Organic – IB Examination – Short Questions

1. The compound 2-bromobutane, $CH_3CHBrCH_2CH_3$, can react with sodium hydroxide to form compounds **M**, **N** and **O**.

Compound **M**, $C_4H_{10}O$, exists as a pair of optically active isomers. Compounds **N** and **O**, C_4H_8, are structural isomers, and compound **O** exists as a pair of geometrical isomers.

(a) Draw diagrams to show the relationship between the **two** isomers of **M**. 2

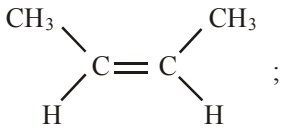
(b) Draw diagrams to show the shapes of the **two** isomers of **O**. 2

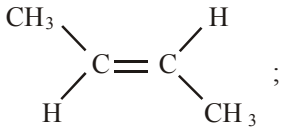
(c) Write equations, using curly arrows to represent the movement of electron pairs, to show the mechanism of the reaction in which **N** is formed. 3

Answer: 1. (a) 2

*Award **[2]** for both tetrahedral structures, or*
***[1]** if tetrahedral structure not clear.*

(b) 2





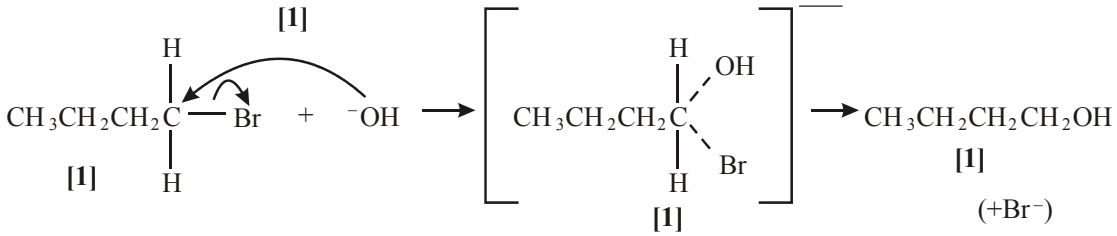
(c) curly arrow showing attack by ^-OH on end H;
curly arrow showing C–Br bond fission;
curly arrow showing formation of double bond;
H_2O and Br^- shown as products; 3 max

2. (a) The reaction of warm aqueous KOH with 1-bromobutane occurs by an S_N2 mechanism. Draw the mechanism for this reaction, including the structural formulas of 1-bromobutane, the transition state and the organic product. 4

(b) State and explain how the rate of the above reaction is affected when the concentration of the KOH is doubled. 2

(c) State and explain how the rate of reaction of 1-chlorobutane in the above S_N2 reaction compares with that of 1-bromobutane. 2

Answer: 2. (a)



suitable diagram with structure of 1-bromobutane;
two correctly positioned curly arrows;
(second one must start from O or – sign)
transition state structure with partial bonds to OH and Br and a negative charge;
Correct structure of butan-1-ol; 4

(b) the rate of the reaction doubles;
the rate is proportional to $[OH^-]/OH^-$ appears in the rate-determining step/first order with respect to OH^-; 2

(c) (1-chlorobutane reaction rate) is slower;
C—Cl bond is stronger/harder to break. 2

3. Ethene, propene and but-2-ene are members of the alkene homologous series.

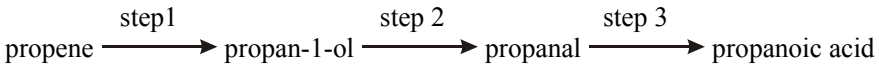
(a) Describe **three** features of members of a homologous series. 3

(b) State and explain which compound has the highest boiling point. 3

(c) Draw the structural formula and give the name of an alkene containing five carbon atoms.

(d) Write an equation for the reaction between but-2-ene and hydrogen bromide, showing the structure of the organic product. State the type of reaction occurring. 3

(e) Propene can be converted to propanoic acid in three steps:



State the type of reaction occurring in steps 2 and 3 and the reagents needed. Describe how the conditions of the reaction can be altered to obtain the maximum amount of propanal, and in a separate experiment, to obtain the maximum amount of propanoic acid. 5

(f) Identify the strongest type of intermolecular force present in each of the compounds propan-1-ol, propanal and propanoic acid. List these compounds in decreasing order of boiling point.

Answer: 3. (a) same general formula/C_nH_{2n};
formulas of successive members differ by CH_2;
similar chemical properties/same functional group;
gradation/gradual change in physical properties; 3
*Award **[1]** each for any three.*

(b) but-2-ene;

strongest intermolecular/van der Waals' forces;
largest (molecular) mass/size/surface area/area of contact; 3

(c) $CH_2CHCH_2CH_2CH_3$/$CH_3CHCHCH_2CH_3$/any correct branched structure;
Accept more detailed formula.

pent-1-ene/pent-2-ene; 2

(d) $C_4H_8 + HBr \rightarrow CH_3CH_2CHBrCH_3$;

addition; 3

(e) oxidation/redox;
(potassium) dichromate(VI)/ $Cr_2O_7^{2-}$;
(sulfuric) acid;
distilling off propanal as it is formed;
heating under reflux (to obtain propanoic acid); 5

(f) (propan-1-ol) hydrogen bonding;
(propanal) dipole-dipole attractions;
(propanoic acid) hydrogen bonding;
propanoic acid > propan-1-ol > propanal; 4

4. (a) Compounds of formula C_4H_7Cl exhibits both geometrical and optical isomerism.

(i) Explain why C_4H_7Cl shows geometrical isomerism. 1

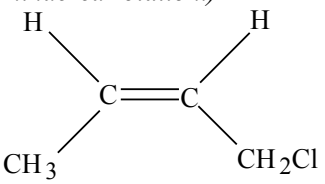
(ii) Draw the cis and trans isomers of C_4H_7Cl. 2

(iii) Draw the structural formula of C_4H_7Cl that shows only optical isomerism. Show the chiral carbon atom with " * ". 2

(b) Explain why 1,2-dichlorocyclopropane has *cis* and *trans* isomers. Draw the structural formulas of the two isomers. 3

Answer: 4. (a) (i) no rotation possible due to double bond/π bond; 1

Accept restricted or hindered rotation.)



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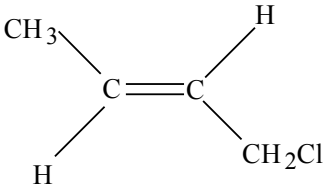
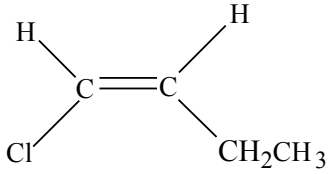
Cis



;

trans

OR



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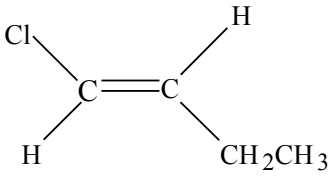
Cis



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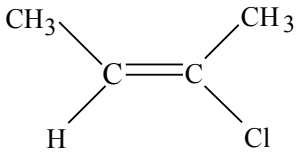
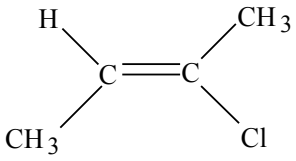
trans

OR



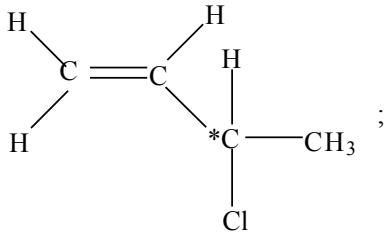
Cis



trans

Answer: 4 (cont.)

(iii)



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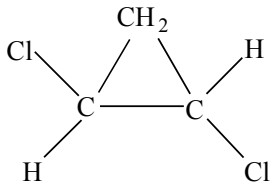
2

*Award **[1]** for the structure and **[1]** for showing * on the correct carbon atom.*

(b) restricted rotation because C—C bond is now part of a cyclic system; 3



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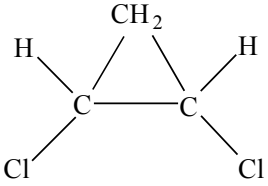
trans



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Cis

5. (a) State **two** characteristics of a homologous series. 2

(b) Describe a chemical test to distinguish between alkanes and alkenes, giving the result in each case. 3

Answer: 5. (a) same <u>general</u> formula; successive members differ by CH_2;
Do not allow elements or just "they".
similar chemical properties; Allow same/constant.
gradual change in physical properties; Do not allow change periodically.
same functional group;

(b) add bromine (water);
alkanes – no change/stays or turns brown;
Allow red-brown or any combination of brown, orange or yellow.
alkenes – bromine (water) decolorizes*; Do not allow clear or discoloured.*
or

add (acidified) $KMnO_4$;
alkanes – no change;
alkenes – $KMnO_4$ decolorizes/brown/black; 3

6. (a) List **two** characteristics of a homologous series. *1*

(b) Ethanol and ethanoic acid can be distinguished by their melting points. State and explain which of the two compounds will have a higher melting point. 2

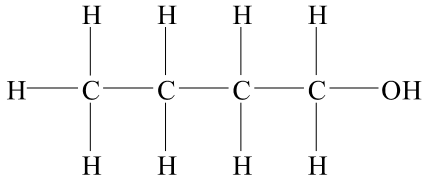
(c) Draw the **three** isomers containing the alcohol functional group of formula C_4H_9OH. 3

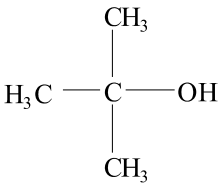
Answer: 6. (a) one general formula/same general formula;
differ by CH_2;
similar chemical properties;
gradual change in physical properties; 1

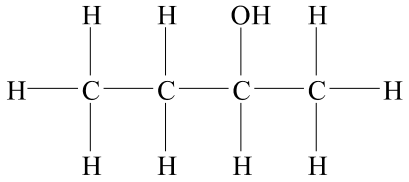
(b) ethanol lower/ethanoic acid higher;

due to larger mass of ethanoic acid/stronger van der Waals'/ London/dispersion forces;
due to stronger hydrogen bonding/2 hydrogen bonds per molecule; 2

(c)







7. The compound, 2-bromobutane, $CH_3CHBrCH_2CH_3$, can react with sodium hydroxide to form compounds **F**, **G** and **H**.

Compound **F**, $C_4H_{10}O$, exists as a pair of optical isomers. Compounds **G** and **H**, C_4H_8, are structural isomers, and compound **H** exists as a pair of geometrical isomers.

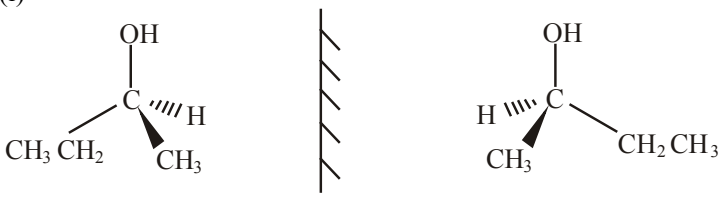
(i) Draw the structures of the two optical isomers of **F**. 2

(ii) Outline the use of a polarimeter in distinguishing between the optical isomers. 2

(iii) Draw diagrams to show the shapes of the two geometrical isomers of **H**. 2

(iv) Draw the mechanism, using curly arrows to represent the movement of electron pairs, to show the formation of **G**. 3

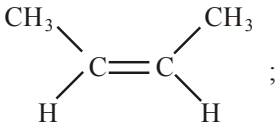
Answer: 7. (i)



2

(ii) plane polarized light;
rotation in opposite/different directions; 2

(iii)



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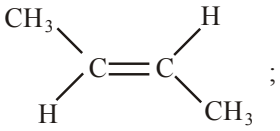


; 2

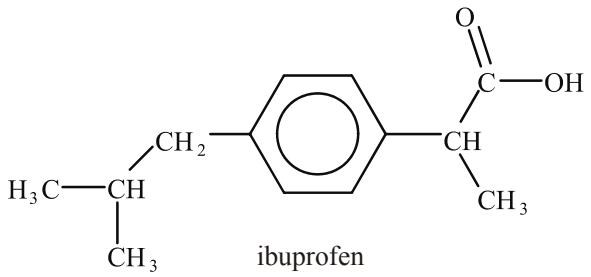
(iv) curly arrow showing attack by ^{-}OH on end H;
curly arrow showing C–Br bond fission;
curly arrow showing formation of double bond;
H_2O and Br^{-} shown as products; 3 max

8. A compound, **J**, has the molecular formula $C_2H_4O_2$ and is obtained from a reaction between methanoic acid and methanol. Write an equation for this reaction and state the name of compound **J**. 3

Answer: 8. $CH_3OH + HCOOH \rightarrow HCOOCH_3 + H_2O$

methyl methanoate; 3

9. Ibuprofen is an analgesic with the following structure:



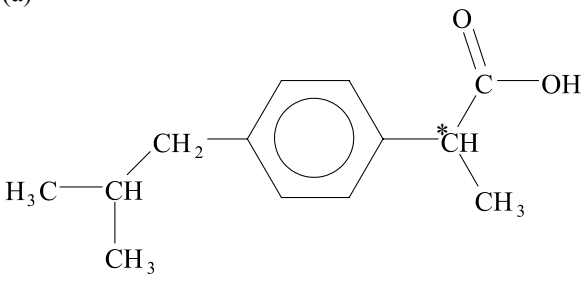
ibuprofen

(a) Identify the chiral carbon atom in the structure of ibuprofen using an asterisk (*).

(1)

(b) Describe how chiral auxiliaries can be used to synthesize only the desired enantiomeric form of a drug from a non-chiral starting compound. Explain why it is important to use only the desired enantiomeric form of a drug and state an example of what can happen if a racemic mixture is used. 5

Answer: 9. (a)



1

(b) a chiral auxiliary is itself an enantiomer;
it is bonded to the reacting molecule to create the stereochemical conditions necessary to follow a certain pathway;
once the desired enantiomer is formed the auxiliary is removed;
different enantiomers may have different biological effects (some of which may be harmful);
genetic defects/deformities; 5

[6]