

Organic Chemistry*(Past Year Topical Questions 2010-2015)*May/June 2010/(31)

- 2 Ozone is a form of oxygen. Ozone is present in the upper atmosphere and it prevents dangerous solar radiation from reaching the Earth's surface. Some of the chemicals that diffuse into the upper atmosphere decompose ozone. Chemicals that have this effect are methane (CH_4), chloromethane (CH_3Cl) and an oxide of nitrogen (NO_2).

(iii) How can chloromethane be made from methane?

reagent

condition [2]

- 8 Methanoic acid is the first member of the homologous series of carboxylic acids.

(a) Give **two** general characteristics of a homologous series.

.....
.....
..... [2]

(b) In some areas when water is boiled, the inside of kettles become coated with a layer of calcium carbonate. This can be removed by adding methanoic acid.

(i) Complete the equation.

..... $\text{HCOOH} + \text{CaCO}_3 \rightarrow \text{Ca}(\text{HCOO})_2 + \dots + \dots$ [2]

(ii) Methanoic acid reacts with most metals above hydrogen in the reactivity series. Complete the word equation.

zinc + methanoic acid \rightarrow + [2]

(c) Give the name, molecular formula and empirical formula of the fourth acid in this series.

name [1]

molecular formula [1]

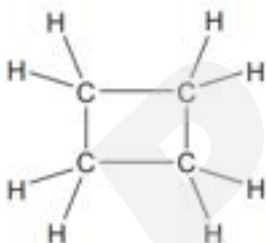
empirical formula [1]

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4 But-1-ene is a typical alkene. It has the structural formula shown below.



The structural formula of cyclobutane is given below.



(a) These two hydrocarbons are isomers.

(i) Define the term *isomer*.

.....
 [2]

(ii) Draw the structural formula of another isomer of but-1-ene.

[1]

(iii) Describe a test which would distinguish between but-1-ene and cyclobutane.

reagent

result with but-1-ene

.....

result with cyclobutane

..... [3]

(b) Describe how alkenes, such as but-1-ene, can be made from alkanes.

.....

..... [2]

(c) Name the product formed when but-1-ene reacts with:

bromine, [1]

hydrogen, [1]

steam, [1]

[Total: 11]

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5 Monomers polymerise to form polymers or macromolecules.

(a) (i) Explain the term *polymerise*.

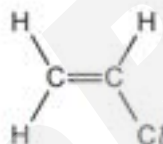
.....
 [1]

(ii) There are two types of polymerisation - addition and condensation. What is the difference between them?

.....

 [2]

(b) An important monomer is chloroethene which has the structural formula shown below.



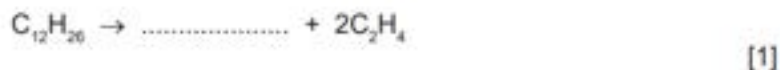
It is made by the following method.



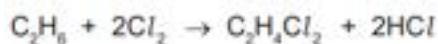
This is heated to make chloroethene.



(i) Ethene is made by cracking alkanes. Complete the equation for cracking dodecane.



Another method of making dichloroethane is from ethane.



(ii) Suggest a reason why the method using ethene is preferred.

.....
..... [1]

(iii) Describe an industrial method of making chlorine.

.....
..... [2]

(iv) Draw the structural formula of poly(chloroethene).

Include three monomer units.

[2]

[Total: 9]

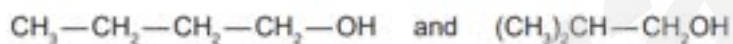
Oct/Nov 2010/(32)

6 The alcohols form an homologous series.

(a) Give **three** characteristics of an homologous series.

.....
.....
.....
..... [3]

(b) The following two alcohols are members of the series and they are isomers.



(i) Explain why they are isomers.

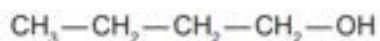
.....
.....
..... [2]

(ii) Give the structural formula of another alcohol which is also an isomer of these alcohols.

[1]

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- 6 The structural formula of a butanol is given below.



- (a) Butanol can be made from petroleum and also by fermentation.

- (i) Describe the chemistry of making butanol from petroleum by the following route.

petroleum → butene → butanol

.....
.....
..... [3]

- (ii) Explain, in general terms, what is meant by *fermentation*.

.....
.....
.....
..... [3]

- (c) Butanol reacts with ethanoic acid to form a liquid, **X**, which has the sweet smell of bananas. Its empirical formula is $\text{C}_3\text{H}_6\text{O}$ and its M_r is 116.

- (i) What type of compound is liquid **X**?

..... [1]

- (ii) Give the molecular formula of liquid **X**.

..... [1]

(iii) Draw the structural formula of X. Show all the individual bonds.

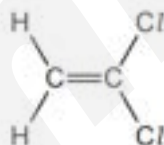
[2]

8 There are two types of polymerisation - addition and condensation.

(a) Explain the difference between them.

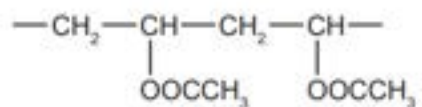
.....
.....
..... [2]

(b) Poly(dichloroethene) is used to package food. Draw its structure. The structural formula of dichloroethene is shown below.



[2]

- (c) The polymer known as PVA is used in paints and adhesives. Its structural formula is shown below.



Deduce the structural formula of its monomer.

[1]

- (d) A condensation polymer can be made from the following monomers.



Draw the structural formula of this polymer.

[3]

[Total: 8]

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(c) Petroleum-based diesel is a mixture of hydrocarbons, such as octane and octene.

(i) 'Oct' means eight carbon atoms per molecule. Draw a structural formula of an octene molecule.

[1]

(ii) Describe a test which would distinguish between octane and octene.

test

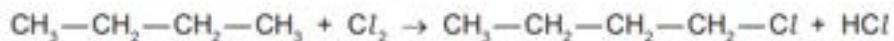
result with octane

result with octene [3]

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(b) Alkanes are hydrocarbons and are generally unreactive. Their reactions include combustion, substitution and cracking.

(i) Chlorine reacts with butane in a substitution reaction.



Give the structural formula of another possible product of this reaction.

[1]

(ii) What is the essential condition for this reaction?

[1]

(iii) Explain what is meant by *cracking*. Give an example of a cracking reaction and explain why the process is used.

[4]

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6 Structural formulae are an essential part of Organic Chemistry.

(a) Draw the structural formula of each of the following. Show all the bonds in the structure.

(i) ethanoic acid

[1]

(ii) ethanol

[1]

(b) (i) Ethanoic acid and ethanol react to form an ester.
What is the name of this ester?

..... [1]

(ii) The same linkage is found in polyesters. Draw the structure of the polyester which can be formed from the monomers shown below.



[3]

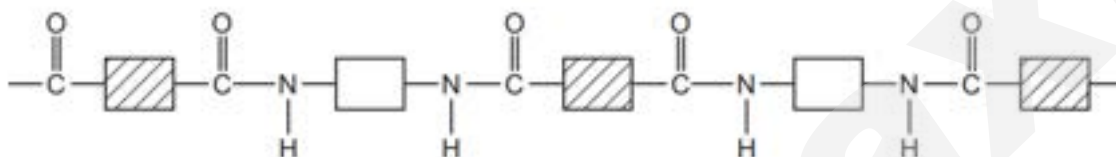
(iii) Describe the pollution problems caused by non-biodegradable polymers.

.....

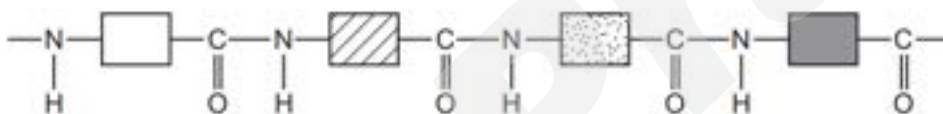
.....

..... [2]

(c) Two macromolecules have the same amide linkage.
Nylon, a synthetic polymer, has the following structure.



Protein, a natural macromolecule, has the following structure.



How are they different?

.....

.....

..... [2]

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- 5 The alcohols form a homologous series. Two characteristics of a homologous series are that the physical properties of the members vary in a predictable way and they have similar chemical properties.

(a) Complete the table.

name	formula	mass of one mole / g	boiling point / °C
methanol	$\text{CH}_3\text{-OH}$	32	64
ethanol	$\text{CH}_3\text{-CH}_2\text{-OH}$	46	78
propan-1-ol	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-OH}$	60	98
butan-1-ol	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-OH}$	74	118
pentan-1-ol			138
hexan-1-ol	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-OH}$	102	

[3]

(b) Give two other characteristics of a homologous series.

.....

..... [2]

- (c) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound methanol.
Use x to represent an electron from a carbon atom.
Use o to represent an electron from an oxygen atom.
Use • to represent an electron from a hydrogen atom.

[3]

- (ii) Describe how ethanol could be oxidised to ethanoic acid by fermentation.

.....
..... [2]

- (e) Propan-1-ol and ethanoic acid react together to form an ester. Give its name and structural formula.

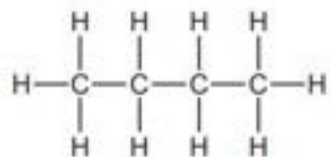
name [1]

formula

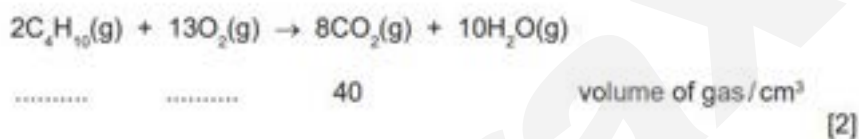
[1]

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- 6** Butane is an alkane. It has the following structural formula.



- (a) The equation for the complete combustion of butane is given below. Insert the two missing volumes.



- (b) Butane reacts with chlorine to form two isomers of chlorobutane.

- (i) What type of reaction is this?

..... [1]

- (ii) Explain the term *isomer*.

.....
 [2]

- (iii) Draw the structural formulae of these two chlorobutanes.

[2]

(c) One of the chlorobutanes reacts with sodium hydroxide to form butan-1-ol. Butan-1-ol can be oxidised to a carboxylic acid.

(i) State a reagent, other than oxygen, which will oxidise butan-1-ol to a carboxylic acid.

..... [1]

(ii) Name the carboxylic acid formed.

..... [1]

(iii) Butan-1-ol reacts with ethanoic acid to form an ester. Name this ester and give its structural formula showing all the individual bonds.

name [1]

structural formula

[2]

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- (b) (i) There are two types of polymerisation reaction. Give their names and explain the differences between them.

.....

.....

.....

..... [4]

- (ii) Give the structural formula of a polymer which is formed from two different monomers.

[2]

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7 The alkenes are unsaturated hydrocarbons. They form a homologous series, the members of which have similar chemical properties:

- easily oxidised
- addition reactions
- polymerisation
- combustion.

(a) All the alkenes have the same empirical formula.

(i) State their empirical formula.

..... [1]

(ii) Why is the empirical formula the same for all alkenes?

..... [1]

(c) Complete the following equations for the addition reactions of propene.

(i) $\text{CH}_3\text{-CH=CH}_2 + \text{Br}_2 \rightarrow \dots\dots\dots$ [1]

(ii) $\text{CH}_3\text{-CH=CH}_2 + \text{H}_2\text{O} \rightarrow \dots\dots\dots$ [1]

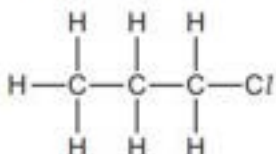
(d) Draw the structural formula of poly(propene)

[2]

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3 Many organic compounds which contain a halogen have chloro, bromo or iodo in their name.

(a) The following diagram shows the structure of 1-chloropropane.



(i) Draw the structure of an isomer of this compound.

[1]

(ii) Describe how 1-chloropropane could be made from propane.

.....
..... [2]

(iii) Suggest an explanation why the method you have described in (ii) does not produce a pure sample of 1-chloropropane.

.....
..... [2]

(b) Organic halides react with water to form an alcohol and a halide ion.



(i) Describe how you could show that the reaction mixture contained an iodide ion.

.....
..... [2]

(ii) Name the alcohol formed when 1-chloropropane reacts with water.

..... [1]

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1 Petroleum contains hydrocarbons which are separated by fractional distillation.

(a) (i) Complete the following definition of a hydrocarbon.

A hydrocarbon is a compound which
..... [2]

(ii) Explain what is meant by the term *fractional distillation*.

.....
.....
..... [2]

(b) Some of the fractions obtained from petroleum are given below.
State a use for each fraction.

bitumen

lubricating fraction

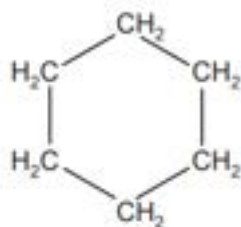
paraffin fraction

gasoline fraction

[4]

[Total: 8]

- 4 The structural formula of cyclohexane is drawn below.



- (a) The name gives information about the structure of the compound.
Hex because there are six carbon atoms and **cyclo** because they are joined in a ring.
 What information about the structure of this compound is given by the ending **ane**?

.....
 [2]

- (b) What are the molecular and empirical formulae of cyclohexane?

molecular formula

empirical formula

[2]

- (c) Draw the structural formula of cyclobutane.

[1]

(d) (i) Deduce the molecular formula of hexene.

..... [1]

(ii) Explain why cyclohexane and the alkene, hexene, are isomers.

.....
.....
..... [2]

(e) Describe a test which would distinguish between cyclohexane and the unsaturated hydrocarbon hexene.

test

result of test with cyclohexane

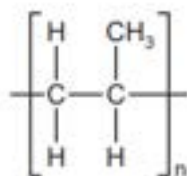
result of test with hexene

..... [3]

[Total: 11]

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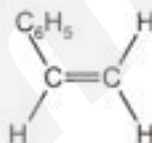
- (b) (i) Deduce the structural formula of the monomer from that of the polymer.



structural formula of monomer

[1]

- (ii) Deduce the structural formula of the polymer, poly(phenylethene), from the formula of its monomer, phenylethene.



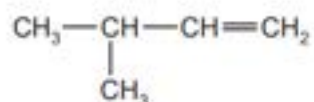
structural formula of polymer

[2]

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- 5 The alkenes are unsaturated hydrocarbons. They form a homologous series, the members of which have the same chemical properties. They undergo addition reactions and are easily oxidised.

(a) The following hydrocarbons are isomers.



- (i) Explain why these two hydrocarbons are isomers.

.....
 [2]

- (ii) Give the structural formula of another hydrocarbon which is isomeric with the above.

[1]

(b) Give the structural formula and name of each of the products of the following addition reactions.

- (i) ethene and bromine

structural formula of product

name of product [2]

(ii) propene and hydrogen

structural formula of product

name of product [2]

(iii) but-1-ene and water

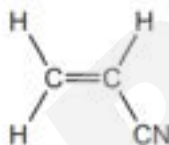
structural formula of product

name of product [2]

(d) Alkenes polymerise to form addition polymers.

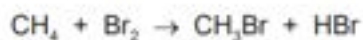
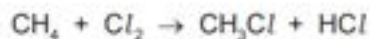
Draw the structural formula of poly(cyanoethene), include at least two monomer units.

The structural formula of the monomer, cyanoethene, is given below.



[3]

- 7 (a) The following are two examples of substitution reactions. Only the reaction involving chlorine is a photochemical reaction.



- (i) Explain the phrase *substitution reaction*.

.....
..... [1]

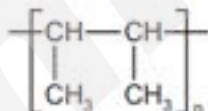
- (ii) How do photochemical reactions differ from other reactions?

.....
..... [1]

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- 8 Polymers are made by the polymerisation of simple molecules called monomers.

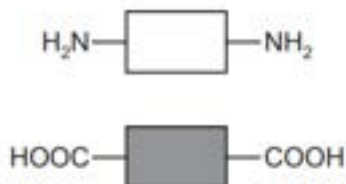
- (a) (i) The structural formula of a polymer is given below.



This polymer is made by addition polymerisation. Draw the structural formula of its monomer.

[1]

- (ii) The two monomers shown below form a nylon which is a condensation polymer.



Draw its structural formula showing one repeat unit of the polymer.

[3]

- (iii) Name the natural macromolecule which contains the same linkage as nylon.

..... [1]

- (iv) Explain the difference between addition polymerisation and condensation polymerisation.

.....

 [2]

- (b) Many polymers are non-biodegradable.

- (i) Explain the term *non-biodegradable*.

.....
 [2]

- (ii) State **three** problems caused by the disposal of non-biodegradable polymers.

.....

 [3]

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4 Propanoic acid is a carboxylic acid. Its formula is $\text{CH}_3\text{-CH}_2\text{-COOH}$.

(a) Propanoic acid is the third member of the homologous series of carboxylic acids.

(i) Give the name and structural formula of the fourth member of this series.

name

formula [2]

(ii) Members of a homologous series have very similar chemical properties.
State **three** other characteristics of a homologous series.

.....

.....

.....

..... [3]

(c) Complete the following equations for some of the reactions of propanoic acid.
The salts of this acid are called propanoates.

(i) zinc + propanoic acid \rightarrow + hydrogen [1]

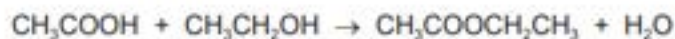
(ii) calcium + propanoic \rightarrow +
oxide acid [1]

(iii) $\text{LiOH} + \text{CH}_3\text{CH}_2\text{COOH} \rightarrow$ + [1]

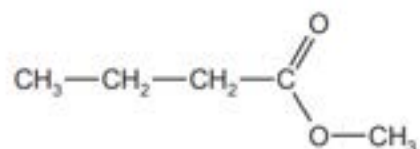
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6 Esters, polyesters and fats all contain the ester linkage.

(a) Esters can be made from alcohols and carboxylic acids. For example, the ester ethyl ethanoate can be made by the following reaction.



(i) Name the carboxylic acid and the alcohol from which the following ester could be made.



name of carboxylic acid

name of alcohol

[2]

(b) The following two monomers can form a polyester.

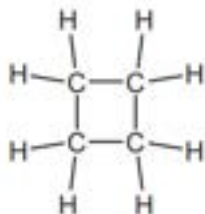


Draw the structural formula of this polyester. Include two ester linkages.

[3]

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- 3 (a) A hydrocarbon has the following structural formula.



- (i) State the molecular formula and the empirical formula of this hydrocarbon.

molecular formula

empirical formula

[2]

- (ii) Draw the structural formula of an isomer of the above hydrocarbon.

[1]

- (iii) Explain why these two hydrocarbons are isomers.

.....

..... [2]

- (iv) Are these two hydrocarbons members of the same homologous series?
Give a reason for your choice.

.....

..... [1]

(b) Alkenes can be made from alkanes by cracking.

(i) Explain the term *cracking*.

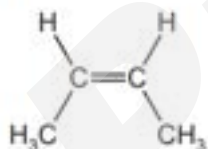
.....
..... [2]

(ii) One mole of an alkane, when cracked, produced one mole of hexane, C_6H_{14} , and two moles of ethene.
What is the molecular formula of the original alkane?

..... [1]

(c) Alkenes are used in polymerisation reactions and addition reactions.

(i) Draw the structural formula of the product formed by the addition polymerisation of but-2-ene. Its formula is given below.



[3]

- (ii) Give the name and structural formula of the addition product formed from ethene and bromine.

name

structural formula

[2]

[Total: 14]

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- 4 The alcohols form a homologous series.

- (a) (i) Give **three** characteristics which all members of a homologous series share.

.....
.....
.....
..... [3]

- (ii) Give the name of the third member of this series.

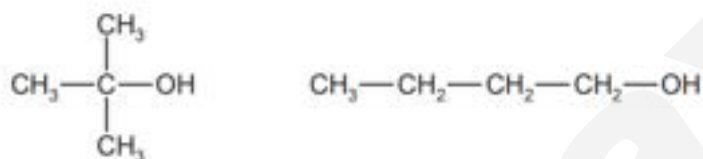
name [1]

(iii) Deduce the molecular formula of the alcohol whose $M_r = 158$. Show your working.

.....

 [2]

(b) Explain why the following two alcohols are isomers.



.....
 [2]

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(c) One use of ethanol is in alcoholic drinks.

Give **two** other uses of ethanol.

..... [2]

(d) Alcohols can be made from petroleum by the following sequence of reactions.



Describe the manufacture of ethanol from hexane, C_6H_{14} . Include in your description an equation and type of reaction for each step.

.....

 [5]

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4 (a) Synthetic polymers are disposed of in landfill sites and by burning.

(i) Describe **two** problems caused by the disposal of synthetic polymers in landfill sites.

.....
 [2]

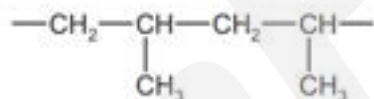
(ii) Describe **one** problem caused by burning synthetic polymers.

..... [1]

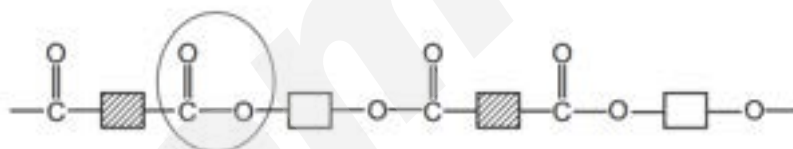
(b) State **two** uses of synthetic polymers.

.....
 [1]

(c) The structural formulae of two synthetic polymers are given below.



polymer A



polymer B

(i) Draw the structural formula of the monomer of polymer A.

[2]

(ii) Identify the functional group circled in polymer **B**.

..... [1]

(iii) Deduce the **two** types of organic compound which have reacted to form polymer **B**.

..... [2]

(d) Explain the difference between addition and condensation polymers. Classify **A** and **B** as either addition or condensation polymers.

.....
.....
.....
..... [3]

5 (a) A compound, **X**, contains 55.85% carbon, 6.97% hydrogen and 37.18% oxygen.

(i) How does this prove that compound **X** contains only carbon, hydrogen and oxygen?

..... [1]

(ii) Use the above percentages to calculate the empirical formula of compound **X**.

..... [2]

(iii) The M_r of **X** is 86.

What is its molecular formula?

..... [2]

(b) (i) Bromine water changes from brown to colourless when added to **X**.

What does this tell you about the structure of **X**?

..... [1]

(ii) Magnesium powder reacts with an aqueous solution of **X**. Hydrogen is evolved.

What does this tell you about the structure of **X**?

..... [1]

(iii) **X** contains two different functional groups.

Draw a structural formula of **X**.

[1]

[Total: 8]

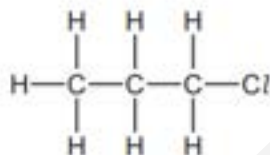
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- 4 (a) Propane reacts with chlorine to form a mixture of chloropropanes. This is a photochemical reaction.

(i) What is meant by the phrase *photochemical reaction*?

.....
..... [1]

- (ii) The products of this reaction include two isomers, one of which has the following structural formula.



Draw the structural formula of the other isomer.

[1]

- (iii) Explain why these two different compounds are isomers.

.....
..... [2]

(c) (i) Chloropropane can be hydrolysed to propanol, $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$, by sodium hydroxide.

Write the equation for this reaction.

..... [2]

(ii) Propanol can be dehydrated. It loses a water molecule to form a hydrocarbon.

Give the name and structural formula of this hydrocarbon.

name

structural formula

[2]