Halogenoalkane Exam Style Questions

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Question 1

In the stratosphere, nitrogen monoxide, NO, is linked with ozone depletion.

Complete the equations below that describe how NO contributes to ozone depletion.

Step 1: $NO + O_3 \rightarrow$ ..... + ...

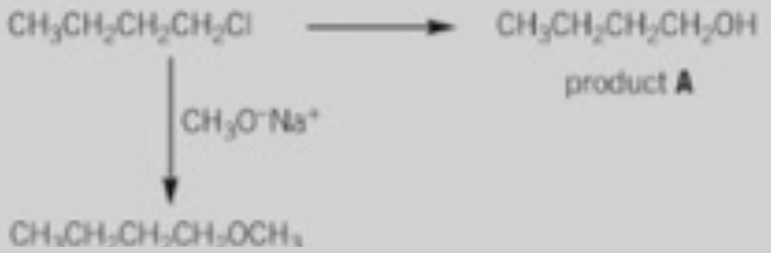
Step 2: NO_2 + ... $\rightarrow NO +$ .....

Overall: ..... + ... $\rightarrow 2O_2$

(3 marks)

Question 2

Haloalkanes are useful synthetic reagents for the preparation of many important chemicals. Some reactions of 1-chlorobutane is shown below:



a Write an equation for the preparation of product **A** from 1-chlorobutane and name product **A**. *(1 mark)*

b The formation of product **A** is an example of a hydrolysis reaction.

Name the type of mechanism for the hydrolysis of haloalkanes. *(1 mark)*

c State and explain the effect on the rate of hydrolysis of replacing 1-chlorobutane with 1-bromobutane. *(1 mark)*

d Methoxybutane can be made from 1-chlorobutane and sodium methoxide. The methoxide ion acts as a nucleophile.

Suggest a mechanism for this reaction.

(3 marks)

Question 3

This question is about halogenated hydrocarbons.

a Haloalkanes 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, $CH_3CH_2CH_2NH_2$.

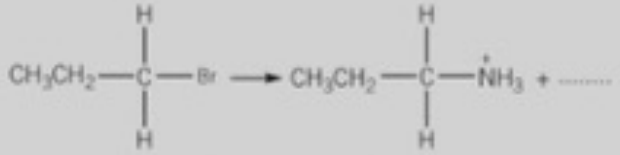
$CH_3CH_2CH_2Br + 2NH_3 \rightarrow CH_3CH_2CH_2NH_2 + NH_4Br$

(i) Iodoethane is reacted with ammonia.

Write an equation for this reaction.

(1 mark)

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



Complete the mechanism. Include relevant dipoles, lone pairs, curly arrows and the missing product. *(3 marks)*

b A student investigates the rate of hydrolysis of six haloalkanes. The student mixes 5 cm^3 of ethanol with five drops of haloalkane. 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 haloalkane. The time taken for a precipitate to form is recorded in the results table. The student repeats the whole experiment at 60 °C instead of 50 °C.

Haloalkane	Time taken for a precipitate to form / s	
	50 °C	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 haloalkanes. Include ideas about

- the halogen in the haloalkanes
- the groups attached to the carbon of the carbon–halogen bond (the type of haloalkane)
- the temperature of the hydrolysis.

In your answer you should link the evidence with your explanation. *(7 marks)*

Answers coming up

Question 1

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Complete the equations below that describe how NO contributes to ozone depletion.

Step 1: $NO + O_3 \rightarrow$ ..... + ...

Step 2: NO_2 + ... $\rightarrow$ NO + ...

Overall: ..... + ... $\rightarrow$ $2O_2$

(3 marks)

Step 1 $\bullet NO + O_3 \rightarrow \bullet NO_2 + O_2$

Step 2 $\bullet NO_2 + O \rightarrow \bullet NO + O_2$

Overall: $O_3 + O \rightarrow 2O_2$

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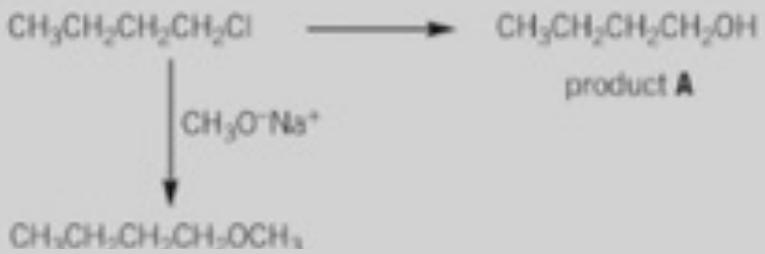

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d Methoxybutane can be made from 1-chlorobutane and sodium methoxide. The methoxide ion acts as a nucleophile.

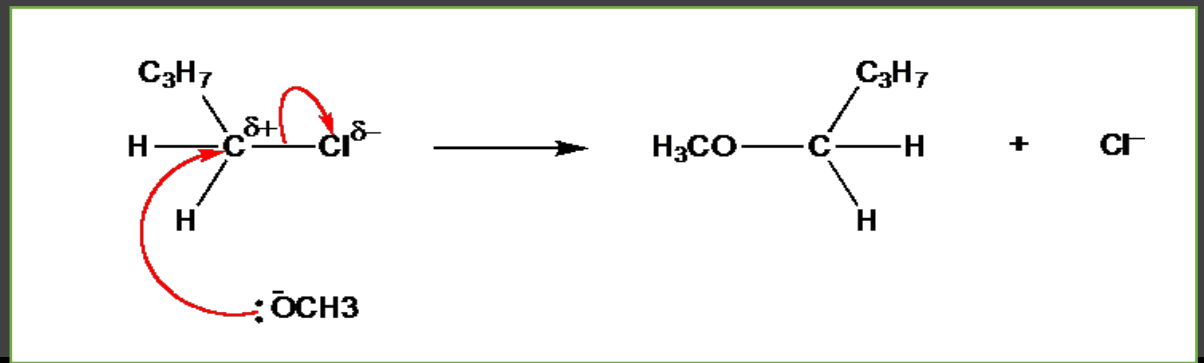
Suggest a mechanism for this reaction. *(3 marks)*

Butan-1-ol

$CH_3CH_2CH_2CH_2Cl + NaOH \rightarrow CH_3CH_2CH_2CH_2OH + NaCl$

Nucleophilic substitution

The rate would increase because a C–Br bond is weaker and broken more easily



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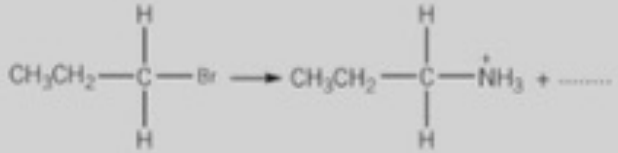

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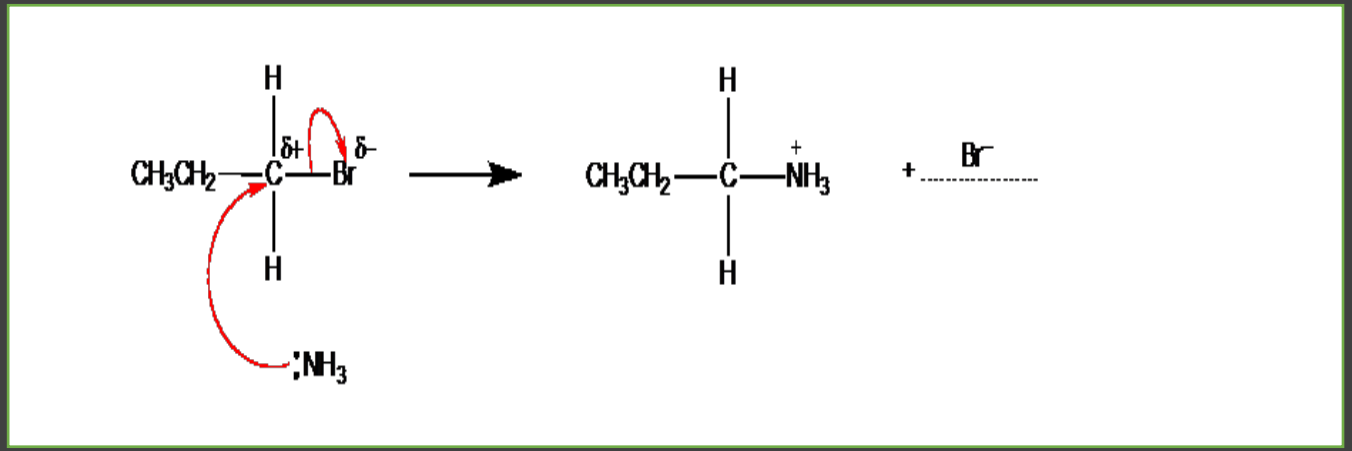
$CH_3CH_2I + 2NH_3 \rightarrow CH_3CH_2NH_2 + NH_4I$



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Changing the halogen

The rate of reaction increases in the order

C-I fastest
C-Br,
C-Cl slowest

As the halogen increases in size down group 7, the C-Halogen bond becomes longer and weaker and is broken more easily.

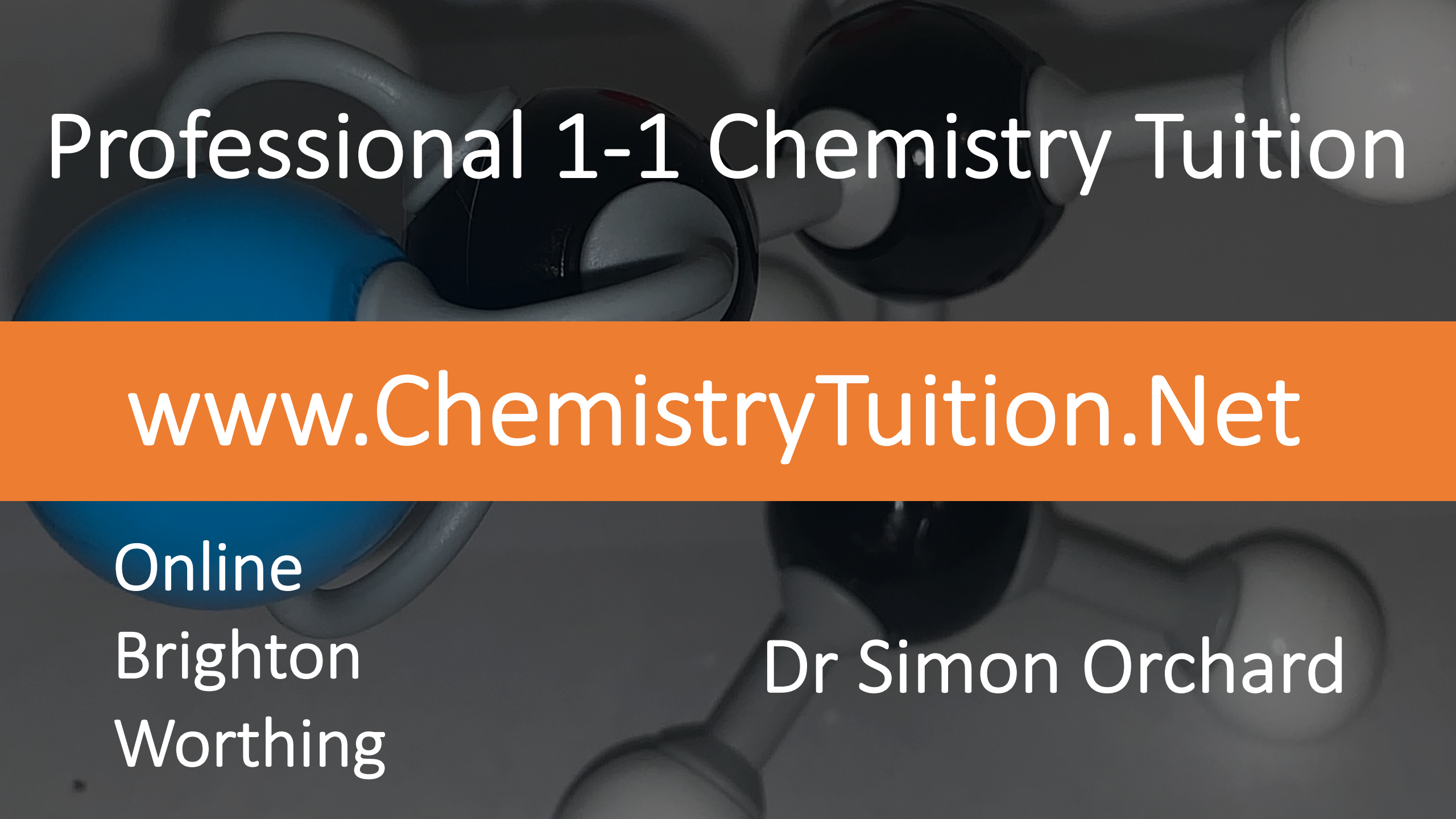
Changing the number of groups attached to the C in the C-Hal bond

The reaction time is less with tertiary haloalkanes than primary haloalkanes, Branched haloalkanes hydrolyse faster than straight chain haloalkanes.

This suggests that the C—Hal bond gets weaker as the number of groups attached to the C atom in C-Hal increases

Changing the temperature

For all haloalkanes, the rate increases with temperature, eg $CH_3CH_2CH_2Cl$ the time taken for the reaction decreases by 122 s when the temperature is increased by 10 °C. More energy available to break the C–Hal bond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