

## 7

## Chemical Reactions of Organic Compounds

Some important Chemical reactions of organic compounds are given below.

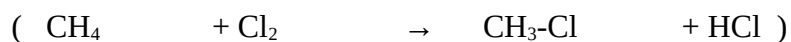
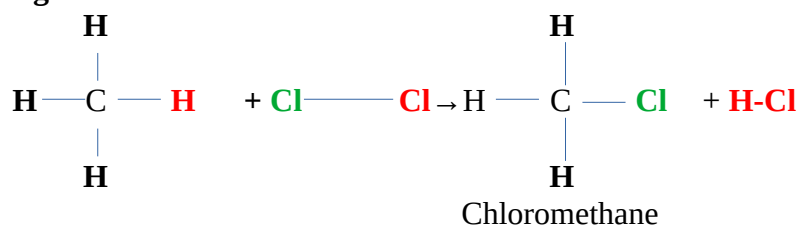
Sl No	Reaction
1	Substitution Reactions
2	Addition Reactions
3	Polymerisation
4	Combustion of Hydrocarbons
5	Thermal Cracking

## 1. Substitution Reactions



Examine the different stages of the reaction of methane ( $\text{CH}_4$ ) with chlorine **in the presence of sunlight**.

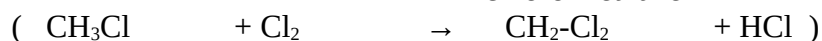
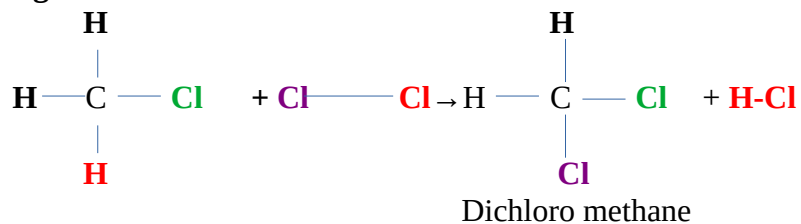
Stage 1



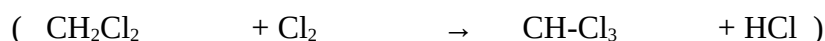
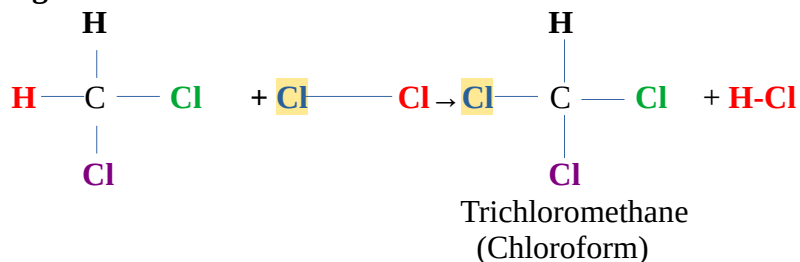
Here, one hydrogen atom of methane molecule is replaced by one chlorine atom.

If this process continues..

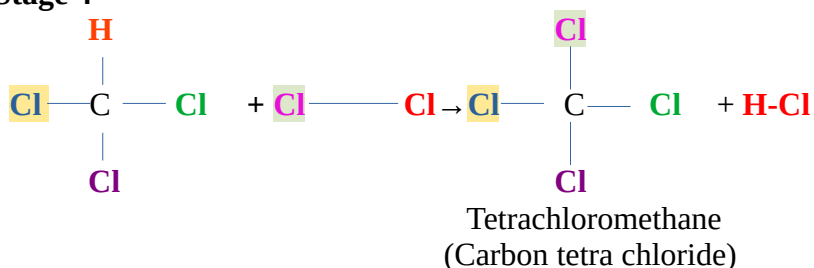
Stage 2



Stage 3



Stage 4



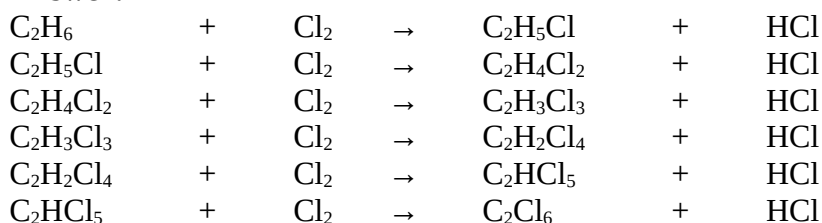
When methane reacts with chlorine each hydrogen atom of methane is replaced successively by chlorine atom. As a result, a mixture of  $\text{CH}_3\text{Cl}$  (Chloromethane),  $\text{CH}_2\text{Cl}_2$  (dichloromethane),  $\text{CHCl}_3$  (trichloromethane) and  $\text{CCl}_4$  (Tetrachloromethane) is formed.

Such reactions are called Substitution reactions.

A reaction in which an atom or a group in a compound is replaced by another atom or a group is called substitution reaction

1. What are the compounds formed when  $\text{CH}_3-\text{CH}_3$  ( $\text{C}_2\text{H}_6$ , ethane) undergoes substitution reaction with chlorine?

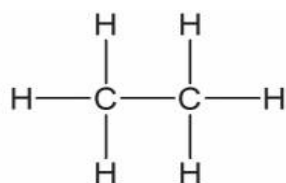
**Answer:**



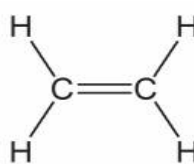
♥♥♥ 2. Addition Reactions



Look at the structural formulae of ethane and ethene.



**Ethane**



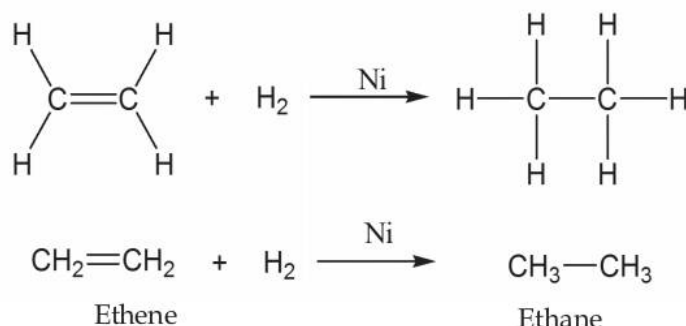
**Ethene**

\*What is the peculiarity of the carbon - carbon bond in ethene?

**Ethene** is an **unsaturated** compound due to the presence of the carbon - carbon **double bond**. When unsaturated compounds take part in chemical reactions they tend to form saturated compounds

Let us examine a chemical reaction of ethene molecule.

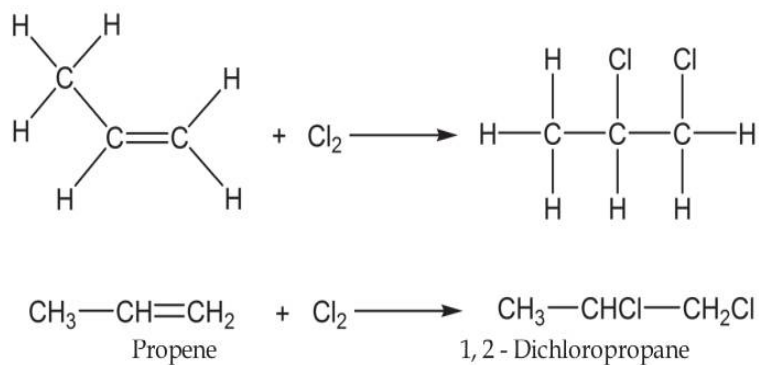
The chemical equation of **ethene reacting with hydrogen in the presence of the nickel (Ni) catalyst** at high temperature is given.



\* What do we get as the product?

Answer: Ethane ( CH<sub>3</sub>-CH<sub>3</sub> or C<sub>2</sub>H<sub>6</sub> )

Let us examine another similar reaction.



\* Which hydrocarbon is the reactant here?

Answer: Propene ( $\text{CH}_3-\text{CH}=\text{CH}_2$ )

\* Is the product saturated or unsaturated?

Answer: Saturated

2. ❤️❤️❤️ Identify the products in the following addition reactions and complete table

Chemical reaction	Product	IUPAC name of the product
$\text{CH}_2=\text{CH}_2 + \text{Cl}_2$	.....	.....
$\text{CH}_2=\text{CH}_2 + \text{HCl}$	.....	.....
$\text{CH}_3-\text{CH}=\text{CH}_2 + \text{H}_2$	.....	.....
$\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3 + \text{HBr}$	.....	.....

Answer:

Chemical reaction	Product	IUPAC name of the product
$\text{CH}_2=\text{CH}_2 + \text{Cl}_2$	$  \begin{array}{c}  \text{CH}_2-\text{CH}_2 \\    \quad   \\  \text{Cl} \quad \text{Cl}  \end{array}  $	1,2-Dichloroethane
$\text{CH}_2=\text{CH}_2 + \text{HCl}$	$\text{CH}_3-\text{CH}_2-\text{Cl}$	Chloroethane
$\text{CH}_3-\text{CH}=\text{CH}_2 + \text{H}_2$	$\text{CH}_3-\text{CH}_2-\text{CH}_3$	Propane
$\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3 + \text{HBr}$	$  \begin{array}{c}  \text{CH}_3-\text{CH}_2-\text{CH}-\text{CH}_3 \\  \text{Br}  \end{array}  $	2-Bromobutane

♥♥♥ Similarly, take note of the following chemical reactions

<b>Chemical reaction</b>	<b>Product</b>
$\text{CH}\equiv\text{CH} + \text{H}_2$ Ethyne	$\text{CH}_2=\text{CH}_2$ Ethene
$\text{CH}_2=\text{CH}_2 + \text{H}_2$ Ethene	$\text{CH}_3-\text{CH}_3$ Ethane
$\text{CH}_3-\text{C}\equiv\text{CH} + \text{H}_2$ Propyne	$\text{CH}_3-\text{CH}=\text{CH}_2$ Propene
$\text{CH}_3-\text{CH}=\text{CH}_2 + \text{H}_2$ Propene	$\text{CH}_3-\text{CH}_2-\text{CH}_3$ Propane

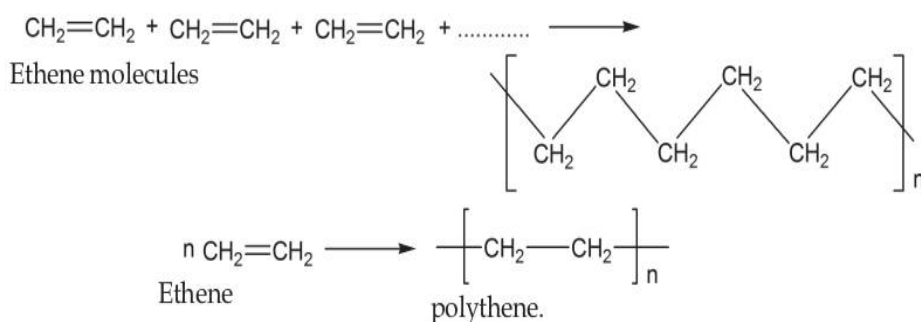
Reactions in which unsaturated organic compounds with double bond or triple bond react with other molecules to form saturated compounds are called addition reactions

♥♥♥ 3. Polymerisation



We have learned that ethene molecules undergo addition reaction to form saturated compounds.

Consider the reaction in which a **large number of ethene molecules combine under high pressure and temperature in the presence of a catalyst**. The **product** formed here is **polythene**.

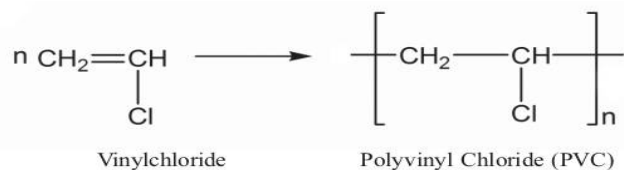


Polymerisation is the process in which a large number of simple molecules combine under suitable conditions to form complex molecules. The product molecules are called polymers

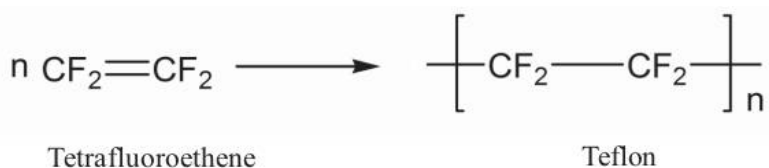
**The simple molecules which combine in this manner are called monomers.**

We use a number of natural and man - made polymers in our daily life.

PVC (Polyvinyl Chloride) is a polymer commonly used for making pipes. It is formed by the polymerisation of a large number of chloroethene (Vinyl chloride) molecules.



**Teflon** is a polymer which is familiar to us. It is used **for coating on the inner surface of non-stick cookware. Its monomer is tetrafluoroethene.**



3. ♥♥♥♥ Complete the following table suitably.

Monomer	Polymer	Use
.....	PVC	.....
Ethene	.....	.....
Isoprene	Natural rubber (Polyisoprene)	.....
.....	Teflon	.....

Answer:

Monomer	Polymer	Use
Vinyl Chloride (Chloroethene)	PVC	For making pipes, electronic equipments, buckets, vinyl flooring, table cloths etc
Ethene	Polythene	For making Polythene bags, rain coats etc.
Isoprene	Natural Rubber (Poly Isoprene)	For making tyres, foot wares etc
Tetra Fluoroethene	Teflon (Poly Tetra Fluoroethene)	For coating on the inner surface of non-stick cookware

#### ♥♥♥♥ 4. Combustion of Hydrocarbons\*



Most of the hydrocarbons are used as fuels.

Examples: Kerosene, Petrol, LPG

When hydrocarbons burn they combine with the oxygen in the air to form  $\text{CO}_2$  and  $\text{H}_2\text{O}$  along with heat and light. This process is called combustion

**\*Complete combustion**

**Example:  $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} + \text{Heat} + \text{Light}$**

Hydrocarbons are used as fuels because of the exothermic nature of the combustion process.

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♥♥♥ More worked out examples.

1.

Unbalanced	Balanced
$\text{CH}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} + \text{Heat} + \text{Light}$
$\text{C}_3\text{H}_8 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	$\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O} + \text{Heat} + \text{Light}$
$\text{C}_5\text{H}_{12} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	$\text{C}_5\text{H}_{12} + 8\text{O}_2 \rightarrow 5\text{CO}_2 + 6\text{H}_2\text{O} + \text{Heat} + \text{Light}$
$\text{C}_7\text{H}_{16} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	$\text{C}_7\text{H}_{16} + 11\text{O}_2 \rightarrow 7\text{CO}_2 + 8\text{H}_2\text{O} + \text{Heat} + \text{Light}$
$\text{C}_6\text{H}_{12} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	$2 \text{C}_6\text{H}_{12} + 9 \text{O}_2 \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{Heat} + \text{Light}$

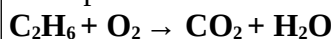
2 ♥♥♥

Unbalanced	Balanced
$\text{C}_2\text{H}_6 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	$2 \text{C}_2\text{H}_6 + 7\text{O}_2 \rightarrow 4\text{CO}_2 + 6\text{H}_2\text{O} + \text{Heat} + \text{Light}$
$\text{C}_4\text{H}_{10} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	$2 \text{C}_4\text{H}_{10} + 13\text{O}_2 \rightarrow 8\text{CO}_2 + 10\text{H}_2\text{O} + \text{Heat} + \text{Light}$
$\text{C}_6\text{H}_{14} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	$2 \text{C}_6\text{H}_{14} + 19 \text{O}_2 \rightarrow 12\text{CO}_2 + 14\text{H}_2\text{O} + \text{Heat} + \text{Light}$
$\text{C}_6\text{H}_6 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	$2 \text{C}_6\text{H}_6 + 15 \text{O}_2 \rightarrow 12\text{CO}_2 + 6\text{H}_2\text{O} + \text{Heat} + \text{Light}$
$\text{C}_3\text{H}_6 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	$2 \text{C}_3\text{H}_6 + 9 \text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{Heat} + \text{Light}$

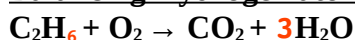
**Hint:** Balance Hydrogen atoms first, then balance carbon atoms. *Finally balance Oxygen atoms.*  
**If It is a fraction like 5/2, 7/2, 15/2 etc, multiply all by 2, like a mathematical equation.**

Explanation

Example



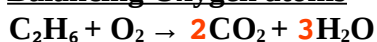
**a. Balancing Hydrogen atoms**



**b. Balancing Carbon atoms**

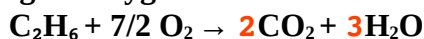


**c. Balancing Oxygen atoms**

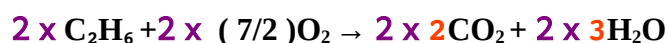


Total number of oxygen atoms on the right side = (2 x 2) + (3 x 1) = 4 + 3 = 7

To get 7 oxygen atoms on the left side, multiply O<sub>2</sub> with 7/2



Since 7/2 is a fraction, multiply all by 2

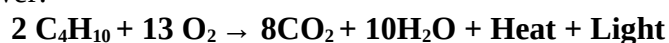


**Answer:**  $2 \text{C}_2\text{H}_6 + 7\text{O}_2 \rightarrow 4 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{Heat} + \text{Light}$

3. Butane is one of the important components in the domestic fuel, LPG.

Write the balanced chemical equation for the combustion of butane (C<sub>4</sub>H<sub>10</sub>)

Answer:





♥♥♥ 5. Thermal Cracking

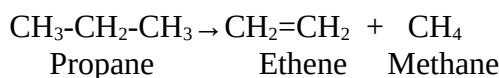


Some hydrocarbons with high molecular masses, when heated in the absence of air undergo decomposition to form hydrocarbons with lower molecular masses.

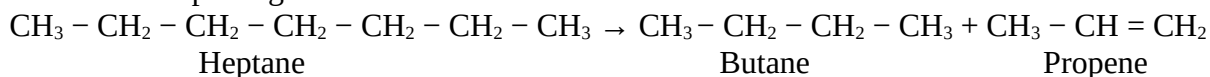
This process is called Thermal cracking. A number of products are made in this way.

Propane is one of the simplest hydrocarbons which can undergo thermal cracking.

Examine the equation for the thermal cracking of propane.



Another example is given below



The same question can be answered in many ways. Look at a few of those

$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3 \rightarrow$	$\text{CH}_3\text{-CH}_2\text{-CH}_3$	$+$	$\text{CH}_3\text{-CH}_2\text{-CH=CH}_2$
7 Carbon atoms	3 Carbon atoms		4 Carbon atoms
$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3 \rightarrow$	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3$	$+$	$\text{CH}_2\text{=CH}_2$
7 Carbon atoms	5 Carbon atoms		2 Carbon atoms
$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3 \rightarrow$	$\text{CH}_3\text{-CH}_3$	$+$	$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH=CH}_3$
7 Carbon atoms	2 Carbon atoms		5 Carbon atoms
$\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_3 \rightarrow$	$\text{CH}_4$	$+$	$\text{CH}_3\text{-CH}_2\text{-CH=CH-CH}_2\text{-CH}_3$
7 Carbon atoms	One carbon atom		6 Carbon atoms

[ Here we have 7 carbon atoms. The number 7 can be split in many ways (4+3, 5+2, 6+1) . Double bond can be given in between any two carbon atoms. Total number of C, H & O should be the same on both sides.]

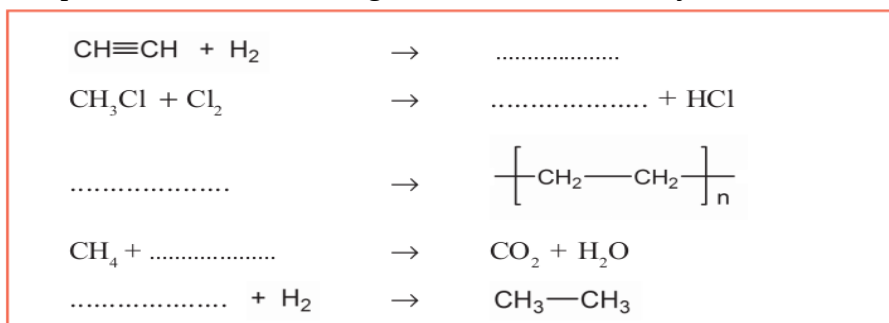
When hydrocarbons with larger number of carbon atoms undergo thermal cracking, the carbon chain can undergo cleavage or breaking in a number of ways. The products formed as a result of thermal cracking depend on the nature of the hydrocarbons getting cracked, temperature and pressure.

When saturated hydrocarbons are subjected to thermal cracking the products formed contain both saturated and unsaturated hydrocarbons.

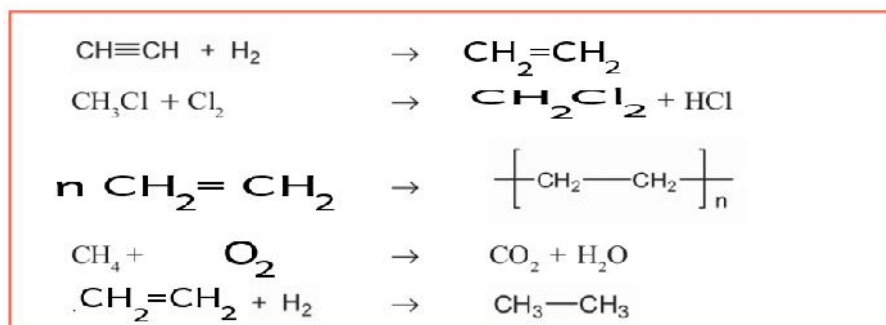
Plastic wastes, which are polymers can be converted to simpler molecules by thermal cracking. This helps to control pollution to some extent.

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♥♥♥ Complete the table containing chemical reaction of hydrocarbons



Answer:



♥♥♥ Find out the appropriate reactions and match the columns A ,B and C suitably

Reactants (A)	Products (B)	Name of the reaction (C)
$\text{CH}_3 - \text{CH}_3 + \text{Cl}_2$	$\text{CO}_2 + \text{H}_2\text{O}$	Addition reaction
$\text{C}_2\text{H}_6 + \text{O}_2$	$\text{CH}_2 = \text{CH}_2$	Thermal cracking
$n\text{CH}_2 = \text{CH}_2$	$\text{CH}_2 = \text{CH}_2 + \text{CH}_4$	Substitution reaction
$\text{CH}_3 - \text{CH}_2 - \text{CH}_3$	$\text{CH}_3 - \text{CH}_2\text{Cl} + \text{HCl}$	Polymerisation
$\text{CH}\equiv\text{CH} + \text{H}_2$	$\left[ \text{CH}_2 - \text{CH}_2 \right]_n$	Combustion

Answer:

Reactants (A)	Products (B)	Name of the reaction (C)
$\text{CH}_3 - \text{CH}_3 + \text{Cl}_2$	$\text{CH}_3 - \text{CH}_2\text{Cl} + \text{HCl}$	<b>Substitution reaction</b>
$\text{C}_2\text{H}_6 + \text{O}_2$	$\text{CO}_2 + \text{H}_2\text{O}$	<b>Combustion reaction</b>
$n\text{CH}_2 = \text{CH}_2$	$\left[ \text{CH}_2 - \text{CH}_2 \right]_n$	<b>Polymerisation</b>
$\text{CH}_3 - \text{CH}_2 - \text{CH}_3$	$\text{CH}_2 = \text{CH}_2 + \text{CH}_4$	<b>Thermal cracking</b>
$\text{CH}\equiv\text{CH} + \text{H}_2$	$\text{CH}_2 = \text{CH}_2$	<b>Addition reaction</b>