Mr Cole Science

Name: _____ Date: _____

AQA A-LEVEL CHEMISTRY

Cracking Hydrocarbons: Thermal and Catalytic Cracking

Learn Pack

This pack is designed to be completed alongside the video to help you build a secure understanding of this topic before moving on to revision and exam practice.

WATCH THE LESSON

Cracking

Cracking is the process of breaking large hydrocarbon molecules into smaller hydrocarbon molecules.

The process of cracking hydrocarbon molecules requires lots of energy due to the strong carbon-carbon and carbon-hydrogen bonds present in alkanes.

Lesson Objectives:

- Be able to explain the economic reasons for cracking alkanes.
- Know that cracking involves breaking strong C-C bonds in alkanes.
- Know the conditions for and products of thermal cracking.
- Know the conditions for and products of catalytic cracking and be able to name the catalyst used.

Why carry out Cracking?

Explain why long chain hydrocarbon molecules are cracked.

Long chain hydrocarbons are produced in much greater quantities than what we need, whereas short-chain hydrocarbons have a greater demand than supply. Therefore large-chain hydrocarbons are cracked to produce more valuable short-chain products.

Products of Cracking

During cracking, large hydrocarbon molecules are broken down into a variety of smaller hydrocarbon molecules, including:

- Alkanes
- Alkenes
- Cycloalkanes
- Aromatic hydrocarbons

However, since during chemical reaction atoms can neither be created nor destroyed. This means that the total number of carbon and hydrogen atoms in the starting hydrocarbon molecules must equal the total number of carbon and hydrogen atoms in the products.

Explain why cracking long chain alkanes cannot only produce short chain alkanes.

Atoms are conserved during chemical reactions, when an alkane is split during cracking no additional hydrogen atoms are added and so there aren't enough hydrogens to only form alkanes.

During cracking the point at which the hydrocarbon molecule breaks varies, meaning multiple different combinations of products can form. Using decane ($C_{10}H_{22}$) as an example, write balanced symbol equations, using molecular formulae, to show how cracking can produce different products:

1. $C_{10}H_{22} \longrightarrow C_8H_{18} + C_2H_4$
2. $C_{10}H_{22} \longrightarrow C_7H_{16} + C_3H_6$
3. $C_{10}H_{22} \longrightarrow C_5H_{12} + C_5H_{10}$
4. $C_{10}H_{22} \longrightarrow C_5H_{12} + C_3H_6 + C_2H_4$
5. $C_{10}H_{22} \longrightarrow C_4H_{10} + 2C_3H_6$

Industrial Cracking

Explain why the process of cracking requires high temperatures.

Lots of energy is required to break the strong carbon-carbon and carbon-hydrogen covalent bonds in the hydrocarbon molecules.

There are two different methods used in industrial cracking; thermal cracking and catalytic cracking. Both methods break large hydrocarbon molecules into smaller, more valuable, hydrocarbon molecules but they do so under different conditions and therefore produce slightly different combinations of products.

Thermal Vs Catalytic Cracking

Complete the table below:

Conditions	Thermal Cracking	Catalytic Cracking
Temperature	High	High
Pressure	High	Slight
Catalyst	—	Zeolite
Favoured Products	Alkenes	Branched-chain Alkanes Aromatic Hydrocarbons

What is the same about both processes?

Both processes require high temperatures and break long chain hydrocarbons into short-chain hydrocarbons.

What is different about both processes?

Catalytic cracking uses a zeolite catalyst and slight pressure whereas thermal cracking requires a high pressure. Thermal favours the formation of alkenes whereas catalytic favours branched-chain alkanes and aromatic hydrocarbons.

Why are alkenes valuable products?

They are valuable chemical feedstock and can be used to make plastics.

Why are branched-chain alkanes valuable products?

They are used in motor fuels.

Practise Questions – Fact Recall

1. What is cracking?

   Breaking of long-chain hydrocarbons into short-chain hydrocarbons.

2. What are the two types of cracking?

   Thermal and catalytic

3. Explain why heavier petroleum fractions are cracked.

   Long chain hydrocarbons are produced in much greater quantities than what we need, whereas short-chain hydrocarbons have a greater demand than supply. Therefore large-chain hydrocarbons are cracked to produce more valuable short-chain products.

4. State the conditions necessary for, and the products favoured by thermal cracking.

   High temperature and high pressure.
   Alkenes.

Practise Questions – Application

1. One molecule of C_9H_{20} can be cracked to form one molecule of pentane and one other product. Write an equation for this cracking reaction. State why a high temperature is needed for cracking reactions to occur.

   $C_9H_{20} \longrightarrow C_5H_{12} + C_4H_8$
   Lots of energy is required to break the strong carbon-carbon and carbon-hydrogen covalent bonds in the hydrocarbon molecules.

What next?

The next step in the Learn, Revise, Practise Method is Revise, where you'll strengthen your memory through retrieval practice exercises before moving on to Practise and applying your knowledge to exam questions.