IB · SL · Chemistry

1 hour 9 questions

Structured Questions

Electron Sharing Reactions

Radicals / Homolytic Fission / Halogenation of Alkanes

Easy (3 questions)	/16
Medium (3 questions)	/32
Hard (3 questions)	/24
Total Marks	**/72**

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Easy Questions

1 (a) There are three steps to the free radical substitution mechanism. When ethane and chlorine react in the presence of UV light, chloroethane is produced. Write the equation for the initiation step.

....

(1 mark)

(b) Write two equations for the propagation steps for the reaction outlined in part (a).

....

....

(2 marks)

(c) Write the equation using structural formulae for the termination reaction between two $CH_3CH_2^{\bullet}$ free radicals.

....

(1 mark)

(d) State the type of bond breaking that occurs in the initiation reaction to produce free radicals.

....

(1 mark)

2 (a) State why a bromine atom can be described as an *atomic radical*.

....

(1 mark)

(b) i) Draw the Lewis formula for the ethyl radical.

[1]

ii) Explain why this radical is not a long lasting species.

[1]

....

....

(2 marks)

(c) State **two** conditions that are required to form a bromine radical from a bromine molecule.

....

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(2 marks)

3 (a) State **two** reasons why alkanes are unreactive.

....

....

(2 marks)

(b) Methane reacts with chlorine to produce chloromethane, CH_3Cl. The reaction is initiated by the formation of chlorine radicals.

State the type of bond fission is involved in this reaction.

....

(1 mark)

(c) Chloromethane will be formed via several steps.

i) Write the equations for the **two** propagation steps.

[2]

ii) Write an equation to show how ethane can be formed in this reaction.

[1]

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....

....

(3 marks)

Medium Questions

1 (a) Alkanes are generally unreactive and do not react with acids, bases, or with oxidising or reducing agents. However, they will react with halogens under suitable conditions, to form halogenoalkanes.

Methane reacts with chlorine in this way to form chloromethane.

i) State the name of this type of reaction mechanism.

[1]

ii) Write an overall equation for the reaction and give the reaction conditions.

[2]

....

....

....

(3 marks)

(b) The reaction described in part (a) consists of three steps. In the first step, the Cl-Cl bond is broken to form two chlorine free radicals.

i) State and explain the type of bond breaking that occurs in the initiation step.

[1]

ii) Define the term *free radical*.

[1]

iii) Explain why the C-H bond in the alkane does not break in the initiation step instead of the Cl-Cl bond.

[1]

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(3 marks)

(c) Give the equations for each step of the reaction between methane and chlorine as described in part (a).

Label each equation with the name of the correct step. You only need to provide one equation for the final step.

(4 marks)

(d) Chlorofluorocarbons (CFCs) are organic compounds consisting of carbon, chlorine, and fluorine atoms. They are believed to destroy the ozone layer in a similar reaction to the one described in part (a).

Ozone can be broken down by radicals formed in the atmosphere. The ozone layer is important to protecting the Earth from harmful exposure to ultraviolet light. Without this ozone layer, life on Earth would be very different.

An example of a CFC which can damage the ozone layer is CCl_3F.

i) Explain why these free radicals act as catalysts in the breakdown of ozone to oxygen. Support your answer by writing suitable equations.

[3]

ii) Draw the three-dimensional structure of CCl_3F and name the shape of the molecule.

[1]

(4 marks)

2 (a) Trichloromethane is one of the products formed when dichloromethane reacts with excess chlorine in UV light.

i) Name this mechanism.

[1]

ii) Write equations for the initiation and propagation steps.

[3]

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(4 marks)

(b) Dichloromethane can also be formed in this reaction.

i) Write the overall equation for the formation dichloromethane from chloromethane.

[1]

ii) A compound was found to contain 20.3% carbon, 48.1% fluorine, 30.0% chlorine and 1.6% hydrogen. Calculate the empirical formula for this compound.

[2]

....

....

....

(3 marks)

(c) Suggest the structural formula of **two** bromine containing compounds that are formed during the reaction of bromine and dibromomethane in the presence of UV light.

....

....

(2 marks)

3 (a) Consider the following reaction

$$RCH_3 \xrightarrow{Cl_2,\ UV} RCH_2Cl$$

i) The alkane contains 17.4% of hydrogen. Calculate the empirical formula of the alkane.

[3]

ii) Equal volumes of methyl vinyl ether, $CH_3OCH{=}CH_2$ and the unknown alkane are found to have the same mass, measured to an accuracy of two significant figures, at the same temperature and pressure. Deduce the molecular formula of the alkane.

[1]

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(4 marks)

(b) The reaction in part a) involves a free-radical mechanism to form the chloroalkane.

Describe the mechanism, by giving equations to represent the initiation, propagation and termination steps.

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(4 marks)

(c) Draw the full displayed formula of the haloalkane formed if excess chlorine is used in the reaction in part a).

....

(1 mark)

Hard Questions

1 (a) Dichloromethyl benzene reacts with chlorine to produce trichloromethyl benzene. State the name of this type of mechanism and the required condition.

....

....

(2 marks)

(b) Outline the mechanism for the reaction occurring in part a).

....

....

....

....

(4 marks)

(c) A reaction pathway is shown below. Compound **J** reacts with bromine water to form a colourless solution.

State the IUPAC name for Compound J.

....

(1 mark)

(d) Identify the reagents and conditions for the formation of Compound Y from Compound J.

....

....

(2 marks)

2 (a) For the reaction profile outlined in the reaction profile below, state the mechanism or type of reaction for steps 1 and 2.

$$\text{Propane} \xrightarrow{\text{Step 1}} \text{1-bromopropane} \xrightarrow{\text{Step 2}} \text{Compound X} \xrightarrow{\text{Step 3}} \text{Propanal}$$

Step 1 ....

Step 2 ....

(2 marks)

(b) Compound **X** can be oxidised by the reaction with acidified potassium dichromate to give propanal. Compound **X** will oxidise to propanoic acid if allowed to fully oxidise. Explain how full oxidation can be prevented.

(3 marks)

(c) State the following for step 1.

Reagents and conditions ....

Mechanism ....

(4 marks)

3 (a) This question is about free radical substitution.

1,2-dibromoethane reacts with bromine in UV light to produce a mixture of further substituted haloalkanes.

i) Write an equation for the initiation step.

[1]

ii) Explain why this is an example of homolytic fission.

[1]

....

....

(2 marks)

(b) Write two equations showing the propagation of this chain reaction to produce 1,1,2-tribromoethane.

....

....

(2 marks)

(c) Traces of 1,2,3,4-tetrabromobutane are found in the reaction mixture.

i) Write an equation to show how this product is formed.

[1]

ii) Write a balanced symbol equation to show the overall reaction between 1,1,2-tribromoethane with bromine in UV light to form hexabromoethane.

[1]

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(2 marks)