1 A reaction mechanism shows the individual steps that take place during a reaction.

(a) Methane reacts with bromine in the presence of ultraviolet radiation to form several products. Two of these products are bromomethane and hydrogen bromide.

(i) Write an equation for the reaction between methane and bromine to make bromomethane and hydrogen bromide.

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

(ii) Name one other bromine-containing organic product which is formed when methane reacts with bromine.

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

(iii) The mechanism for this reaction is called radical substitution.

Describe the mechanism for the radical substitution of methane by bromine to make bromomethane.

Use the mechanism to suggest why a small amount of ethane is also formed.

In your answer, you should organise your answer and use the correct technical terms.

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..... **[7]**

(b) The 'curly arrows' model is used in reaction mechanisms to show the movement of electron pairs during chemical reactions.

Choose a reaction mechanism that you have studied involving the curly arrow model.

Name and describe your chosen reaction mechanism.

In your answer, include:

- an example of the reaction with the chosen mechanism,
- the type of bond fission that occurs,
- relevant dipoles.

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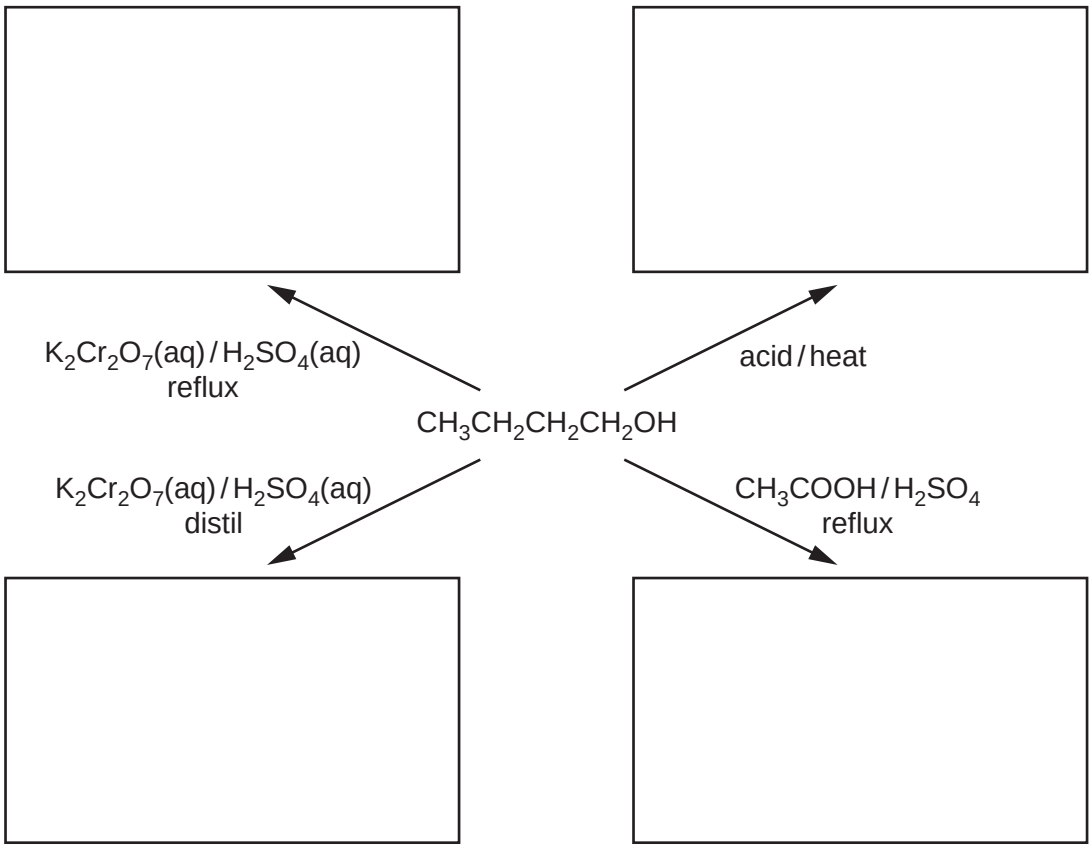
[6]

[Total: 15]

2 Alcohols are used in the industrial production of many organic compounds.

(a) Complete the flowchart below to show the organic product formed in each of the reactions of butan-1-ol.



[4]

(b) Butan-1-ol can be prepared by the alkaline hydrolysis of 1-iodobutane.

$$CH_3CH_2CH_2CH_2I + OH^- \rightarrow CH_3CH_2CH_2CH_2OH + I^-$$

The reaction mixture is gently heated for 20 minutes.

(i) The curly arrow model is used in reaction mechanisms to show the movement of electron pairs.

Use the curly arrow model to outline the mechanism for the alkaline hydrolysis of 1-iodobutane.

In your answer, include the name of the mechanism, the type of bond fission and relevant dipoles.

name of mechanism .....

type of bond fission ..... **[5]**

(ii) A student decides to prepare butan-1-ol by the alkaline hydrolysis of 1-chlorobutane.

Suggest, with reasons, any change in the conditions from those used in the alkaline hydrolysis of 1-iodobutane.

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

[Total: 11]

3 A student carried out an investigation to compare the rates of hydrolysis of 1-iodopropane and 1-bromopropane. The student heated hot aqueous sodium hydroxide with each halogenoalkane and found that 1-iodopropane was hydrolysed faster.

The equation for the reaction with 1-iodopropane is shown below.

$$CH_3CH_2CH_2I + OH^- \rightarrow CH_3CH_2CH_2OH + I^-$$

(a) (Outline the mechanism for this hydrolysis of 1-iodopropane.

Show curly arrows and relevant dipoles.

[3]

(ii) State the name of this type of mechanism.

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

(b) Explain why 1-iodopropane is hydrolysed faster than 1-bromopropane.

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

(c) Chlorofluoroalkanes, CFCs, were developed from fluoroalkanes and were used in aerosols and as refrigerants. Under the Montreal Protocol, CFCs are now largely banned because of their ozone-depleting properties. CFCs have now been replaced in many applications.

Suggest **two** reasons why there is still concern about ozone depletion.

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

(d) Fluoroalkenes are used to make polymers. For example, PVF, $(CH_2CHF)_n$, is used to make non-flammable interiors of aircraft.

(i) Draw **two** repeat units of the polymer PVF showing all bonds.

[1]

(ii) Draw the structure of the monomer of PVF.

[1]

(e) Once polymers have been used, they become waste.

Outline **two** ways that waste polymers are processed usefully, rather than just dumped in landfill sites.

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

[Total: 12]

4 Crude oil is a source of alkanes.

(a) Fractional distillation is used to separate useful hydrocarbons found in crude oil.

Explain, in terms of intermolecular forces, how fractional distillation works.

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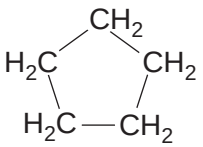
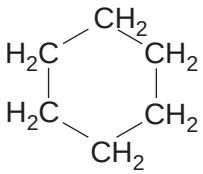
..... **[2]**

(b) The petroleum industry processes straight-chained alkanes into cycloalkanes such as cyclopentane and cyclohexane.



cyclopentane



cyclohexane

(i) Deduce the general formula of a **cycloalkane**.

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

(ii) Construct the equation to show the formation of cyclohexane from hexane.

[1]

(iii) Suggest why the petroleum industry processes hexane into cyclohexane.

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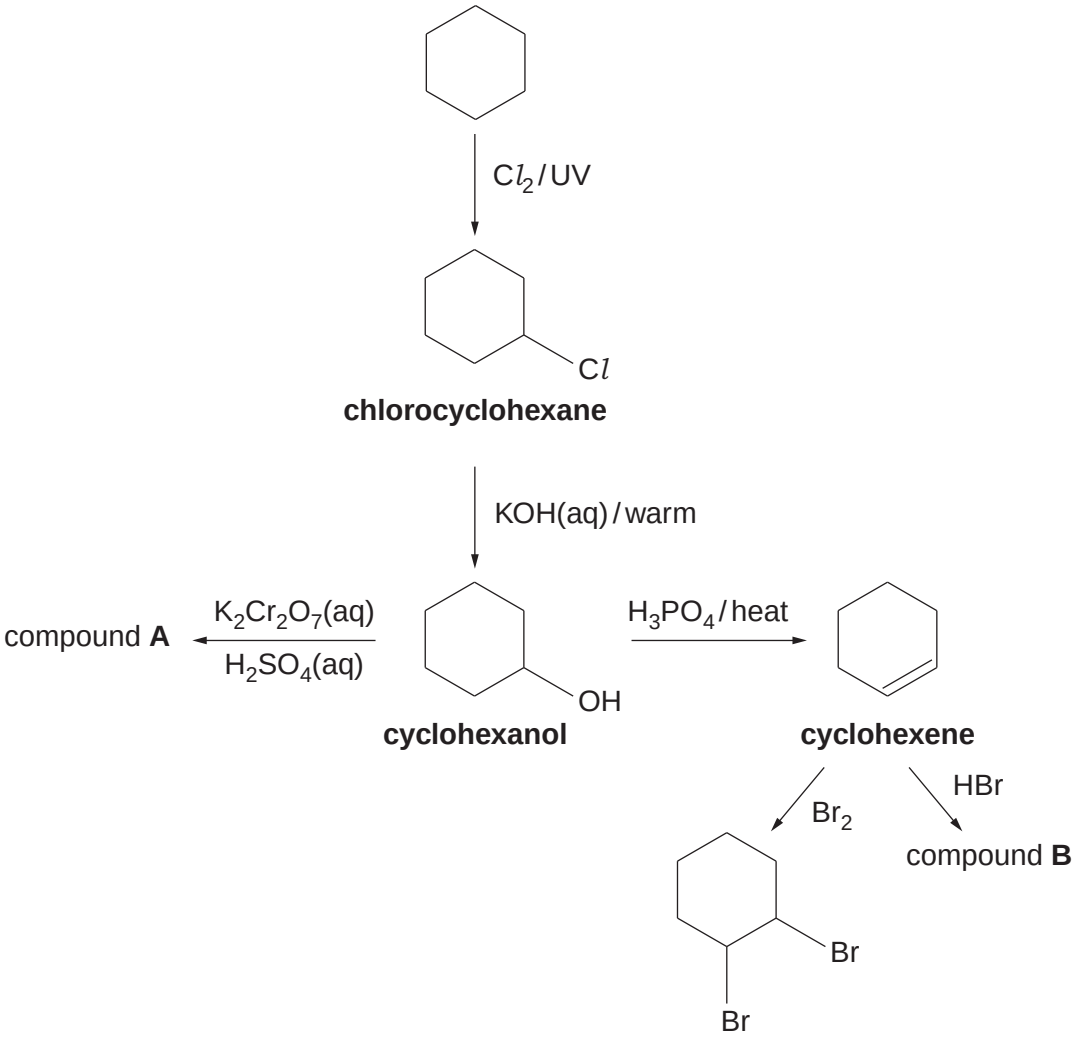
..... **[1]**

(c) The flowchart below shows some of the organic compounds that could be made starting from cyclohexane.



(i) Explain why cyclohexene is described as *unsaturated* and as a *hydrocarbon*.

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

(ii) The reaction between chlorine and cyclohexane is an example of radical substitution.

State **one** problem of using this reaction to prepare a sample of chlorocyclohexane.

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

(iii) The formation of cyclohexanol from chlorocyclohexane involves the reaction of a nucleophile, the hydroxide ion.

Suggest what feature of the hydroxide ion makes it able to act as a nucleophile.

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

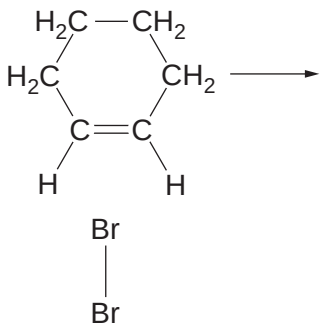
(iv) Using the flowchart, draw the structures of compound **A** and compound **B**.

compound **A**	compound **B**

[2]

(v) Describe, using the 'curly arrow model', the mechanism for the reaction between Br_2 and cyclohexene.

Show relevant dipoles and charges.



[4]

[Total: 15]