1 Alkenes and cycloalkanes have the same general formula, but react very differently with halogens.

(a) Give the general formula that applies to both alkenes and cycloalkanes.

(1)

(b) Using structural formulae, complete the overall equation for the reaction of an alkene of your own choice, containing fewer than four carbon atoms, with liquid bromine.

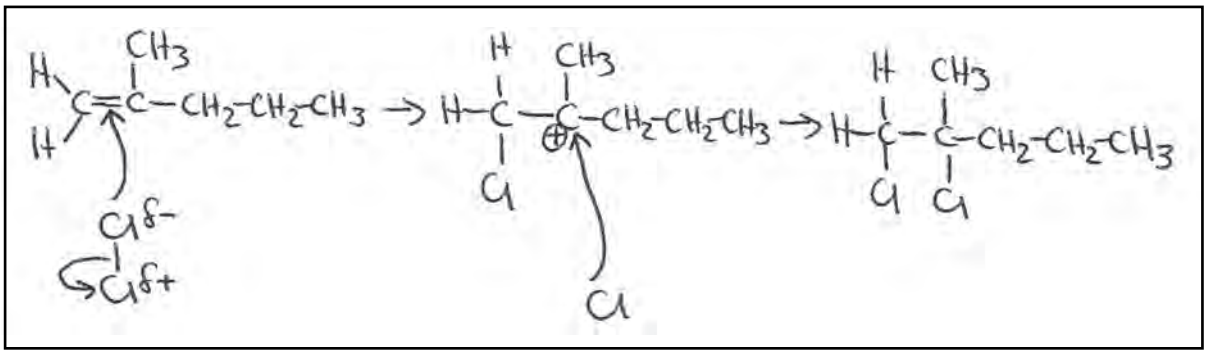
Name the product.

(3)

$+ \quad Br_2 \quad \rightarrow$

Name: .....

*(c) An example of an alkene with six carbon atoms is 2-methylpent-1-ene. It reacts with chlorine by means of an electrophilic addition reaction. The diagram below shows a student's attempt at drawing the mechanism for this reaction.



(i) Identify the three errors in this student's drawing of the mechanism.

(3)

Error 1.....

.....

Error 2.....

.....

Error 3.....

.....

(ii) The structure of the carbocation intermediate is correctly drawn. Explain why the positive charge is on the carbon atom shown.

(1)

.....

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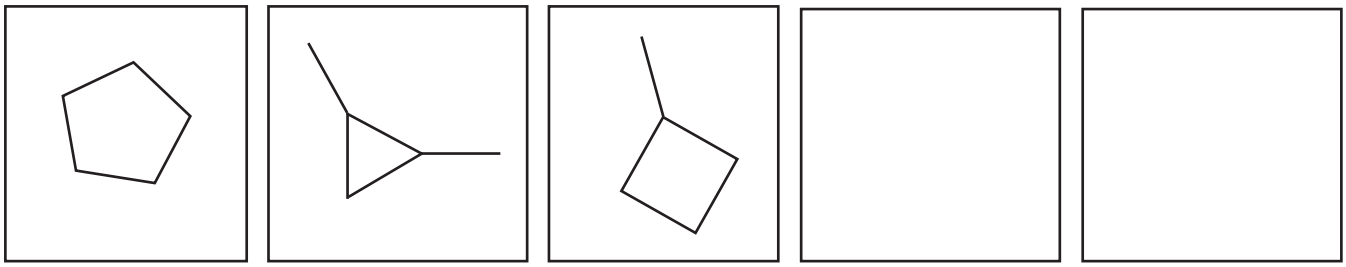
.....

(d) There are five possible cycloalkanes, each containing five carbon atoms. Three of the isomers are given below. Complete the other two boxes, by adding the skeletal formulae of the other two structural isomers.

(2)



(e) Define the term **structural isomerism**.

(1)

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.....

.....

(f) Another example of a cycloalkane is cyclobutane. This compound, like other cycloalkanes, can also react with chlorine.

The overall reaction of cyclobutane with chlorine is as follows:

$$C_4H_8 + Cl_2 \rightarrow C_4H_7Cl + HCl$$

(i) This reaction can occur at room temperature and pressure.
What further condition is needed for this reaction to take place?

(1)

.....

(ii) Using the appropriate arrows, complete the equation for the initiation step of the reaction mechanism for the reaction of chlorine with cyclobutane.

(2)

Cl — Cl $\rightarrow$

(iii) Using molecular formulae, write equations for the **two** propagation steps of this mechanism.

(2)

First propagation step:

Second propagation step:

(iv) Name the type of bond fission which occurs in these propagation steps.

(1)

.....

(v) There are also termination steps in this mechanism. Explain how these differ from the other steps in the mechanism and why these result in the reaction ending.

(2)

.....

.....

.....

.....

(g) If the reaction with cyclobutane is carried out with an excess of chlorine, how are the products of the reaction affected?

(1)

.....

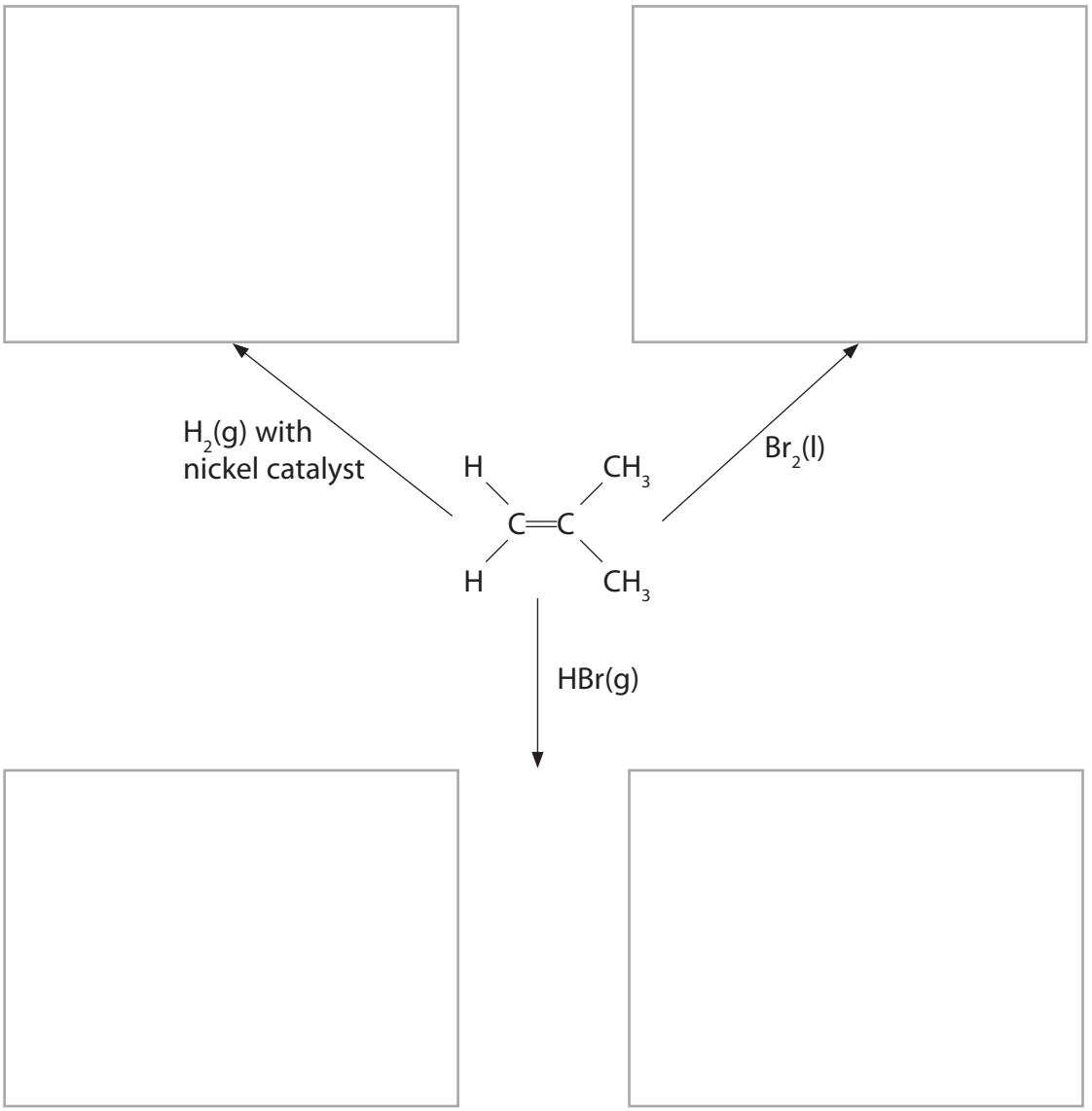
.....

(Total for Question = 20 marks)

2 Alkenes are unsaturated hydrocarbons. They are used in the industrial production of many organic compounds.

(a) Add structural formulae to the flowchart below to show the organic product formed in each addition reaction of 2-methylpropene.

(4)



mixture of isomers

(b) Suggest a mechanism for the reaction of 2-methylpropene with bromine, $Br_2(l)$. Include curly arrows.

(3)

(c) Ethene, C_2H_4, was prepared from ethanol, C_2H_5OH, by the following reaction

$$C_2H_5OH \rightarrow C_2H_4 + H_2O$$

A chemist reacted 9.2 g of ethanol, C_2H_5OH, and obtained 4.2 g of ethene.

Calculate the percentage yield of ethene in the reaction.

(2)

(Total for Question = 9 marks)

3 This question is about ethene and related compounds.

(a) One way to manufacture ethene is by cracking hydrocarbon molecules such as liquid paraffin.

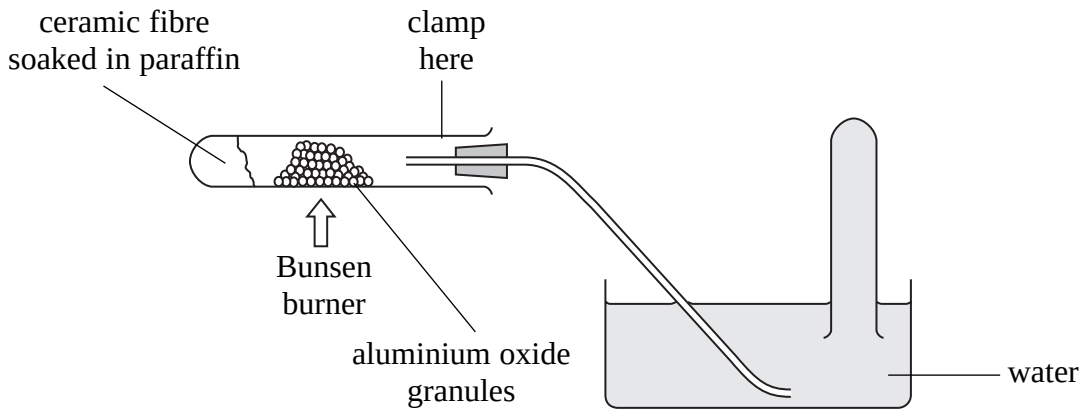
(i) Name a raw material from which liquid paraffin can be obtained.

(1)

(ii) Describe what is meant by **cracking**.

(2)

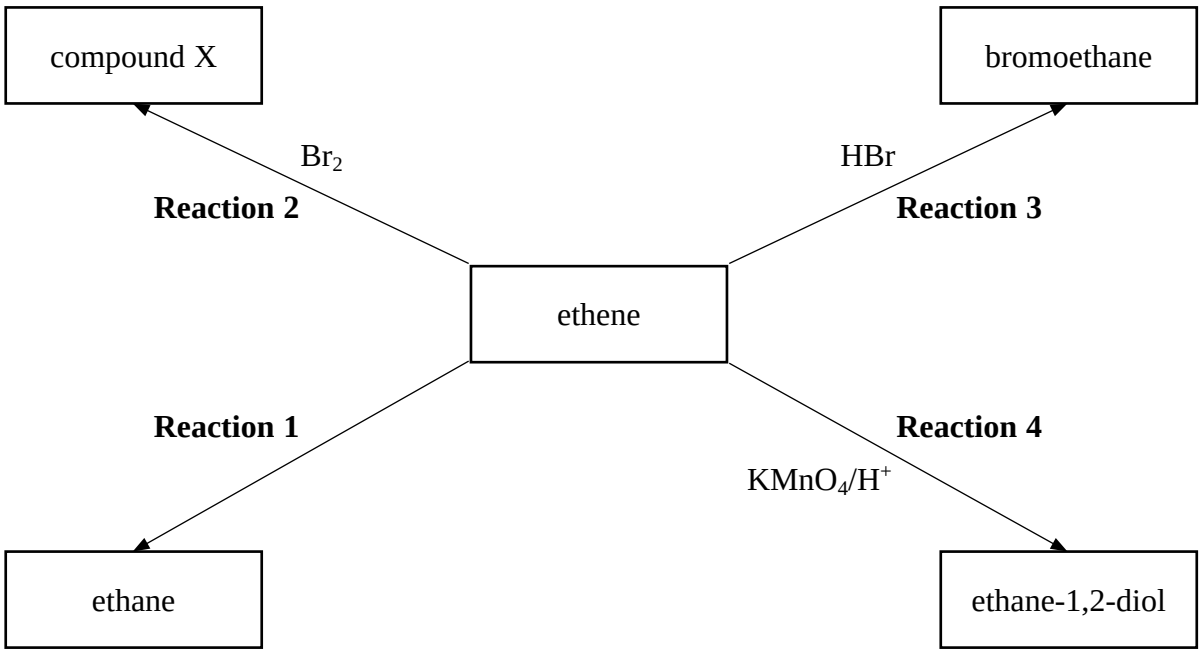
(iii) It was proposed to set up the apparatus below on a laboratory bench, in order to crack paraffin.



State TWO of the **risks** of using the apparatus in this way and suggest how you would amend the set-up to minimise each risk.

(4)

(b) Study the reaction scheme below and then answer the questions that follow.



(i) Name the reagent and catalyst needed for **Reaction 1**.

(2)

Reagent

Catalyst

(ii) Give the name and displayed formula of **compound X**.

(2)

Name

Displayed formula

(iii) Describe what colour change you would see during **Reaction 4** if a small amount of acidified $KMnO_4(aq)$ was shaken with ethene.

(1)

From **to**

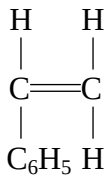
(c) (i) Use displayed formulae to show the mechanism for **Reaction 3**.

(3)

(ii) Explain why the alkene, propene, could form two products when it reacts with hydrogen bromide in a similar way.

(1)

(d) The formula of the alkene phenylethene, often called styrene, is shown below. It can be used to make the polymer poly(styrene).



phenylethene

Draw a section of the poly(styrene) polymer chain formed from **two** monomer units.

(2)

(e) The table below shows some data used in a life cycle analysis of polystyrene and paper drinking cups.

	Paper Cup	**Polystyrene Cup**
Raw Materials (per cup)		
Wood or bark	26 g	0 g
Petroleum fractions	2.2 g	3.4 g
Energy used (per tonne of material made)	980 kWh	280 kWh
Water released into environment (per tonne of material made)	120 m^3	2.5 m^3
Air emissions (per tonne of material made)		
Chlorine / chlorine dioxide	0.4 kg	0 kg
Sulfides / sulfur dioxide	11 kg	3.5 kg
Hydrocarbons	0 kg	40 kg

(i) Some people argue that using a polystyrene cup has less environmental impact than using a paper cup.

Choose TWO pieces of data to support this argument, explaining your choices.

(2)

(ii) Suggest TWO further pieces of information, not given in the table, regarding the life cycle of the cups that would make any assessment of the environmental impact more reliable.

(2)

(Total for Question = 22 marks)