Stereochemsitry

Question Paper 2

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Stereochemsitry- Organic Chemistry
Booklet	Question Paper 2

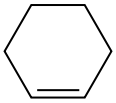
Time Allowed: **55 minutes**

Score: **/46**

Percentage: **/100**

Grade Boundaries:

1. Cyclohexene behaves as a typical alkene.



(a) (i) Give the name of the type of polymerisation that cyclohexene undergoes.

..... [1]

(ii) Draw, using a skeletal formula, a section of the polymer consisting of three repeat units.

[2]

(iii) A sample of cyclohexene is polymerised to a relative molecular mass of 2500, on average.

Calculate the number of complete cyclohexene units that polymerise in each polymer molecule on average. Show your working.

number of cyclohexene units = ... [1]

(b) Cyclohexene will react with bromine at room temperature.

(i) Write the equation for the reaction.

..... [1]

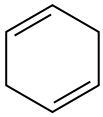
(ii) Show the structure of the product. Ignore any stereochemistry.

[1]

(iii) Give the name of the product.

..... [1]

(c) Cyclohexa-1,4-diene also displays reactivity typical of alkenes. Its structure is shown.



Draw the structures of all possible products of the reaction when one molecule of cyclohexa-1,4-diene completely reacts with two molecules of **hydrogen bromide**.

Ignore any stereochemistry.

[2]

(d) When a **bromine** molecule adds across a C=C double bond the two bromine atoms bond to opposite faces of the molecule.

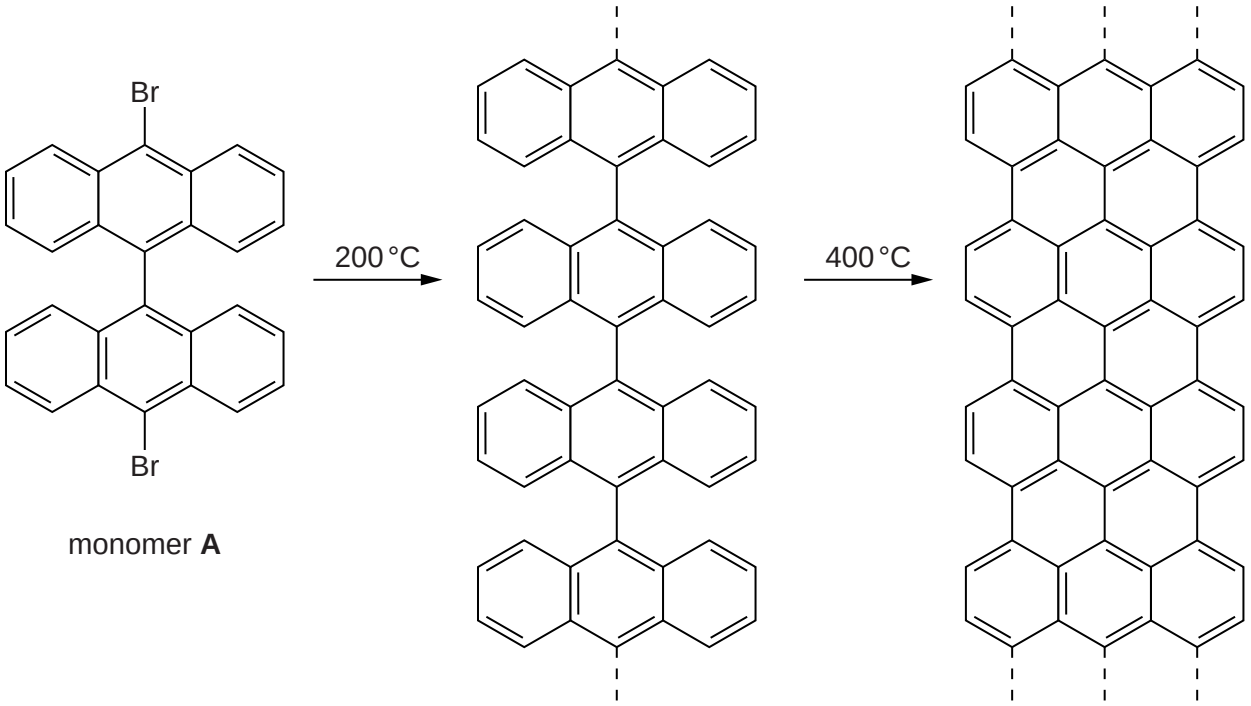
Draw all different possible products when one molecule of cyclohexa-1,4-diene reacts with two molecules of bromine.

Show the six-membered carbon ring as a hexagon in the plane of the paper and use hashed and wedged bonds to bromine to show the stereochemistry.

[3]

(e) A graphene sheet is a layer of graphite.

A recent development has been the synthesis of graphene ribbons (reported in *Nature*, 2010). A reaction scheme is shown.



monomer **A**

2 units of polymer **B**

2 units of polymer **C**

(i) When monomer **A** is polymerised to make **B** there is also another product, **X**.

Give the molecular formula of **X**.

X is ..... [1]

(ii) In the transformation of polymer **B** into polymer **C**, another product, **Y**, is produced.

Give the molecular formula of **Y**.

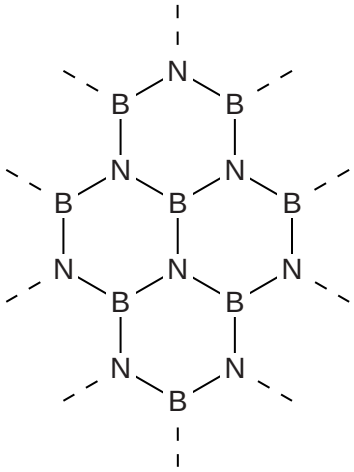
Y is ..... [1]

(iii) Deduce the number of moles of **X** and **Y** produced **per mole of monomer A**.

number of moles of **X** ..... number of moles of **Y** ..... [2]

(iv) Boron nitride, BN, forms sheets similar to graphene except they contain dative covalent bonds as well as covalent bonds.

Add all the possible dative covalent bonds between the atoms shown in the structure below.



[2]

(v) Boron nitride can also form a giant covalent structure in which each atom has four single bonds.

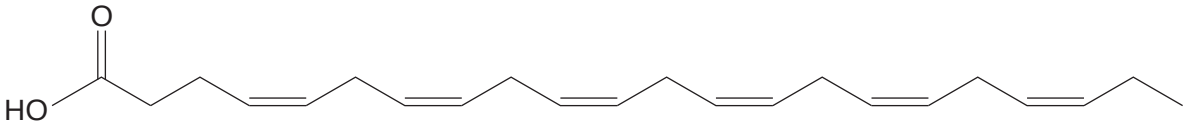
Suggest the name of another substance which has this type of structure.

..... [1]

[Total: 19]

2. Evidence is accumulating that omega-3 oils help to protect us from schizophrenia and depression, and even improve learning and memory. Omega-3 oils are glyceryl esters of omega-3 fatty acids.

One omega-3 fatty acid is cervonic acid.

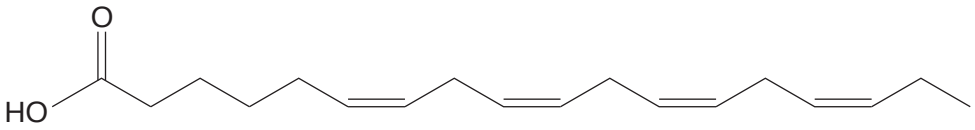


cervonic acid

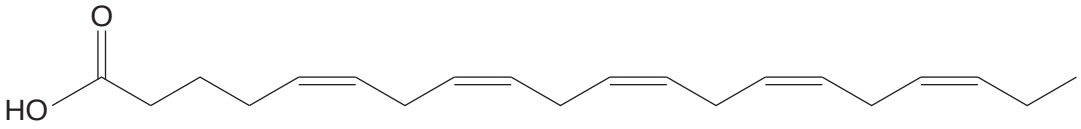
(a) Which configuration of the C=C double bonds is present in this molecule?

.....[1]

The systematic name of cervonic acid (ignoring geometric isomerism) is docosa-4,7,10,13,16,19-hexaenoic acid. "Docosa" indicates that there is a 22-carbon chain. The numbers indicate the carbon atom where the C=C double bonds start, counting from the carboxylic acid (–COOH) functional group. "Hexaen" indicates that there are six double bonds in the chain. Two other omega-3 fatty acids are stearidonic acid and timnodonic acid.



stearidonic acid



timnodonic acid

(b) "Octadeca" indicates that there is an 18-carbon chain. Write down the systematic name for stearidonic acid. Ignore the geometric isomerism.

.....[1]

(c) How many geometric isomers are there of timnodonic acid, including the molecule shown?

.....[1]

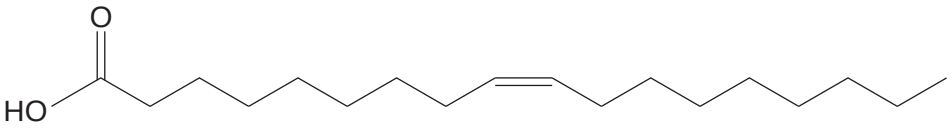
(d) What is the name of the intermolecular force that will operate between the hydrocarbon chains? Ring the correct option. [1]

permanent dipole-permanent dipole

hydrogen bonding

instantaneous dipole-induced dipole

(e) Another fatty acid that is believed to have beneficial health effects is oleic acid.



oleic acid

"Omega" is the **last** letter of the Greek alphabet. By comparing oleic acid, which is **not** an omega-3 acid, with the omega-3 fatty acids in part **(a)**, suggest what "omega-3" relates to in the structure of these oils and fatty acids.

.....

.....[1]

(f) It is possible to differentiate between different types of fatty acids and oils in the laboratory by measuring the degree of unsaturation in the hydrocarbon chains. Halogens react with alkenes in an addition reaction.

Draw the structure of the product when propene reacts with Br_2 and name it systematically.

structure
name

[2]

(g) Table 8.1 shows information about various fatty acids.

Table 8.1

fatty acid	molecular formula	molar mass / g mol^{-1}	number of C=C double bonds
cervonic acid	$C_{22}H_{32}O_2$	328	6
stearidonic acid	$C_{18}H_{28}O_2$	276	4
timnodonic acid	$C_{20}H_{30}O_2$	302	5
oleic acid		282	1

(i) The degree of unsaturation in a fatty acid is commonly expressed by the mass of iodine that reacts with 100.0 g of the acid. Use the information in Table 8.1 to calculate the mass of iodine that would react with 100.0 g of cervonic acid. Use an appropriate number of significant figures in your answer.

.....[2]

(ii) Write the molecular formula of oleic acid in Table 8.1. [1]

(h) The interhalogen compound ICl also reacts with alkenes in an addition reaction. It is commonly used as *Wijs' reagent*, a 0.100 mol dm^{-3} solution of ICl in glacial ethanoic acid. ICl reacts faster with alkenes than the pure halogens and so can be used to determine volumetrically the unsaturation in fatty acids and oils.

(i) Suggest why ICl reacts with alkenes faster than the pure halogens, Cl_2, Br_2 and I_2.

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..... [1]

For the volumetric determination, 30 minutes is required for the reaction between the fatty acid and Wijs' reagent to go to completion. A common solvent for Wijs' reagent and the fatty acids is 1,1,1-trichloroethane.

You are to design an experiment using Wijs' reagent to identify an unknown fatty acid that is one of cervonic acid, stearidonic acid or timnodonic acid. You have 0.100 g of the unknown acid dissolved in 20 cm^3 of 1,1,1-trichloroethane.

You should aim to produce data that is as accurate as possible using conventional laboratory methods.

You should use the information in Table 8.1.

(ii) The first part of the experiment involves adding an accurately known excess of Wijs' reagent to the fatty acid solution. The amount of Wijs' reagent should be at least 25 % greater than the maximum amount that could be required to react with the fatty acid.

Work out a suitable volume of Wijs' reagent to add to the fatty acid solution and explain how you would add this quantity in the laboratory.

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..... [4]

After this reaction is complete, 10 cm^3 of a 2.0 mol dm^{-3} aqueous solution of KI is added to the non-aqueous fatty acid solution to convert the excess ICl to iodine, I_2.

$$ICl + KI \longrightarrow I_2 + KCl$$

This quantity of KI(aq) should be a large excess. Next, 100 cm^3 of deionised water is added to the mixture. The iodine is distributed between the aqueous and non-aqueous phases.

(iii) The second part of the experiment involves determining the amount of iodine generated by the excess ICl. This is done using a 0.100 mol dm^{-3} solution of sodium thiosulfate, $Na_2S_2O_3$.

$$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$$

The whole mixture is reacted with sodium thiosulfate in one batch since the iodine is distributed between the phases. In this reaction considerable shaking is needed to ensure adequate mixing of the phases.

Write out a method for both parts of the experiment that a fellow student could follow. The original fatty acid solution comes in a small sample bottle that is nearly full. Include safety considerations.

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(iv) Explain how you would work out the identity of the fatty acid given the volume of thiosulfate obtained from the experiment.

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.....[4]

[Total: 27]