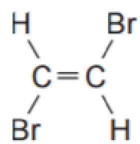
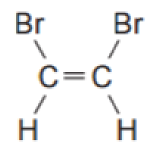
ISOMERS

Modified questions from 2016

(a) (ii) Draw and name the THREE constitutional (structural) isomers of the organic compound C_5H_{12}.

(c) Some alkenes are able to form cis and trans (geometric) isomers.

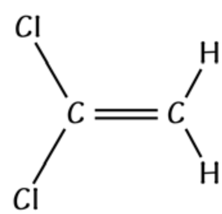
(i) Complete the names of structures A and B in the table below.

A	B
	
______ 1,2-dibromoethene	______ 1,2-dibromoethene

(ii) Elaborate on the structure of the organic compound 1,2-dibromoethene to explain why it is able to form cis and trans (geometric) isomers.

Modified questions from 2015

(a) Explain why 1,1-dichloroethene cannot exist as a cis-trans isomer.



(b) A structural isomer of 1,1-dichloroethene can exist as cis-trans isomers. Draw and name the cis-trans isomers.

Modified questions from 2014

(a) Draw a primary, a secondary, and a tertiary alcohol for the molecule $C_5H_{11}OH$.

(b) The structures of three organic compounds are shown below.

Compound **A**	$CH_3CH_2CH=CHCH_3$
Compound **B**	$CH_3CH_2CH_2CH=CH_2$
Compound **C**	$CH_3CH_2CH_2CH_2CH_3$

Explain why compound **A** can exist as geometric (*cis* and *trans*) isomers, but compounds **B** and **C** cannot.

In your answer you should:

- draw the geometric (*cis* and *trans*) isomers of compound **A**
- explain the requirements for geometric (*cis* and *trans*) isomers by referring to compounds **A**, **B**, and **C**.

Modified questions from 2013

The structures of some organic compounds containing chlorine are shown below.

A $CH_3CHClCH_2CH_3$	B $CH_3CH_2CH_2Cl$	C $CH_3CH_2CHCCl_2$
D $CH_3CH_2CHCHCl$	E $CH_3CH_2CH_2CHCl_2$	F $CH_3CH_2CH_2CH_2Cl$

(a) Identify two molecules from the table in (a) that are constitutional (structural) isomers of each other.

Write the letters. Justify your choice.

(b) Molecule **D** can exist as geometric (*cis* and *trans*) isomers.

(i) Draw the geometric (*cis* and *trans)* isomers for molecule **D**

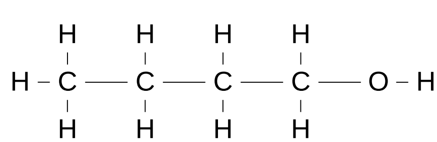
(ii) Justify why molecule D can exist as geometric (*cis* and *trans)* isomers.

Your answer should include:

- an explanation of the requirements for cis and trans isomers
- reference to the structure of molecule D.

Modified questions from 2012

(a) Four of the structural isomers of $C_4H_{10}O$ are alcohols. One of these isomers has been drawn and named for you below.



Butan-1-ol

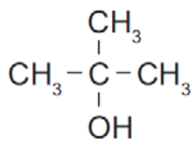
Draw the other three alcohols.

(b) Can the compound $CH_3CH_2CH{=}CH_2$ exist as geometric (*cis-trans*) isomers? Justify your answer, including reference to the requirements for geometric (*cis-trans*) isomers.

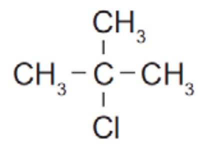
Modified questions from 2011 (expired AS 90309)

(a) Explain why **Molecule 1** and **Molecule 2** are not structural isomers of each other.

In your answer, you should outline what a structural isomer is, and refer to both molecules.



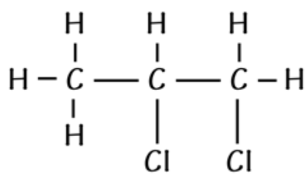
Molecule 1



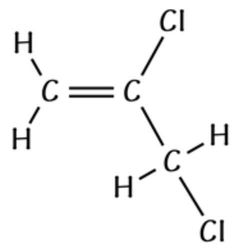
Molecule 2

(b) Draw a structural isomer of **Molecule 1.**

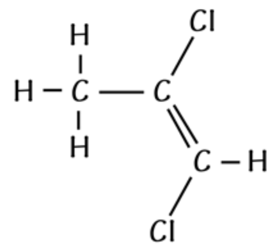
(c) **Molecule C** can exist as geometric (*cis-trans*) isomers.



Molecule A



Molecule B



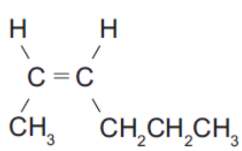
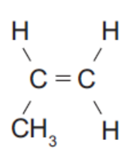
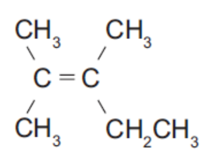
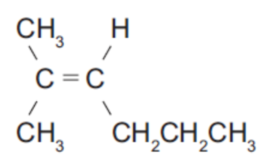
Molecule C

Draw the geometric (*cis-trans*) isomers of **Molecule C**

(d) Discuss why **Molecule C** can exist as geometric (*cis-trans*) isomers but **Molecule A** and **Molecule B** cannot exist as geometric isomers.

In your answer you must include an explanation of what a geometric isomer is.

Modified questions from 2010 (expired AS 90309)

A	B	C	D
			

(a) Identify TWO molecules that are structural isomers of each other using the letters from the table above. Explain why the molecules you have selected are structural isomers.

(b) Identify ONE molecule that can exist as geometric (*cis–trans*) isomers using the letter from the table above. Draw the *cis* and *trans* isomers for your chosen molecule.

(c) Discuss why the molecule you have selected in (b) can exist as *cis–trans* isomers. Your answer must include:

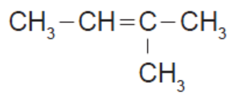
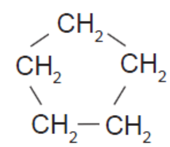
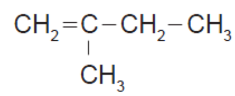
- an explanation of why *cis–trans* isomers can exist
- reference to the structure of the selected molecule.

Modified questions from 2009 (expired AS 90309)

Draw ALL the structural isomers of alkenes of molecular formula C_4H_8.

Modified questions from 2008 (expired AS 90309)

Four different molecules with the molecular formula C_5H_{10} are given below.

A	B	C	D
$CH_3-CH=CH-CH_2-CH_3$			

(a) Describe why these molecules are **structural isomers**.

(b) One of the molecules shown above may exist as *cis-trans* isomers.

(i) Identify this molecule using the letter from the above table.

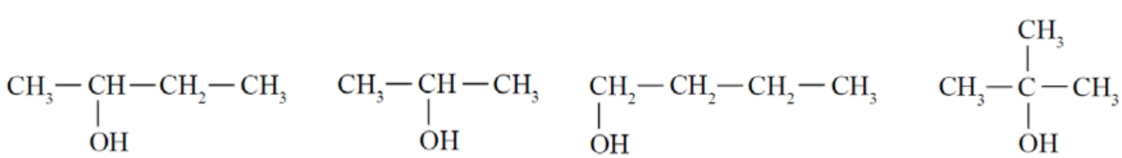
(ii) Draw the *cis* and *trans* isomers of the molecule identified in (i).

(c) Discuss why the molecule you selected in (b)(i) may exist as *cis-trans* isomers, while the other three isomers cannot.

Modified questions from 2007 (expired AS 90309)

(a) Consider the following compounds.

E **F** **G** **H**



(i) Which compounds are structural isomers? Identify using the letters E-H.

(ii) Explain why the compounds you have selected are structural isomers.

(b) But–2–ene forms cis–trans (geometric) isomers while but–1–ene does not.

(i) Discuss why this is the case.

(ii) Use diagrams to support your answer.

Modified questions from 2006 (expired AS 90309)

Structural isomers of the molecular formula $C_2H_2Cl_2$ are 1,1–dichloroethene and 1,2–dichloroethene.

(a) Circle the compound that can exist as cis-trans isomers.

1,1–dichloroethene **1,2–dichloroethene**)

(b) Draw the cis and trans isomers of the compound you circled in (a).

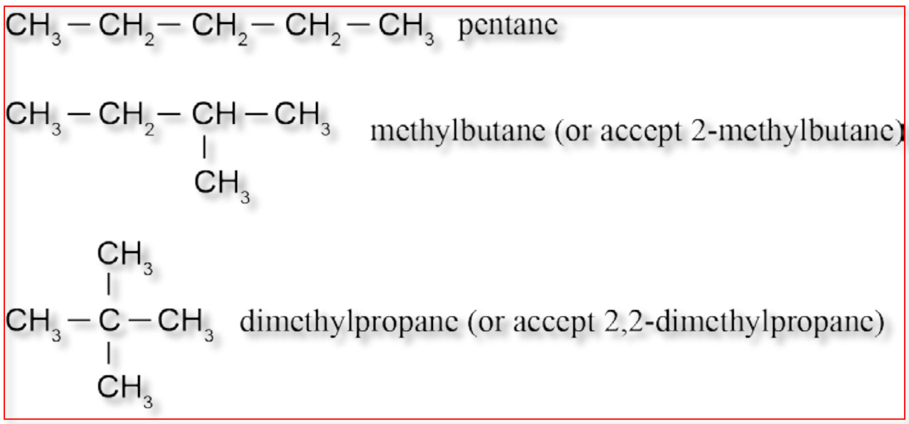
(c) Discuss the requirements for cis-trans isomerism. In your answer include reasons explaining why the structural isomer you selected above can exist as cis-trans isomers while the other structural isomer cannot.

ANSWERS

ISOMERS

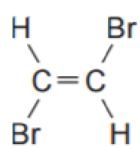
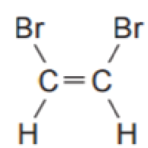
Modified questions from 2016

(a) (ii) Draw and name the THREE constitutional (structural) isomers of the organic compound C_5H_{12}.



(c) Some alkenes are able to form cis and trans (geometric) isomers.

(i) Complete the names of structures A and B in the table below.

A	B
	
______ 1,2-dibromoethene	______ 1,2-dibromoethene

trans cis

(ii) Elaborate on the structure of the organic compound 1,2-dibromoethene to explain why it is able to form cis and trans (geometric) isomers.

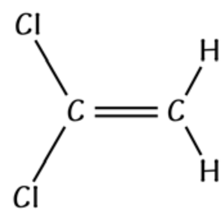
1,2-dibromoethene can form cis and trans isomers because it has a double bond. The double bond between two carbon atoms does not allow any rotation of atoms around it.

As well as the double bond, the C atoms directly attached to it must have two different atoms or groups attached to them. For 1,2-dibromoethene, both the C atoms on the double bond have an H and a Br atom bonded to them.

When these two requirements are met, two alkenes can have the same molecular formula and the same sequence of atoms in the formula, but a different arrangement in space (a different 3D formula), hence they are cis and trans isomers.

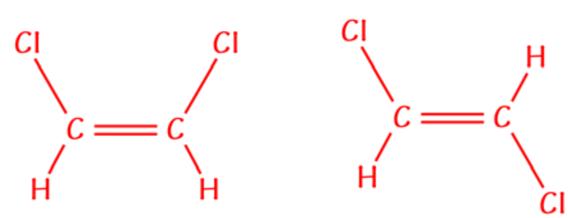
Modified questions from 2015

(a) Explain why 1,1-dichloroethene cannot exist as a cis-trans isomer.



1,1-dichloroethene cannot exist as a geometric isomer because, although there is a double bond, the atoms / groups on each of the carbons of the double bond are the same (2 Cl on one C and 2 H on the other C).

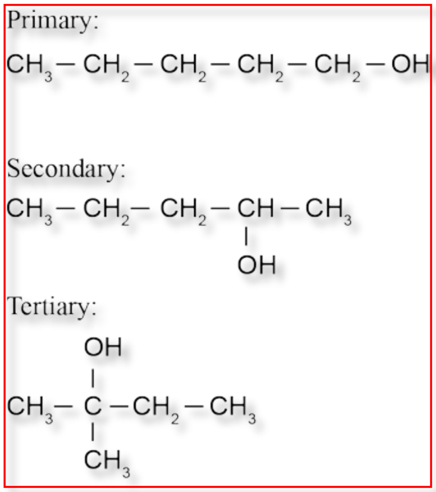
(b) A structural isomer of 1,1-dichloroethene can exist as cis-trans isomers. Draw and name the cis-trans isomers.



cis-1,2-dichloroethene trans-1,2-dichloroethene

Modified questions from 2014

(a) Draw a primary, a secondary, and a tertiary alcohol for the molecule $C_5H_{11}OH$.



(b) The structures of three organic compounds are shown below.

Compound **A**	$CH_3CH_2CH{=}CHCH_3$
Compound **B**	$CH_3CH_2CH_2CH{=}CH_2$
Compound **C**	$CH_3CH_2CH_2CH_2CH_3$

Explain why compound **A** can exist as geometric (*cis* and *trans*) isomers, but compounds **B** and **C** cannot.

In your answer you should:

- draw the geometric (*cis* and *trans*) isomers of compound **A**
- explain the requirements for geometric (*cis* and *trans*) isomers by referring to compounds **A**, **B**, and **C**.

cis *trans*

For cis and trans isomers to occur a carbon-carbon double bond must be present as this prevents any rotation about this bond, and the atoms or groups of atoms attached to the two carbon atoms are therefore fixed in position. This means that molecule C cannot have cis and trans isomers as it does not have a double bond.

For compound B one of the carbon atoms in the double bond has two of the same atom attached to it (two H's). Therefore, it cannot have cis and trans isomers because if these two H atoms swapped position it would still be the same molecule.

Therefore, only compound A can have cis and trans isomers as it does have a double bond preventing free rotation, and it does not have one of the carbons in the double bond with two of the same atom or groups of atoms attached to it.

Modified questions from 2013

The structures of some organic compounds containing chlorine are shown below.

A $CH_3CHClCH_2CH_3$	B $CH_3CH_2CH_2Cl$	C $CH_3CH_2CHCCl_2$
D $CH_3CH_2CHCHCl$	E $CH_3CH_2CH_2CHCl_2$	F $CH_3CH_2CH_2CH_2Cl$

(a) Identify two molecules from the table in (a) that are constitutional (structural) isomers of each other.

Write the letters. Justify your choice.

A and F

Constitutional / structural isomers have the same molecular formula (they have the same type and number of atoms) but different constitutional / structural formulae (atoms are arranged differently).

These molecules both have the same number and type of atoms but the atoms are arranged differently; C_4H_9Cl / the chlorine is on a different carbon atom.

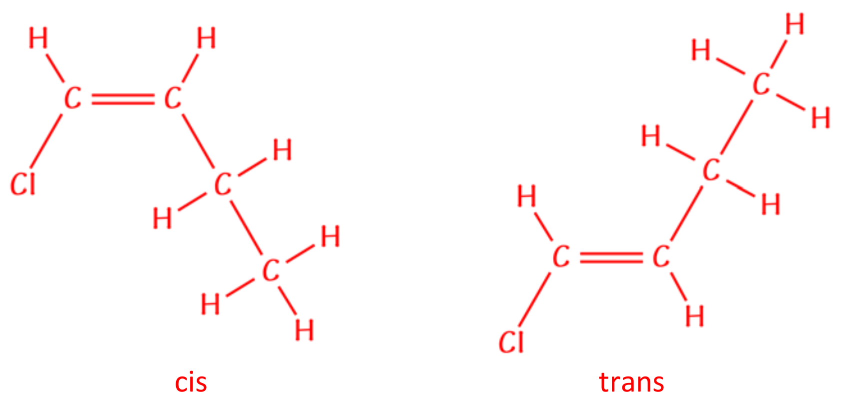
(b) Molecule **D** can exist as geometric (*cis* and *trans*) isomers.

(i) Draw the geometric (*cis* and *trans)* isomers for molecule **D**

(ii) Justify why molecule D can exist as geometric (*cis* and *trans)* isomers.

Your answer should include:

- an explanation of the requirements for cis and trans isomers
- reference to the structure of molecule D.

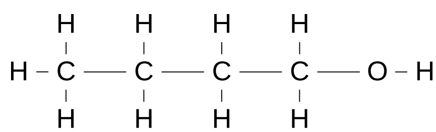


Cis-trans isomers can occur in molecules that have (carbon to carbon) double bond because atoms are not free to rotate around (the axis of) the double bond. They must also have two different groups attached to each carbon (involved in the double bond).

This molecule has a carbon-carbon double bond. One carbon of the double bond is attached to a hydrogen atom and an ethyl group. The other is attached to a hydrogen atom and a chlorine atom.

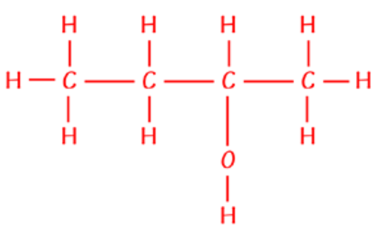
<u>Modified questions from 2012</u>

(a) Four of the structural isomers of $C_4H_{10}O$ are alcohols. One of these isomers has been drawn and named for you below.

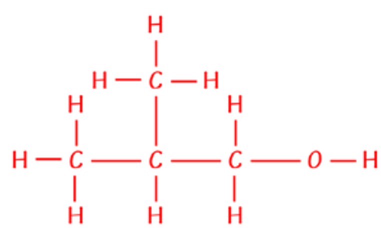


Butan-1-ol

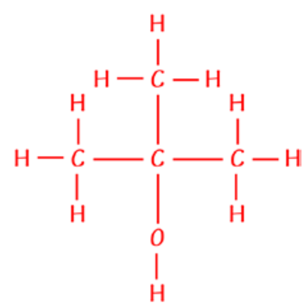
Draw the other three alcohols.



Butan-2-ol



methylpropan-1-ol



methylpropan-2-ol

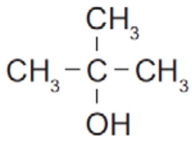
(b) Can the compound $CH_3CH_2CH=CH_2$ exist as geometric (*cis-trans*) isomers? Justify your answer, including reference to the requirements for geometric (*cis-trans*) isomers.

No; for a molecule to exist as geometric isomers, it must contain a double bond, and each carbon (involved in the double bond) must have two different atoms / groups attached to it. Compound $CH_3CH_2CH=CH_2$ has a double bond, but the atoms attached to one carbon are both the same (two hydrogen atoms) so it does not form a geometric isomer.

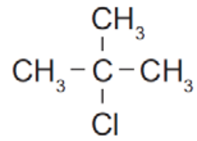
<u>Modified questions from 2011</u> (expired AS 90309)

(a) Explain why **Molecule 1** and **Molecule 2** are not structural isomers of each other.

In your answer, you should outline what a structural isomer is, and refer to both molecules.



Molecule 1

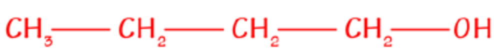


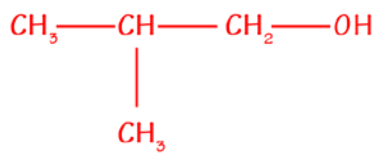
Molecule 2

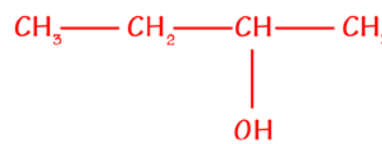
The carbon of the OH group is attached to three other carbon atoms, in the alcohol. The carbon the Cl is attached to, in the haloalkane, is attached to three other carbon atoms. A structural isomer has the same number and type of each atom (same molecular formula), but the atoms are arranged differently (different structural formula). These two molecules do not have the same types of atoms.

(b) Draw a structural isomer of **Molecule 1.**

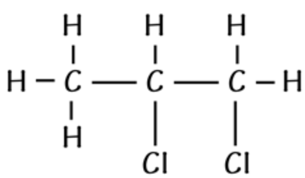
A correct structural isomer for the alcohol drawn



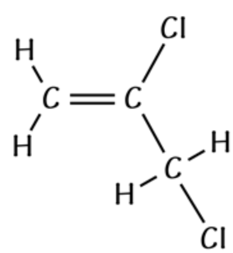




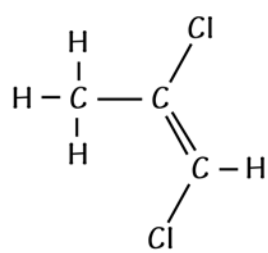
(c) **Molecule C** can exist as geometric (*cis-trans*) isomers.



Molecule A

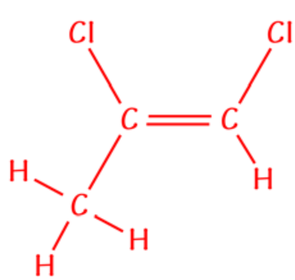


Molecule B

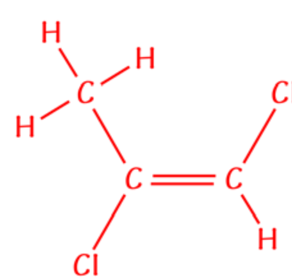


Molecule C

Draw the geometric (*cis-trans*) isomers of **Molecule C**



cis

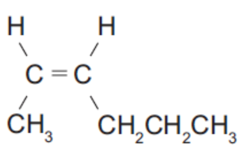
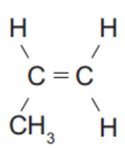
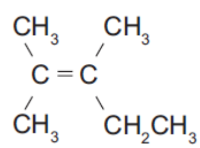
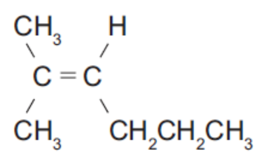


trans

(d) Discuss why **Molecule C** can exist as geometric (*cis-trans*) isomers but **Molecule A** and **Molecule B** cannot exist as geometric isomers.
In your answer you must include an explanation of what a geometric isomer is.

Geometric isomers occur in molecules that have a carbon to carbon double bond which restricts the rotation of atoms about the axis of this double bond and two different groups attached to each of the carbons involved in the double bond. Molecule C can exist as cis-trans isomers, because this molecule has a carbon to carbon double bond, and it also has a chlorine atom and a hydrogen atom (two different groups) attached to each of the carbons involved in the double bond. Molecule A cannot be a geometric isomer, as it does not have a carbon to carbon double bond. Molecule B cannot be a geometric isomer, because although it has a carbon to carbon double bond, the two atoms attached to these carbons are both the same / hydrogen atoms.

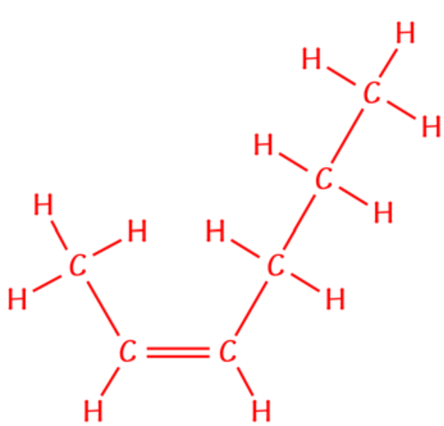
<u>Modified questions from 2010</u> (expired AS 90309)

A	B	C	D
			

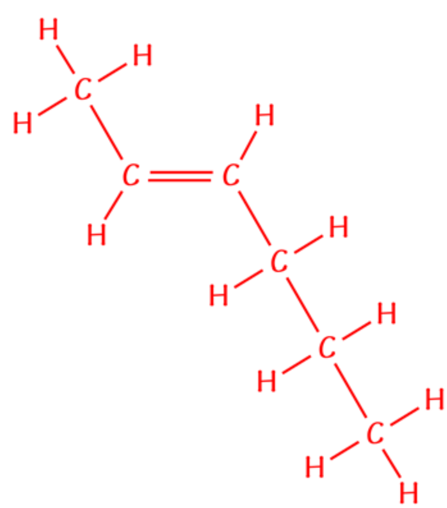
(a) Identify TWO molecules that are structural isomers of each other using the letters from the table above. Explain why the molecules you have selected are structural isomers.

C and D (1) They have the same molecular formula C7H14, the same number of carbon and hydrogen atoms, but their atoms are arranged differently

(b) Identify ONE molecule that can exist as geometric (*cis–trans*) isomers using the letter from the table above. Draw the *cis* and *trans* isomers for your chosen molecule.



cis-hex-2-ene



trans-hex-2-ene

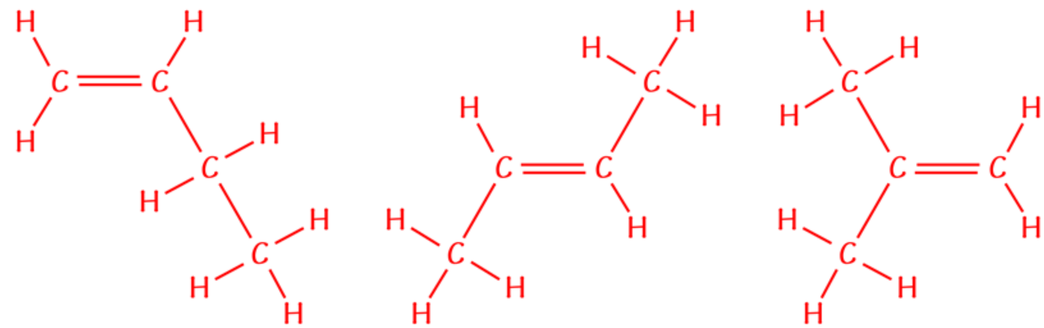
(c) Discuss why the molecule you have selected in (b) can exist as *cis–trans* isomers. Your answer must include:

- an explanation of why *cis–trans* isomers can exist
- reference to the structure of the selected molecule

Cis-trans isomers occur in molecules that have carbon-to-carbon double bonds because rotation of the atoms about the axis of the carbon-to-carbon double bond is restricted. They must also have two different groups attached to each of the carbons involved in the double bond. Molecule A, hex-2-ene, has a double bond. It has two different groups attached to the carbons, i.e. one carbon of the double bond is attached to H and CH_3 and the other carbon is attached to H and $CH_2CH_2CH_3$.

Modified questions from 2009 (expired AS 90309)

Draw ALL the structural isomers of alkenes of molecular formula C_4H_8.



but-1-ene   but-2-ene   2-methyl propene

Modified questions from 2008 (expired AS 90309)

Four different molecules with the molecular formula C_5H_{10} are given below.

A	B	C	D
$CH_3-CH=CH-CH_2-CH_3$	$CH_3-CH=C-CH_3$ | CH_3	CH_2 CH_2 CH_2 CH_2-CH_2	$CH_2=C-CH_2-CH_3$ | CH_3

(a) Describe why these molecules are **structural isomers**.

(b) One of the molecules shown above may exist as *cis-trans* isomers.

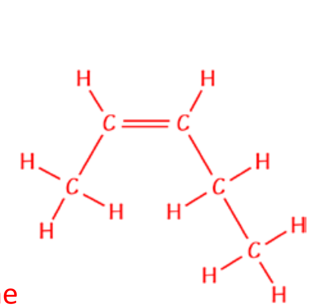
(i) Identify this molecule using the letter from the above table.

(ii) Draw the *cis* and *trans* isomers of the molecule identified in (i).

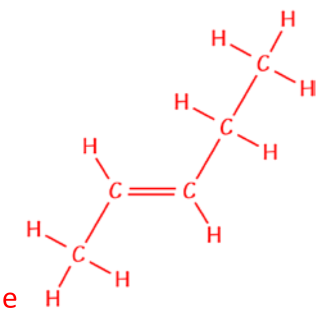
(c) Discuss why the molecule you selected in (b)(i) may exist as *cis-trans* isomers, while the other three isomers cannot.

(a) Structural isomers have the same molecular formula but they differ in the sequence in which the atoms are joined together.

(b) A



Cis-pent-2-ene



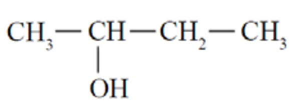
trans-pent-2-ene

(c) Cis-trans isomers can occur in molecules that have double bonds, because rotation of the atoms about the axis of the carbon to carbon double bond is restricted. They must also have two different groups attached to each of the carbons involved in the double bond. Molecule A (pent-2-ene) has a double bond, and each carbon involved in the double bond has two different groups attached to them. Molecule C has no double bonds, so cannot exist as cis-trans isomers. Molecule B and Molecule D have double bonds. However, each carbon involved in the double bond does not have 2 different groups attached.

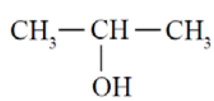
<u>Modified questions from 2007</u> (expired AS 90309)

(a) Consider the following compounds.

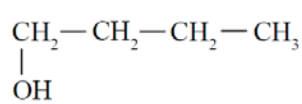
E



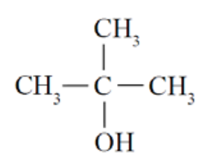
F



G



H



(i) Which compounds are structural isomers? Identify using the letters E-H. E G and H

(ii) Explain why the compounds you have selected are structural isomers.

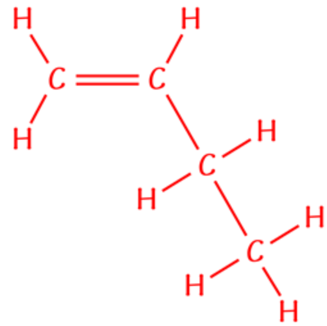
Structural isomers have the same number of atoms of each element / E, G and H all contain 4 C's, 10 H's and 1 O atom / same molecular formula and they have a different structure / atoms a

(b) But–2–ene forms cis–trans (geometric) isomers while but–1–ene does not.

(i) Discuss why this is the case.

(ii) Use diagrams to support your answer.

Geometric (cis–trans) isomers exist where there is a C =C that cannot freely rotate. If there are two different groups bonded to the C's of the double bond, two arrangements are possible. But–2–ene meets these requirements since each C of the double bond has –H and –CH_3, i.e. two different groups. But–1–ene does not meet these requirements as it has 2 H atoms on one C of the double bond.



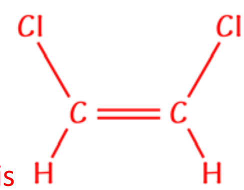
Modified questions from 2006 (expired AS 90309)

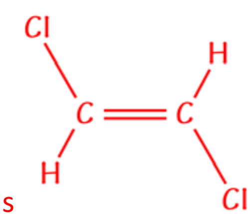
Structural isomers of the molecular formula $C_2H_2Cl_2$ are 1,1–dichloroethene and 1,2–dichloroethene.

(a) Circle the compound that can exist as cis-trans isomers.

1,1–dichloroethene **1,2–dichloroethene**

(b) Draw the cis and trans isomers of the compound you circled in (a).

cis 

trans 

(c) Discuss the requirements for cis-trans isomerism. In your answer include reasons explaining why the structural isomer you selected above can exist as cis-trans isomers while the other structural isomer cannot.

Cis–trans (geometric) isomers exist where there is a C=C which cannot freely rotate. If there are two different groups bonded to the Cs of the double bond, two arrangements are possible. 1,2–dichloroethene meets these requirements since each C of the double bond has –H and –Cl, i.e. different groups. However, 1,1–dichloroethene does not meet these requirements since the two groups on the Cs of the double bond are the same, i.e. one C has two –H and the other two –Cl.