Additions and Eliminations

Question Paper

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Additions & eliminations - Organic Chemistry
Booklet	Question Paper

Time Allowed: **72 minutes**

Score: **/60**

Percentage: **/100**

Grade Boundaries:

1. This question is about halogenoalkanes.

(a) Propane is treated with bromine while irradiated with ultraviolet light, producing isomers of $C_3H_6Br_2$.

(i) Write a chemical equation using molecular formulae for the preparation of $C_3H_6Br_2$ by this reaction.

..... [1]

(ii) Name the type of reaction.

..... [1]

(iii) Draw 3D diagrams to show the optical isomers of 1,2-dibromopropane.

[2]

(iv) State how many different carbon-atom environments there are in

1,2-dibromopropane (considering one enantiomer) ..... ,

2,2-dibromopropane ..... . [2]

(b) 1,2-dibromopropane may be converted to propane-1,2-diol.

State the reagent and solvent used for this reaction.

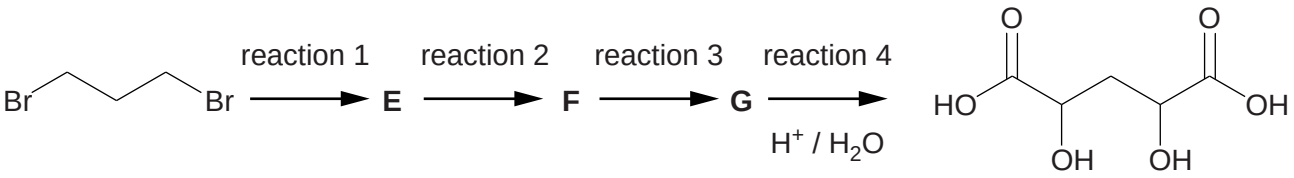
reagent .....

solvent ..... [2]

(c) Draw the structure of the product formed when 2,2-dibromopropane is reacted under the same set of conditions as those in part **(b)**.

[1]

(d) 1,3-dibromopropane is the starting point for a four-step reaction sequence which produces 2,4-dihydroxypentane-1,5-dioic acid. The four reactions are shown.



Compound **F** has the molecular formula $C_3H_4O_2$. If it is tested with Tollens' reagent, a silver mirror is produced.

(i) What functional group is present in **F**?

.....

[1]

(ii) What change in functional group level did **F** undergo when it reacted with Tollens' reagent?

from functional group level ..... to .....

[1]

(iii) When preparing **F** from **E** it is important that the product is distilled off rather than continually refluxed.

State which unwanted product is avoided by distilling off compound **F**.

.....

[1]

(iv) 9.0 g of 1,3-dibromopropane was used by experimenters who converted it into **F** with an overall yield of 67%. Calculate the mass of **F** that was obtained.

mass of **F** = ... g [2]

(v) Draw the structures of **E** and **F**.

structure of **E**	structure of **F**

[2]

(vi) **G** is converted into the final product by reaction with dilute acid. Suggest the structure of **G**.

[1]

(e) 1,3-dibromopropane can undergo an elimination reaction to form compound **H**.
H has the molecular formula C_3H_4 and is not cyclic.

(i) Suggest the structure of **H**.

[1]

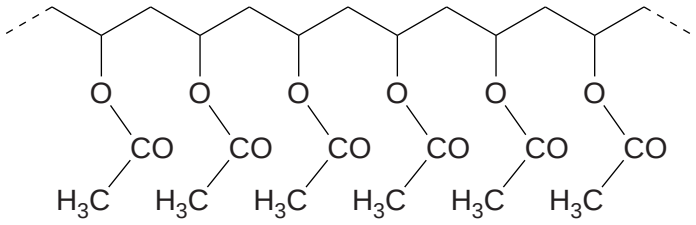
(ii) **H** can isomerise into **I**, which has three different carbon environments.

Draw the structure of **I**.

[1]

[Total: 19]

2. **(a)** Polyvinyl acetate (PVA) is produced on a large scale for use in glues.



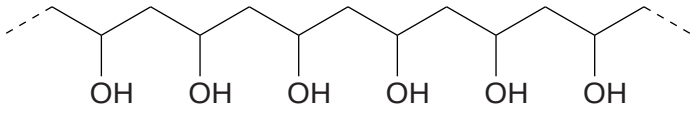
PVA

(i) Circle one repeat unit of the polymer. [1]

(ii) Draw the structure of the monomer used to make PVA.

[1]

(iii) Complete hydrolysis of PVA results in a polymer **Q** and a second product, **R**.



Q

Identify **R**.

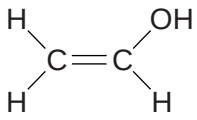
[1]

(iv) Polymer **Q** is unusual in that it dissolves in water. Suggest why it dissolves in water.

.....

..... [1]

(v) A logical monomer to make **Q** is shown.

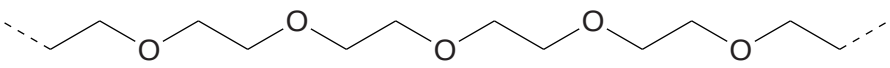


In fact this molecule is not stable. Two isomers of this molecule, **S** and **T**, can be isolated. Draw the structures of **S** and **T**.

structure of **S** structure of **T**

[2]

(vi) One of the isomers, **S** or **T**, is the monomer for the polymer PEG.



PEG

State the functional group level of the carbon atoms in PEG and explain how this identifies which of the isomers, **S** or **T**, is the monomer for PEG.

functional group level .....

explanation .....

.....

..... [2]

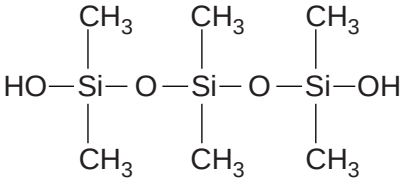
(b) **(i)** The complete hydrolysis of dimethyldichlorosilane, $(H_3C)_2SiCl_2$ gives two products, **V**, which contains silicon, and **W**, which does not. The Si−C bond is stable towards hydrolysis. **V** has a molar mass of 92 g mol^{-1}.

Draw the structure of **V** and give the formula of **W**.

structure of **V** formula of **W** .....

[2]

(ii) Three molecules of **V** can combine to form the molecule shown.



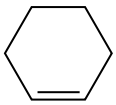
Five molecules of **V** can combine to form a molecule with a relative molecular mass of 370, where all the silicon atoms are in equivalent environments.

Suggest the structure of this molecule.

[1]

[Total: 11]

3. 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]

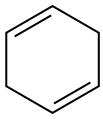
(ii) Show the structure of the product. Ignore any stereochemistry.

[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]

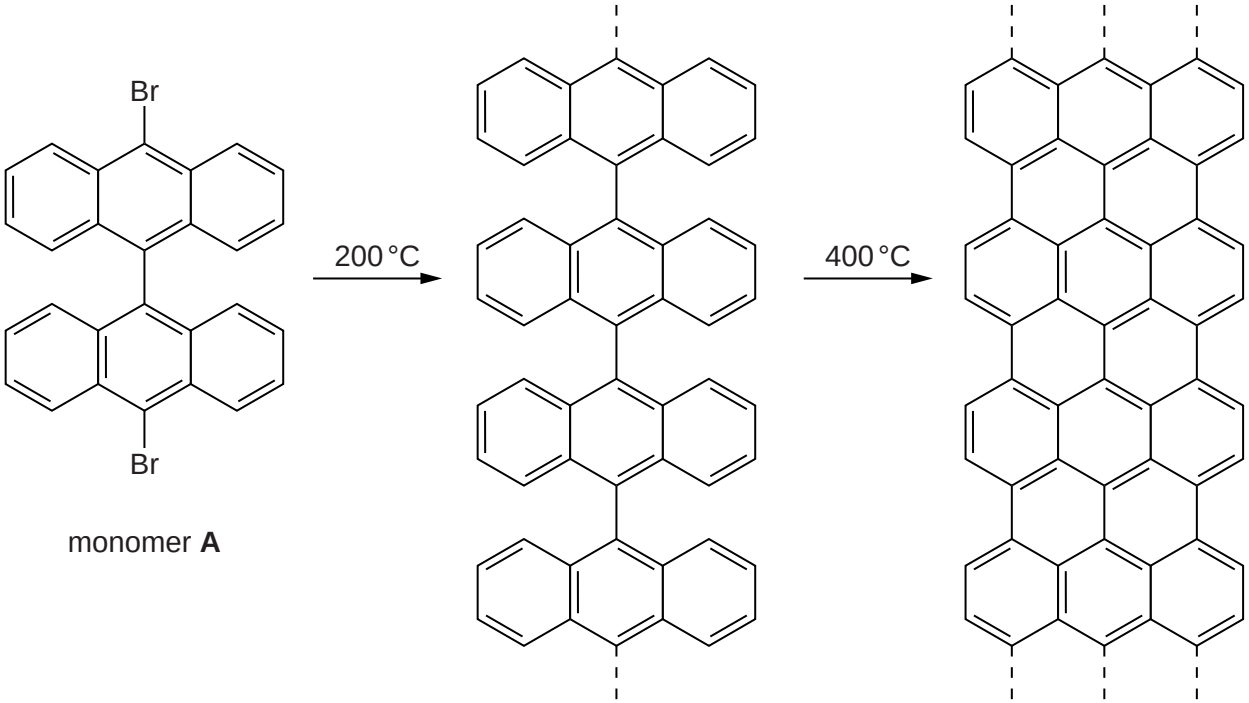
(d) When a **bromine** molecule adds across a C=C double bond the two bromine atoms bond to opposite faces of the molecule.

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.

(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**.

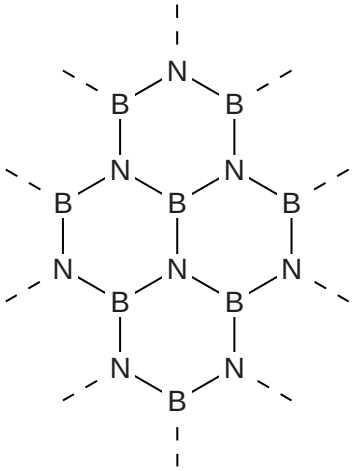
Y is ..... [1]

(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]

4 Chemists have recently found a way of making the strong, light-weight and thermally stable polymer, Kevlar®, to be antibacterial (reported in *Industrial & Engineering Chemistry Research*, 2008). This was achieved by coating it with another polymer, a fragment of which is shown in Fig. 4.1.

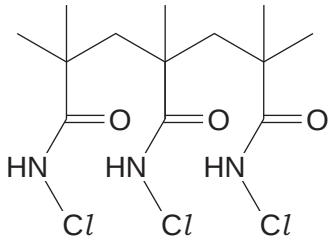


Fig. 4.1

(a) Draw the repeat unit of the polymer structure shown in Fig. 4.1.

[1]

(b) The polymer shown in Fig. 4.1 is made by the following reactions:

reaction 1	an addition polymerisation reaction of a monomer known as MAA
reaction 2	the substitution of a hydrogen atom in the polymer with a chlorine atom using bleach

Draw the structure of the monomer MAA.

[1]

(c) Not all the nitrogen atoms in the polymer end up bonded to a chlorine atom. The quantity of chlorine actually present in the polymer can be determined using **reactions 3**, **4** and **5**.

A known mass of polymer (written as XCONH–C*l*) is hydrolysed to convert the chlorine content of the polymer to chloric(I) acid, HOC*l*:

reaction 3 $XCONH–Cl + H_2O \longrightarrow XCONH_2 + HOCl$
(where X = remainder of polymer)

The chlorine content is then 'converted' to iodine:

reaction 4 $HOCl + 2KI + H^+ \longrightarrow I_2 + KCl + H_2O + K^+$

The quantity of iodine is determined using a titration with sodium thiosulfate:

reaction 5 $I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$

(i) State the oxidation number of the chlorine in $HOCl$.

.....[1]

(ii) Given that **reaction 3** is a hydrolysis reaction, state the oxidation number of chlorine in the polymer.

.....[1]

(iii) Write ionic half equations for the oxidation and reduction processes in **reaction 4**.

oxidation .....

reduction .....[2]

In the analysis of a sample of polymer, 1.00 g of the polymer was hydrolysed (**reaction 3**).

The resulting mixture was reacted with excess acidified potassium iodide (**reaction 4**) and then made up to 100 cm^3 with distilled water.

10.0 cm^3 of this solution reacted with exactly 12.50 cm^3 of sodium thiosulfate solution of concentration 0.100 mol dm^{-3} (**reaction 5**).

(iv) Name a suitable indicator for this titration.

..... [1]

(v) Determine the amount (in moles) of sodium thiosulfate used in the titration.

..... mol [1]

(vi) Determine the amount (in moles) of iodine, I_2, in the titration.

..... mol [1]

(vii) Determine the mass of chlorine present in the sample of polymer.

.....[2]

[Total: 11]