91391 Demonstrate understanding of the properties of organic compounds

COLLATED ISOMERISM QUESTIONS – optical, geometrical and constitutional.

2021:1

(b) $C_5H_{10}O_2$ can exist as a number of different constitutional (structural) isomers. Draw the structural formulae for the isomers of $C_5H_{10}O_2$ that meet the following requirements:

(i) A straight-chain molecule that will form bubbles when reacted with Na_2CO_3 solution.

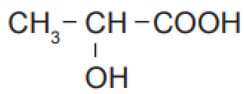
(ii) A branched-chain molecule with two different functional groups that cannot react with either MnO_4^-/H^+ or Na_2CO_3 solution.

(iii) A branched-chain molecule that smells pleasant and exists as enantiomers.

(iv) A straight-chain molecule that can decolourise bromine water, but cannot exist as geometric (cis-trans) isomers. It can react with $Cr_2O_7^{2-}/H^+$, but the resulting organic product will not form an orange-red solid when heated with Benedict's solution.

2021:3

(a) 2-hydroxypropanoic acid, otherwise known as lactic acid, exists as enantiomers (optical isomers).

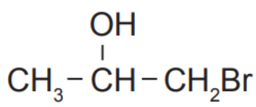


(i) Draw the enantiomers of lactic acid.

(ii) Explain how the two enantiomers of lactic acid could be distinguished.

2020:2

(a) 1-bromopropan-2-ol exists as enantiomers (optical isomers).



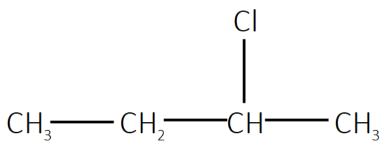
(i) Draw the enantiomers of 1-bromopropan-2-ol in the box below.

(ii) Why can 1-bromopropan-2-ol exist as enantiomers?

(iii) Explain how the two enantiomers of 1-bromopropan-2-ol could be distinguished.

2019:2

(a) 2-chlorobutane can exist as enantiomers (optical isomers).



(i) Draw the enantiomers of 2-chlorobutane.

(ii) Explain how the two enantiomers of 2-chlorobutane could be distinguished.

(c) $C_5H_{10}O$ can exist as a number of different constitutional (structural) isomers. Draw the structural formulae for the isomers of $C_5H_{10}O$ that meet the following requirements.

(i) Straight-chain molecule that forms a silver mirror when heated with Tollens' reagent.

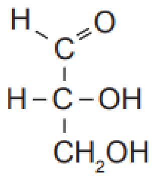
(ii) Branched-chain molecule that does not form a silver mirror when heated with Tollens' reagent.

(iii) Five-carbon ring cyclic molecule that forms steamy fumes when reacted with thionyl chloride, $SOCl_2$.

(iv) Straight-chain secondary alcohol that decolourises bromine water, and can exist as both cis-trans (geometric) isomers and enantiomers (optical isomers).

2018:2

(a) The structural formula of 2,3-dihydroxypropanal, more commonly known as glyceraldehyde, is shown below.



Glyceraldehyde can exist as enantiomers (optical isomers).

(i) Draw the enantiomers of glyceraldehyde.

(ii) Explain why glyceraldehyde can exist as enantiomers.

(iii) How could the two enantiomers of glyceraldehyde be distinguished? Explain your answer.

2017:1

(c) Some organic compounds can exist as enantiomers (optical isomers). An example is a secondary alcohol with the molecular formula C_4H_9OH.

(i) Draw the enantiomers of C_4H_9OH.

(ii) Explain what is meant by the term enantiomers (optical isomers). In your answer, you should:

- identify the structural requirement for a molecule, such as C_4H_9OH, to exist as enantiomers
- explain how enantiomers can be distinguished from each other

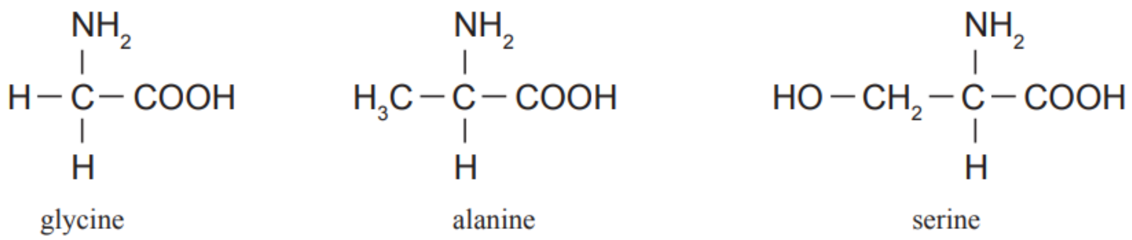
2017:2

(a) Compound P and compound Q are straight-chain constitutional (structural) isomers with the molecular formula $C_5H_{12}O$. Compound P can form optical isomers, whereas compound Q cannot.
When reacted with concentrated sulfuric acid, compound P forms two products, compounds R and S; compound Q forms only one product, compound S.
When compound Q is reacted with Reagent 1, it forms a chloroalkane, compound T.
Compound T reacts with concentrated NH_3 to form compound U.
Compound Q can also be oxidised to form compound V, which will turn moist blue litmus paper red.
Compound V can also be reacted with compound Q and Reagent 2, to form a sweet-smelling liquid, compound W.

Use the information above to identify compounds P to W, and reagents 1 and 2.

2016:1

(c) Glycine, alanine, and serine are three amino acids shown below.



(i) Draw the 3-D structures of the enantiomers (optical isomers) of serine.

(ii) Circle the amino acid below which does NOT display optical isomerism:

glycine alanine serine

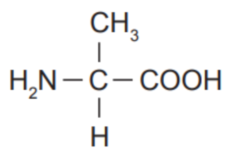
Explain your answer.

2015:1

(c) (i) Draw the three structural isomers of C_4H_9Cl that represent a primary, secondary and tertiary haloalkane.

2015:2

Alanine is an amino acid. Its structure is shown below.



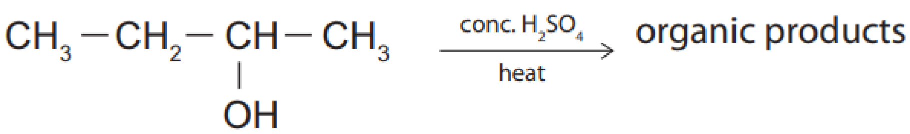
(a) (i) Describe the structural feature necessary for a compound to exist as enantiomers (optical isomers).

(ii) Identify one physical property that is the same for both enantiomers of alanine, and one that is different, clearly describing how this property could be used to distinguish between the enantiomers.

(b) Draw 3-D structures of the enantiomers of alanine.

2014:1

(b) When butan-2-ol undergoes a reaction with concentrated H_2SO_4, three possible organic products form, which are isomers of each other.

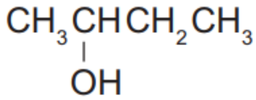


(i) Draw the three isomers formed during this reaction.

(ii) Which of the three isomers from part (i) will be formed in the smallest amount? Explain your answer.

2013:1

(b) The alcohol below can exist as two enantiomers (optical isomers).



(i) Draw three-dimensional structures for the two enantiomers.

(ii) Link the structure of enantiomers to a physical property that can be used to distinguish them from non-optically active molecules.

2012:1

An alcohol A with the molecular formula $C_4H_{10}O$ can exist as enantiomers (optical isomers).

(a) (i) State the structural requirement for a molecule to be able to exist as enantiomers.

(ii) Describe a property of enantiomers that would enable them to be distinguished from each other.

(iii) Draw the structural formulae of the enantiomers of alcohol A.

(b) Part Q

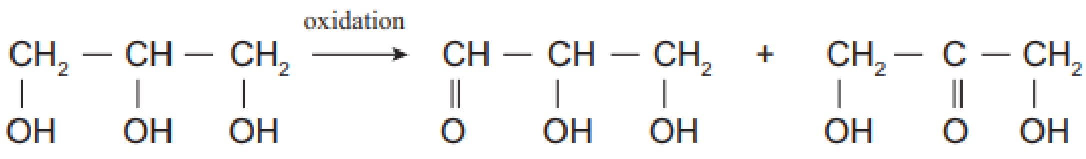
Alcohol A, ($C_4H_{10}O$) can react with $Cr_2O_7^{2-}$ /H+ to give compound B which does not react with Tollens' reagent. *Compound A also reacts with $SOCl_2$ to give a haloalkane C, which when reacted with alcoholic KOH, gives two products, D and E, which are not geometric isomers.*

2011:1

(b) (ii) Identify an isomer of Compound A (which has the molecular formula $C_4H_8O_2$) that can exist as a pair of enantiomers (optical isomers). Draw the structural formulae, and state why the isomers are considered enantiomers

2010: 1

(b) It is thought that Compound A, along with glyceraldehyde (2,3-dihydroxypropanal), is formed by the action of a mild oxidising agent on glycerol (propan-1,2,3-triol).



glycerol glyceraldehyde Compound **A**

(i) Draw a circle around the product of the reaction above that will show optical isomerism (exist as enantiomers). Give a reason for your answer.

(ii) Explain how the two enantiomers of the compound circled above could be distinguished from each other.

2009:1

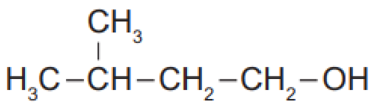
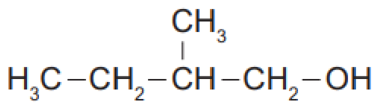
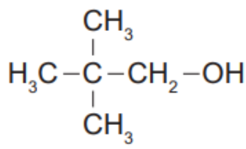
$C_5H_{11}OH$ is an example of an alcohol that can exist as a number of different isomers.

(a) Draw structures of the isomers of $C_5H_{11}OH$ that satisfy the requirements below.

- A branched-chain secondary alcohol (A)
- A branched-chain tertiary alcohol (B)

(b) Part Q

The structures of the three branched-chain primary alcohols with the formula $C_5H_{11}OH$ are given below.

C	D	E
		

(ii) Explain why D is the only primary alcohol isomer drawn above that is able to exist as a pair of enantiomers (optical isomers).

2008:3

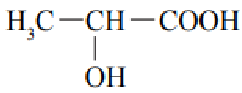
(a) Draw structural formulae for all the possible constitutional (structural) isomers of $C_4H_{10}O$ that are alcohols.

(b) (i) Circle any isomer above that can exist as a pair of enantiomers (optical isomers).

(ii) Explain what physical property would allow the two enantiomers to be distinguished.

2007:2

Lactic acid is the common name for 2-hydroxypropanoic acid. Lactic acid can exist as enantiomers (optical isomers).



(a) Draw three-dimensional structures for the two enantiomers of lactic acid that clearly show the relationship between them.

(b) Compound X is a structural isomer of lactic acid. Compound X will turn blue litmus red but cannot exist as enantiomers.

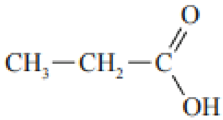
(i) Draw the structural formula for Compound X.

(ii) Explain why this structure cannot exist as enantiomers.

2006:1

(b) An alcohol ($C_4H_{10}O$) can exist as optical isomers (enantiomers). Draw three-dimensional structures that show the relationship between the two enantiomers.

(c) (i) Draw and name a structural (constitutional) isomer of



(ii) Discuss the differences in chemical and physical properties between samples of these two structural isomers.

2005:2

Compounds A to F are all isomers of molecular formula C_4H_8O.

(a) Compound A can exist as two enantiomers (optical isomers). It contains two different functional groups – an alcohol (OH–) group and an alkene group.
Draw 3-dimensional structures for both enantiomers that clearly show the relationship between them.

(b) Two compounds (B and C) have the same molecular formula, C_4H_8O. They are cis-trans isomers that contain a primary alcohol group. Both compounds rapidly decolourise bromine solution. Draw the structural formulae of compounds B and C.

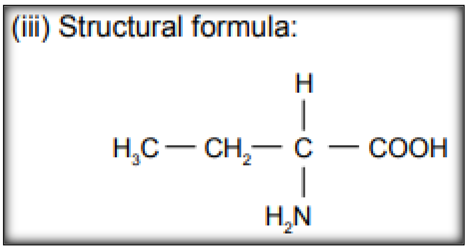
- Compound B is the *cis* isomer
- Compound C is the *trans* isomer

(c) Compound D, an isomer of compound A with molecular formula C_4H_8O, will react with both Tollens' reagent and Benedict's solution. (i) Draw the structural formula of compound D and give its systematic name.

(d) Compounds E and F have molecular formula C_4H_8O. Compounds E and F do not have the same functional group. Neither of these compounds reacts with Tollens' reagent or Benedict's solution and they do not rapidly decolourise bromine solution. Only compound F reacts with acidified potassium dichromate. Give the structural formulae for compound E and compound F

2004:1

(c) Compound (iii) can exist as two optical isomers (enantiomers).

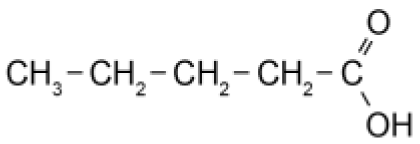


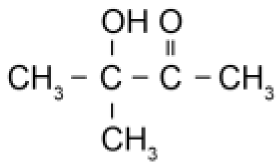
Draw 3-dimensional structures that clearly show the relationship between the two enantiomers.

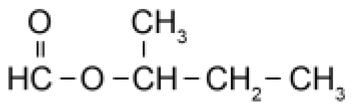
(d) Describe similarities and differences in the chemical and physical properties of the enantiomers in part (c).

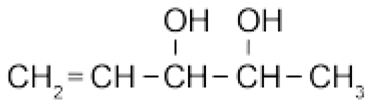
Answers

2021: 1

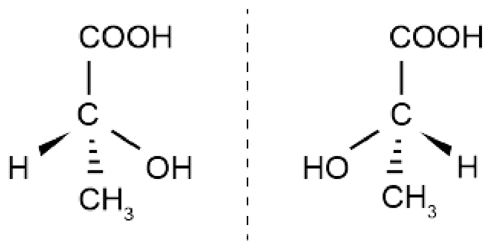
(b) (i) 

(ii) 

(iii) 

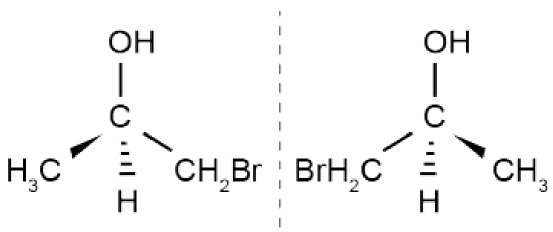
(iv)  OH groups can also be on carbons 2 and 3 or carbons 2 and 4.

2021: 3

(a) (i) 

(ii) The enantiomers can be distinguished based on their ability to rotate plane polarised light. One enantiomer will rotate the plane-polarised light to the left, while the other enantiomer will rotate the plane-polarised light to the right.

2020:2

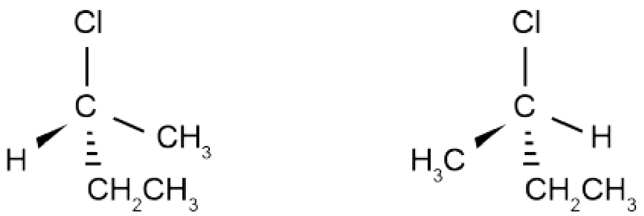
(a) (i) 

(ii) 1-bromopropan-2-ol exists as enantiomers as it has an asymmetric carbon atom, i.e. a carbon which is attached to four different atoms or groups of atoms. In this case, carbon 2 is the asymmetric carbon. (This makes the molecule chiral.)

(iii) The enantiomers can be distinguished since they rotate plane polarised light in opposite direction.

(2019:2)

(a) (i)

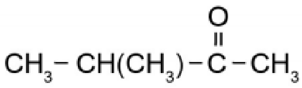


(ii) The enantiomers can be distinguished based upon their ability to rotate plane-polarised light. One enantiomer will rotate the plane polarised light to the left while the other enantiomer will rotate the plane-polarised light to the right.

(c) (i)

$CH_3-CH_2-CH_2-CH_2-CHO$

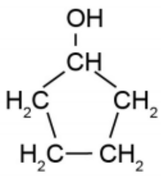
(ii)



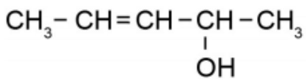
OR

Branched alkenes with alcohol group include:
$CH_2-CH=CH(CH_3)CH_2OH$
$CH_3-CH=C(CH_3)-CH_2OH$
$CH_3-C(CH_3)=CH-CH_2OH$
$CH_3-C(CH_3)=COH-CH_3$
$CH_3-COH=C(CH_3)-CH_3$

(iii)

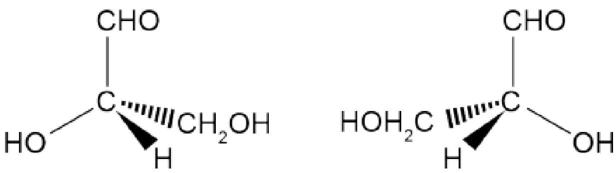


(iv)



(2018:2)

(a) (i)

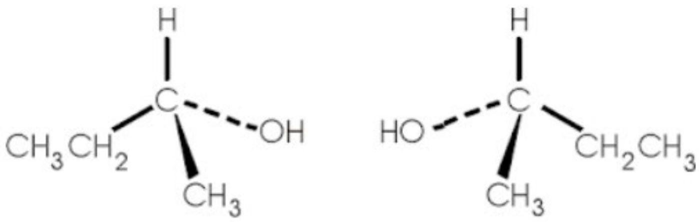


(iv) Glyceraldehyde can exist as enantiomers because it has an asymmetric carbon atom, i.e. a carbon atom with four different groups attached.

(v) The enantiomers can be distinguished based upon their ability to rotate plane polarised light. One enantiomer will rotate the plane polarised light to the left while the other enantiomer will rotate the plane polarised light to the right.

(2017:1)

(c) (i)



(ii) There must be a carbon atom that has four different species (groups) attached to it. This creates two molecules that are mirror images of each other that are non-superimposable. The different isomers will rotate (plane)-polarised light in opposite directions. This will distinguish the isomers.

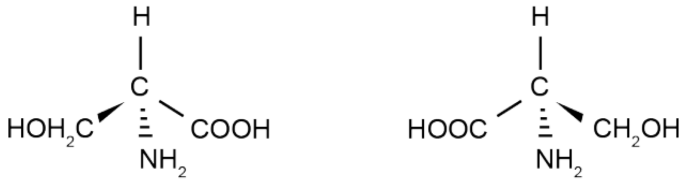
(2017:2)

(a)

Compound	Structure
P	$CH_3CH_2CH_2CH(OH)CH_3$
Q	$CH_3CH_2CH_2CH_2CH_2-OH$
R	$CH_3CH=CHCH_2CH_3$
S	$CH_2=CHCH_2CH_2CH_3$
T	$CH_3CH_2CH_2CH_2CH_2-Cl$
U	$CH_3CH_2CH_2CH_2CH_2-NH_2$
V	$CH_3CH_2CH_2CH_2C(=O)-OH$
W	$CH_3CH_2CH_2CH_2C(=O)-O-CH_2CH_2CH_2CH_2CH_3$

(2016:1)

(c) (i)



(ii) Glycine. It does NOT have a chiral C, i.e. it needs four different groups around the central C atom, glycine only has three.

(2015:1)

(c) (i) Primary $H_3C–CH_2–CH_2–CH_2–Cl$ or $H_3C–CH_2–CH(CH_3)–Cl$

Secondary $H_3C–CH(Cl)–CH_2–CH_3$

Tertiary $H_3C–CCl(CH_3)CH_3$

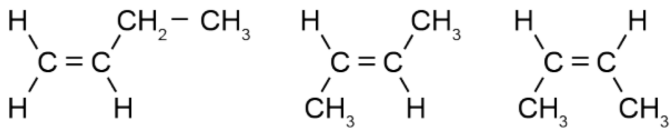
(2015:2)

(a) (i) A chiral compound contains a carbon atom with 4 different groups attached.

(ii) Same – boiling point / melting point / density / solubility. Different – enantiomers rotate plane-polarised light in different directions

(b)

(2014:1)

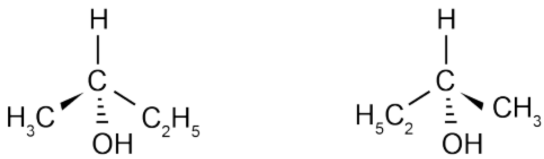


(b) (i) in lowest concentration

(ii) The minor product is but-1-ene. Saytzeff's rule: the minor product will have the least substituted double bond OR Saytzeff's rule is explained. Eg: the minor product is formed by the removal of the OH group and a hydrogen atom is removed from the carbon adjacent to the C-OH that has the most hydrogens.

(2013:1)

(b) (i) 3-D structure drawn, eg: Any pair of enantiomers that are valid 3-D structures will be accepted



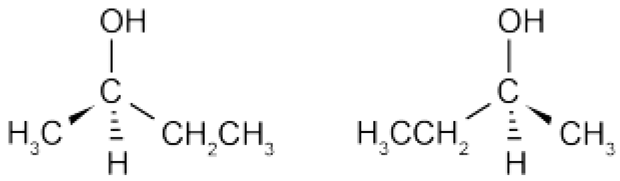
(vi) Enantiomers exist for atoms containing a carbon atom with 4 different groups attached / Non-optically active substances do not have any carbon with 4 different groups attached. Enantiomers rotate (plane) polarised light in opposite directions.

(2012:1)

(a) (i) A carbon atom must have four different groups / atoms.

(ii) They rotate (plane) polarised light in opposite / different directions OR they undergo stereospecific reactions e.g. enzymes, smell.

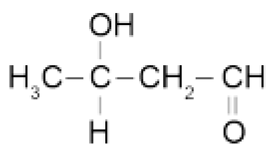
(iii)



(b) D is but-1-ene, E is but-2-ene

(2011:1)

(b) (ii) This isomer contains an asymmetric C atom. Four different groups are attached to the chiral carbon. (substituents) (Not four different functional groups/species.) (Accept list of groups.)



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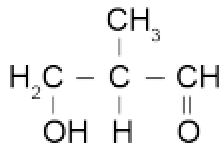
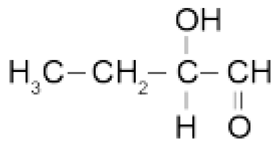
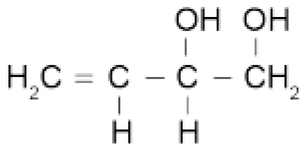
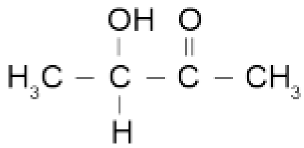


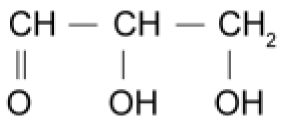






(2010:1)

(b) (i) The middle/central/second carbon has four different groups/groups of atoms attached. (not four different functional groups) (accept list of groups)



(ii) Optical isomers rotate plane polarised light in opposite directions.

(2009:1)

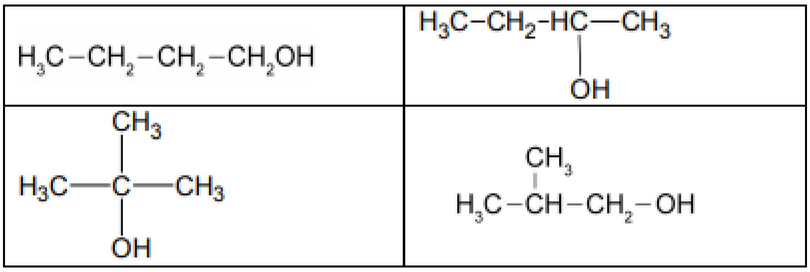
(a) A: Secondary alcohol $(CH_3)_2CHCH(OH)CH_3$

B: Tertiary alcohol $(CH_3)_2C(OH)CH_2CH_3$

(b) (ii) Isomer D has four different groups attached to one of the carbon atoms.

(2008:3)

(a)

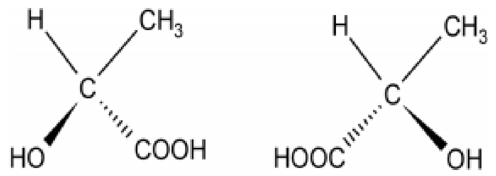


(b) (i) Butan-2-ol identified

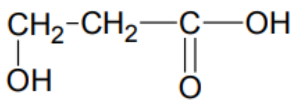
(ii) Optical isomers rotate plane polarised light in opposite directions.

(2007:2)

(a)



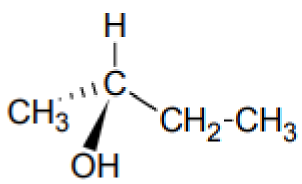
(b) (i)



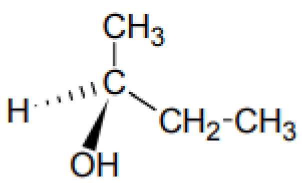
(ii) Compound does not have a chiral carbon - a C with 4 different groups attached.

(2006:1)

(b)



and



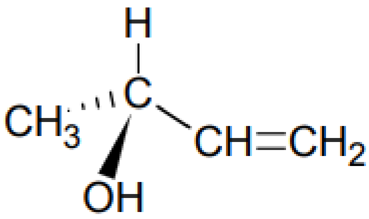
(c) (i) Name and structural formula of methyl ethanoate or ethyl methanoate or other valid compounds.

(ii) One chemical and physical property which is different is compared. Examples below.

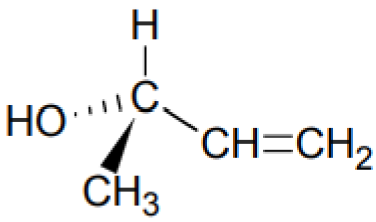
	Property	Carboxylic acid	Ester
Physical	Smell	Acrid	Sweet, fruity
	Boiling point	Higher	Lower
	Solubility	Soluble in water	Lower solubility
Chemical	pH	Low (<7)	Neutral
	Reaction	Weak acid reactions	No acidic properties

(2005:2)

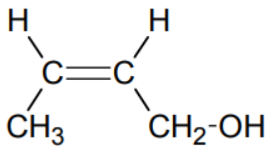
(a) Enantiomers of compound A



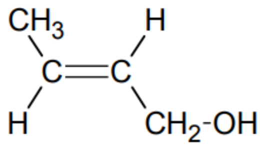
and



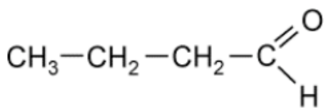
(b) Compound B (cis)

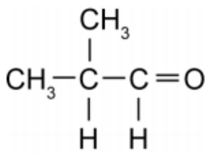


Compound C (trans)

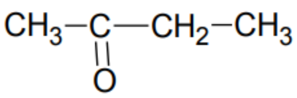


(c) (i) Compound D is butanal OR methyl propanal

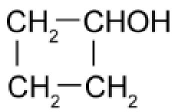




(d) Compound E is

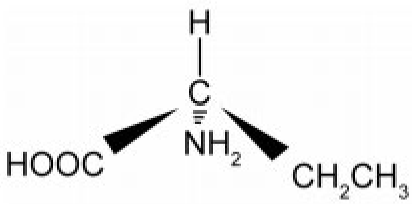


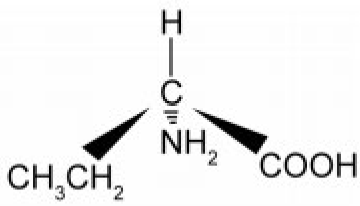
Compound F is



(2004:1)

(c)





(d) Solutions rotate plane polarised light in different directions. Same physical properties e.g. same boiling point, melting point, density, polarity; very similar chemical properties (identical in reaction with optically inactive molecules because the same bonds will be broken).