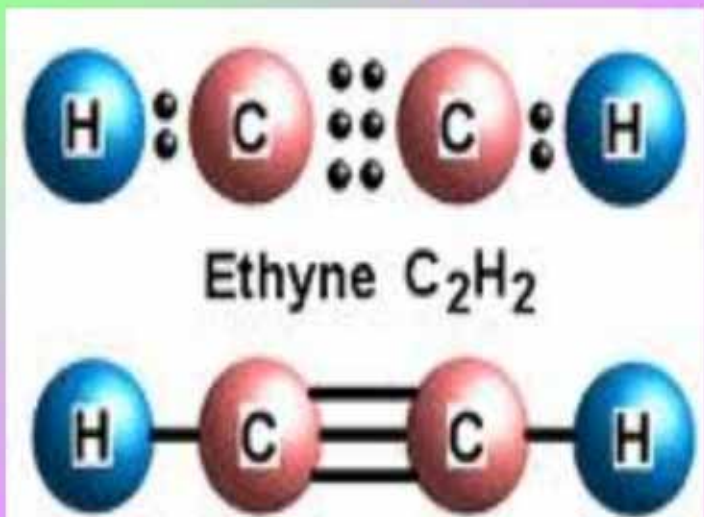
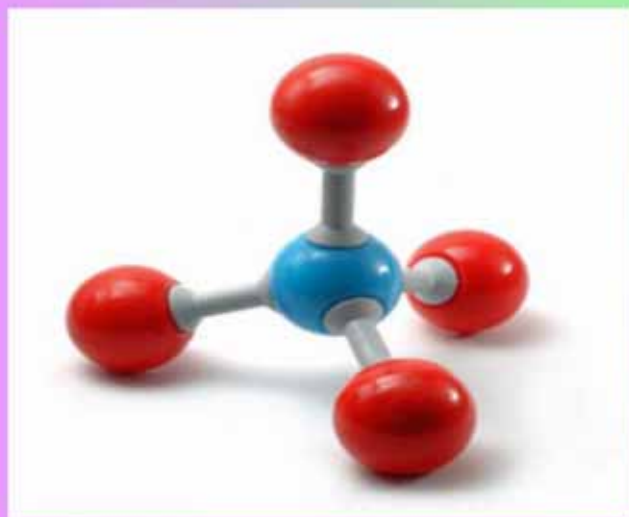


# Chemistry of Methane and Ethyne



## **Learning Outcomes:**

### **Students will be able to:**

- 1. describe the preparation, properties and uses of methane;**
- 2. describe the preparation, properties and uses of ethyne or acetylene.**

## **Methane:**

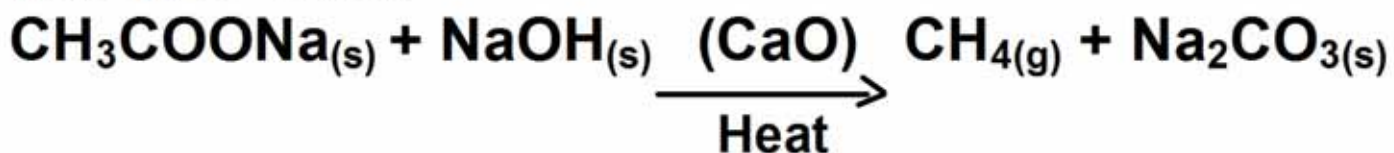
**Methane (CH<sub>4</sub>) is the simplest compound among hydrocarbons. It is found in marshes where it is formed by the decay of organic matter. Hence, it is named as marsh gas.**

**Methane also issues out from petroleum wells with other gases and the mixture is termed as natural gas. Natural gas consists of about 80-95 percent of methane.**

## **Preparation of Methane:**

### **1. Laboratory Preparation of Methane:**

Methane is prepared in the laboratory by the decarboxylation of sodium acetate. A mixture of dry sodium acetate and dry soda lime is heated in a test tube. Soda lime is a mixture obtained by adding a concentrated solution of NaOH to CaO.

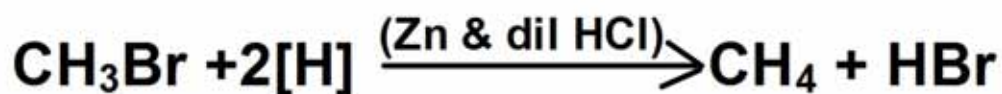


**Methane evolved is collected over water.**

## **Other Methods of Preparing Methane:**

### **1. By the Reduction of Alkyl Halides:**

Methyl halides are reduced by nascent hydrogen, using zinc and dilute HCl. Other reducing agents, like Na and alcohol or Zn-Cu couple and H<sub>2</sub>O, may also be used.



### 3. From Aluminium Carbide:

When water is dropped over  $\text{Al}_4\text{C}_3$ , methane is evolved which is collected over water.



## **Properties of Methane:**

### **Physical Properties:**

- 1. It is a colourless and odourless gas with a boiling point of  $-162^{\circ}\text{C}$ .**
- 2. It is insoluble in water but soluble in organic solvents like alcohol.**
- 3. It is one of the lightest gas.**
- 4. It is present in large amount in natural gas.**

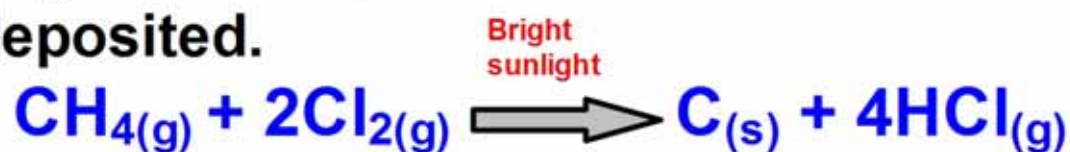
## **Chemical Properties:**

**In methane, C-H bonds are strong sigma bonds. Hence, a large amount of energy is required to break these bonds. Also, the bonds in methane are almost non-polar. Hence, it is not easily attacked by both the electrophiles and nucleophiles. Therefore, methane is chemically quite inactive. Some important reactions of methane are given below:**

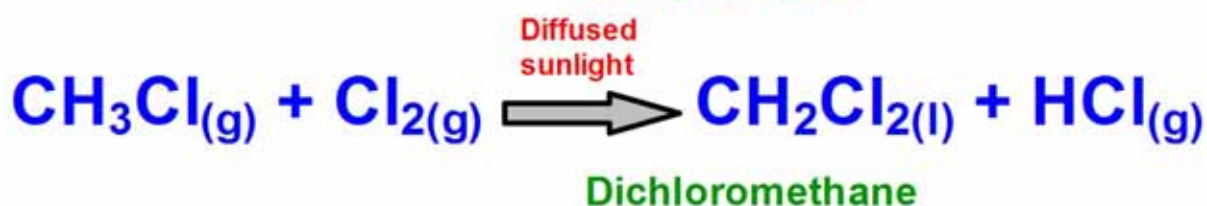
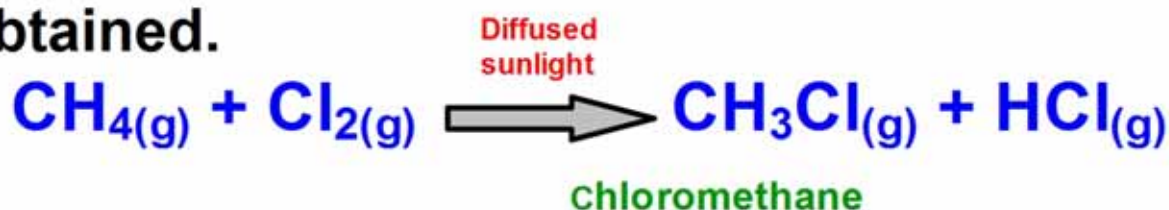


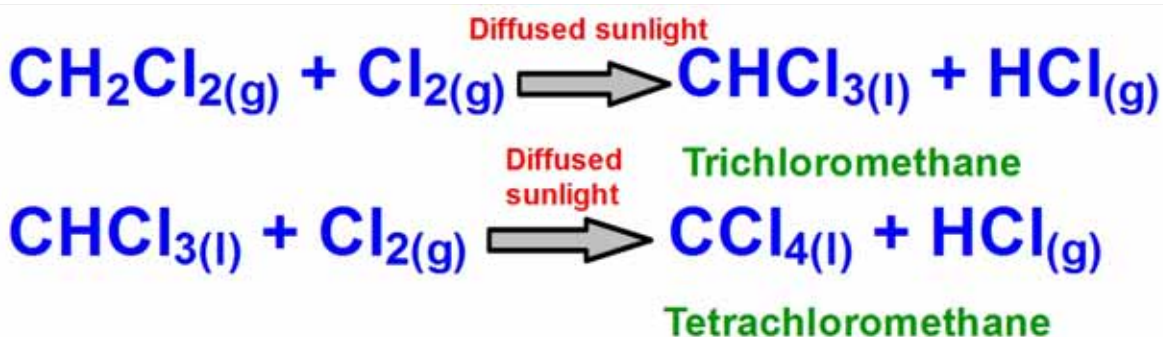
## 1. Halogenation:

i. Methane reacts with chlorine in direct sunlight with explosive violence and carbon is deposited.



ii. In diffused sunlight or ultra violet light, reaction takes place without explosion and a mixture of several chloro derivatives is obtained.





## 2. Combustion:

Methane burns in the presence of excess of air (or oxygen) forming  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . The reaction is highly exothermic and because of this methane is used as a fuel.

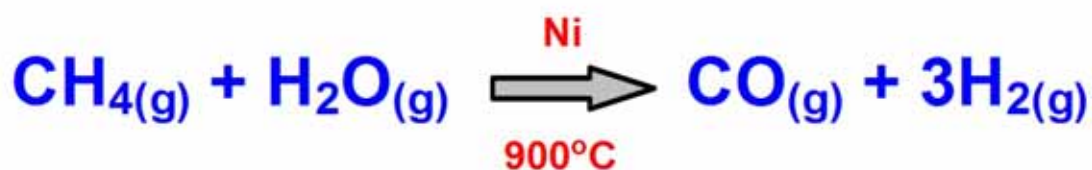


In a limited supply of oxygen, there is incomplete combustion and carbon (soot) and carbon monoxide are the main products.



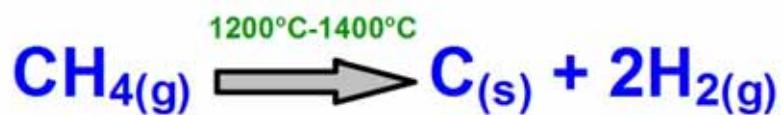
### 3. Action with Steam:

When a mixture of methane and superheated steam is passed through heated metallic tubes containing nickel catalyst, a mixture of carbon monoxide and hydrogen is obtained.



## 4. Pyrolysis:

Methane, when subjected to high temperature, in the absence of air, decomposes to give carbon and hydrogen.



## **Uses of Methane:**

- i. Methane is an important fuel.**
- ii. It is used for preparing carbon black which is an important component of paints, black polishes and automobile tyres.**
- iii. Methane is used in the manufacturing of several important chemicals such as chloroform, methanol, methanal and  $\text{CCl}_4$ .**
- iv. For obtaining hydrogen on a large scale, methane is used in the manufacturing of ammonia and urea.**

## **Ethyne:**

### **Laboratory Preparation of Ethyne:**

Ethyne may be prepared in the laboratory by dropping water over calcium carbide.  $\text{H}_2\text{S}$ , which is present as the main impurity in ethyne, is removed by passing the gas through a slightly acidified solution of copper sulphate.

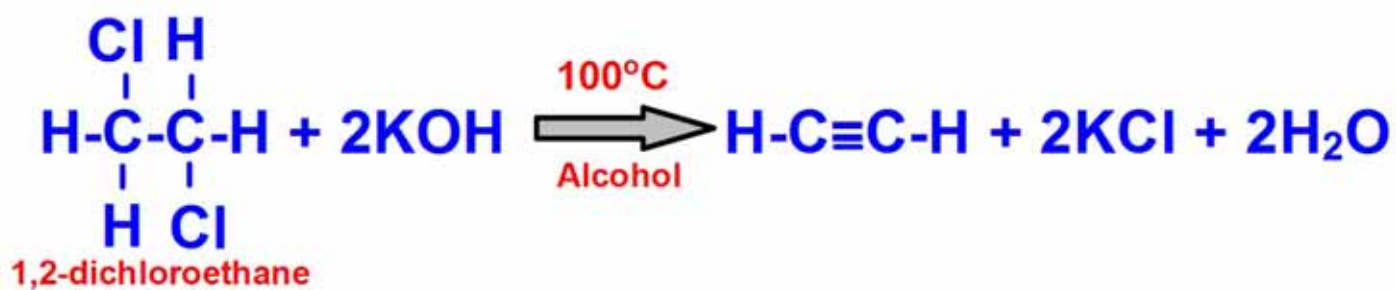


### **Other Methods of Obtaining Ethyne:**

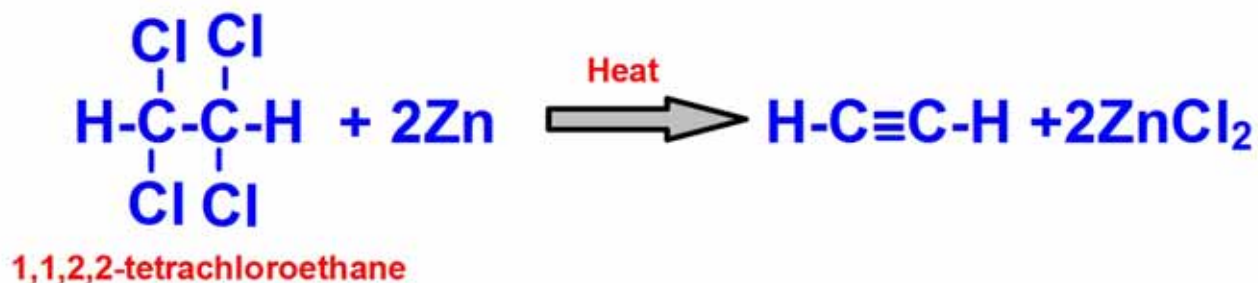
#### **1. From Alkyl dihalides by dehydrohalogenation:**

When an alkyl dihalide is heated with alcoholic potassium hydroxide, two halogen atoms and two

beta-hydrogens are removed from two adjacent carbon atoms with the formation of an alkyne.



## 2. From Alkyl Tetrahalides by Heating with Zinc Dust:



## **Properties of Ethyne:**

### **1. Physical Properties:**

- i. Ethyne is a colourless gas having garlic-like smell.**
- ii. It is only slightly soluble in water, but dissolves readily in acetone.**
- iii. Boiling point of ethyne is  $-80^{\circ}\text{C}$ . When it is cooled, it forms a white solid.**
- iv. Ethyne is slightly lighter than air.**

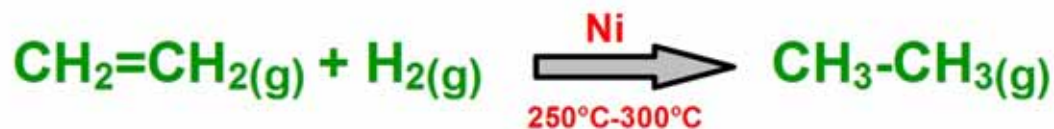
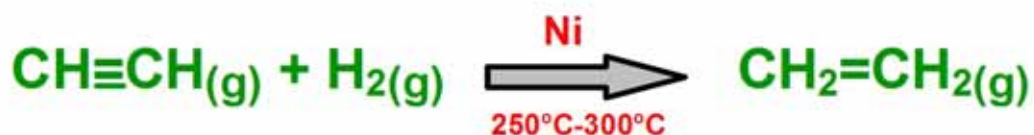


## Chemical Properties:

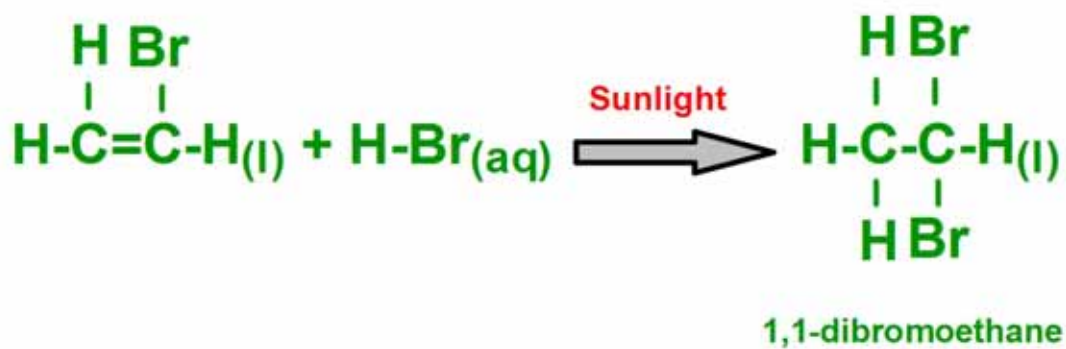
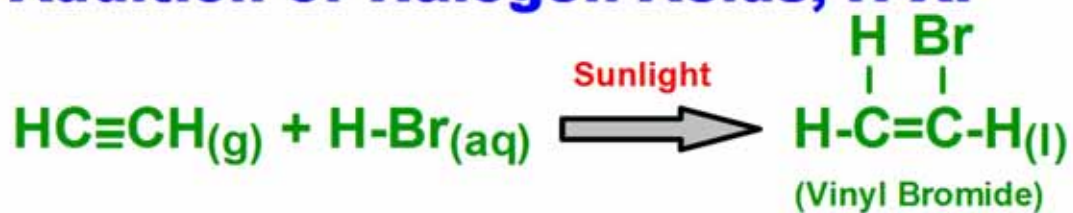
Some of the major chemical properties of ethyne are as follows:

### 1. Addition of hydrogen:

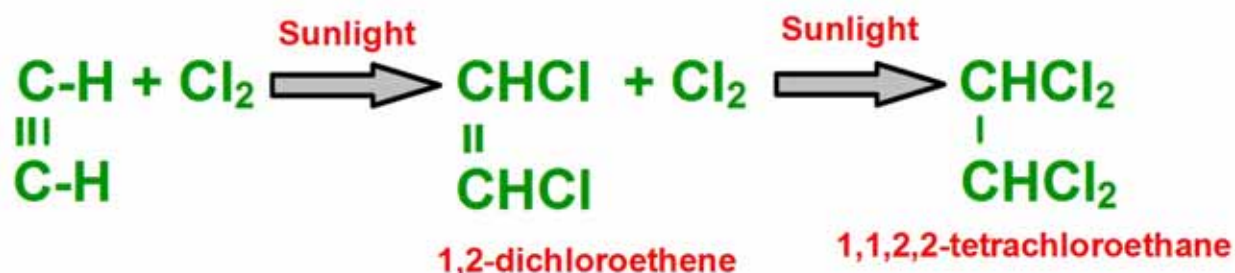
Hydrogen gas adds at  $250^{\circ}\text{C}$ , in the presence of Ni. If Pt or Pd are used as catalyst, addition takes place at room temperature.



## 2. Addition of Halogen Acids, H-X:

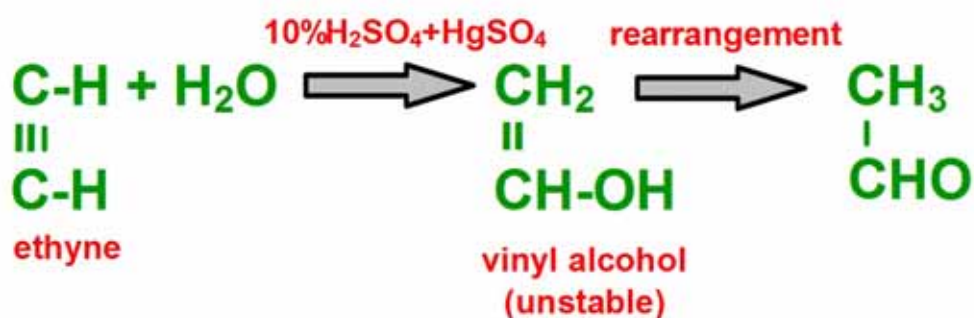


### 3. Addition of Halogens:



### 4. Addition of Water:

Ethyne adds a molecule of water in the presence of 10%  $\text{H}_2\text{SO}_4$  and  $\text{HgSO}_4$  to form Ethanal (acetaldehyde). Higher alkynes, except 1-alkynes, give ketones under these conditions. The reaction is supposed to take place in two steps.



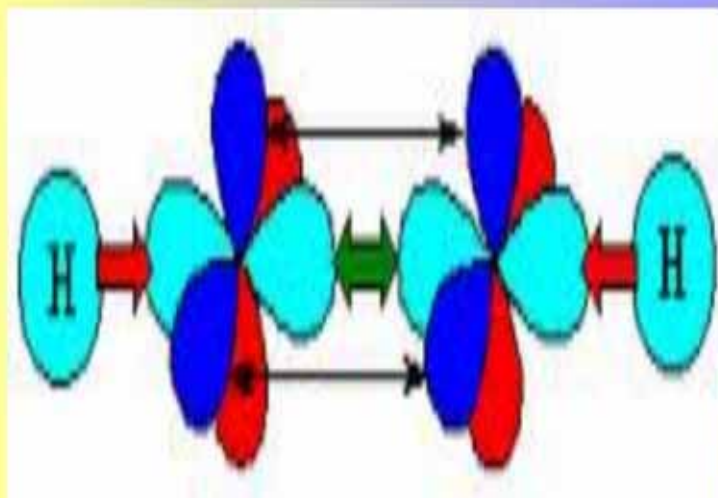
## Uses of Ethyne:

1. Ethyne is employed on a large scale for welding and cutting metals, because when it is burnt with oxygen, the oxy-acetylene flame reaches a temperature of about  $3000^{\circ}\text{C}$ .

For cutting purposes, an excess of oxygen is used and thus, the oxyacetylene flame is capable of cutting nickel-chrome plate.

- 2. Ethyne is used in the commercial preparation of acetaldehyde, acetic acid, etc.**
- 3. Ethyne is used in the manufacturing of ethyl alcohol, synthetic fabrics, synthetic rubber and plastics.**
- 4. Ethyne is also used to prepare acetylene tetrachloride which has a wide application as a solvent for varnishes and rubber.**
- 5. Ethyne is also used for the artificial ripening of fruit.**

# Multiple Choice Questions



**1. Which of the following gas is produced by dropping water on calcium carbide ( $\text{CaC}_2$ )?**

- A. methane**
- B. ethane**
- C. ethylene**
- D. acetylene**

**2. The reaction in which elimination of a hydrogen halide (HX), takes place from two adjacent carbon atoms is called**

- A. hydrohalogenation.**
- B. hydrogenation.**
- C. halogenation.**
- D. dehydrohalogenation.**



**3. Which of the following is produced when a mixture of sodium acetate and soda lime is heated together?**

- A. ethene**
- B. ethyne**
- C. ethane**
- D. methane**