

5 Production of Ethene (Ethylene)

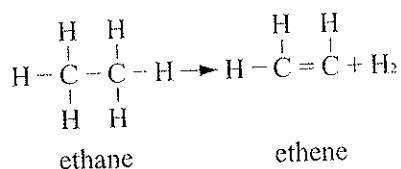
Most organic chemicals, including ethene, come from petroleum or natural gas. However, ethene does not occur naturally in either of these resources, so it has to be made from other chemicals in them.

In Europe and Japan, ethane is obtained from **petroleum** by fractional distillation and thermal or catalytic cracking.

In Australia and the USA, where **natural gas** is more readily available, we mostly pipe natural gas directly from its source and crack it to obtain ethene.

Cracking is a process in which molecules of carbon compounds are broken down into smaller molecules with the help of heat and/or catalysts.

Ethene is produced from **natural gas** by **thermal cracking**, using steam, of the small quantities of **ethane, propane and butane** present in natural gas.



Ethene is produced from **crude oil** by **cracking** of fractions from the distillation column. This process involves **surface reactions with inorganic catalysts** such as **alumina-silica gel powder**. The reaction occurs as the ethane gas comes into contact with the surface of the solid catalyst. A typical modern cracker will generate 600 000 to 1 000 000 tonnes of ethene per year.

For You To Do

- A suitable catalyst for the cracking of crude oil to produce ethene would be:
(A) iron
(B) concentrated sulfuric acid
(C) a transition metal
(D) alumina-silica gel powder
- In Australia and USA the main source of ethane is:
(A) fractional distillation of petroleum
(B) cracking of natural gas
(C) fractional distillation of natural gas
(D) fractional distillation of coal
- Thermal cracking is a process whereby:
(A) a high temperature is used to produce methane from petrol
(B) steam is passed over a catalyst, forming hydrogen
(C) ethane and other longer chain alkanes are converted, using steam, to ethene
(D) ethene and other longer chain alkanes are converted, using steam, to methane

- Plants in Australia produce about 360 000 tonnes of ethene per year.
(a) State another name for ethene.
(b) Write the structural formula for ethene.
(c) Identify the main source of ethene in:
(i) the USA and Australia
(ii) Europe.
(d) Account for the greater use by industry of ethene rather than ethane.
(e) List a number of commercial, everyday products whose manufacture starts with ethene.
- (a) Outline the mechanism for cracking of crude oil.
(b) During this process, air is excluded. Deduce the reason for this.
(c) By controlling the temperature and the catalyst used, the products of cracking can be controlled. One of these products is ethene. Discuss the need for ethene production.
- Construct balanced equations for the following reactions:
(a) cracking of propane to form ethene
(b) cracking of $\text{C}_{16}\text{H}_{34}$ to form a C_8 alkane and an alkene
(c) cracking of a C_6 alkane to form ethene and ethane
- Read the following passage about the production of ethene and answer the questions below.

Ethene Production

Ethene can be produced by the thermal cracking of ethane from natural gas. Australia has natural gas deposits that supply our industrial and domestic needs. Natural gas is mainly methane, with some ethane, as well as lesser amounts of propane, butane and impurities. The thermal cracking of natural gas involves the following steps.

Step 1

Ethane and steam are pumped into a steam cracker. Steam is fed in at intervals to react with any carbon deposits and remove them by forming carbon dioxide and hydrogen.

The ethane and steam mixture is heated to high temperatures, between 750–900 °C, for very short periods of time, typically for only about 1 second. This converts most of the ethane to ethene and hydrogen. The gas that leaves the thermal cracker furnace is a mixture of ethene, unreacted ethane and impurities such as methane, carbon dioxide, hydrogen, hydrogen sulfide, propane and acetylene (ethyne).

Step 2

This mixture of gases goes into a quench tower which allows the gases to be cooled quickly by

water until it is about 30 °C. Cooling the gases stops any further cracking.

Step 3

Impurities are removed by passing the gas through a caustic tower where dilute sodium hydroxide is added. Sodium hydroxide reacts with any hydrogen sulfide to form sodium sulfide solution and with carbon dioxide to form sodium carbonate solution.

All water is also removed by a desiccator. This is essential, otherwise during the next stage, when the gases are cooled below 0 °C, ice would form and block pipes.

A catalyst such as nickel-iron is used to hydrogenate the acetylene, converting it to ethene.

Step 4

The mixture of gases remaining is separated into its components by fractional distillation. To do this it must first be turned into a liquid by putting it under pressure (which heats it again), then cooling it to about -100 °C.

Step 5

Fractional distillation of the gases is carried out in a series of distillation columns. The first column removes the light fractions such as hydrogen and methane. The second column separates ethene from heavier impurities. The purity of the ethene is by then more than 99.85% w. A third column separates out any unused ethane and returns it to the cracking furnace.

Questions

- (a) Identify the main components of natural gas.
- (b) Write an equation to show the thermal cracking of ethane to produce ethene.

- (c) Write an equation to show the reaction of steam with carbon deposits.
 - (d) Suggest a possible origin of the carbon deposits in the steam cracker.
 - (e) Use two equations to show the chemical reactions in the caustic tower that remove impurities.
 - (f) Use an equation to show the hydrogenation of acetylene.
 - (g) Explain what is meant by the statement that the purity is more than 99.85% w.
 - (h) If 1000 kg of product is produced, calculate the mass of ethene present.
 - (i) What is another name for acetylene?
 - (j) Identify the function of a quench tower.
 - (k) Define fractional distillation.
8. Check your knowledge with this quick quiz.
- (a) Identify the main source of ethane in Australia and the USA.
 - (b) Identify the processes used to obtain ethene from natural gas.
 - (c) Identify the processes used to obtain ethene from crude oil.
 - (d) Name a catalyst used in the production of ethane from petroleum.
 - (e) What is the main characteristic of ethene that makes it suitable for the formation of many products?
 - (f) State another name for ethene.
 - (g) What do we call the process that involves organic molecules being broken down into smaller molecules by heat and/or catalysts?
 - (h) Identify the method of separating the components of a mixture based on their different boiling points.