20.1 Electron sharing: radicals

Name: _____ Class: _____ Date: _____ **Total: 18 marks**

KEY WORDS radical • homolytic fission • initiation • propagation • termination • substitution

Objective

Build the skills to answer exam questions on **electron sharing reactions** : radicals, homolytic fission and the substitution of alkanes.

You must be able to:

- define a radical and describe homolytic fission
- write the initiation, propagation and termination steps for the reaction of an alkane with a halogen
- explain the conditions needed and why a mixture of products forms

1 Key knowledge and worked examples

Radicals

A **radical** is a species with an **unpaired electron**, shown by a dot: $Cl^{\bullet}$, $CH_3^{\bullet}$. Radicals are very reactive.

Homolytic fission: a covalent bond breaks and **each atom takes one electron**: Cl–Cl → $2Cl^{\bullet}$. It needs **UV light** (or high temperature).

Alkane + halogen (UV light): radical substitution. $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$.

stage	what happens	example
initiation	radicals are made	$Cl_2 \rightarrow 2Cl^{\bullet}$
propagation	a radical reacts and makes a new radical	$Cl^{\bullet} + CH_4 \rightarrow CH_3^{\bullet} + HCl$; $CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$
termination	two radicals join, so radicals are removed	$Cl^{\bullet} + CH_3^{\bullet} \rightarrow CH_3Cl$

Propagation is a **chain reaction**: one $Cl^{\bullet}$ can cause thousands of reactions. Further substitution (CH_2Cl_2, $CHCl_3$, CCl_4) and termination (C_2H_6) give a **mixture of products**.

Worked example 1: a radical. $Br^{\bullet}$ has 7 outer electrons, one of them **unpaired**.

Worked example 2: propagation. $Br^{\bullet} + C_2H_6 \rightarrow \mathbf{C_2H_5^{\bullet}} + \mathbf{HBr}$.

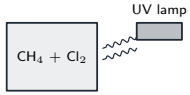
Answer shapes: put the dot on every radical; in propagation a radical appears on both sides.

2 Practice

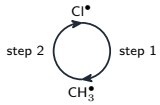
2.1 Define a radical, and describe what happens to the bonding electrons in homolytic fission. [2]



2.2 Write the equation for the initiation step when chlorine reacts with methane, and state the condition needed. Explain why this condition is needed. [3]



2.3 Write the two propagation steps that form chloromethane, and explain why this is called a chain reaction. [3]



2.4 Write two possible termination steps, and explain why termination stops the reaction. [3]



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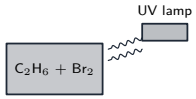
3 Exam-style questions

3.1 Ethane reacts with bromine in ultraviolet light.

(a) Write the overall equation for the formation of bromoethane. [1]

(b) Name the type of reaction. [1]

(c) Write the initiation step and the two propagation steps. [3]



(d) Explain why no reaction happens in the dark at room temperature. [1]

(e) A small amount of butane, C_4H_{10}, is also formed. Explain how. [1]

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