



Physics. You work it out.

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# Chiral Antibiotics

A Level



## Part A Chloramphenicol

Chloramphenicol is an antibiotic drug. Its formula is given below.

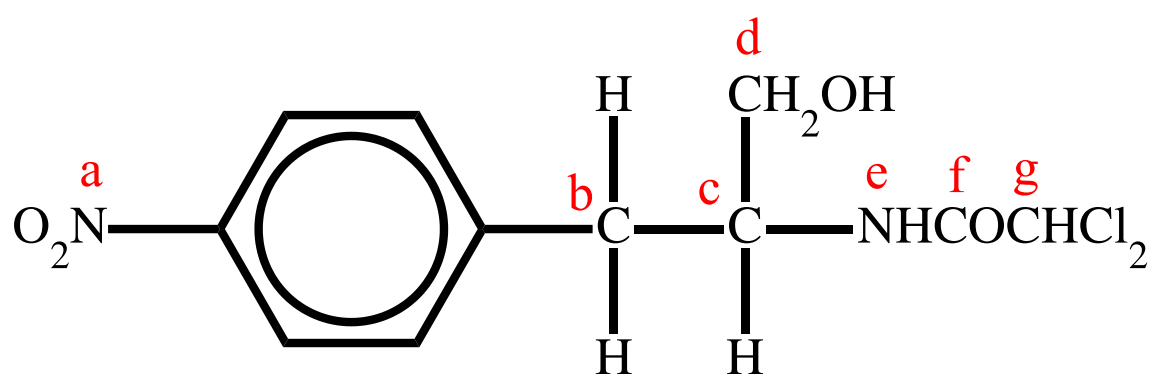
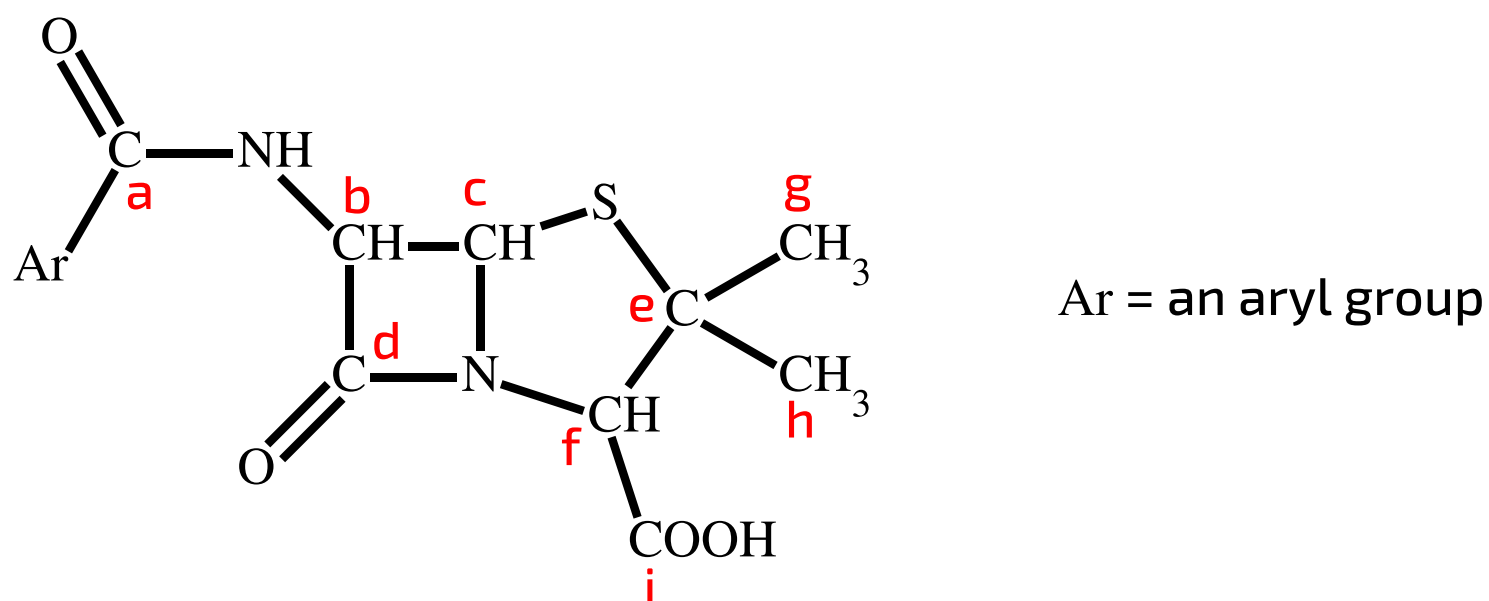


Figure 1: Structure of chloramphenicol

List any of the letters **a-g** which are chiral centres in alphabetical order without spaces e.g. "ab".

## Part B Penicillin

Penicillin is widely used to kill bacteria. The general structure of a penicillin molecule is given below.



**Figure 2:** General structure of penicillin

List in alphabetical order (e.g. "ab") any of the carbon atoms **a-i** which are chiral centres.

Part A adapted with permission from UCLES, A-Level Chemistry, June 1991, Paper 2, Question 5;

Part B adapted with permission from UCLES, A-Level Chemistry, November 1995, Paper 3, Question 5



# Asthma drugs

A Level



## Part A Salbutamol

Salbutamol is a widely used anti-asthmatic drug. The structure of salbutamol is:

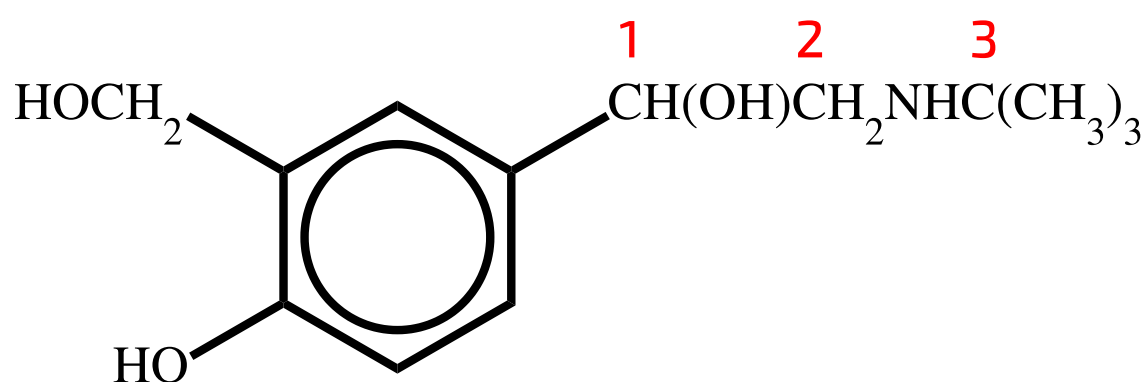


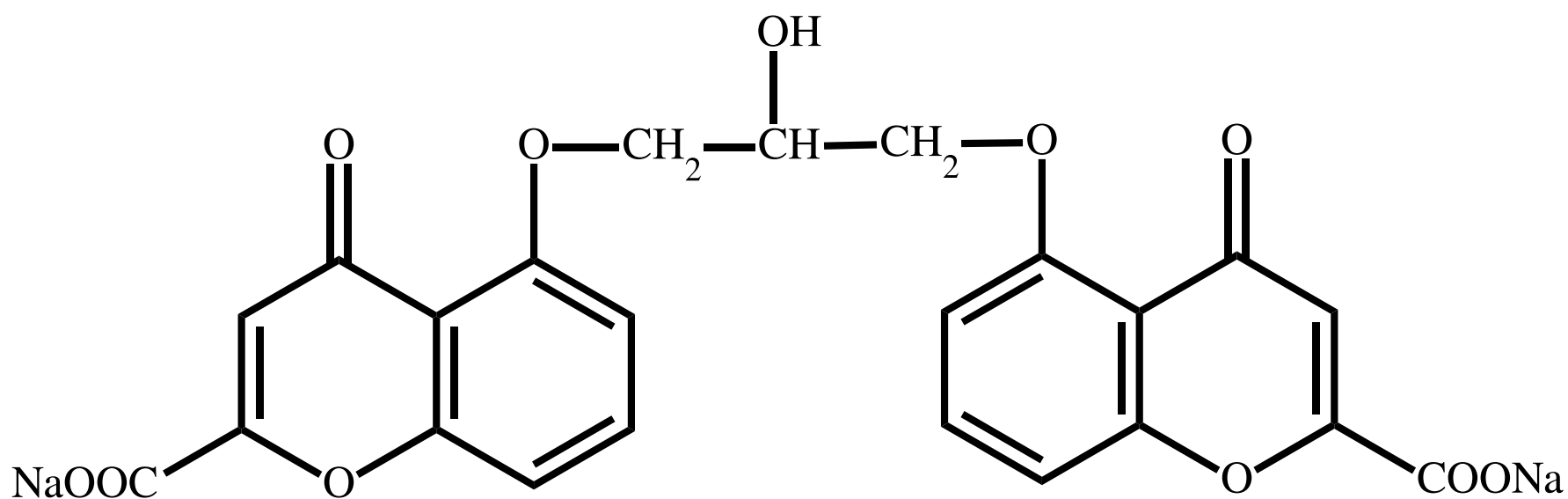
Figure 1: Structure of salbutamol

Which of the carbon atoms numbered on the structure are chiral?

- ☐ 1, 2 and 3 are chiral
- ☐ 1 and 2 only are chiral
- ☐ 1 and 3 only are chiral
- ☐ 2 and 3 only are chiral
- ☐ 1 only is chiral
- ☐ 2 only is chiral
- ☐ 3 only is chiral
- ☐ None of the labelled carbons are chiral

## Part B Intal

The anti-asthma drug *Intal* contains disodium cromoglycate, which has the following structure:



**Figure 2:** Structure of disodium cromoglycate

How many chiral centres are there in the molecule?

Part A adapted with permission from UCLES, A-Level Chemistry, November 1995, Paper 4, Question 38;

Part B adapted with permission from UCLES, A-Level Chemistry, June 1988, Paper 3, Question 22

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# Chiral Centres

A Level



## Part A Amino acids

Which of the following amino acids contains *two* chiral carbon atoms?

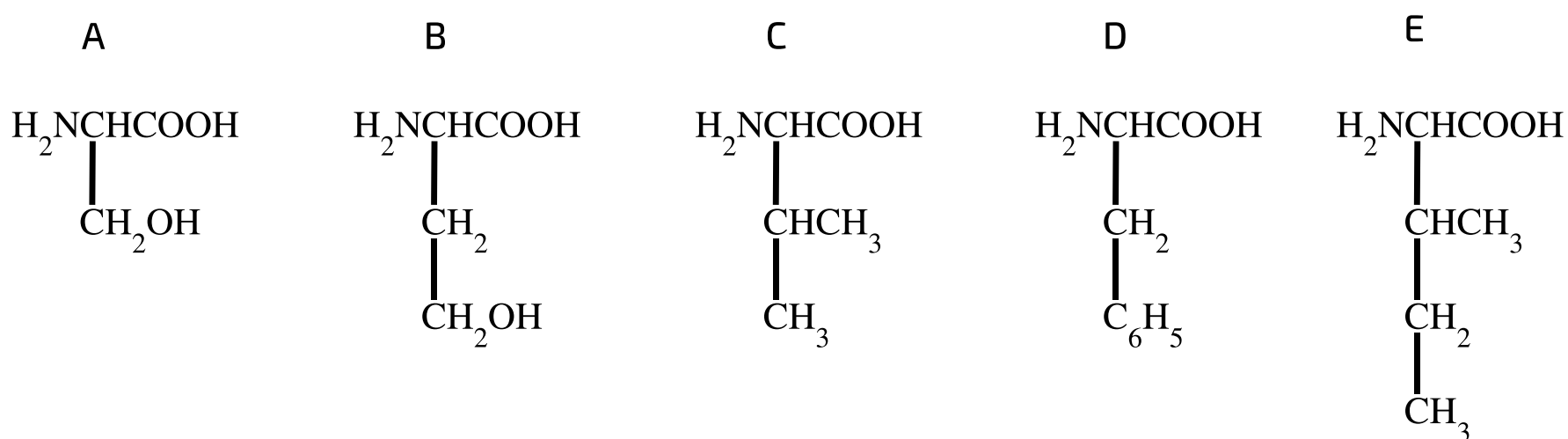
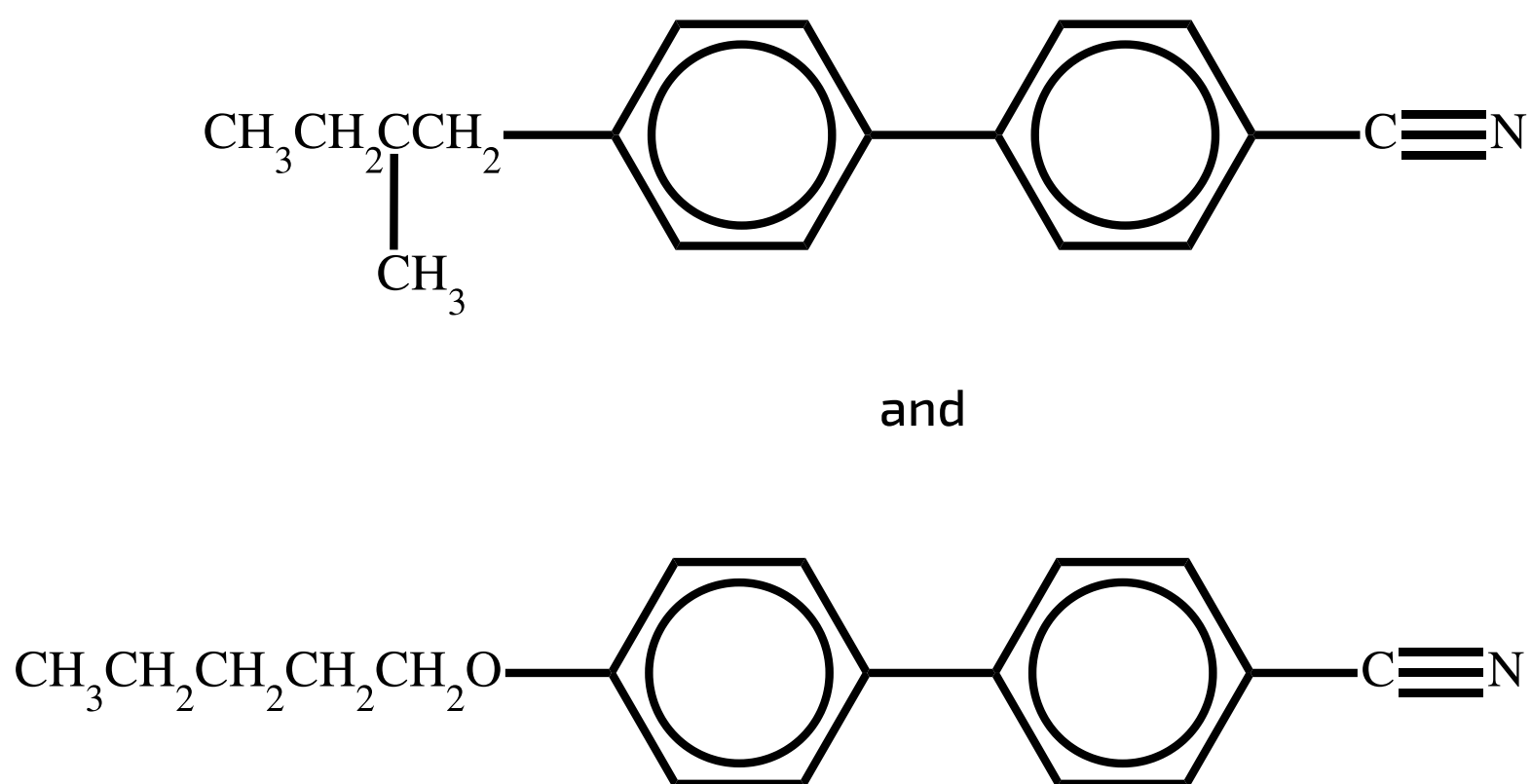


Figure 1: Amino acids A - E.

- ☐ A  
☐ B  
☐ C  
☐ D  
☐ E

## Part B Liquid crystal displays

The following compounds are used in liquid crystal displays in watches and calculators.



**Figure 2:** Compounds used in liquid crystal displays.

Which of the following are correct statements about these molecules?

1. Both can exist in optically active forms.
2. Both have permanent dipoles.
3. Both react with bromine in the dark.

- ☐ 1, 2 and 3 are correct
- ☐ 1 and 2 only are correct
- ☐ 1 and 3 only are correct
- ☐ 2 and 3 only are correct
- ☐ 1 only is correct
- ☐ 2 only is correct
- ☐ 3 only is correct
- ☐ None of the statements is correct.



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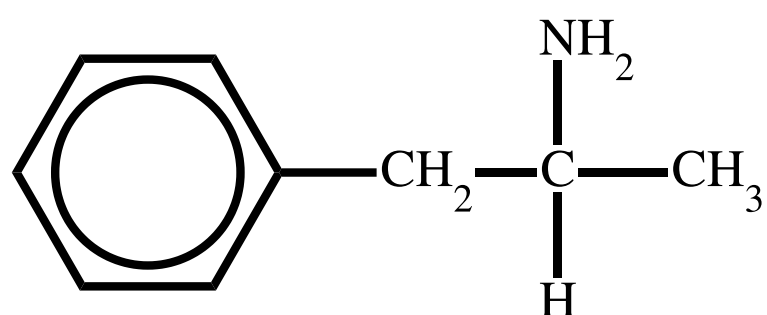
# Drugs and Poisons

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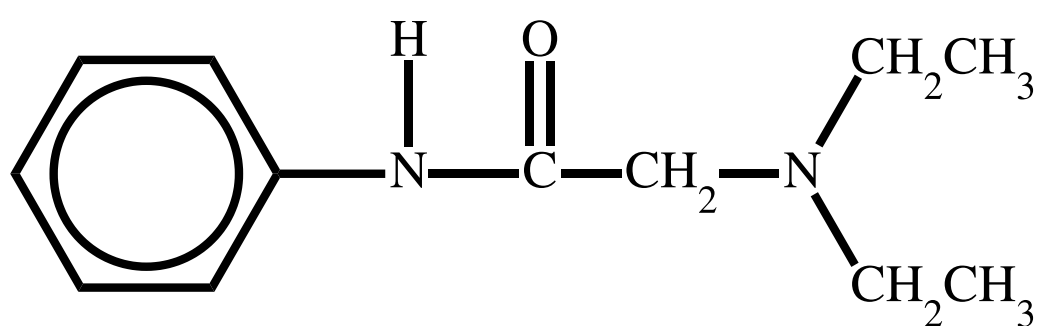
**A Level**



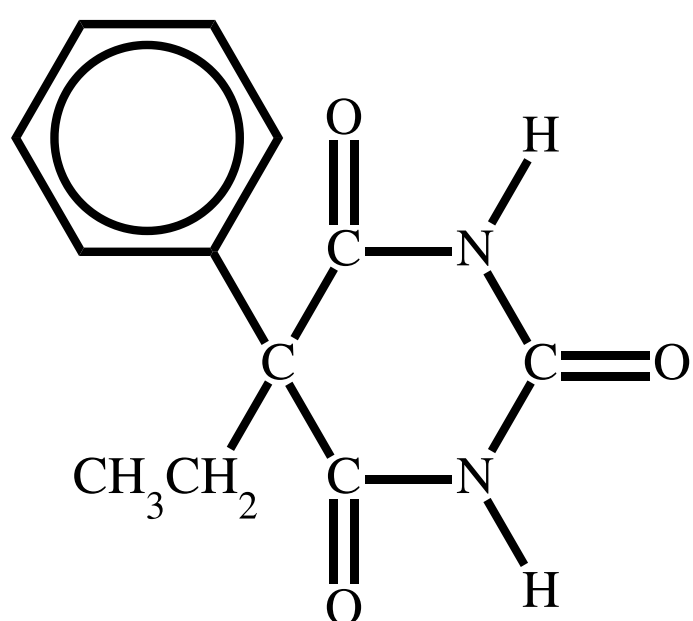
Many drugs show optical isomerism. The diagrams show the structure of three drugs.



amphetamine



lidocaine



phenobarbital

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**Figure 1:** Structures of amphetamine, lidocaine and phenobarbital.

What is the total number of chiral carbon centres in these three structures?

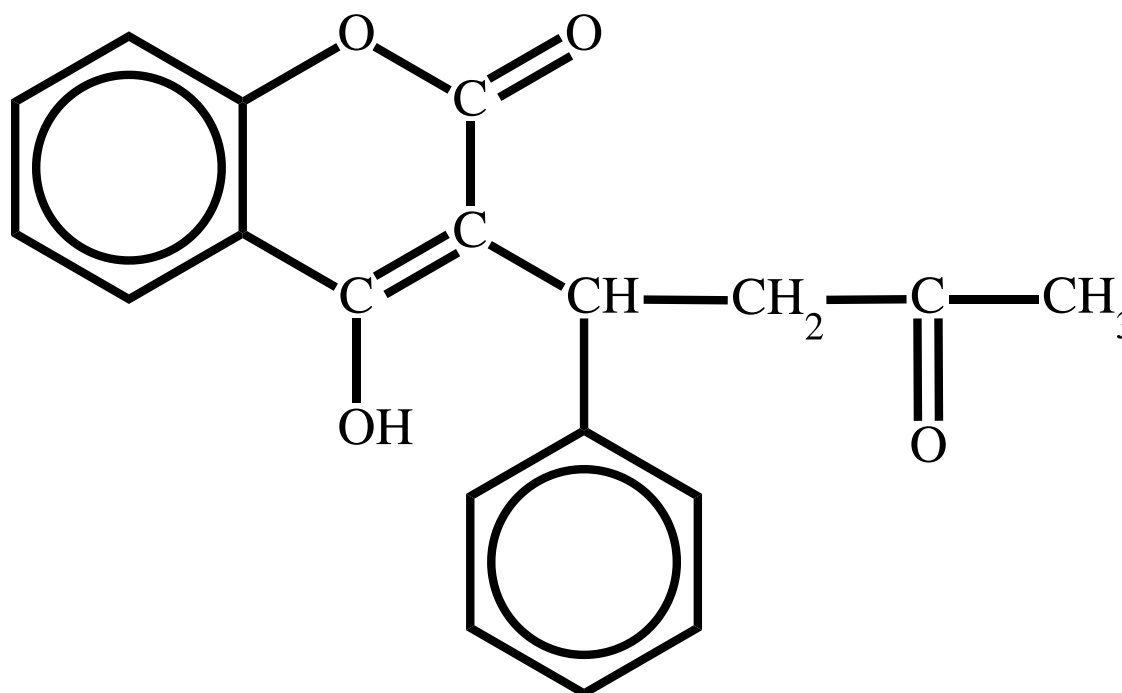
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## Part B   Poisons

*Warfarin* is used as a rat poison.



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**Figure 2:** Structure of *Warfarin*.

How many chiral centres are present in the *Warfarin* molecule?

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Part B adapted with permission from UCLES, A-Level Chemistry, November 1992, Paper 4, Question 21

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# Types of Isomerism

Which types of stereoisomerism would be exhibited by the following compounds?

## Part A Compound A

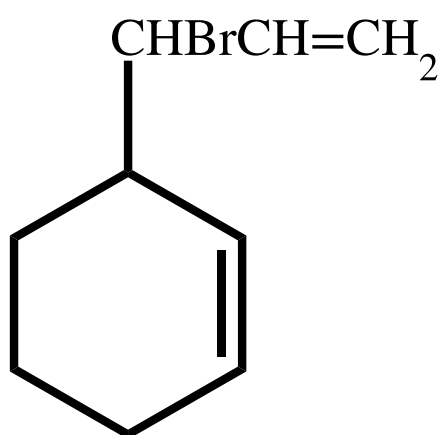


Figure 1: Compound A.

- ☐ *Cis-trans*
- ☐ Optical
- ☐ Both *cis-trans* and optical
- ☐ No isomerism

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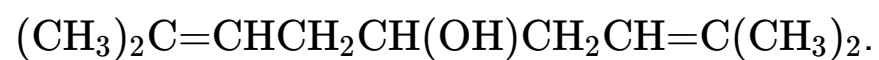
**Part B    Compound B**



- ☐ *Cis-trans*
- ☐ Optical
- ☐ Both *cis-trans* and optical
- ☐ No isomerism
- 

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**Part C    Compound C**



- ☐ *Cis-trans*
- ☐ Optical
- ☐ Both *cis-trans* and optical
- ☐ No isomerism
- 

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# Natural Products

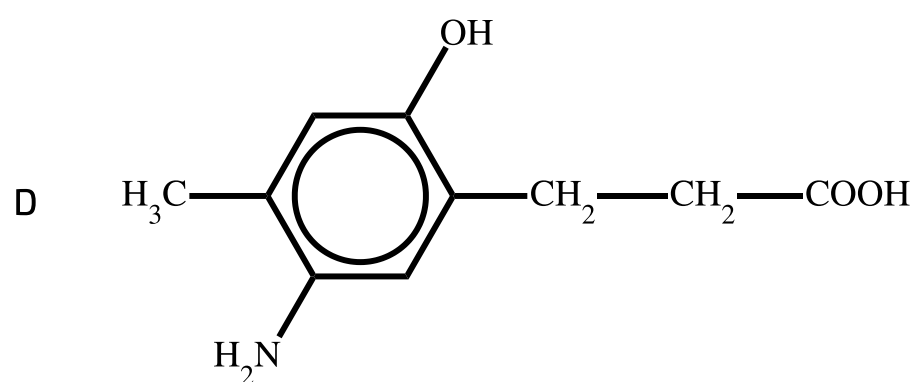
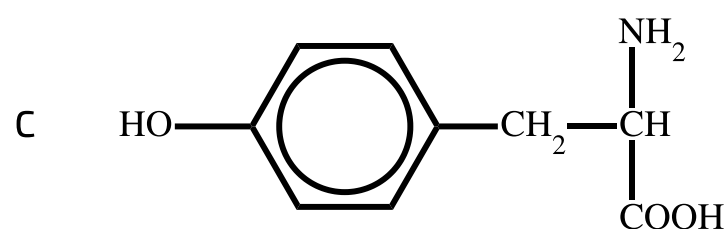
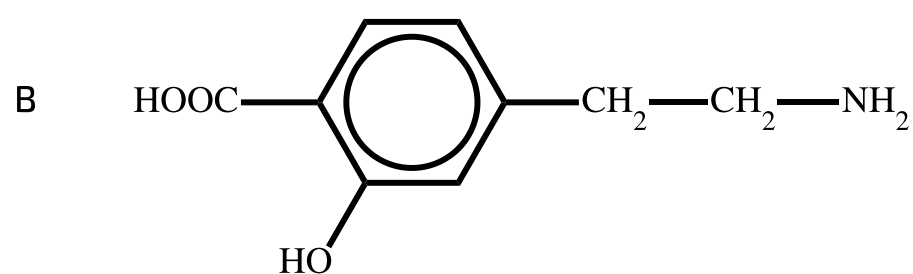
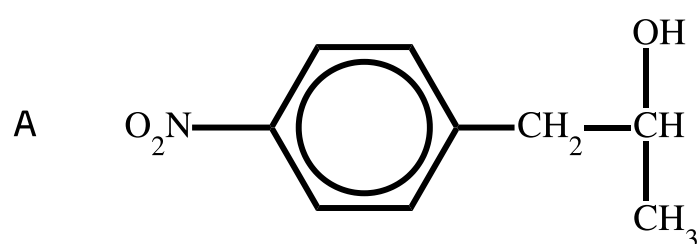
A Level



## Part A Compound P

A product **P**, isolated from a naturally-occurring source, has a molecular formula of  $\text{C}_9\text{H}_{11}\text{NO}_3$ . It possesses a chiral centre and it forms a zwitterion.

What could the structure of **P** be?

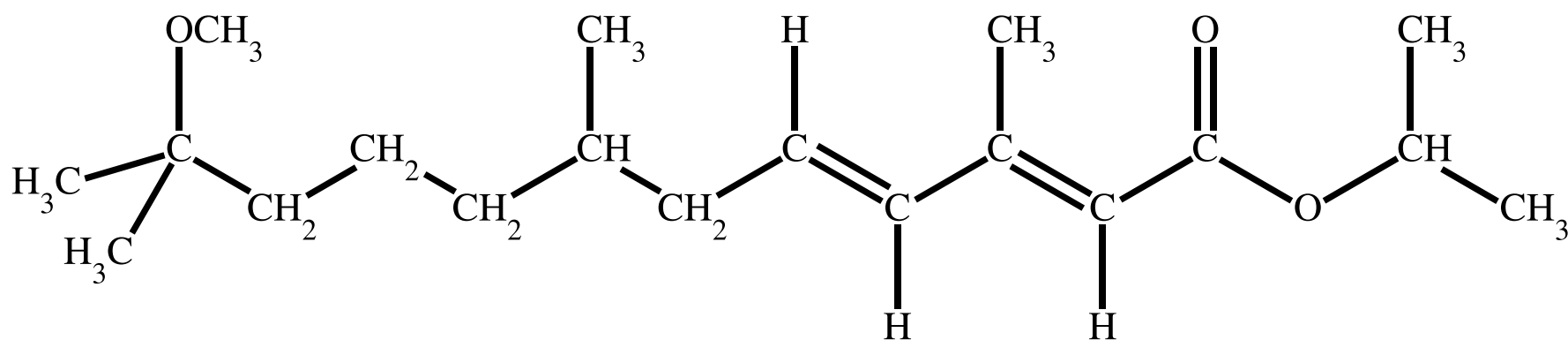


**Figure 1:** Possible structures of compound **P**.

- ☐ **A**  
☐ **B**  
☐ **C**  
☐ **D**

## Part B Insect attractant

The diagram shows the structure of the insect attractant *methoprene*.



**Figure 2:** Structure of *methoprene*.

What is the total number of stereoisomers (*cis-trans* and optical) of this molecule?

Part A adapted with permission from UCLES, A-Level Chemistry, November 1995, Paper 4, Question 29;

Part B adapted with permission from UCLES, A-Level Chemistry, June 1993, Paper 4, Question 22

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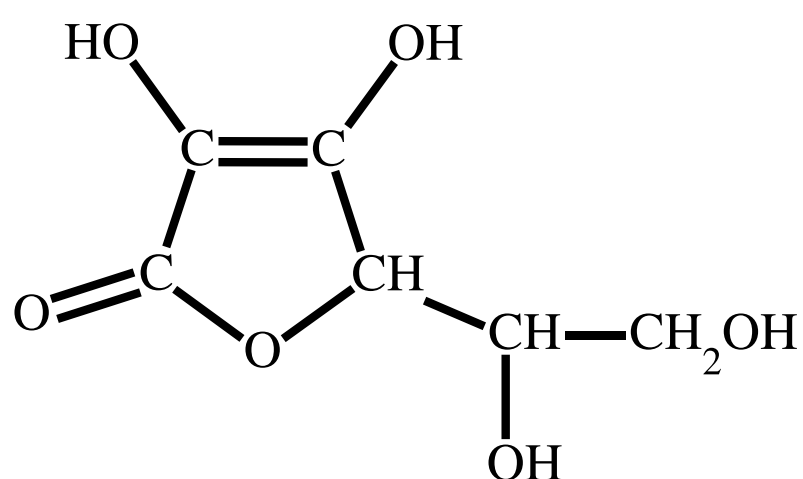
# More Natural Products

A Level



## Part A Vitamin C

The diagram shows the structure of vitamin C.



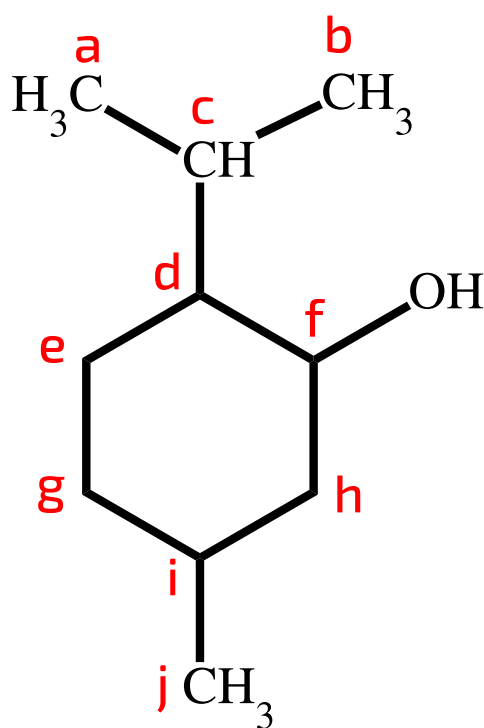
**Figure 1:** Structure of vitamin C.

How many chiral centres are there in one molecule of vitamin C?

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

## Part B Menthol

Menthol, a cyclohexane derivative is used in skin lotions since it counteracts itching. The structural formula of menthol is shown below.



**Figure 2:** Structure of menthol.

List in alphabetical order without spaces (e.g. **abc**) any of the carbon atoms **a-j** which are chiral.

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Part B adapted with permission from UCLES, A-Level Chemistry, June 1992, Paper 3, Question 4

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# Optical Isomerism

## Part A Definition

Optical isomers are  that have the same structural and molecular , but are  of each other.

Optical isomerism is caused by molecules with a carbon atom joined to  different groups. We call the carbon atom a  or an  carbon. It is often indicated by an asterisk, \*. The two isomers are known as .

Items:

three

molecules

mirror images

two

asymmetric

enantiomers

non-superimposable

formulae

four

chiral centre

## Part B Chiral alkane

Draw the structural formula of an alkane with the lowest  $M_r$  that can exhibit optical isomerism.

Use the [structure editor](#) to generate a SMILES string.



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## Part C Chiral alcohol

Draw the structural formula of one of the optical isomers of the alcohol with the lowest  $M_r$  that can show optical isomerism, indicating the stereochemistry with a wedged or hashed bond.

Use the [structure editor](#) to generate a SMILES string.

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Part A created for isaacphysics.org by R. Less;

Part B adapted with permission from UCLES, A-Level Chemistry, June 1995, Paper 1, Question 9;

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# Formulae and Isomers

**A Level****Part A**  $\text{C}_4\text{H}_{10}\text{O}$ 

How many isomers (including both structural isomers and stereoisomers) are possible for  $\text{C}_4\text{H}_{10}\text{O}$ ?

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**Part B**  $\text{C}_2\text{H}_2\text{Br}_2$ 

In what ways could two compounds of molecular formula  $\text{C}_2\text{H}_2\text{Br}_2$  be related to each other?

1. structural isomers
2. *cis-trans* isomers
3. optical isomers

- ☐ 1, 2 and 3 are correct
- ☐ 1 and 2 only are correct
- ☐ 2 and 3 only are correct
- ☐ 1 only is correct
- ☐ 2 only is correct
- ☐ 3 only is correct
- ☐ 1 and 3 only are correct

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## Part C Chlorination of ethane

How many chiral compounds is it possible to prepare by subjecting ethane to repeated substitution by chlorine?

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Part A adapted with permission from UCLES, A-Level Chemistry, 1989, Paper 3, Question 22;

Part B adapted with permission from UCLES, A-Level Chemistry, 1988, Paper 3, Question 38;

Part C adapted with permission from UCLES, A-Level Chemistry, June 1993, Paper 4, Question 23

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# Chiral Resolution

A Level



Separating enantiomers from a racemic mixture, also known as chiral resolution, can be achieved in multiple ways. In this question, we will focus on the technique of reacting the mixture with a **chiral resolving agent**.

## Part A Moscher's acid

One chiral resolving agent, Moscher's acid, has the structure shown below.

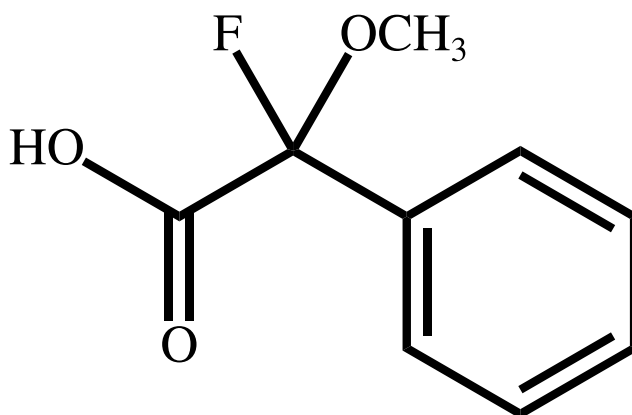


Figure 1: Moscher's acid

Which of the following classes of compounds would react with Moscher's acid? Select all that apply

- ☐ amines
- ☐ carboxylic acids
- ☐ amides
- ☐ alcohols

## Part B Alanine

Alanine is the  $\alpha$ -amino acid with a methyl side-chain. What are the two isomers present in a racemic mixture of alanine? Give your answer in the form of SMILES strings copied from the [structure editor](#) separated by commas (no spaces).

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## Part C Separating isomers

The two alanine isomers are  (non-superimposable mirror images), so they have the same melting point, boiling point, etc. They therefore cannot be separated by conventional means. However, by reacting a racemic mixture of alanine with a specific stereoisomer of Moscher's acid, two  are obtained, which have different physical properties and can therefore be separated. This method works, because Moscher's acid contains a .

Items:

double bond

benzene ring

enantiomers

diastereomers

chiral centre

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