

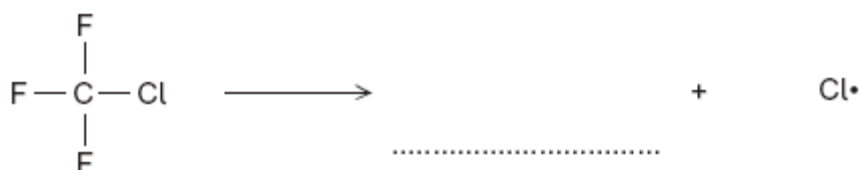
**Q1.** Oxygen and ozone (O<sub>3</sub>) both occur as gases in the upper atmosphere. Chlorine atoms catalyse the decomposition of ozone and contribute to the formation of a hole in the ozone layer. These chlorine atoms are formed from chlorofluorocarbons (CFCs) such as CF<sub>3</sub>Cl

(a) (i) Give the IUPAC name of CF<sub>3</sub>Cl

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(1)

(ii) Complete the following equation that shows the formation of a chlorine atom from a molecule of CF<sub>3</sub>Cl



(1)

(iii) State what the • represents in Cl•

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(1)

(b) Write two equations that show how chlorine atoms catalyse the decomposition of ozone into oxygen.

Equation 1 .....

Equation 2 .....

(2)

(c) An equilibrium is established between oxygen and ozone molecules as shown below.



(i) State Le Chatelier's principle.

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(1)

- (ii) Use Le Chatelier's principle to explain how an increase in temperature causes an increase in the equilibrium yield of ozone.

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(2)

- (d) Chemists supported the legislation to ban the use of CFCs. Modern refrigerators use pentane rather than CFCs as refrigerants. With reference to its formula, state why pentane is a more environmentally acceptable refrigerant.

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(1)

(Total 9 marks)

- Q2.** (a) The reaction of bromine with propane is similar to that of chlorine with methane. Three steps in the mechanism for the bromination of propane to form 1-bromopropane are shown below.



- (i) Name the type of mechanism in this reaction.

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(1)

(ii) Give an essential condition for Step 1 to occur.

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(1)

(iii) Name the type of step illustrated by Steps 2 and 3.

.....

(1)

(iv) In this mechanism, a different type of step occurs in which free radicals combine. Name this type of step.  
Write an equation to show how hexane could be formed from two free radicals in the mechanism of this reaction.

Type of step .....

Equation .....

(2)

(v) Write an overall equation for the reaction between bromine and propane by the same mechanism to produce octabromopropane ( $C_3Br_8$ ).

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(1)

(b) Bromine reacts with alkenes, even though bromine is a non-polar molecule.

(i) Explain why bromine molecules react with the double bonds in alkenes.

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(2)

(ii) Name the type of mechanism involved in this reaction.

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(1)

(iii) Draw the structure of the compound with  $M_r = 387.6$  formed when penta-1,4-diene ( $\text{H}_2\text{C}=\text{CHCH}_2\text{CH}=\text{CH}_2$ ) reacts with an excess of bromine.

(1)

(c) Two products are formed when propene reacts with hydrogen bromide. Draw the structure of the intermediate that leads to the formation of the major product in the reaction of propene with hydrogen bromide. Give the name of this type of intermediate.

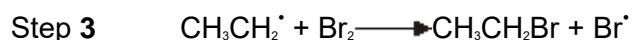
Structure of intermediate

Type of intermediate .....

(2)

(Total 12 marks)

**Q3.** The reaction of bromine with ethane is similar to that of chlorine with ethane. Three steps in the bromination of ethane are shown below.



(a) (i) Name this type of mechanism.

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(ii) Suggest an essential condition for this reaction.

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(iii) Steps **2** and **3** are of the same type. Name this type of step.

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(iv) In this mechanism, another type of step occurs in which free-radicals combine. Name this type of step. Write an equation to illustrate this step.

*Type of step* .....

*Equation*.....

(5)

(b) Further substitution in the reaction of bromine with ethane produces a mixture of liquid organic compounds.

(i) Name a technique which could be used to separate the different compounds in this mixture.

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(ii) Write an equation for the reaction between bromine and ethane which produces hexabromoethane,  $C_2Br_6$ , by this substitution reaction.

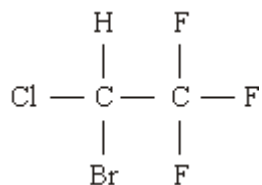
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(2)

(c) The compound 1,2-dibromo-1,1,2,2-tetrafluoroethane is used in some fire extinguishers. Draw the structure of this compound.

(1)

(d) Halothane is used as an anaesthetic and has the following structure.



(i) Give the systematic name of *halothane*.

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(ii) Calculate the  $M_r$  of halothane.

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(iii) Calculate the percentage by mass of fluorine in halothane.

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(3)  
(Total 11 marks)

**Q4.** One of the first substances used as an anaesthetic in medicine was chloroform (trichloromethane,  $\text{CHCl}_3$ ). By 1950, *halothane* was in common use but by 1990 this had been replaced by more acceptable anaesthetics such as *desflurane*.



One reason for replacing *halothane* was that it is an organic compound that contains chlorine. Chlorine-containing organic compounds are thought to cause damage to the ozone layer in the upper atmosphere.

(a) Name and outline a mechanism for the reaction of chlorine with methane to form chloromethane ( $\text{CH}_3\text{Cl}$ ).

Write an overall equation for the reaction of chlorine with methane to form trichloromethane ( $\text{CHCl}_3$ ).

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(5)

- (b) Explain how chlorine atoms are formed from chlorine-containing organic compounds in the upper atmosphere.

Explain, with the aid of equations, how chlorine atoms act as a catalyst in the decomposition of ozone into oxygen.

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(6)

- (c) Use the formulae of the two anaesthetics, *halothane* and *desflurane*, to help to explain why *desflurane* is considered to be a more **environmentally** acceptable anaesthetic than *halothane*.

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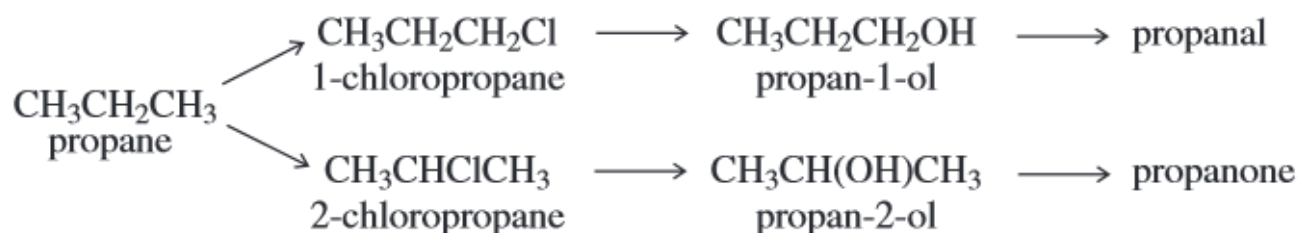
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(2)  
(Total 13 marks)

**Q5.** Consider the following scheme of reactions.



- (a) State the type of structural isomerism shown by propanal and propanone.

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(1)

- (b) A chemical test can be used to distinguish between separate samples of propanal and propanone.

Identify a suitable reagent for the test.

State what you would observe with propanal and with propanone.

Test reagent.....

Observation with propanal.....

Observation with propanone.....

(3)



- (c) State the structural feature of propanal and propanone which can be identified from their infrared spectra by absorptions at approximately  $1720\text{ cm}^{-1}$ .

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(1)

- (d) The reaction of chlorine with propane is similar to the reaction of chlorine with methane.

- (i) Name the type of mechanism in the reaction of chlorine with methane.

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(1)

- (ii) Write an equation for each of the following steps in the mechanism for the reaction of chlorine with propane to form 1-chloropropane ( $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ ).

Initiation step

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First propagation step

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Second propagation step

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A termination step to form a molecule with the empirical formula  $\text{C}_3\text{H}_7$

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(4)

- (e) High resolution mass spectrometry of a sample of propane indicated that it was contaminated with traces of carbon dioxide.

Use the data in the table to show how precise  $M_r$  values can be used to prove that the sample contains both of these gases.

Atom	Precise relative atomic mass
$^{12}\text{C}$	12.00000
$^1\text{H}$	1.00794
$^{16}\text{O}$	15.99491

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(2)  
(Total 12 marks)