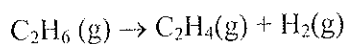


4 Ethane and Ethene

Fossil fuels provide us with energy. They also provide **chemicals** that are used in many industries, such as the manufacture of plastics, rubbers, fertilisers, synthetic textiles and pharmaceuticals. One of the most useful chemicals in industry is **ethene** (also called **ethylene**), which is made from other carbon compounds in fossil fuels. It is used in the production of a vast range of products, such as poly(ethene), polyvinyl chloride, polystyrene, radiator coolant, brake fluid, industrial solvents, detergents, shampoos, cosmetics, paints and toothpastes. Ethene must be handled carefully because, although it is not toxic, it is a lung irritant. Ethene is produced industrially from ethane, which is present in petroleum and in natural gas.

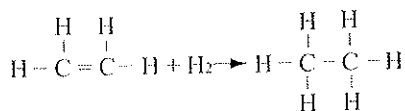


Ethane (C_2H_6) and **ethene** (C_2H_4) are both hydrocarbons with a 2-carbon chain. They **share a number of properties** in common with other alkanes and alkenes. They are both non-polar molecules with weak dispersion forces between their molecules and thus they are relatively insoluble in water and have low melting and boiling points. They both undergo combustion with oxygen, forming carbon dioxide and water, and are used as fuels. However, they **differ in reactivity**; ethene is more reactive than ethane due to its double bond. This reactivity is the main reason for the extensive use of ethene in industry, especially in the production of polymers.

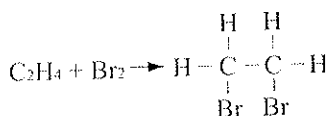
Addition Reactions of Alkenes

Ethene (and other alkenes) undergoes addition reactions, which involve the breaking of a double bond and the 'adding in' of other atoms or groups of atoms (e.g. H_2 , HCl , H_2O or halogens).

Addition of hydrogen allows the formation of alkanes from alkenes (e.g. ethane from ethene).

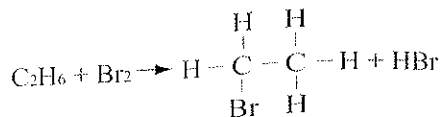


Addition of halogens forms haloalkanes (e.g. 1,2-dibromoethane).



Substitution Reactions of Alkanes

Ethane (and other alkanes) undergoes substitution reactions. An atom is substituted for another already in the molecule; for example ethane, in the presence of UV light, will undergo a slow substitution reaction with bromine water to form bromoethane and hydrogen bromide.



Test for an Unsaturated Carbon Compound

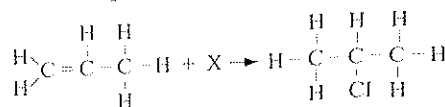
This reaction with bromine water can be used as a **test for the presence of a double or triple bond**. To a sample of an unknown hydrocarbon add bromine water, which is a red-brown colour, and see if it reacts.

An **alkene** will undergo an **addition reaction**, decolourising the bromine water very **quickly**.

An **alkane** will undergo a **substitution reaction** with bromine water, but this reaction is very **slow** and only occurs in the **presence of light**. This reaction may take several hours, or even days, to complete.

For You To Do

- Ethene reacts with hydrogen to form ethane. This reaction can be described as:
(A) combustion
(B) hydrolysis
(C) substitution
(D) addition
- In the equation:



the substance X could be:

- hydrogen
 - chlorine
 - hydrogen chloride
 - both A and B
- (a) Identify the industrial source of ethene.
(b) Identify the property of ethene that allows it to be readily transformed into many useful products.
 - Explain the relationship between the properties of alkanes and alkenes and their:
(a) non-polar nature
(b) weak intermolecular dispersion forces
(c) carbon-carbon bonding.
 - Hydrocarbons can be saturated or unsaturated.
(a) Distinguish between these two terms.
(b) Outline the test you would carry out to see whether a hydrocarbon is saturated or unsaturated.

6. Compounds called haloalkanes can be produced by the reactions of halogens with alkenes (addition reactions) and with alkanes (substitution reactions).
- (a) Name the following haloalkanes:
- (i)
- $$\begin{array}{ccccccc}
 & \text{H} & \text{H} & \text{H} & \text{Br} & \text{H} & \\
 & | & | & | & | & | & \\
 \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{H} \\
 & | & | & | & | & | & \\
 & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} &
 \end{array}$$
- (ii)
- $$\begin{array}{ccccccc}
 & \text{H} & \text{H} & \text{H} & \text{H} & \text{Br} & \\
 & | & | & | & | & | & \\
 \text{H} & - \text{C} & - \text{C} & = \text{C} & - \text{C} & - \text{C} & - \text{H} \\
 & | & & & | & | & \\
 & \text{H} & & & \text{H} & \text{H} &
 \end{array}$$
- (b) Write structural formulae for the haloalkanes listed below:
- 2,2-dichloropentane
 - 2-chloro-3-hexene
 - 1,2-dibromopentane
 - 2-iodopentane
 - 3-chloro-2-octene
7. Alkenes can undergo addition reactions with chemicals such as hydrogen, halogens, water and hydrogen halides. Write balanced equations to show the following addition reactions and name the product in each case:
- addition of hydrogen to propene
 - addition of hydrogen to 2-pentene
 - addition of chlorine to butene
 - addition of water to ethene
 - addition of hydrogen chloride to propene
8. (a) Using structural formulae, write equations to show:
- addition of bromine to propene
 - substitution of bromine into propane.
- (b) Identify which of the reactions in (a) above would be faster. Explain.
- (c) Explain the importance of this bromine reaction with alkanes and alkenes.
9. You carried out a first-hand investigation to compare the reaction of bromine water with an alkane and an alkene.
- Outline the method you used.
 - Describe any observations you made during this investigation.
 - Write equations for any reactions observed.
 - Outline any safety precautions necessary during this investigation and explain why they were necessary.
10. Identify two properties of both alkanes and alkenes that result from their molecules being non-polar.
11. Write equations to show any reactions that occur when the following chemicals are mixed at appropriate temperatures and pressures.
- ethene is bubbled through bromine water in a dark environment
 - ethane is bubbled through bromine water in UV light
 - bromine is mixed with ethane in a dark, cold environment
12. Identify the type of carbon-carbon bonding in alkanes and alkenes and the type of reaction they undergo (addition or substitution).
13. Check your knowledge with this quick quiz.
- Identify the main chemical derived from fossil fuels and used as a raw material in industry.
 - Ethene is more reactive than ethane because ethene has a _____.
 - The test for the presence of a double or triple bond in a carbon compound is the _____.
 - Describe the colour change you would expect when an alkene is added to bromine water.
 - Which is more active, an alkene or the corresponding alkane?
 - Name the type of reaction that involves the breaking of a double or triple bond and the adding in of atoms.
 - Ethene is used in many industries. Identify three uses of ethene other than in the plastics industry.
 - What is our main source of organic chemicals?
 - Which is most used by industry, ethane or ethene?
 - The reaction of hydrogen with propene is what type of reaction?
 - What type of reaction occurs when hydrogen reacts with butane?
 - What is the functional group for an alkene?
 - What do we call a series in which all members have the same functional group and general formula?
 - Name each of the following substances:
 - C_3H_6
 - C_4H_6
 - C_5H_{10}