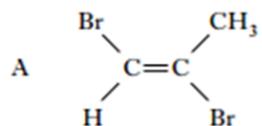
| | X | Y |
|---|---------------------------------------|---------------------------------------|
| A | <i>cis</i> -1,2-dibromocyclopropane | <i>trans</i> -1,2-dibromocyclopropane |
| B | <i>trans</i> -2,3-dibromocyclopropane | <i>cis</i> -2,3-dibromocyclopropane |
| C | <i>trans</i> -1,2-dibromocyclopropane | <i>cis</i> -1,2-dibromocyclopropane |
| D | <i>cis</i> -2,3-dibromocyclopropane | <i>trans</i> -2,3-dibromocyclopropane |

5. Which of the following compounds has non-superimposable mirror images?

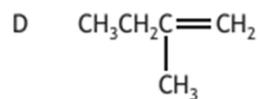
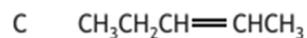
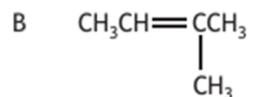
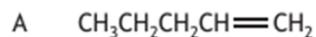


Stereoisomers

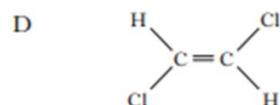
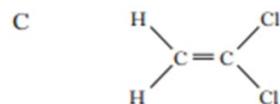
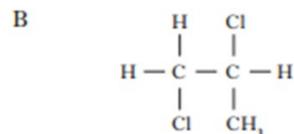
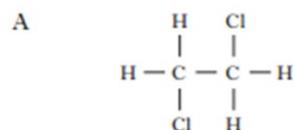
6. Which of the following is the geometric isomer of *trans*-1,2-dibromopropene?



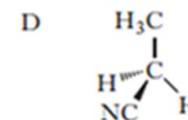
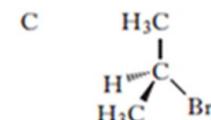
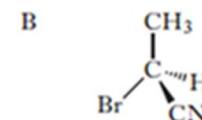
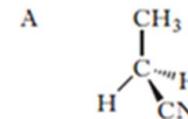
7. Which of the following compounds exhibits geometric isomerism?



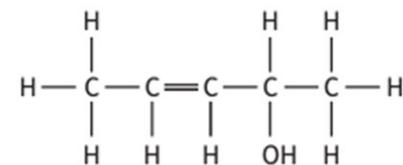
8. Which of the following compounds has a geometric isomer?



10. Which of the following compounds will have an optical isomer?



9.

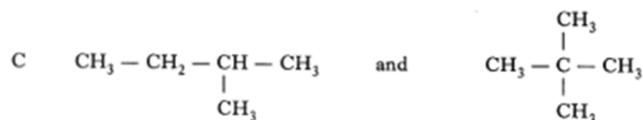
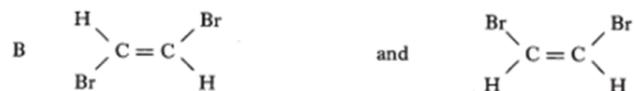


The number of possible stereoisomers for the compound shown is

- A 1
- B 2
- C 3
- D 4

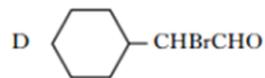
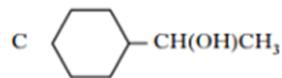
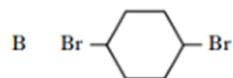
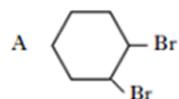
Stereoisomers

11. Which of the following represent the same chemical substance?

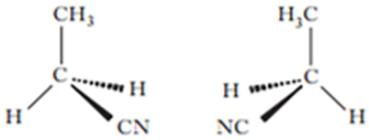
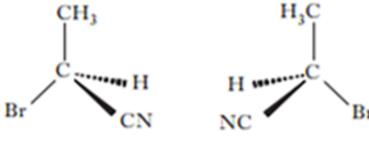
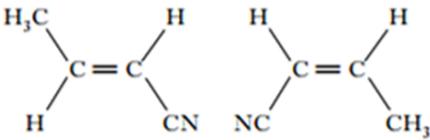
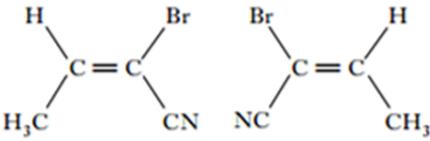


2

12. Which of the following molecules does **not** exhibit optical isomerism?



13. Which line in the table shows a pair of optical isomers?

| | |
|---|--|
| A |  |
| B |  |
| C |  |
| D |  |

15. Mandelic acid has two optical isomers **X** and **Y**. The table shows the rotation of plane polarised light caused by various solutions of **X** and **Y**.

| Volume of 0.1 mol l^{-1} X /cm ³ | Volume of 0.1 mol l^{-1} Y /cm ³ | Volume of water/cm ³ | Observed rotation/° |
|--|--|---------------------------------|---------------------|
| 100 | 0 | 0 | +158 |
| 50 | 0 | 50 | +79 |
| 50 | 50 | 0 | 0 |
| 0 | 100 | 0 | -158 |

What would be the observed rotation for a solution containing 25 cm³ 0.1 mol l^{-1} **X** and 75 cm³ of 0.1 mol l^{-1} **Y**?

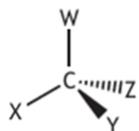
- A -79°
 B -39.5°
 C $+39.5^\circ$
 D $+79^\circ$

14. Which of the following compounds can exhibit geometric isomerism?

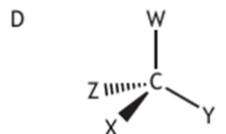
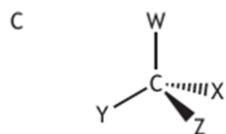
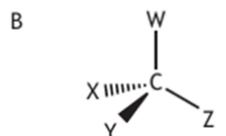
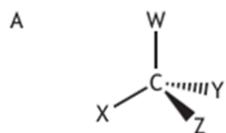
- A CH_2CHBr
 B CHClCH_3
 C $\text{CH}_3\text{CH}_2\text{CHCl}_2$
 D $\text{CH}_3\text{C}(\text{CH}_3)\text{CHCH}_3$

Stereoisomers

- 16 The diagram represents one enantiomer of an optically active compound where W, X, Y and Z are four different groups.



Which of the following represents the other enantiomer of this compound?



- 17 A racemic mixture is defined as

- A a mixture of two enantiomers
- B a pair of enantiomers mixed in equal proportions
- C a mixture of two geometric isomers
- D a pair of geometric isomers mixed in equal proportions.

Stereoisomers

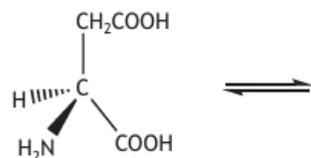
1. Aspartic acid can be used to date material from living things.

Only one optical isomer of aspartic acid is found in living things. This is called L-aspartic acid.

- (a) State what is meant by the term optical isomers. 1

- (b) After living things die, L-aspartic acid converts to the other optical isomer, called D-aspartic acid. An equilibrium is established.

Draw a structural formula for the optical isomer, D-aspartic acid. 1



L-aspartic acid

D-aspartic acid

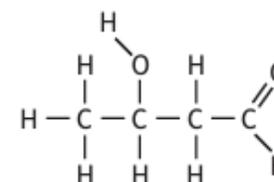
- (c) Compare the effect that these isomers have on plane-polarised light. 1

- (d) State the name given to an equilibrium mixture with equal concentrations of L-aspartic acid and D-aspartic acid. 1

2. Bilirubin can have cis or trans isomerism.

Explain fully why cis and trans isomerism can exist in some compounds with carbon-carbon double bonds. 2

3. 3-hydroxybutanal has optical isomers due to the presence of a chiral centre.



3-hydroxybutanal

- (i) Circle the chiral centre in the structure of 3-hydroxybutanal shown above. 1

(An additional diagram, if required, can be found on page 34.)

- (ii) A sample of 3-hydroxybutanal formed in another reaction was found to be optically inactive. 1

State why this sample is optically inactive.

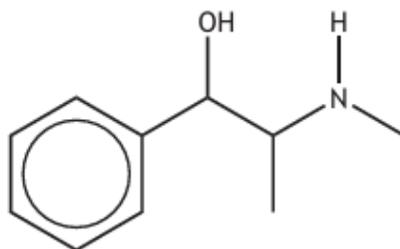
4. 1,2-dichlorocyclohexane has geometric isomers and optical isomers.

- (A) Explain why 1,2-dichlorocyclohexane has geometric isomers. 1

- (B) Draw a cyclic isomer of 1,2-dichlorocyclohexane that does not have an optical isomer. 1

Stereoisomers

5. Ephedrine can be used to prevent low blood pressure.



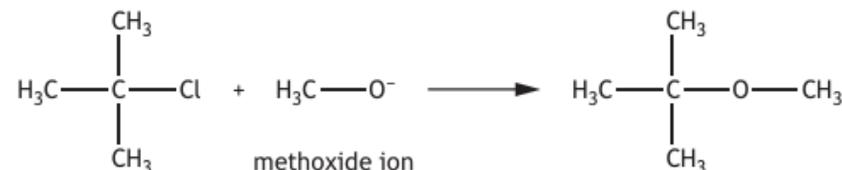
ephedrine

Ephedrine can exist as different optical isomers due to the presence of chiral centres.

- (i) Circle a chiral centre in the structure of ephedrine shown above.
(An additional diagram, if required, can be found on *page 28*.)
- (ii) State what is meant by the term optical isomers.

6. In the reaction of but-1-yne with hydrogen, but-1-ene is formed.
Explain why but-1-ene has no geometric isomers.

7. Compound X can be produced by reacting 2-chloromethylpropane with methoxide ions.

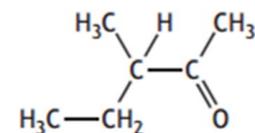


2-chloromethylpropane

compound X

8. 3-Methylpentan-2-one is optically active and exists in equilibrium with its enol tautomer.

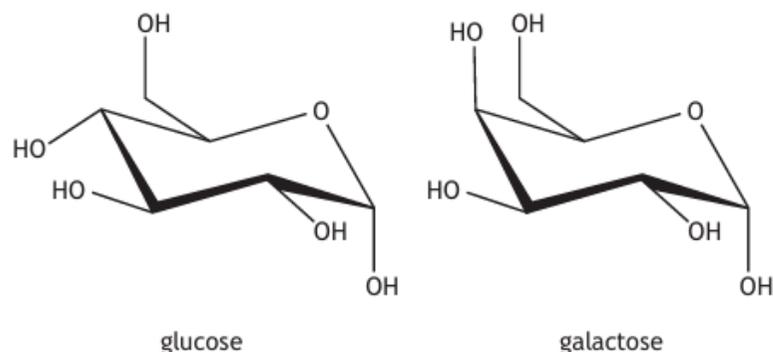
- (i) Circle the chiral centre on 3-methylpentan-2-one.



- (ii) Suggest why the optical activity of 3-methylpentan-2-one decreases over time.

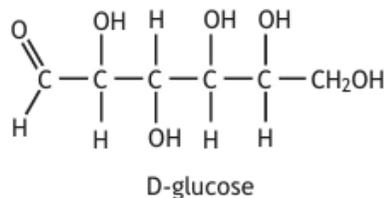
Stereoisomers

9. A more accurate representation of the structure of glucose, and its geometric isomer galactose, is shown below.



- a) With reference to the structures shown, explain why sugars such as glucose and galactose have geometric isomers. 1

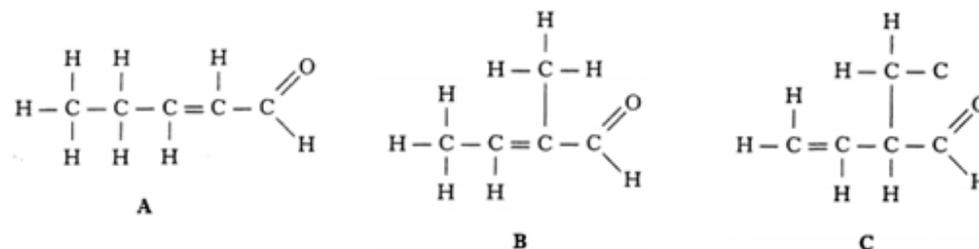
- b) The ring structure of glucose exists in equilibrium with its open-chain structure. The diagram below shows the open-chain structure of one optical isomer of glucose called D-glucose.



- (i) State the number of chiral centres in D-glucose. 1

- (ii) Draw an open-chain structural formula for an optical isomer of D-glucose. 1

10. An unsaturated aldehyde has the molecular formula $\text{C}_5\text{H}_8\text{O}$. The formulae of three of its structural isomers are drawn below.



- (a) Which one of the above compounds does **not** exhibit **geometric isomerism**? 1

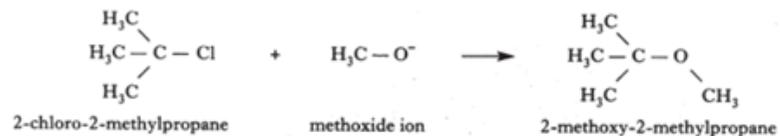
- (b) One of the above compounds exhibits **optical isomerism**.
Copy its structural formula and circle the chiral (asymmetric) carbon atom. 1

11. Difluoromethanimine, $\text{FN} = \text{CHF}$, can exist in two isomeric forms.
When a sample of the *trans*-isomer was dissolved in an organic solvent at 22°C it was slowly converted into the *cis*-isomer. After 7 days, 95% of the *trans*-isomer had been converted and no further conversion occurred thereafter.

Draw the full structural formula of *trans*-difluoromethanimine. 1

Stereoisomers

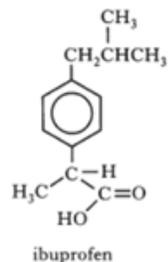
12. 2-Methoxy-2-methylpropane is a compound added to unleaded petrol as a "knock inhibitor". It can be synthesised by the reaction of methoxide ions with 2-chloro-2-methylpropane.



2-Methoxy-2-methylpropane does not display optical isomerism. Draw the structural formula of an isomer of this compound which does display optical isomerism.

1

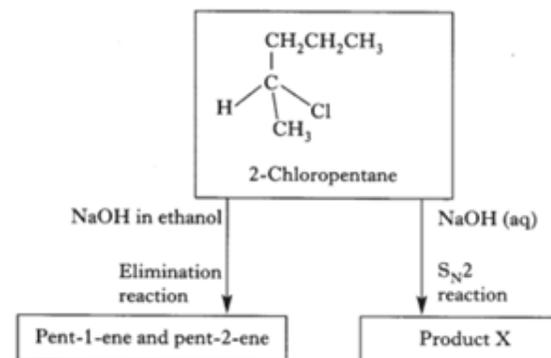
13. Ibuprofen is an anti-inflammatory agent which can be synthesised from benzene as shown below.



Copy the structure of ibuprofen and circle a chiral carbon atom.

1

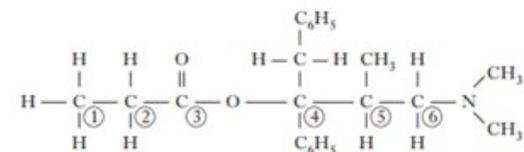
14. In the reaction sequence shown below, 2-chloropentane reacts with sodium hydroxide in different ways depending on the solvent used.



One of the alkenes formed in the elimination reaction is present as two **geometric** isomers. Draw the structures of both geometric isomers and name each one.

2

15. Propoxyphene is a pain-killing drug. Its structure is shown below.



There are two chiral carbons in propoxyphene.

Referring to the structure above, identify both chiral carbons.

1

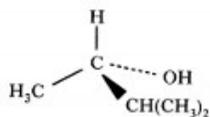
Stereoisomers

16. Mixtures of the isomers of the alcohol, $C_5H_{11}OH$, are used as solvents for resins and oily materials.

The shortened structural formulae for four of these isomers are shown in the table.

| Isomer | Shortened structural formula |
|--------|------------------------------|
| A | $(CH_3)(C_2H_5)CHCH_2OH$ |
| B | $(CH_3)_2CCH_2OH$ |
| C | $(CH_3)_2(C_2H_5)COH$ |
| D | $(C_2H_5)_2CHOH$ |

- a) Another isomer of $C_5H_{11}OH$ displays optical isomerism. One of its optical isomers is shown below.



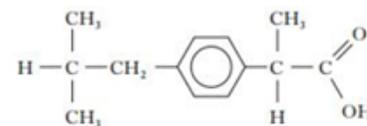
Draw a diagram representing the other optical isomer.

1

- b) One of the four isomers, A to D, in the table above, is also optically active. Draw a similar diagram to that shown in part (b) to represent one of its optical isomers.

1

17. Ibuprofen is one of the most commonly used non-steroidal anti-inflammatory drugs (NSAIDs). The structure of ibuprofen is shown.

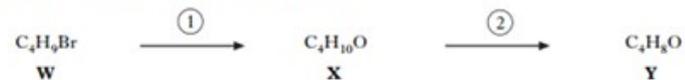


ibuprofen

Copy the relevant part of the structure of ibuprofen and circle the carbon which makes ibuprofen chiral.

1

18. Compound **W** reacts in two steps to form compound **Y**.



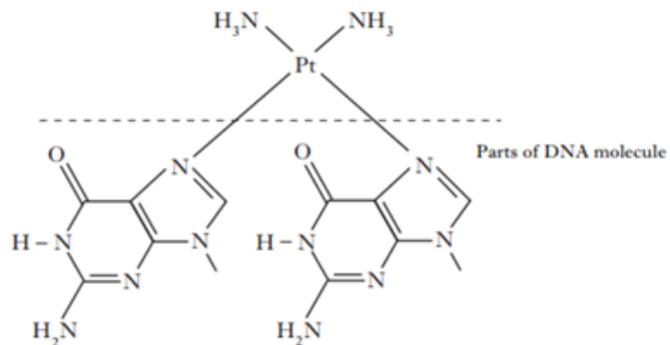
Dehydration of compound **X** produces three unsaturated isomers of molecular formula C_4H_8 . Two of these are **geometric** isomers.

Draw the structures of both **geometric** isomers and name each one.

2

Stereoisomers

19. *cis*-Platin is a highly successful anti-cancer drug. The formula for *cis*-platin is $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$.



Draw a possible structure for the geometric isomer of *cis*-platin.

1

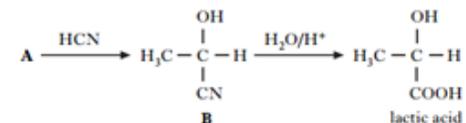
20. Consider the following reaction scheme.



Explain why but-2-ene exhibits geometric isomerism yet its structural isomer but-1-ene does not.

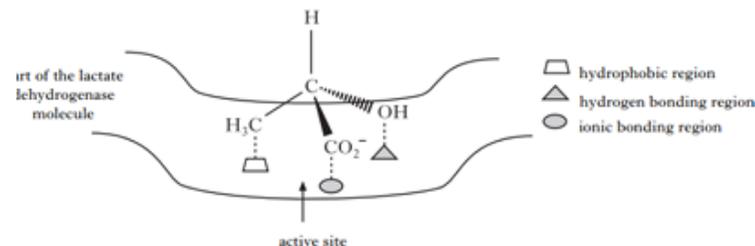
1

21. Consider the following reaction sequence.



Lactic acid in the form of lactate ions is dehydrogenated in the liver by the enzyme, lactate dehydrogenase.

The diagram shows how one of the optical isomers of the lactate ion binds to an active site of lactate dehydrogenase.



- (i) Which type of intermolecular force is involved when the methyl group of the lactate ion binds to the hydrophobic region of the active site?

1

- (ii) Draw a structure for the other optical isomer of the lactate ion.

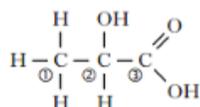
1

- (iii) Explain why this other optical isomer of the lactate ion cannot bind as efficiently to the active site of lactate dehydrogenase.

1

Stereoisomers

22. The structure of lactic acid is

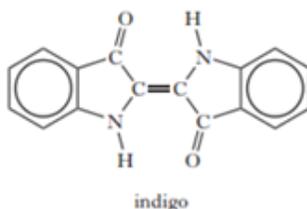


Lactic acid contains an asymmetric carbon atom.

Identify, and **explain**, which one of the numbered carbon atoms is asymmetric.

1

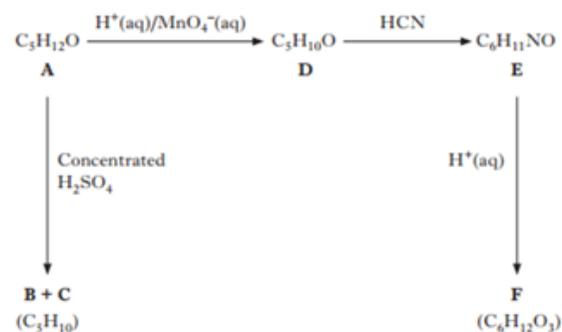
23. The blue colour of denim jeans comes from a dye known as indigo.



Draw a structural formula for the geometric isomer of indigo.

1

24. The diagram below shows a reaction sequence starting from compound **A** which is pentan-2-ol ($\text{C}_5\text{H}_{12}\text{O}$).



Compound **B** can exist as two geometric isomers.

Compound **C** is pent-1-ene.

Compound **D** is the oxidation product of compound **A**.

(a) Name **and** draw the structural formulae for the two geometric isomers of compound **B**.

2

Name **and** draw the structural formulae for the two geometric isomers of compound **B**.

2

25. Lipoic acid has recently been used as a food supplement. The skeletal structural formula of lipoic acid is shown below.



(b) (i) Lipoic acid is optically active. Copy the skeletal structural formula of lipoic acid and circle the carbon atom responsible for the optical activity of lipoic acid.

1

(ii) Why does this carbon atom make lipoic acid optically active?

1

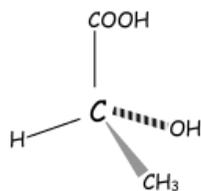
Stereoisomers

26

A monocarboxylic acid, **X**, has an empirical formula of CH_2O . When 10.0 cm^3 of an aqueous solution of **X**, containing 7.85 g l^{-1} , was titrated against 0.049 mol l^{-1} sodium hydroxide the titre volume was 17.8 cm^3 .

X contains an asymmetric carbon atom.

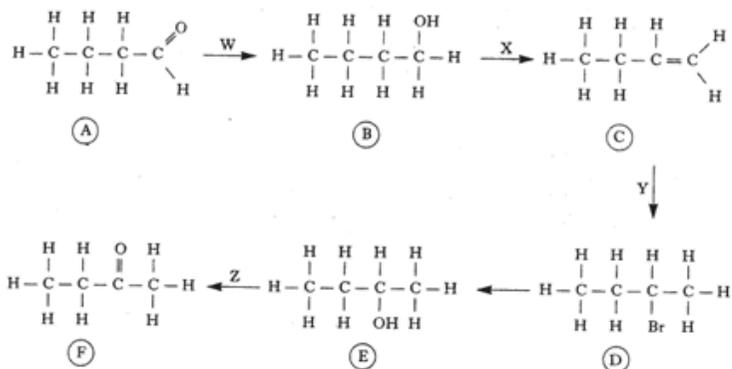
(i) Deduce the structural formula of **X**. 1



(ii) Plane-polarised light is **not** rotated when passed through an aqueous solution of **X**. Suggest a reason for this. 1

27

A student designed the following reaction sequence.



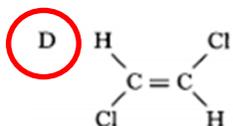
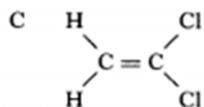
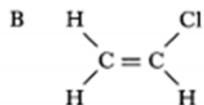
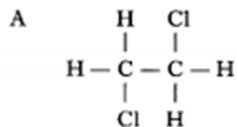
(e) (i) Why does **(C)** not have geometric isomers despite the presence of a carbon to carbon double bond? 1

(ii) Which of the compounds **(A)** - **(F)** have optical isomers? 2

4

Stereoisomers

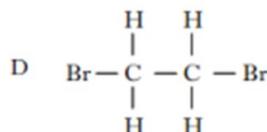
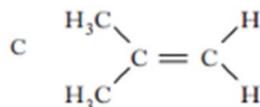
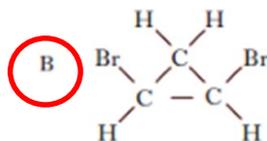
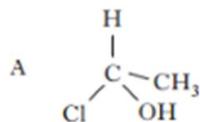
1. Which of the following compounds has a geometric isomer?



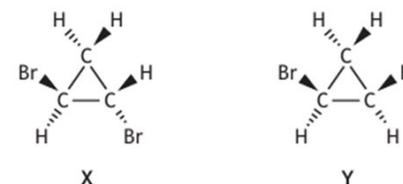
2. Geometric isomers

- A are mirror images of each other
- B always contain a carbon-carbon double bond
- C have the same physical and chemical properties
- D** have two different groups attached to each of the carbon atoms of the bond with restricted rotation.

3. Which of the following has a geometric isomer?



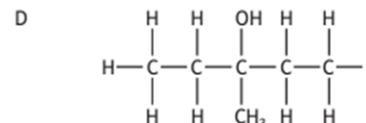
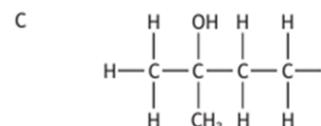
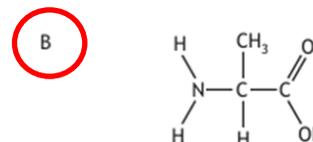
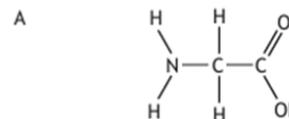
4. X and Y are isomers.



Which line in the table shows the correct names for X and Y?

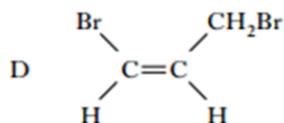
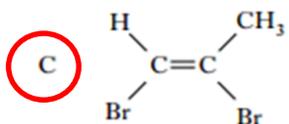
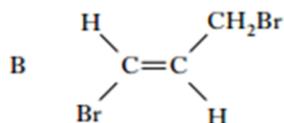
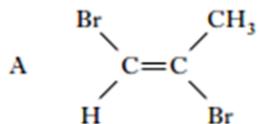
| | X | Y |
|----------|---------------------------------------|---------------------------------------|
| A | <i>cis</i> -1,2-dibromocyclopropane | <i>trans</i> -1,2-dibromocyclopropane |
| B | <i>trans</i> -2,3-dibromocyclopropane | <i>cis</i> -2,3-dibromocyclopropane |
| C | <i>trans</i> -1,2-dibromocyclopropane | <i>cis</i> -1,2-dibromocyclopropane |
| D | <i>cis</i> -2,3-dibromocyclopropane | <i>trans</i> -2,3-dibromocyclopropane |

5. Which of the following compounds has non-superimposable mirror images?

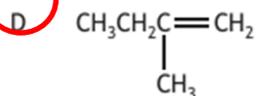
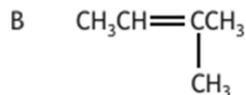
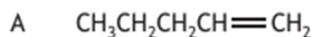


Stereoisomers

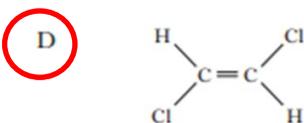
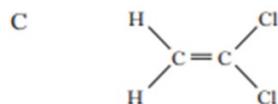
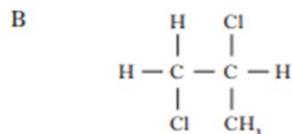
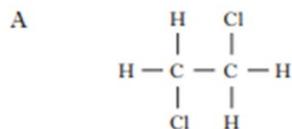
6. Which of the following is the geometric isomer of *trans*-1,2-dibromopropene?



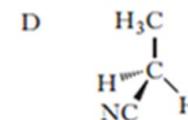
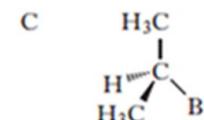
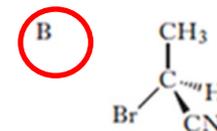
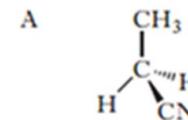
7. Which of the following compounds exhibits geometric isomerism?



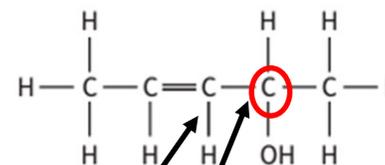
8. Which of the following compounds has a geometric isomer?



10. Which of the following compounds will have an optical isomer?



9.



The number of possible stereoisomers for the compound shown is

A 1

B 2

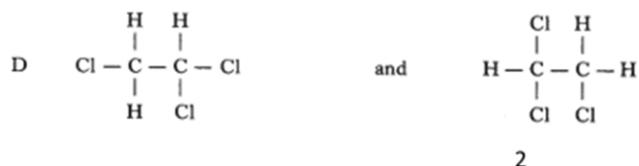
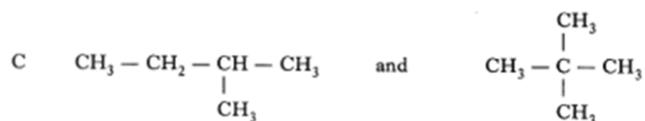
C 3

D 4

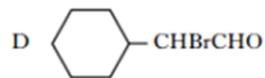
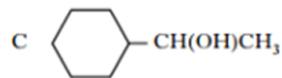
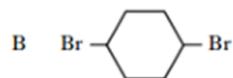
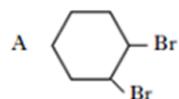
2 geometric and 2 optical

Stereoisomers

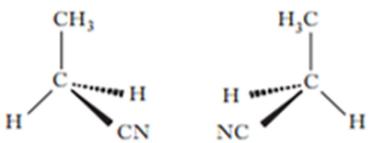
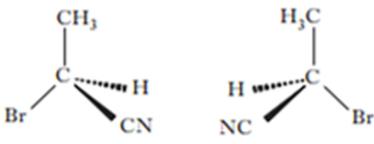
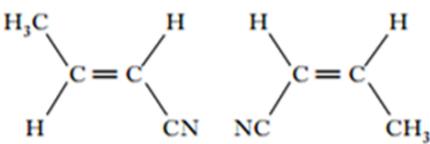
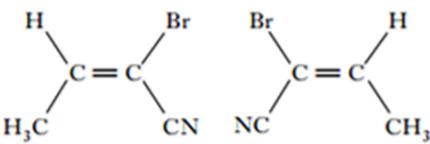
11. Which of the following represent the same chemical substance?



12. Which of the following molecules does **not** exhibit optical isomerism?



13. Which line in the table shows a pair of optical isomers?

| | |
|---|--|
| A |  |
| B |  |
| C |  |
| D |  |

15. Mandelic acid has two optical isomers **X** and **Y**. The table shows the rotation of plane polarised light caused by various solutions of **X** and **Y**.

| Volume of 0.1 mol l^{-1} X /cm ³ | Volume of 0.1 mol l^{-1} Y /cm ³ | Volume of water/cm ³ | Observed rotation/° |
|--|--|---------------------------------|---------------------|
| 100 | 0 | 0 | +158 |
| 50 | 0 | 50 | +79 |
| 50 | 50 | 0 | 0 |
| 0 | 100 | 0 | -158 |

What would be the observed rotation for a solution containing 25 cm³ 0.1 mol l^{-1} **X** and 75 cm³ of 0.1 mol l^{-1} **Y**?

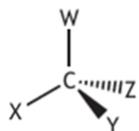
- A -79°
B -39.5°
 C $+39.5^\circ$
 D $+79^\circ$

14. Which of the following compounds can exhibit geometric isomerism?

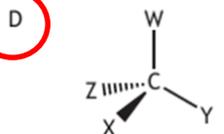
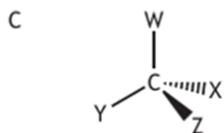
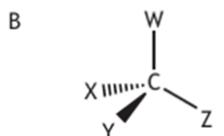
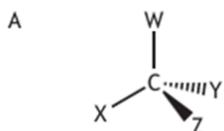
- A CH_2CHBr
B CHClCHCH_3
 C $\text{CH}_3\text{CH}_2\text{CHCl}_2$
 D $\text{CH}_3\text{C}(\text{CH}_3)\text{CHCH}_3$

Stereoisomers

- 16 The diagram represents one enantiomer of an optically active compound where W, X, Y and Z are four different groups.



Which of the following represents the other enantiomer of this compound?



- 17 A racemic mixture is defined as

- A a mixture of two enantiomers
- B a pair of enantiomers mixed in equal proportions**
- C a mixture of two geometric isomers
- D a pair of geometric isomers mixed in equal proportions.

Stereoisomers

1. Aspartic acid can be used to date material from living things.

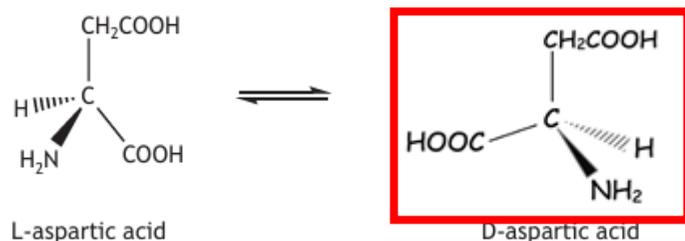
Only one optical isomer of aspartic acid is found in living things. This is called L-aspartic acid.

- (a) State what is meant by the term optical isomers.

non-superimposable mirror images of each other

- (b) After living things die, L-aspartic acid converts to the other optical isomer, called D-aspartic acid. An equilibrium is established.

Draw a structural formula for the optical isomer, D-aspartic acid.



- (c) Compare the effect that these isomers have on plane-polarised light.

Rotates light in same amounts in opposite directions

- (d) State the name given to an equilibrium mixture with equal concentrations of L-aspartic acid and D-aspartic acid.

Racemic

2. Bilirubin can have cis or trans isomerism.

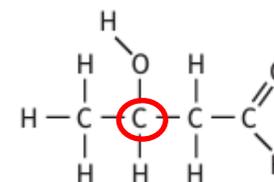
Explain fully why cis and trans isomerism can exist in some compounds with carbon-carbon double bonds.

Two different groups attached to each carbon atom (1)

Restricted rotation (around the carbon carbon double bond) (1)

3. 3-hydroxybutanal has optical isomers due to the presence of a chiral centre.

1



3-hydroxybutanal

1

- (i) Circle the chiral centre in the structure of 3-hydroxybutanal shown above.

(An additional diagram, if required, can be found on page 34.)

1

- (ii) A sample of 3-hydroxybutanal formed in another reaction was found to be optically inactive.

State why this sample is optically inactive.

Cis pent-2-ene
Racemic mixture

1

1,2-dichlorocyclohexane has geometric isomers and optical isomers.

4. (A) Explain why 1,2-dichlorocyclohexane has geometric isomers.

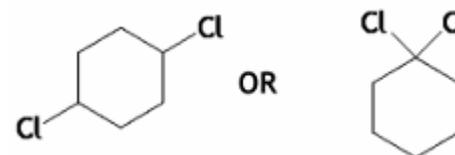
Restricted rotation in the ring

1

- (B) Draw a cyclic isomer of 1,2-dichlorocyclohexane that does not have an optical isomer.

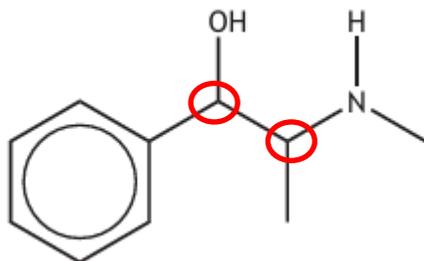
1

2



Stereoisomers

5. Ephedrine can be used to prevent low blood pressure.



ephedrine

Ephedrine can exist as different optical isomers due to the presence of chiral centres.

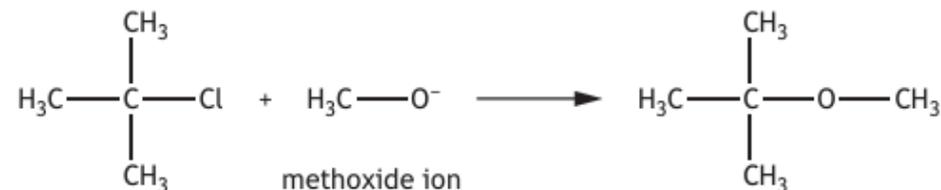
- (i) Circle a chiral centre in the structure of ephedrine shown above.
(An additional diagram, if required, can be found on *page 28*.)
- (ii) State what is meant by the term optical isomers.

non-superimposable mirror images of each other

6. In the reaction of but-1-yne with hydrogen, but-1-ene is formed.
Explain why but-1-ene has no geometric isomers.

But-1-ene has two hydrogens/the same group on first carbon of the C=C

7. Compound X can be produced by reacting 2-chloromethylpropane with methoxide ions.

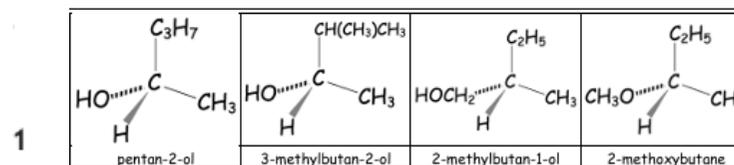


2-chloromethylpropane

compound X

Compound X is not optically active.

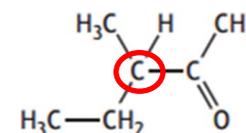
Draw an isomer of compound X that is optically active.



1

8. 3-Methylpentan-2-one is optically active and exists in equilibrium with its enol tautomer.

- (i) Circle the chiral centre on 3-methylpentan-2-one.

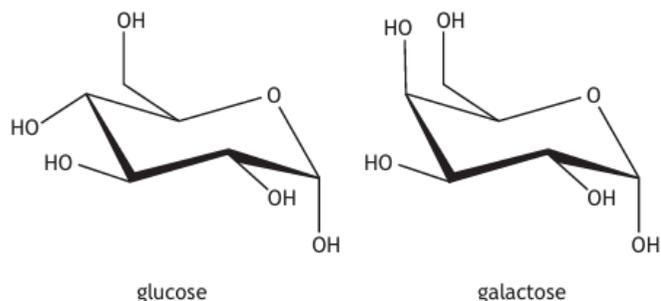


- (ii) Suggest why the optical activity of 3-methylpentan-2-one decreases over time.

A racemic mixture is forming

Stereoisomers

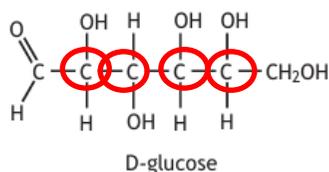
- 9a) A more accurate representation of the structure of glucose, and its geometric isomer galactose, is shown below.



With reference to the structures shown, explain why sugars such as glucose and galactose have geometric isomers. 1

Restricted rotation in the ring

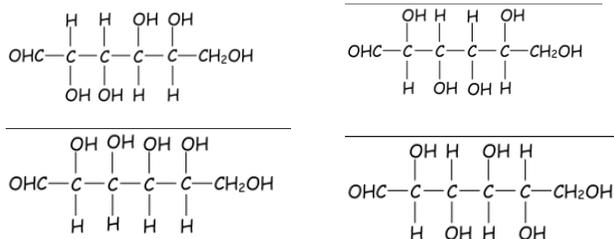
- b) The ring structure of glucose exists in equilibrium with its open-chain structure. The diagram below shows the open-chain structure of one optical isomer of glucose called D-glucose.



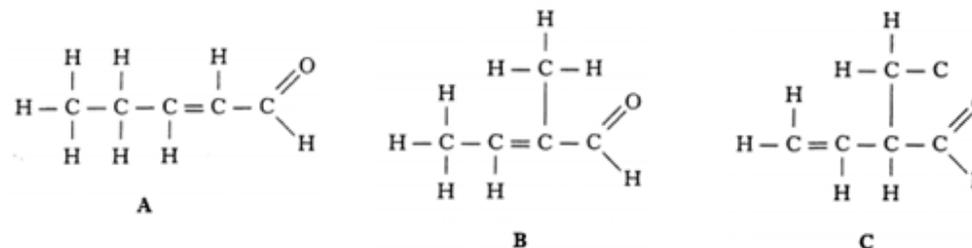
- (i) State the number of chiral centres in D-glucose. 1

4

- (ii) Draw an open-chain structural formula for an optical isomer of D-glucose. 1



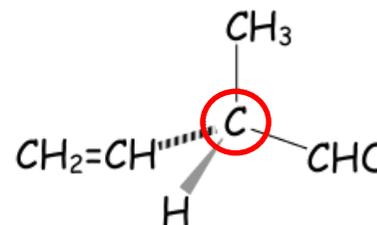
10. An unsaturated aldehyde has the molecular formula $\text{C}_5\text{H}_8\text{O}$. The formulae of three of its structural isomers are drawn below.



- (a) Which one of the above compounds does **not** exhibit **geometric isomerism**? 1

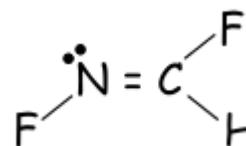
Molecule C

- (b) One of the above compounds exhibits **optical isomerism**. Copy its structural formula and circle the chiral (asymmetric) carbon atom. 1



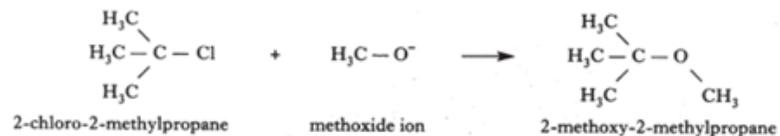
11. Difluoromethanimine, $\text{FN}=\text{CHF}$, can exist in two isomeric forms. When a sample of the *trans*-isomer was dissolved in an organic solvent at 22°C it was slowly converted into the *cis*-isomer. After 7 days, 95% of the *trans*-isomer had been converted and no further conversion occurred thereafter.

Draw the full structural formula of *trans*-difluoromethanimine. 1



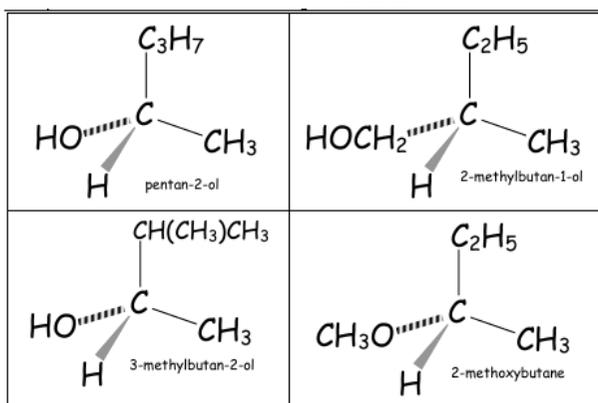
Stereoisomers

12. 2-Methoxy-2-methylpropane is a compound added to unleaded petrol as a "knock inhibitor". It can be synthesised by the reaction of methoxide ions with 2-chloro-2-methylpropane.

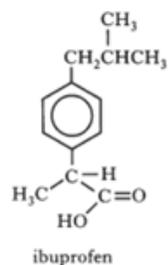


2-Methoxy-2-methylpropane does not display optical isomerism. Draw the structural formula of an isomer of this compound which does display optical isomerism.

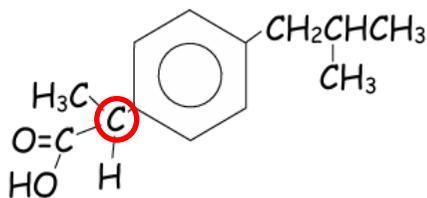
Any one.



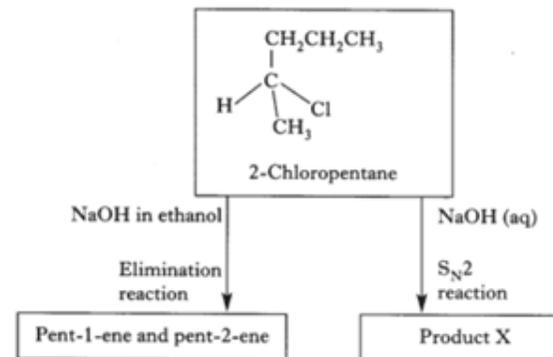
13. Ibuprofen is an anti-inflammatory agent which can be synthesised from benzene as shown below.



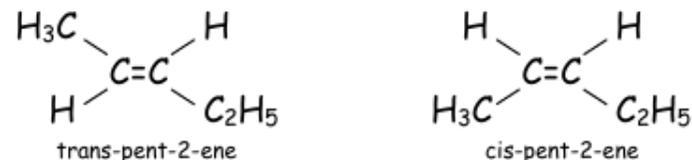
Copy the structure of ibuprofen and circle a chiral carbon atom.



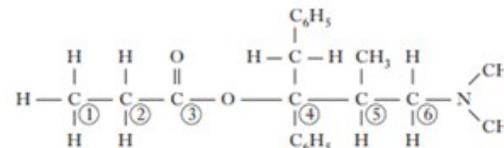
14. In the reaction sequence shown below, 2-chloropentane reacts with sodium hydroxide in different ways depending on the solvent used.



One of the alkenes formed in the elimination reaction is present as two **geometric** isomers. Draw the structures of both geometric isomers and name each one.



15. Propoxyphene is a pain-killing drug. Its structure is shown below.



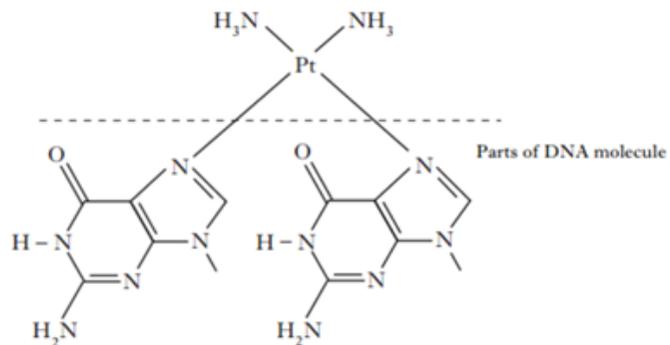
There are two chiral carbons in propoxyphene.

Referring to the structure above, identify both chiral carbons.

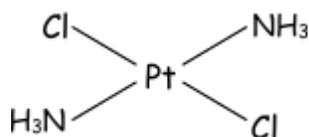
Carbon 4 & 5

Stereoisomers

19. *cis*-Platin is a highly successful anti-cancer drug. The formula for *cis*-platin is $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$.



Draw a possible structure for the geometric isomer of *cis*-platin.



20. Consider the following reaction scheme.



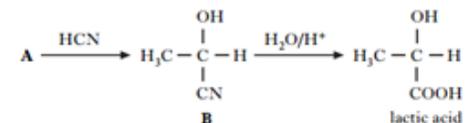
Explain why but-2-ene exhibits geometric isomerism yet its structural isomer but-1-ene does not.

But-2-ene has two different groups attached across the C=C double bond

or

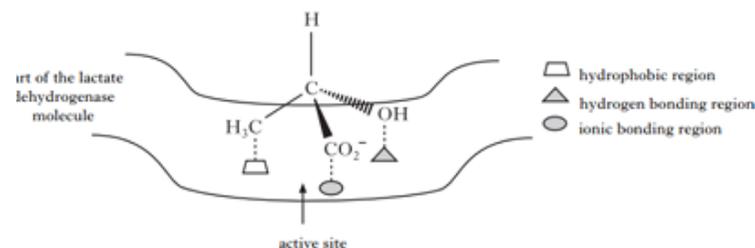
But-1-ene has only 1 group around the C=C double bond and 3 identical groups attached

21. Consider the following reaction sequence.



Lactic acid in the form of lactate ions is dehydrogenated in the liver by the enzyme, lactate dehydrogenase.

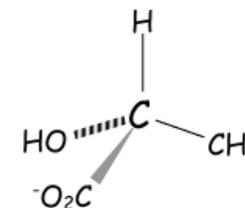
The diagram shows how one of the optical isomers of the lactate ion binds to an active site of lactate dehydrogenase.



(i) Which type of intermolecular force is involved when the methyl group of the lactate ion binds to the hydrophobic region of the active site?

London dispersion force /Van Der Waals'

(ii) Draw a structure for the other optical isomer of the lactate ion.

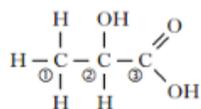


(iii) Explain why this other optical isomer of the lactate ion cannot bind as efficiently to the active site of lactate dehydrogenase.

3 functional groups do not match up to the site on enzyme

Stereoisomers

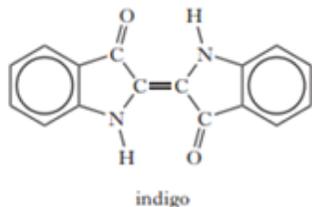
22. The structure of lactic acid is



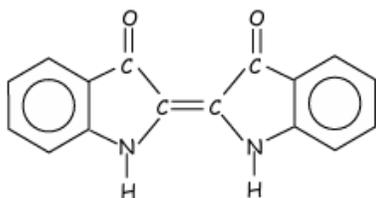
(a) Lactic acid contains an asymmetric carbon atom.
Identify, and **explain**, which one of the numbered carbon atoms is asymmetric.

Carbon atom 2 because it has 4 different groups attached

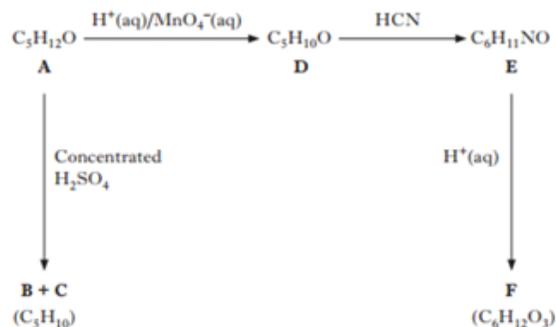
23. The blue colour of denim jeans comes from a dye known as indigo.



(b) Draw a structural formula for the geometric isomer of indigo.



24. The diagram below shows a reaction sequence starting from compound **A** which is pentan-2-ol ($C_5H_{12}O$).

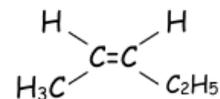


Compound **B** can exist as two geometric isomers.

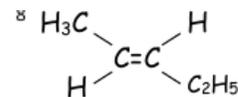
Compound **C** is pent-1-ene.

Compound **D** is the oxidation product of compound **A**.

Name **and** draw the structural formulae for the two geometric isomers of compound **B**.



Cis pent-2-ene

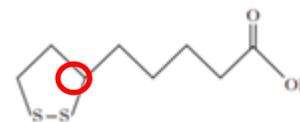


Trans pent-2-ene

25. Lipoic acid has recently been used as a food supplement. The skeletal structural formula of lipoic acid is shown below.



(b) (i) Lipoic acid is optically active. Copy the skeletal structural formula of lipoic acid and circle the carbon atom responsible for the optical activity of lipoic acid.



(ii) Why does this carbon atom make lipoic acid optically active?

It has 4 different groups attached to it

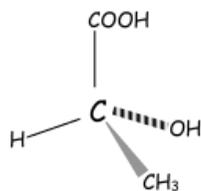
Stereoisomers

26

A monocarboxylic acid, **X**, has an empirical formula of CH_2O . When 10.0 cm^3 of an aqueous solution of **X**, containing 7.85 g l^{-1} , was titrated against 0.049 mol l^{-1} sodium hydroxide the titre volume was 17.8 cm^3 .

X contains an asymmetric carbon atom.

(i) Deduce the structural formula of **X**. 1

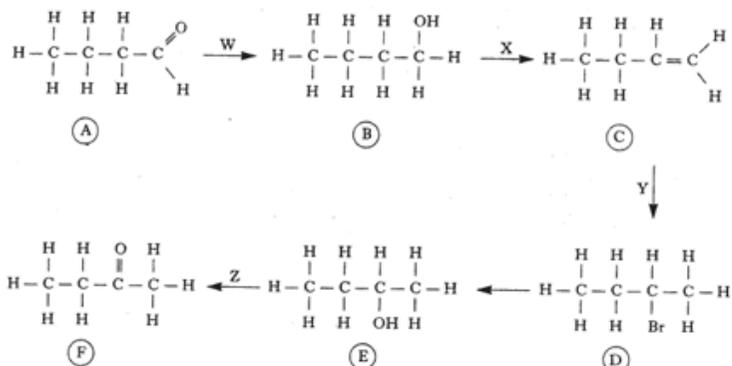


(ii) Plane-polarised light is **not** rotated when passed through an aqueous solution of **X**. Suggest a reason for this. 1

Equal concentration of both optical isomers present (racemic mixture)

27

A student designed the following reaction sequence.



(e) (i) Why does **(C)** not have geometric isomers despite the presence of a carbon to carbon double bond? 1

Both atoms on one carbon of $\text{C}=\text{C}$ double bond are the same

(ii) Which of the compounds **(A)** - **(F)** have optical isomers? 2

D and E

4