

Ozone Depletion

Question Paper 1

Level	A Level
Subject	Chemistry
Exam Board	AQA
Module	3.3 Organic Chemistry
Topic	3.3.3 Halogenoalkanes
Sub-Topic	3.3.3.3 Ozone Depletion
Booklet	Question Paper 1

Time Allowed: 41 minutes

Score: /40

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	75%	70%	60%	55%	50%	<50%

Q1. CCl₄ is an effective fire extinguisher but it is no longer used because of its toxicity and its role in the depletion of the ozone layer. In the upper atmosphere, a bond in CCl₄ breaks and reactive species are formed.

- (a) Identify the condition that causes a bond in CCl₄ to break in the upper atmosphere. Deduce an equation for the formation of the reactive species.

Condition

Equation

.....

(2)

- (b) One of the reactive species formed from CCl₄ acts as a catalyst in the decomposition of ozone.

Write **two** equations to show how this species acts as a catalyst.

Equation 1

.....

Equation 2

.....

(2)

- (c) A small amount of the freon CF₃Cl with a mass of 1.78×10^{-4} kg escaped from a refrigerator, into a room of volume 100 m³. Assuming that the freon is evenly distributed throughout the air in the room, calculate the number of freon molecules in a volume of 500 cm³.

Give your answer to the appropriate number of significant figures.

The Avogadro constant = 6.02×10^{23} mol⁻¹.

Number of molecules =

(3)

(Total 7 marks)

Q2. The refrigerant R410A, used in air conditioners, is a mixture of two fluoroalkanes, pentafluoroethane and difluoromethane.

- (a) (i) The mechanism for the reaction of fluorine with either an alkane or a fluoroalkane is similar to that for the reaction of chlorine with methane.

Name the type of mechanism for the reaction of chlorine with methane.

.....

(1)

- (ii) Write equations for the following steps in the mechanism for the reaction of fluorine with fluoromethane (CH_3F) to form difluoromethane (CH_2F_2).

Initiation step

.....

First propagation step

.....

Second propagation step

.....

A termination step leading to the formation of 1,2-difluoroethane.

.....

(4)

- (iii) Write an overall equation for the reaction of fluorine with ethane to form pentafluoroethane (CF_3CHF_2) by this mechanism.

.....

(1)

- (b) The refrigerant R112A ($\text{CCl}_3\text{CF}_2\text{Cl}$) has been banned because of concerns about ozone depletion.

Give the IUPAC name for $\text{CCl}_3\text{CF}_2\text{Cl}$

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(1)

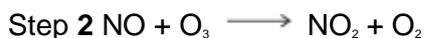
- (c) Nitrogen monoxide (NO) catalyses the decomposition of ozone into oxygen.

- (i) Write the overall equation for this decomposition.

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(1)

- (ii) Use the overall equation to deduce Step 3 in the following mechanism that shows how nitrogen monoxide catalyses this decomposition.



Step 3

(1)

(Total 9 marks)

Q3. Chlorine can be used to make chlorinated alkanes such as dichloromethane.

- (a) Write an equation for each of the following steps in the mechanism for the reaction of chloromethane (CH_3Cl) with chlorine to form dichloromethane (CH_2Cl_2).

Initiation step

.....

First propagation step

.....

Second propagation step

.....
The termination step that forms a compound with empirical formula CH₂Cl.
.....

(4)

- (b) When chlorinated alkanes enter the upper atmosphere, carbon-chlorine bonds are broken. This process produces a reactive intermediate that catalyses the decomposition of ozone. The overall equation for this decomposition is



- (i) Name the type of reactive intermediate that acts as a catalyst in this reaction.

.....

(1)

- (ii) Write **two** equations to show how this intermediate is involved as a catalyst in the decomposition of ozone.

Equation 1.....

Equation 2.....

(2)

(Total 7 marks)

Q4. There are many uses of halogenated organic compounds despite environmental concerns.

- (a) Bromotrifluoromethane is used in fire extinguishers in aircraft. Bromotrifluoromethane is formed when trifluoromethane reacts with bromine.



The reaction is a free-radical substitution reaction similar to the reaction of methane with chlorine.

- (i) Write an equation for each of the following steps in the mechanism for the reaction of CHF₃ with Br₂

Initiation step

.....

First propagation step

.....

Second propagation step

.....

A termination step

.....

(4)

(ii) State **one** condition necessary for the initiation of this reaction.

.....

(1)

(b) Bromine-containing and chlorine-containing organic compounds may have a role in the decomposition of ozone in the upper atmosphere.

(i) Draw an appropriate **displayed formula** in the space provided to complete the following equation to show how CBrF_3 may produce bromine atoms in the upper atmosphere.



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(1)

(ii) In the upper atmosphere, it is more likely for CBrF_3 to produce bromine atoms than it is for CClF_3 to produce chlorine atoms.

Suggest **one** reason for this.

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(1)

(iii) Bromine atoms have a similar role to chlorine atoms in the decomposition of ozone.

The overall equation for the decomposition of ozone is



Write **two** equations to show how bromine atoms (Br^\bullet) act as a catalyst in the decomposition of ozone.

Explain how these two decomposition equations show that bromine atoms behave as a catalyst.

Equation 1

.....

Equation 2

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Explanation

.....

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(3)
(Total 10 marks)

Q5. Trifluoromethane (CHF_3) can be used to make the refrigerant chlorotrifluoromethane (CClF_3).

- (a) Chlorotrifluoromethane is formed when trifluoromethane reacts with chlorine.



The reaction is a free-radical substitution reaction similar to the reaction of methane with chlorine.

- (i) Write an equation for each of the following steps in the mechanism for the reaction of CHF_3 with Cl_2

Initiation step

.....

First propagation step

.....

Second propagation step

.....

Termination step to form hexafluoroethane

.....

(4)

- (ii) Give **one** essential condition for this reaction.

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(1)

(b) In some refrigeration systems, CHF_3 has replaced CClF_3 because of concerns about ozone depletion.

(i) Identify the species formed from CClF_3 that is responsible for the catalytic decomposition of ozone in the upper atmosphere.

.....

(1)

(ii) Write an overall equation to represent the decomposition of ozone into oxygen.

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(1)

(Total 7 marks)