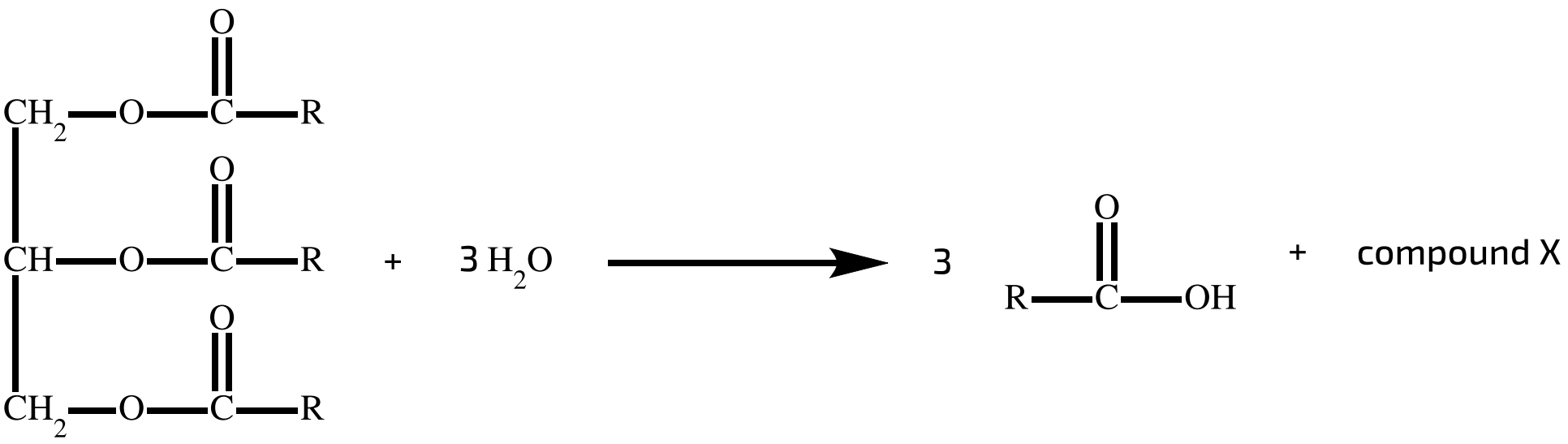
Fatty Acids

A Level

Fatty acids are long-chain carboxylic acids which can be obtained by hydrolysing an oil or fat:



oil or fat

(where R represents a hydrocarbon chain)

Fatty acids vary in the length and structure of their hydrocarbon chains. For example stearic acid $\mathrm{CH_3(CH_2)_{16}COOH}$ is found in solid animal fats whereas oleic acid, $\mathrm{CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH}$, is found in vegetable oils such as olive oil.

Part A Functional group

Name the functional group which is being hydrolysed.

Part B Reaction conditions

Give the correct conditions for carrying out the hydrolysis reaction.

- [ ] Aqueous
- [ ] Concentrated
- [ ] Acid
- [ ] Base
- [ ] Cooling
- [ ] Reflux
- [ ] Bromine
- [ ] Hydrogen gas
- [ ] Potassium dichromate (VI)
- [ ] Potassium manganate (VII)

Part C Compound X

Draw the full structural formula for the compound **X**.

Draw the structure using the structure editor and give your answer as a SMILES string.

Part D Unsaturation

Unsaturated fats react with iodine and the 'iodine value' of a fat is used to measure the degree of unsaturation. Food scientists measure this value in 'grams of iodine which will react with 100 grams of fat'.

Which of the following are correct statements about *unsaturated fats*?

- [ ] They contain single bonds.
- [ ] They contain double bonds.
- [ ] They contain more hydrogens than the corresponding *saturated fats*.
- [ ] They contain the same number of hydrogens as the corresponding *saturated fats*.
- [ ] They contain fewer hydrogens than the corresponding *saturated fats*.

Part E Oleic acid with iodine

Draw the structural formula of the compound formed when iodine reacts with oleic acid, $\mathrm{CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH}$.

Use the structure editor to generate a SMILES string as your answer.

Part F Iodine value

Calculate the iodine value for oleic acid. (M_r for oleic acid is 282; A_r for I is 127).

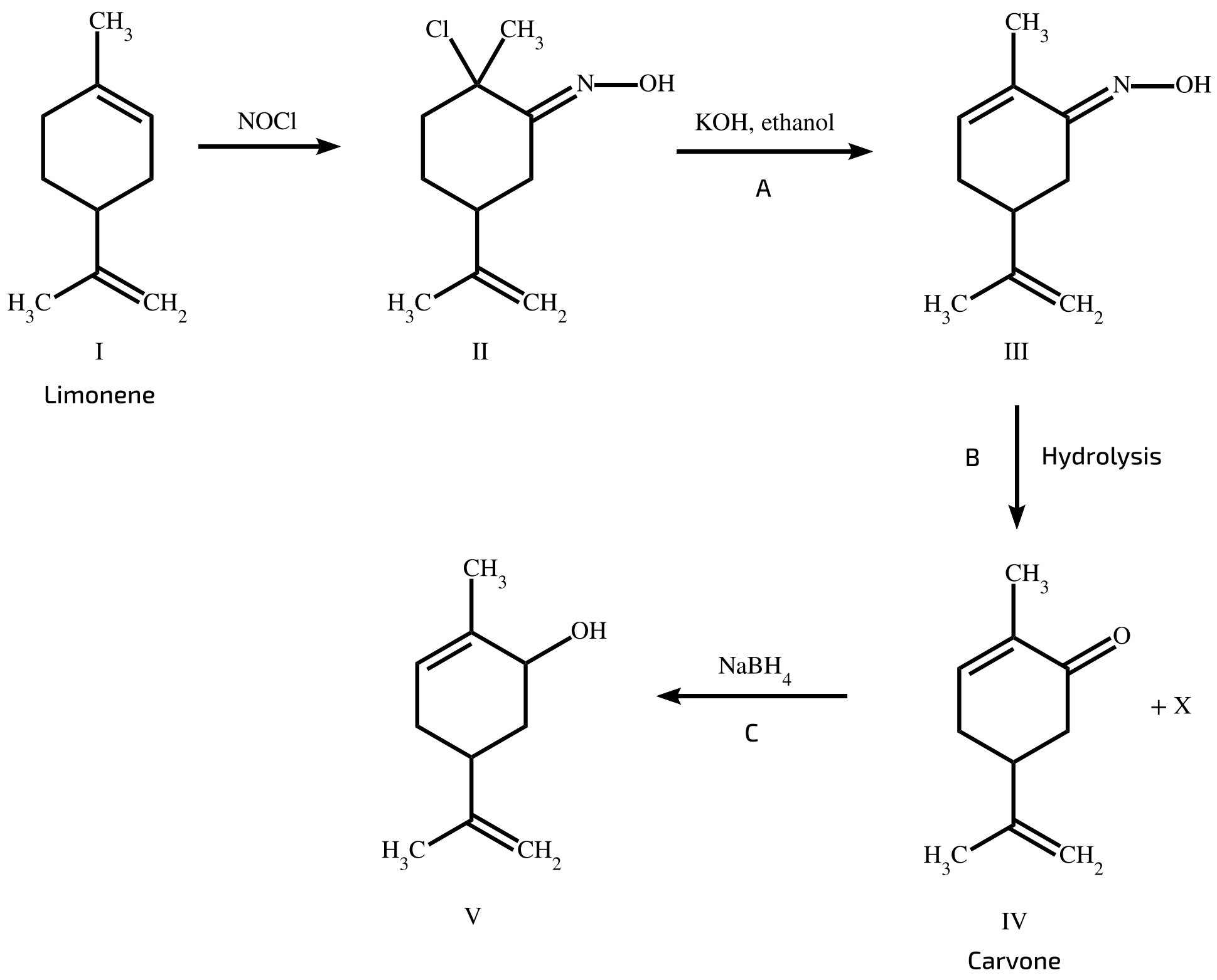
Give your answer to 3 sf.

Adapted with permission from OCSEB, A-Level Chemistry (Salters), June 1995, Paper 1, Question 4.

Limonene

A Level

Limonene, I, is the substance providing the natural odour of lemons. As part of work to relate its structure to that of another important natural product, carvone, IV, and to establish the position of the double bonds in both of these compounds, the following sequence of reactions was carried out. Examine this sequence of reactions carefully and answer the questions which follow it.



I
Limonene

II

III

V

IV
Carvone

Part A Reaction A

What type of reaction is reaction **A**?

Part B Functional groups in IV

Identify the functional groups (excluding alkyl groups) in compound **IV**.

Give your answer in the format "A, B..." (space after comma).

Part C Product X

Suggest the identity of the unspecified product, X, of reaction **B**.

Part D Reaction C

What type of reaction is transformation **C**?

Part E V with ethanoyl chloride

Give the structure of the product from reaction of **V** with ethanoyl chloride. There is no need to indicate stereochemistry.

Use the structure editor to generate a SMILES string.

Part F V with bromine

Give the structure of the product from reaction of **V** with excess bromine. There is no need to indicate stereochemistry.

Use the structure editor to generate a SMILES string.

Adapted with permission from OCSEB Structured Science Scheme, June 1996, Unit C6: Further Organic Chemistry, Question 3.

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Apples

A Level

C C C

Compound **A**, a diacid that occurs in apples and other fruit, has the following composition by mass:

$$\mathrm{C}: 35.8\% \quad \mathrm{H}: 4.5\% \quad \mathrm{O}: 59.7\%$$

A reacts with ethanol in the presence of concentrated sulfuric acid under reflux to give **B**, $\mathrm{C_8H_{14}O_5}$. Compound **B** evolves hydrogen gas when treated with sodium metal and reacts with acidified potassium dichromate(VI) to give compound **C**. Compound **C** produces an orange precipitate with 2,4-dinitrophenylhydrazine* but has no reaction with Fehling's or Tollens' reagent.

* 2,4-dinitrophenylhydrazine gives an orange precipitate in the presence of aldehydes and ketones.

Part A Empirical formula

Calculate the empirical formula of **A**.

Part B Compound A

Suggest a structure for compound **A**.

Draw the structure using the structure editor and give your answer as a SMILES string.

Part C Compound B

Suggest a structure for compound **B**.

Draw the structure using the structure editor and give your answer as a SMILES string.

Part D A ⟶ B reaction

What kind of reaction is the transformation **A** ⟶ **B**?

Part E Compound C

Suggest a structure for compound **C**.

Draw the structure using the structure editor and give your answer as a SMILES string.

Part F B ⟶ C reaction

What kind of reaction is the transformation **B** ⟶ **C**?

Adapted with permission from UCLES, A-Level Chemistry, June 1992, Paper 1, Question 11.

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Chloro Compound

A Level
C C C

A compound **A**, $C_3H_5O_2Cl$, after boiling for half an hour with aqueous acid, yielded compounds **B**, $C_2H_3O_2Cl$, and **C**, CH_4O. Boiling **A** for half an hour with aqueous sodium hydroxide, yielded compounds **D**, $C_2H_3O_3Na$, and **C**.

When compound **B** was boiled with aqueous sodium hydroxide, and the mixture acidified, it gave **E**, $HOCH_2CO_2H$. Treatment of **E** with aqueous sodium carbonate resulted in a vigorous effervescence as **E** was converted into **D**.

Deduce the structures of compounds **A** to **D** inclusive.

Use the structure editor to generate SMILES strings as your answers.

Part A Compound A

Compound **A** is:

Part B Compound B

Compound **B** is:

Part C Compound C

Compound **C** is:

Part D Compound D

The *anion* of compound **D** is:

Part E E and C reaction

What product would be obtained when compounds **E** and **C** react together?

Adapted with permission from OCSEB A Level Structured Science Scheme, January 1997, Unit C3: Essential Organic Chemistry, Question 3.

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Geraniol

A Level

Geraniol, $C_{10}H_{18}O$, has a rose-like odour and is present in many plants including *Pelargonium odoratissimum*; it has a melting point of $77^{\circ}C$ and a boiling point of $230^{\circ}C$.

It is easily oxidised by acidified potassium dichromate(VI), first to **citral** $C_{10}H_{16}O$, then to **geranic acid**, $C_{10}H_{16}O_2$. Prolonged oxidation of geraniol yields a variety of products, the principal ones being **propanone**, **ethanedioic acid** and **4-oxopentanoic acid**, $CH_3COCH_2CH_2CO_2H$.

One mole of geraniol absorbs two moles of hydrogen when reduced in the presence of a platinum catalyst to give **3,7-dimethyloctanol**; under milder conditions only one mole of hydrogen is absorbed to give **citronellol**, which occurs naturally as an optically active compound but is optically inactive when prepared by reduction of geraniol.

Part A 3,7-dimethyloctanol

Draw the structure of 3,7-dimethyloctanol.

Use the structure editor to generate a SMILES string.

Part B Geraniol

Suggest a likely structure of geraniol.

Use the structure editor to generate a SMILES string.

Part C Citral

Give the structure of citral.

Use the structure editor to generate a SMILES string.

Part D Geranic acid

Give the structure of geranic acid.

Use the structure editor to generate a SMILES string.

Part E Citronellol

Give the structure of citronellol.

Use the structure editor to generate a SMILES string.

Adapted with permission from UCLES, A-Level Chemistry, November 1989, Special Paper, Question 9.

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Perfumery

A Level

The esters of alcohol **J** are used in the perfumery industry. The alcohol exhibits optical isomerism. When treated with hot concentrated sulfuric acid, each optical isomer of **J** produces three substances **K**, **L** and **M**, which are isomers of each other. Only a small quantity of **M** is produced. Both **K** and **L** react with bromine to give 1,2-dibromo-1-phenylpropane, whereas **M** with the same reagent gives 2,3-dibromo-1-phenylpropane.

Part A Compound J

Suggest a structure for alcohol **J**.

Draw the structure using the structure editor and give your answer as a SMILES string.

Part B Compounds K and L

Suggest structures for compounds **K** and **L**.

Draw the structures using the structure editor and give your answer as SMILES strings in the format A, B (space after comma).

Part C Compound M

Suggest a structure for compound **M**.

Draw the structure using the structure editor and give your answer as a SMILES string.

Part D Isomerism K and L

What type of isomerism do compounds **K** and **L** show with respect to each other?

- Structural Isomerism - Chain
- Stereoisomerism - Optical
- Structural Isomerism - Position
- Stereoisomerism - Geometric
- Structural Isomerism - Functional

Part E Isomerism M and L

What type of isomerism do compounds **M** and **L** show with respect to each other?

- Structural Isomerism - Chain
- Stereoisomerism - Geometric
- Structural Isomerism - Position
- Stereoisomerism - Optical
- Structural Isomerism - Functional

Part F J $\longrightarrow$ K, L, M reaction

What type of reaction does alcohol **J** undergo to produce compounds **K**, **L** and **M**?

Adapted with permission from UCLES, A-Level Chemistry, November 1994, Paper 1, Question 11.

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Kevlar

A Level

Kevlar is a polymer that finds many uses due to its high strength despite being relatively light. It is made from two monomers that both contain 1,4-disubstituted benzene rings.

Part A Diamine

One starting material contains a primary amine group in both positions. Use the structure editor to draw this monomer.

Give your answer as a SMILES string.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

Part B Diacyl chloride

The other starting material contains an acyl chloride group in both positions. Use the structure editor to draw this monomer.

Give your answer as a SMILES string.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

Part C Polymerisation type

What type of polymerisation is used to form Kevlar?

Part D Functional group

What functional group forms during the polymerisation?

Created for isaacphysics.org by Andrea Chlebikova

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Teflon

A Level

Teflon is a polymer known for its unreactive and hydrophobic nature. Alongside its high heat resistance, this makes it useful for coating frying pans to give them "non-stick" properties.

Part A Monomer

Teflon contains a long, singly-bonded carbon chain with each carbon bonded to two fluorines. What is the structure of the monomer used to produce Teflon?

Use the structure editor to draw the monomer.

Give your answer as a SMILES string.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

Part B Polymerisation type

What type of polymerisation is used to form Teflon?

Part C Tefzel

Tefzel is another fluorine-based polymer with a singly-bonded carbon chain. Instead of every carbon atom being bonded to two fluorine atoms, after two such carbon atoms there are two carbon atoms bonded to two hydrogen atoms each, followed again by two carbon atoms bonded to two fluorine atoms each, and so on. Tefzel is a *copolymer*, and its production requires two different monomers, one of which is identified in Part A. Give the structure of the other monomer.

Use the structure editor to draw the monomer.

Give your answer as a SMILES string.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

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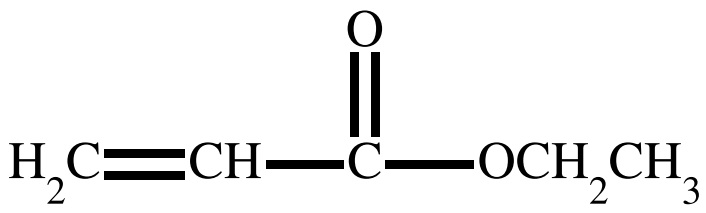
Unsaturated Compounds

A Level

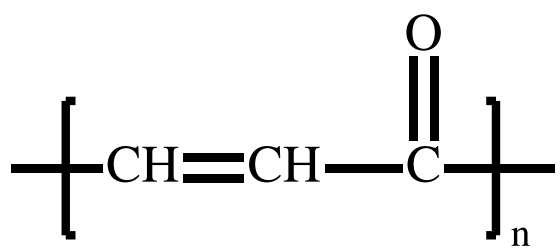
Part A Poly(acrylate)

The sticky substance of adhesive tape can be a poly(acrylate) made from an 'acrylic ester' such as that shown.

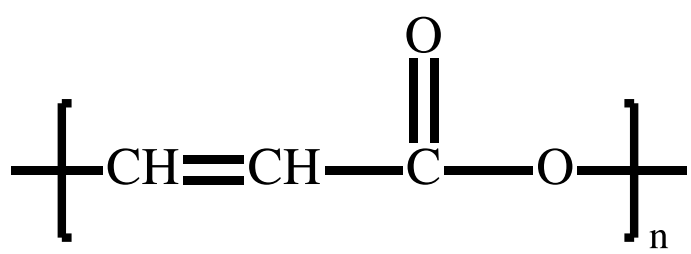


What is the structure of the poly(acrylate) made from this monomer?

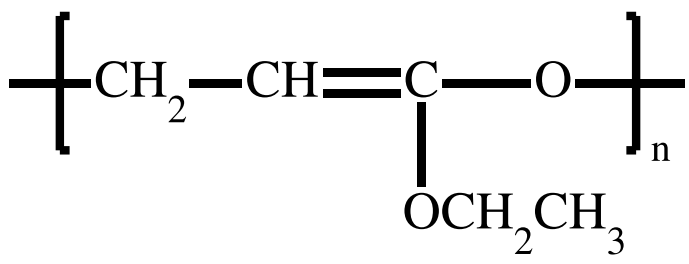
A



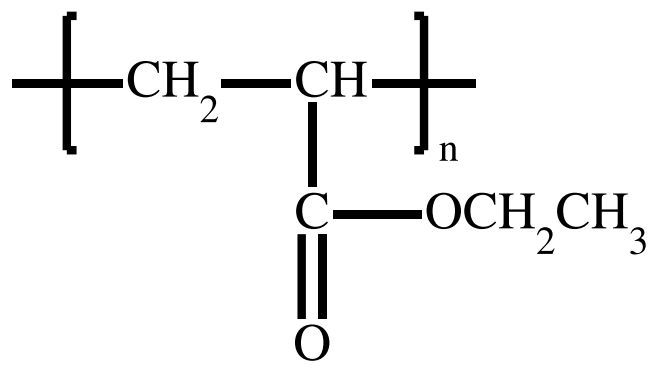
B



C



D



- A
- B
- C
- D

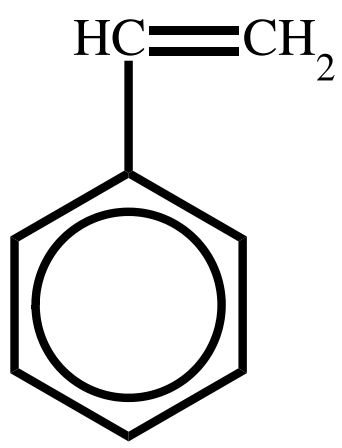
Part B Smoke

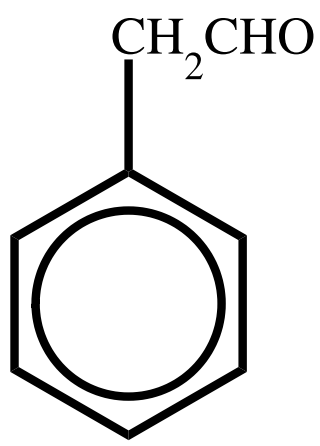
Smoke from a bonfire contains a compound that causes irritation to the eyes. This compound readily decolourises aqueous bromine and produces a precipitate of silver when bubbled into Tollens' reagent.

What is a possible structure of the compound?

A 

B 

C 

D 

- A
- B
- C
- D

Epoxy Resins

A Level

Monomer **A** reacts with the diphenol **B** below to give a polymer as shown in the reaction scheme below:

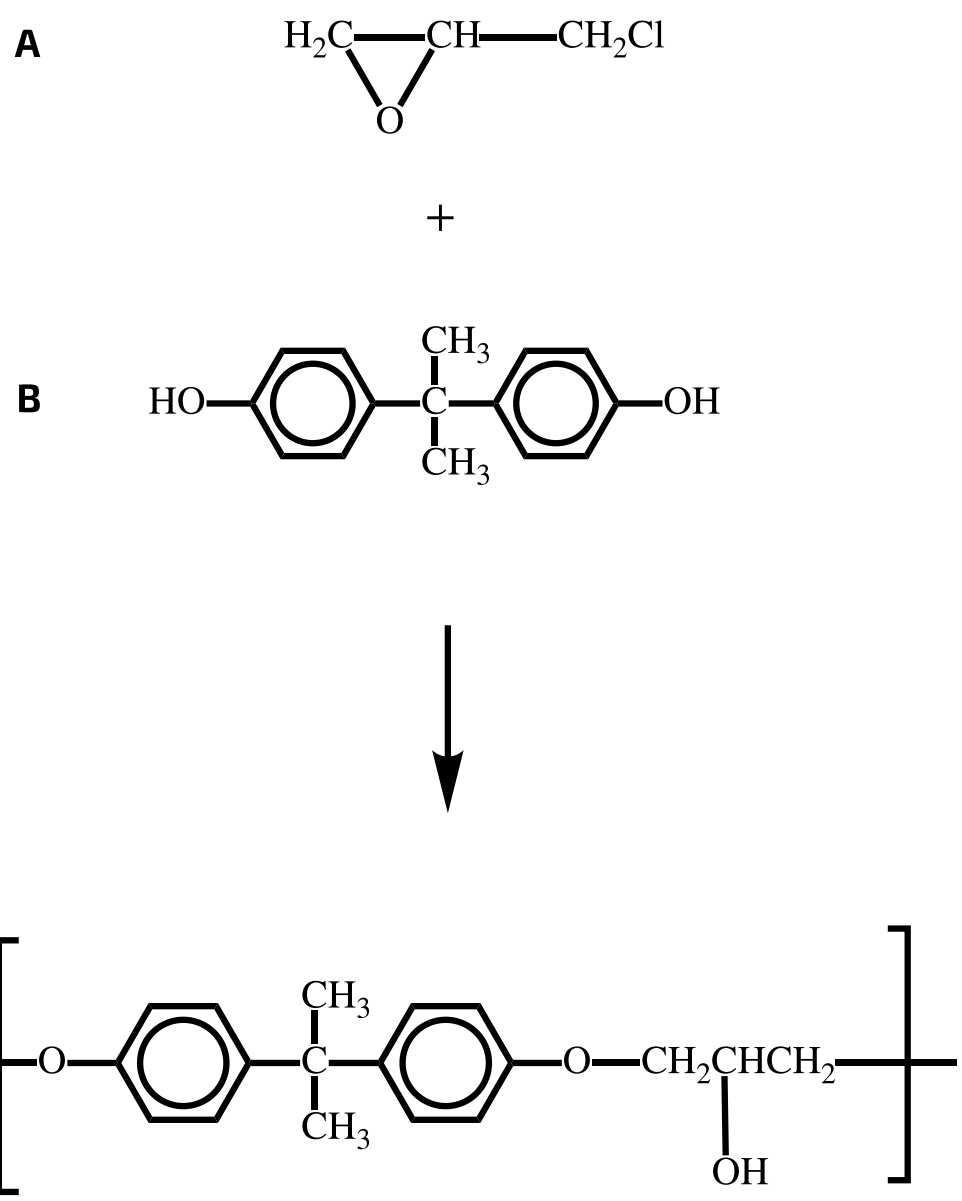


Figure 1: Epoxy resin polymer reaction

Part A Which bonds broken?

From the displayed formula below, state in alphabetical order (e.g. **ab**) which bonds must break for the polymer to be formed.

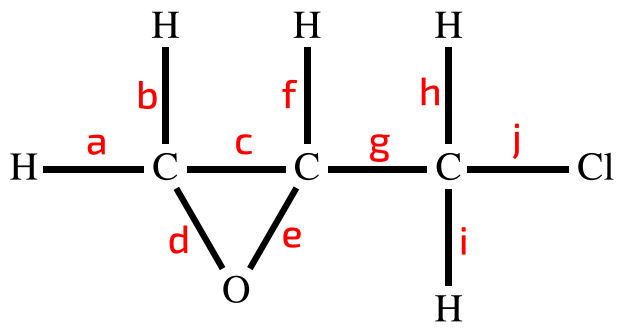


Figure 2: Structure of epoxy monomer unit

Part B What is condensed out?

This is an example of condensation polymerisation.

State which small molecule is condensed out.

Part C How many molecules removed?

How many of these molecules are removed per repeat unit of the polymer?

Adapted with permission from UCLES, A-Level Chemistry, November 1994, Paper 3, Question 4