Q1.

Which compound is an isomer of ethyl ethanoate?

A butyl methanoate ⬭

B methyl propanoate ⬭

C methyl butanoate ⬭

D propanoic acid ⬭

(Total 1 mark)

Q2.

The number of structural isomers of molecular formula C_4H_9Br is

A 5

B 4

C 3

D 2

(Total 1 mark)

Q3.

How many structural isomers have the molecular formula C_4H_9Br?

A 2 ⬭

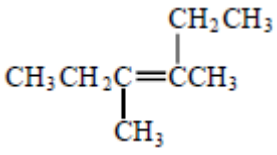
B 3 ⬭

C 4 ⬭

D 5 ⬭

(Total 1 mark)

Q4.

The correct systematic name for  is

A 2,3-diethylbut-2-ene

B 2-ethyl-3-methylpent-2-ene

C 4-ethyl-3-methylpent-3-ene

D 3,4-dimethylhex-3-ene

(Total 1 mark)

Q5.

Which alkene shows *E*–*Z* isomerism?

A 2,3-dimethylbut-2-ene ⬭

B 4-methylpent-2-ene ⬭

C methylpropene ⬭

D pent-1-ene ⬭

(Total 1 mark)

Q6.

How many isomers have the molecular formula C_5H_{12}?

A 2 ⬭

B 3 ⬭

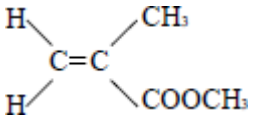
C 4 ⬭

D 5 ⬭

(Total 1 mark)

Q7.

The structure of the molecule of methyl 2-methylpropenoate is shown below.



Which one of the following statements concerning this compound is **not** true?

A It displays geometrical isomerism.

B It forms an addition polymer.

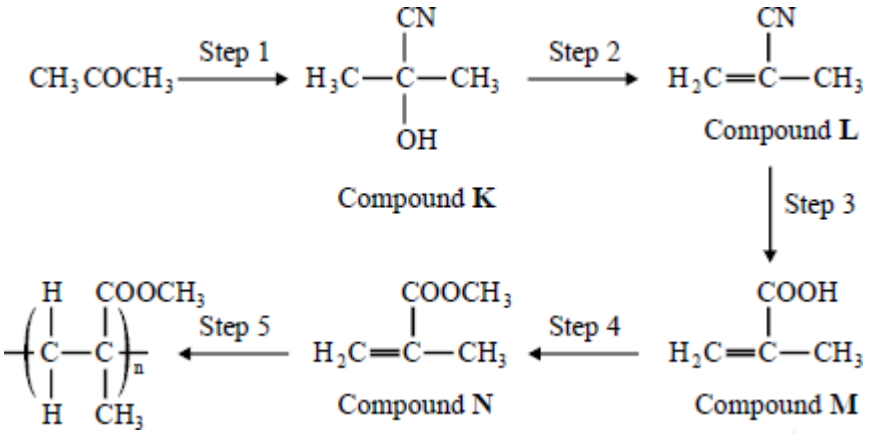
C It undergoes reduction.

D It decolourises bromine.

(Total 1 mark)

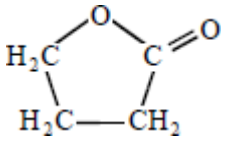
Q8.

This question concerns the preparation of the plastic poly(methyl 2-methylpropenoate) (*Perspex*), starting from propanone.

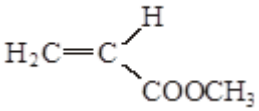


Which one of the following is **not** a structural isomer of Compound **M**?

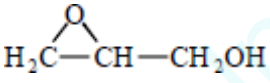
A



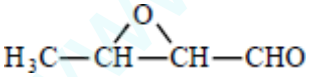
B



C



D



(Total 1 mark)

Q9.

How many structural isomers with an unbranched carbon chain have the molecular formula $C_4H_8Br_2$?

A 4 ⬭

B 5 ⬭

C 6 ⬭

D 7 ⬭

(Total 1 mark)

Q10.

Which compound is **not** an isomer of the following compound?

A $CH_3CH_2COCH_3$ ⬭

B $CH_3CH{=}CHCH_2OH$ ⬭

C $(CH_3)_2CHCHO$ ⬭

D $CH_2{=}CHCH_2CHO$ ⬭

(Total 1 mark)

Q11.

Which is the correct general formula for non-cyclic compounds in the homologous series?

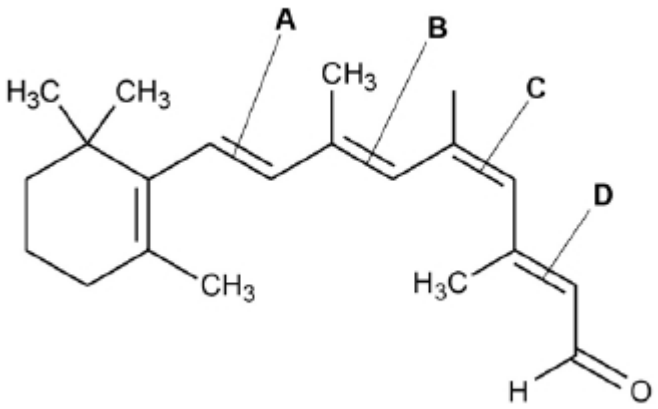
A	alcohols	$C_nH_{2n+2}O$	⬭
B	aldehydes	$C_nH_{2n+1}O$	⬭
C	esters	$C_nH_{2n+1}O_2$	⬭
D	primary amines	$C_nH_{2n+2}N$	⬭

(Total 1 mark)

Q12.

Z-Retinal, shown in the diagram, is a component in vitamin A.

Which of the double bonds, labelled **A**, **B**, **C** or **D**, is responsible for the letter Z in the name?



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

Q13.

Which has *E*-*Z* isomers?

A $C_2H_2Br_2$ ⬭

B C_2H_3Br ⬭

C $C_2H_4Br_2$ ⬭

D C_2H_5Br ⬭

(Total 1 mark)

Q14.

Which can be both an empirical and molecular formula of a stable compound?

A CH_2O ⬭

B P_4O_{10} ⬭

C NH_2 ⬭

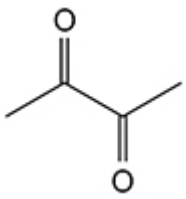
D CH_3 ⬭

(Total 1 mark)

Q15.

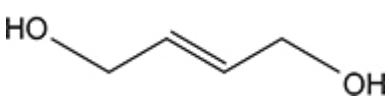
Which compound has a molecular formula that is different from the others?

A



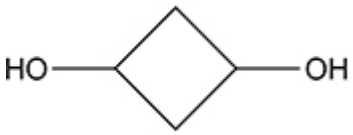
⬭

B

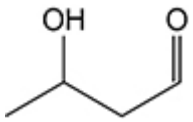


⬭

C



D



(Total 1 mark)

Q16.

The outer layers of some golf balls are made from a polymer called polyisoprene.
The isoprene monomer is a non-cyclic branched hydrocarbon that contains 88.2 % carbon by mass.
The empirical formula of isoprene is the same as its molecular formula.

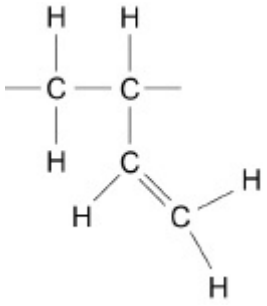
(a) Deduce the molecular formula of isoprene and suggest a possible structure.

Molecular formula _____

Structure

(4)

(b) The insides of some golf balls are made from a mixture of three other polymers.
The repeating unit for one of these polymers is shown.



Draw the skeletal formula of the monomer used to make this polymer.

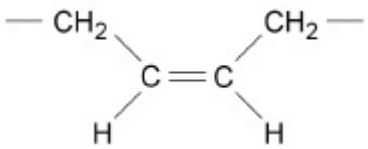
Give the IUPAC name of the monomer.

Skeletal formula of monomer

IUPAC name _____

(2)

(c) A second polymer in the mixture has a repeating unit with the structure shown.



The third polymer in the mixture is a stereoisomer of this polymer.

Draw the structure of the repeating unit of the third polymer.

Give a reason why this type of stereoisomerism arises.

Repeating unit

Reason _____

_____

_____

(2)

Q17.

Octane is the eighth member of the alkane homologous series.

(a) State **two** characteristics of a homologous series.

_____

_____

_____

_____

(2)

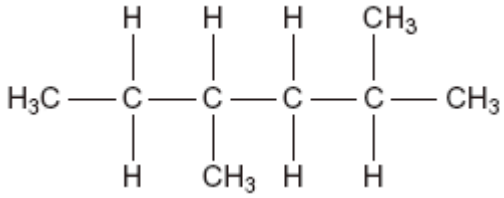
(b) Name a process used to separate octane from a mixture containing several different alkanes.

_____

_____

(1)

(c) The structure shown below is one of several structural isomers of octane.



Give the meaning of the term structural isomerism.
Name this isomer and state its empirical formula.

(4)

(d) Suggest why the branched chain isomer shown above has a lower boiling point than octane.

(2)

(Total 9 marks)

Q18.

Under suitable conditions, 2-bromobutane reacts with sodium hydroxide to produce a mixture of five products, **A**, **B**, **C**, **D** and **E**.

Products **A**, **B** and **C** are alkenes.

A is a structural isomer of **B** and **C**.

A does not exhibit stereoisomerism.

B and **C** are a pair of stereoisomers.

Products **D** and **E** are alcohols.

D and **E** are a pair of enantiomers.

(b) Define the term stereoisomers.

(2)

(f) Draw 3D representations of enantiomers **D** and **E** to show how their structures are related.

(2)

Q19.

Pent-1-ene is a member of the alkene homologous series.

(a) Pent-1-ene can be separated from other alkenes.

State the physical property of alkenes that allows them to be separated from a mixture by fractional distillation.

_____

(1)

(b) (i) State the meaning of the term *structural isomerism*.

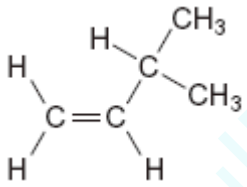
_____

_____

_____

(2)

(ii) Name the branched chain isomer of pent-1-ene shown below.



_____

(1)

(iii) Draw the structure of a functional group isomer of pent-1-ene.

(1)

(c) The cracking of one molecule of compound **X** produces pent-1-ene, ethene and butane in a 1:2:1 mol ratio.
Deduce the molecular formula of **X** and state a use for the ethene formed.

Molecular formula of **X** _____

_____

Use of ethene _____

(2)

(Total 7 marks)

Q20.

Explain the differences between structural isomerism and stereoisomerism. Use examples to show how compounds with the molecular formula C_4H_8 exhibit stereoisomerism and the three types of structural isomerism.

(Total 6 marks)

Q21.

(a) (i) Name the process used to separate petroleum into fractions.

_____

(ii) Give the molecular formula for an alkane with nine carbon atoms.

_____

_____

(iii) Write an equation for the complete combustion of the alkane $C_{11}H_{24}$

_____

(iv) Write an equation for the incomplete combustion of $C_{11}H_{24}$ to produce carbon and water only.

_____

(4)

(b) Alkenes can be produced by cracking the naphtha fraction obtained from petroleum.

(i) Write an equation for the thermal cracking of one molecule of $C_{10}H_{22}$ to give one molecule of propene and one molecule of an alkane only.

_____

(ii) Draw the structure of the chain isomer of but-1-ene.

(2)

(c) The alkanes and the alkenes are examples of homologous series of compounds. One feature of an homologous series is the gradual change in physical properties as the relative molecular mass increases. State **two** other general features of an homologous series of compounds.

Feature 1 _____

_____

Feature 2 _____

_____

(2)

(Total 8 marks)

Q22.

Compounds **A**, **B** and **C** all have the molecular formula C_5H_{10}

A and **B** decolourise bromine water but **C** does not.

B exists as two stereoisomers but **A** does **not** show stereoisomerism.

Use this information to deduce a possible structure for each of compounds **A**, **B** and **C** and explain your deductions.

State the meaning of the term stereoisomers and explain how they arise in compound **B**.

(Total 6 marks)

Q23.

(a) Compounds with double bonds between carbon atoms can exhibit geometrical isomerism.

(i) Draw structures for the two geometrical isomers of 1,2-dichloroethene.

Isomer 1 *Isomer 2*

(ii) What feature of the double bond prevents isomer 1 from changing into isomer 2?

(3)

Q24.

This question is about isomers.

Hex-2-ene has the molecular formula C_6H_{12}

(a) Draw the displayed formula of a **position** isomer of hex-2-ene that exists as *E* and *Z* isomers.

(1)

(b) Draw the displayed formula of a **chain** isomer of hex-2-ene that does **not** exist as *E* and *Z* isomers.

(1)

Butanal has the molecular formula C_4H_8O

LEARN IR FIRST (c) Draw the skeletal formula of a **functional group isomer of butanal that has an absorption in the range 1680–1750 cm^{-1} in its infrared spectrum.

(1)

(d) *****LEARN IR FIRST

Draw the skeletal formula of a structural isomer of butanal that has an absorption in the range 3230–3550 cm^{-1} in its infrared spectrum.

(1)

(e) Several saturated halogenoalkanes contain 17.8% carbon, 3.0% hydrogen and 79.2% bromine by mass.

Calculate the empirical formula of these compounds.

Give the IUPAC names of **two** saturated halogenoalkanes that have this empirical formula.

Empirical formula _____

Names of halogenoalkanes

1 _____

2 _____

(4)

(Total 8 marks)

Q1.

B

methyl propanoate

[1]

Q2.

B

[1]

Q3.

C

[1]

Q4.

D

[1]

Q5.

B

4-methylpent-2-ene

[1]

Q6.

B

[1]

Q7.

A

[1]

Q8.

C

[1]

Q9.

C

[1]

Q10.

D

$CH_2 = CHCH_2CHO$

[1]

Q11.

A

alcohols $C_nH_{2n+2}O$

[1]

Q12.

C

[1]

Q13.

A

[1]

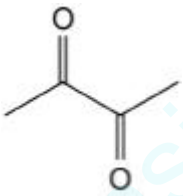
Q14.

A

[1]

Q15.

A



[1]

Q16.

(a)

	C	H
%mass	88.2	11.8
mol	$\frac{88.2}{12}$	$\frac{11.8}{1}$
	= 7.35	= 11.8
÷ smaller	$\frac{7.35}{7.35}$	$\frac{11.8}{7.35}$
	= 1	= 1.61
x5	= 5	= 8

Empirical formula = molecular formula C_5H_8

M1 *for amounts 7.35 and 11.8*

1

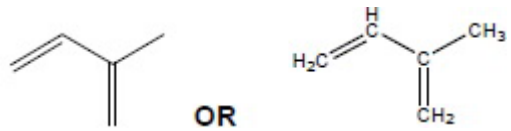
M2 *for process dividing* ***M1*** *by smaller*

1

M3 *for answer* C_5H_8 *only*

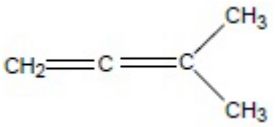
1

M4 (must be branched)



OR

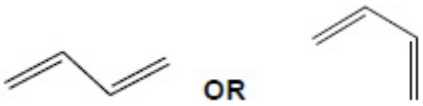
Allow alternatives



HC≡CCH(CH₃)₂

1

(b)



OR

Must be skeletal

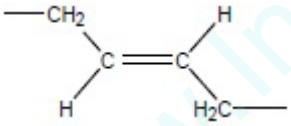
1

Buta-1,3-diene

M2 *can only be this and is independent of* ***M1***

1

(c)



Must show trailing bonds
Ignore brackets and n
Allow skeletal – with brackets

Must be E 'trans'

1

Mark independently

Restricted rotation about the C=C or double bond

Allow lack of rotation/no rotation/limited rotation about the C=C or double bond

Ignore different groups on each carbon of the C=C double bond

1

Q17.

(a)
- (Same) General formula/allow a named homologous series with its general formula
- Chemically similar/same (chemical) reactions
- Same functional group
- Trend in physical properties/eg inc bp as M_r increases
- (Molecules) increase by CH_2/M_r = 14

Any two points

2

(b) Fractional distillation/fractionation/chromatography

Allow GLC

1

(c) (Molecules/compounds/substances) with the same molecular formula/same number and type of atoms

Allow alkanes with same molecular formula

Allow same chemical formula in M1 = 0 but can allow M2

1

but different structural formula/different displayed formula/different arrangement of atoms/different structures

Not different positions in space

1

2,4-dimethylhexane

M2 dependent on M1

1

C_4H_9

Ignore the absence of dash and/or commas

1

(d) less surface contact/less surface area/less polarisable molecule

1

so fewer/weaker/less Van der Waals'/vdw forces

Allow more spherical or fewer points of contact

Not smaller molecule/not more compact molecule/not shorter chain

Allow converse arguments

Must be comparative answer ie not just few VDW forces

QoL

Assume 'it' refers to the branched isomer

1

[9]

Q18.

(b) (Different molecules/compounds with the) same (molecular and) structural formula

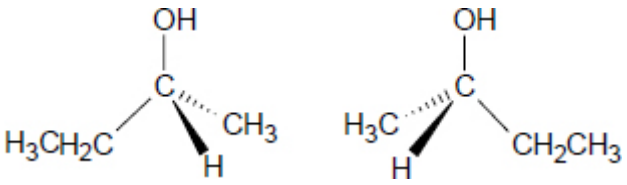
1

Different spatial arrangement of atoms

Allow *different spatial arrangement of bonds/groups*

1

(f)



M1 *any correct 2D or 3D structure of butan-2-ol*

Allow C_2H_5

1

M2 *must show at least one wedge bond and one dash bond in each structure from the chiral C and any bonds* ***in the plane*** *cannot be at 180° to each other*

1

second structure could be drawn as mirror image of first ***or*** *with same orientation of bonds and two groups swapped round*

Allow *ECF for second structure from incorrect first structure, providing molecule is chiral*

Q19.

(a) (Different) boiling points

Ignore mp's, references to imf, different volatilities

1

(b) (i) Compound which have the same molecular formula

Accept same no and type of atom for M1
But If same (chemical) formula M1 = 0 but allow M2
If empirical formula CE = 0/2

1

but different structures/different structural formulae/different displayed formulae

M2 dependent on M1

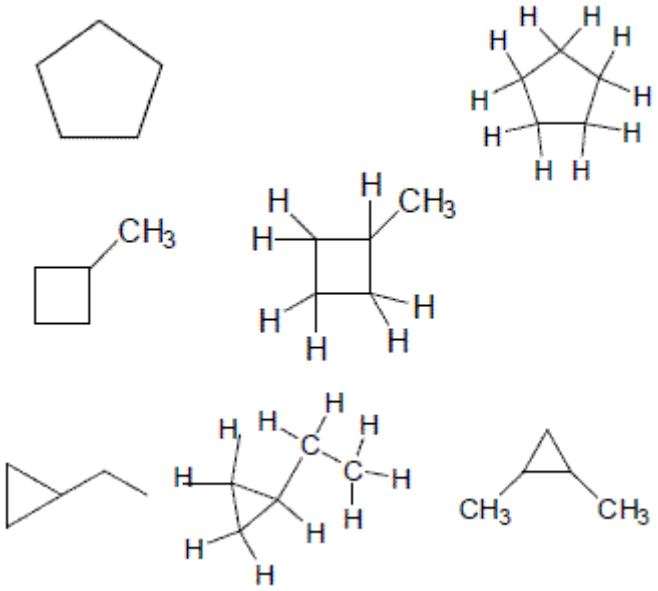
1

(ii) 3-methylbut-1-ene

only
ignore commas and hyphens

1

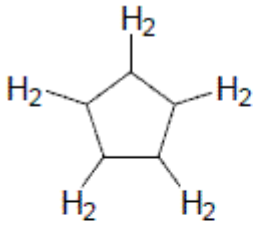
(iii)



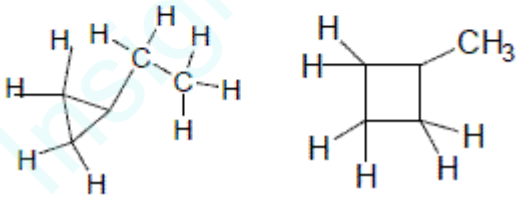
Allow any correct structure with a cyclic alkane

1

Do not allow



or



i.e with an H missing on one C

(c) $C_{13}H_{28}$

only

1

Making plastics/used to make polymers or polythene/used to make antifreeze/make ethanol/ripening fruit/any named additional polymer

*not used **as** a plastic/polymer/antifreeze*
not just 'polymers' – we need to see that they are being made

1

[6]

Q20.

This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.	
Level 3 **5-6 marks**	**All stages are covered and each stage is generally correct and virtually complete.** (6 v 5) Answer is well structured, with no repetition or irrelevant points, and covers all aspects of the question. Accurate and clear expression of ideas with no errors in use of technical terms.
Level 2 **3-4 marks**	**All stages are covered but stage(s) may be incomplete or may contain inaccuracies OR two stages are covered and are generally correct and virtually complete** (4 v 3) Answer has some structure and covers most aspects of the question. Ideas are expressed with reasonable clarity with, perhaps, some repetition or some irrelevant points. If any, only minor errors in use of technical terms.
Level 1 **1-2 marks**	**Two stages are covered but stage(s) may be incomplete or may contain inaccuracies OR only one stage is covered but is generally correct and virtually complete** (2 v 1) Answer includes statements which are presented in a logical order and/or linked.
0 marks	Insufficient correct chemistry to warrant a mark.

Indicative chemistry

Stage 1
Difference between structural & stereoisomers
1a structural isomers = molecules with same molecular formula but different structure
1b stereoisomers = molecules with same structural formula but different arrangement of atoms in space

Stage 2
Stereoisomers
2a lack of rotation around C=C
2b structures of *E*- and *Z*-but-2-ene
2c correct identity of *E* and *Z* isomers

Stage 3
Structural isomers
3a different C chain, e.g. methylpropene & but-1-ene / but-2-ene
3b different position of functional group e.g. but-1-ene & but-2-ene
3c different functional group, e.g. cyclobutane & but-1-ene / but-2-ene / methylpropene

[6]

Q21.

(a) (i) fractional distillation or fractionation

1

(ii) C_9H_{20} only

1

(iii) $C_{11}H_{24} + 17O_2 \rightarrow 11CO_2 + 12H_2O$

1

(iv) $C_{11}H_{24} + 6O_2 \rightarrow 11C + 12H_2O$

1

(b) (i) $C_{10}H_{22} \rightarrow C_3H_6 + C_7H_{16}$

1

(ii) correctly drawn structure of methylpropene

(insist on clearly drawn C-C and C=C bonds)

1

(c) Any <u>two</u> from

- o chemically similar or chemically the same or react in the same way
- o same functional group
- o same general formula
- o differ by CH_2

(penalise same molecular formula or same empirical formula)

2

[8]

Q22.

This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

Level 3 (5 – 6 marks)
All stages are covered, three correct structures are given and each stage is generally correct and virtually complete. Answer communicates reasoning coherently and shows a logical progression through the identification of structures including explaining about stereoisomerism.

Level 2 (3 – 4 marks)
Two stages are covered or parts of three stages (if two stages are covered, they must be complete for 4 marks)

Level 1 (1 – 2 marks)
One stage covered or parts of two stages (if one stage is covered, it must be complete for 2 marks)

Level 0 (0 marks)
No relevant correct chemistry to warrant a mark.

Indicative chemistry content

Stage 1 – deduces which compounds are saturated/unsaturated

1a states that A & B are unsaturated / do contain C=C / alkenes (this can be obtained from the structures)

1b as they decolourise bromine water

1c states that C is saturated / does not contain C=C / is (cyclo)alkane (this can be obtained from the structures)
1d as it does not decolourise bromine water

Stage 2 – deduces the structures
2a suggests suitable name/structure for **A**
- pent-1-ene,
- 2-methylbut-1-ene,
- 3-methylbut-1-ene,
- 2-methylbut-2-ene

2b **B** = pent-2-ene (name / structure)
2c suggests a suitable name / structure of **C** (cyclopentane, methylcyclobutane, any dimethylcyclopropane)

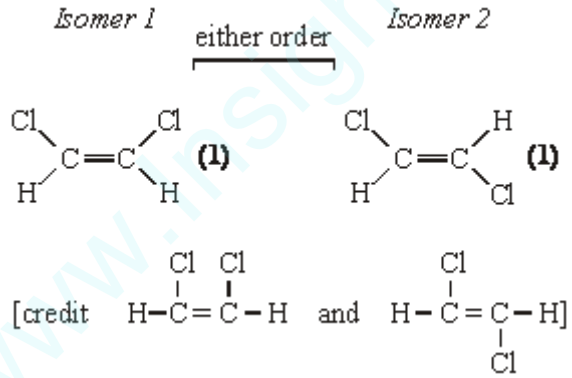
Stage 3 – can explain the stereoisomerism
3a explains what stereoisomerism is in terms of molecules with the same structural formula but a different arrangement of atoms / bonds / groups in space
3b explains how it arises by discussing that C=C cannot rotate,
3c explains how it arises by discussing that each C in C=C has two different groups (ignore reference to Mr in this context) or by drawing the E and Z isomers of **B**

Note
- compounds may be identified by name or structure (but if both given and there is error in one, then award lower mark in whichever level the answer fits, i.e. it penalises the mark within a level, but not the overall level itself).

[6]

Q23.

(a) (i)



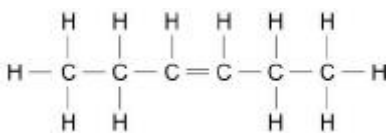
(ii) restricted rotation OR no rotation OR cannot rotate **(1)**

3

[10]

Q24.

(a)

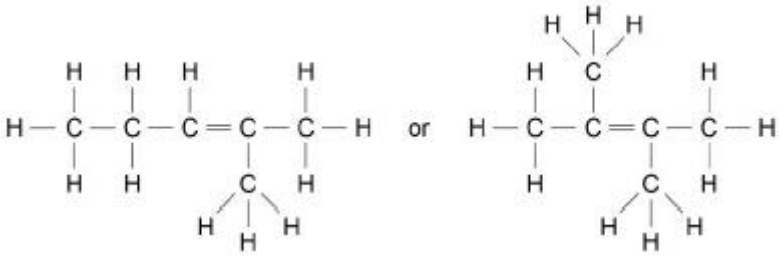


Displayed *structure of hex-3-ene (E or Z isomer)*
Award 1 mark if correct molecules given in (a) and (b) but

they are not displayed structures

1

(b)



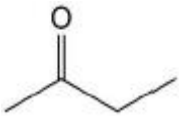
Displayed *formula of 2-methylpent-2-ene or 3,4-dimethylbut-2-ene*

Allow molecules that are both chain and position isomers, eg 2-methylpent-1-ene, 3-methylpent-1-ene, 4-methylpent-1-ene, 3,3-dimethylbut-1-ene, 2,3-dimethylbut-1-ene, 2-ethylbut-1-ene

Award 1 mark if correct compounds given in part (a) and (b) but they are not displayed formulas

1

(c)

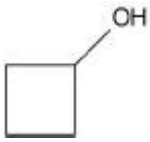


Skeletal *formula*

Award 1 mark if correct compounds given in part (c) and (d) but they are not skeletal formulas

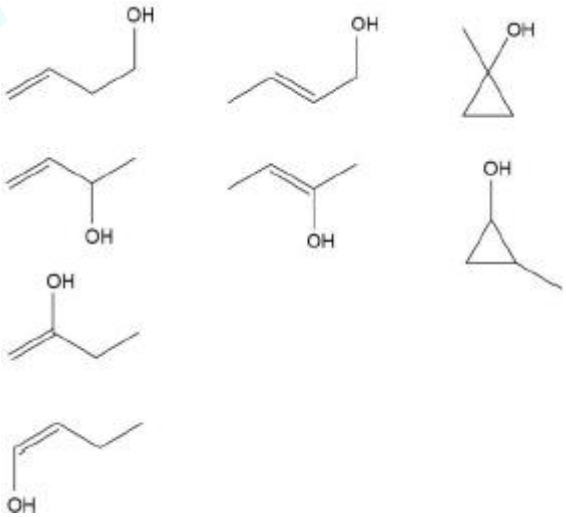
1

(d)



Skeletal *formula*

Alternative answers:



Award 1 mark if correct compounds given in part (c) and (d) but they are not skeletal formulas

1

(e) **M1** divide %s by relative atomic masses:

$$C\ \frac{17.8}{12.0} = 1.48 \qquad H\ \frac{3.0}{1.0} = 3.00 \qquad Br\ \frac{79.2}{79.9} = 0.99$$

*Allow ECF from **M1** to **M2** for a correct empirical formula for their working in **M1***

1

M2 (1.48 : 3.00 : 0.99 = 3 : 6 : 2) empirical formula = $C_3H_6Br_2$

*Allow ECF from **M2** to **M3/4** for compounds that are saturated halogenoalkanes*

1

M3,4 any 2 of:

1,1-dibromopropane
1,2-dibromopropane
1,3-dibromopropane
2,2-dibromopropane

2

[8]