1 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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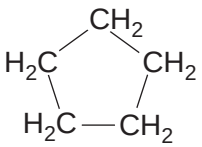
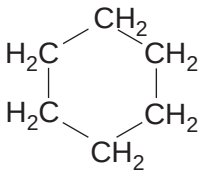
..... **[2]**

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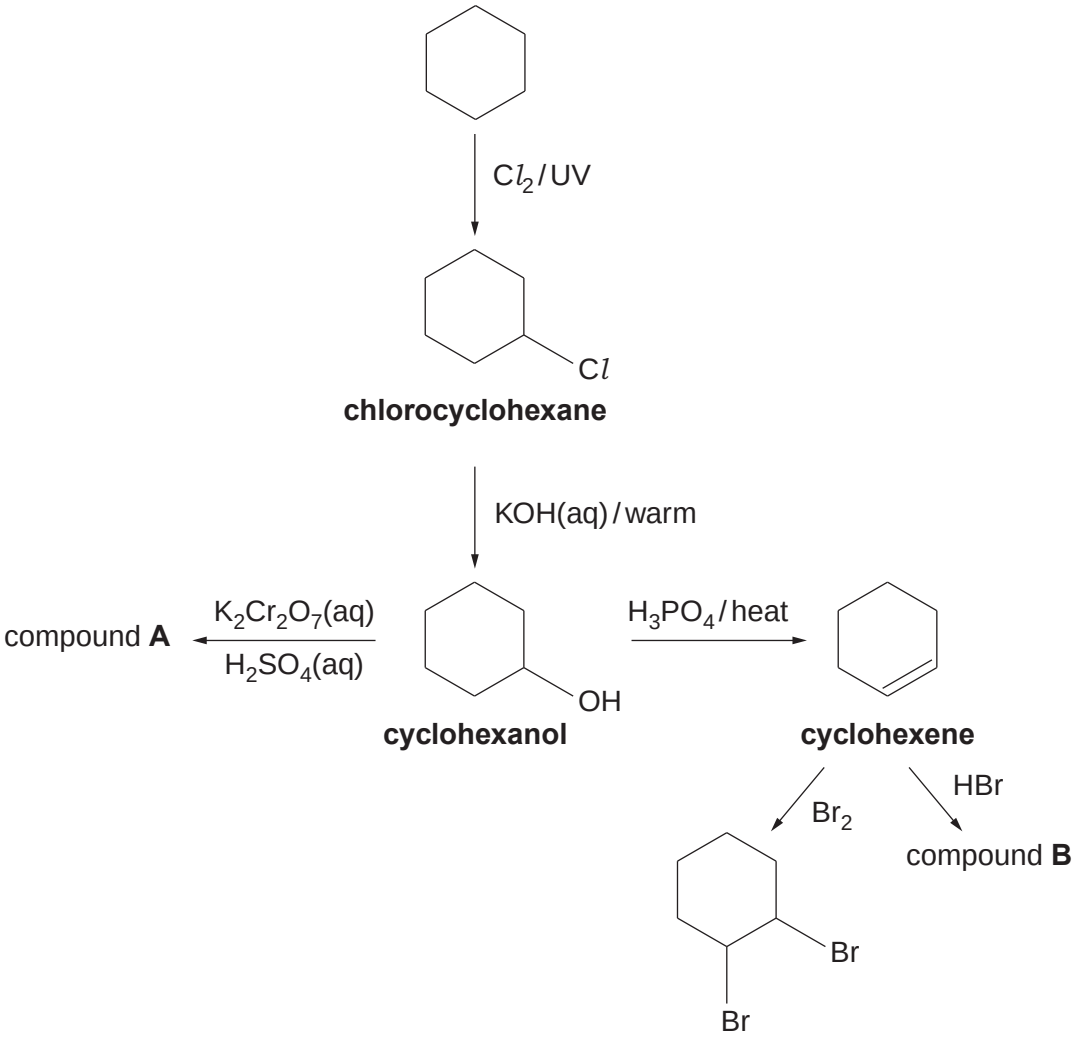
..... **[1]**

(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]**

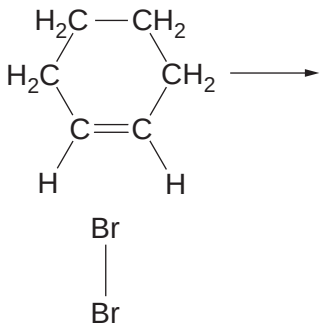
(iv) Using the flowchart, draw the structures of compound **A** and compound **B**.

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]

2 Biofuels such as bioethanol and biodiesel are increasingly being used as an alternative to fossil fuels to provide energy.

(a) Describe, with the aid of an equation, how bioethanol is manufactured by fermentation.

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

(b) Biodiesel is obtained from plant oils. The manufacture involves several stages, all of which have a high energy requirement.

Biodiesel is often described as being 'carbon-neutral' because:

- plants convert atmospheric carbon dioxide into carbon compounds
- on burning biodiesel this carbon dioxide is returned to the atmosphere.

(i) Construct an equation to show the complete combustion of biodiesel.

Assume that the molecular formula of the biodiesel is $C_{15}H_{30}O_2$.

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

(ii) Suggest why biodiesel is **not** completely carbon-neutral.

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

(c) Many scientists suggest that society should use more biofuels rather than fossil fuels to provide energy. Other scientists are worried that biofuels will need large areas of land to grow suitable crops.

Suggest **disadvantages** or **advantages**, other than being carbon-neutral, of using more biofuels.

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

(d) Unsaturated compounds in plant oils can also be used to make margarine.

Describe how.

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

(e) Part of the structure of an unsaturated compound in plant oils is shown below:

$$-CH_2CH_2CH=CHCH_2CH_2-$$

(i) Draw the displayed formula of the *Z* isomer of this part of the structure.

[1]

(ii) Explain why this part of the structure can have an *E* and a *Z* isomer.

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

[Total: 14]

3 Kerosene is used as a fuel for aeroplane engines.

(a) Kerosene is obtained from crude oil.

Name the process used to obtain kerosene from crude oil **and** explain why the process works.

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

(b) Some of the hydrocarbons in kerosene have the formula $C_{10}H_{22}$.

(i) What is the name of the straight chain hydrocarbon with the formula $C_{10}H_{22}$?

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

(ii) Draw the skeletal formula of one branched chain isomer with the formula $C_{10}H_{22}$.

[1]

(iii) Explain why the straight chain isomer of $C_{10}H_{22}$ has a higher boiling point than any of its branched chain structural isomers.

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

(iv) Explain why the straight chain isomer of $C_{10}H_{22}$ is converted by the petroleum industry into its branched chain isomers.

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

(c) When kerosene burns in an aeroplane engine very little carbon monoxide, CO, is formed but a significant amount of nitrogen monoxide, NO, is formed.

(i) Construct the equation to show the **complete** combustion of $C_{10}H_{22}$.

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

(ii) Suggest, with the aid of an equation, how NO is formed within an aeroplane engine.

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

(d) NO is a radical and contributes towards ozone depletion in the stratosphere.

(i) What is a *radical*?

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

(ii) One of the processes leading to the breakdown of ozone in the stratosphere can be represented by the following two equations.

$$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$$

$$NO_2(g) + O(g) \rightarrow NO(g) + O_2(g)$$

What is the role of the NO in this process?

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

(iii) Ozone in the stratosphere is broken down to make O_2 and O.

Describe and explain how the concentration of ozone in the stratosphere is maintained.

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

(iv) Why is it important to life on the Earth's surface that the concentration of ozone in the stratosphere is maintained?

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

[Total: 15]

4 This question is about halogenated hydrocarbons.

(a) Halogenoalkanes undergo nucleophilic substitution reactions with ammonia to form amines. Amines contain the $-NH_2$ functional group.

For example, 1-bromopropane reacts with ammonia to form propylamine, $CH_3CH_2CH_2NH_2$.

$$CH_3CH_2CH_2Br + 2NH_3 \longrightarrow CH_3CH_2CH_2NH_2 + NH_4Br$$

(i) Iodoethane is reacted with ammonia.

Write an equation for this reaction.

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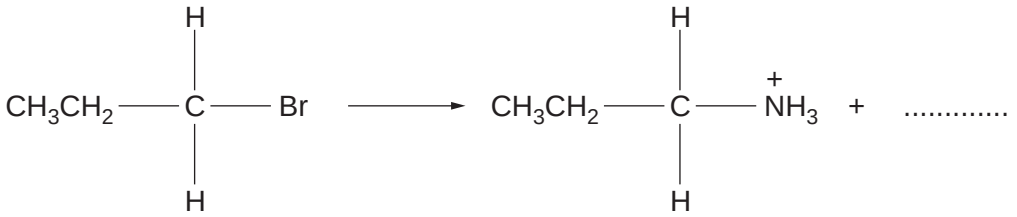
(ii) The first step in the mechanism of the reaction between $CH_3CH_2CH_2Br$ and NH_3 is shown below. It is incomplete.



Complete the mechanism.

Include relevant dipoles, lone pairs, curly arrows and the missing product. **[3]**

(b) A student investigates the rate of hydrolysis of six halogenoalkanes.

The student mixes 5 cm^3 of ethanol with five drops of halogenoalkane. This mixture is warmed to 50 °C in a water bath. The student adds 5 cm^3 of aqueous silver nitrate, also heated to 50 °C, to the halogenoalkane. The time taken for a precipitate to form is recorded in a results table.

The student repeats the whole experiment at 60 °C instead of 50 °C.

halogenoalkane	**time taken for a precipitate to form / s**	
	at 50 °C	**at 60 °C**
$CH_3CH_2CH_2CH_2Cl$	243	121
$CH_3CH_2CH_2CH_2Br$	121	63
$CH_3CH_2CH_2CH_2I$	40	19
$CH_3CH_2CHBrCH_3$	89	42
$(CH_3)_2CHCH_2Br$	110	55
$(CH_3)_3CBr$	44	21

Describe and explain the factors that affect the rate of hydrolysis of halogenoalkanes.

Include ideas about
- the halogen in the halogenoalkanes
- the groups attached to the carbon of the carbon–halogen bond (the type of halogenoalkane)
- the temperature of the hydrolysis.

In your answer you should link the evidence with your explanation.

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(c) Poly(tetrafluoroethene), PTFE, and poly(chloroethene), PVC, are halogenated plastics.

(i) Write an equation, using displayed formulae, for the reaction to form PTFE from its monomer.

[3]

(ii) The combustion of waste polymers can be used for energy production.

What problem is caused by disposing of PTFE and PVC in this way?

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[Total: 16]