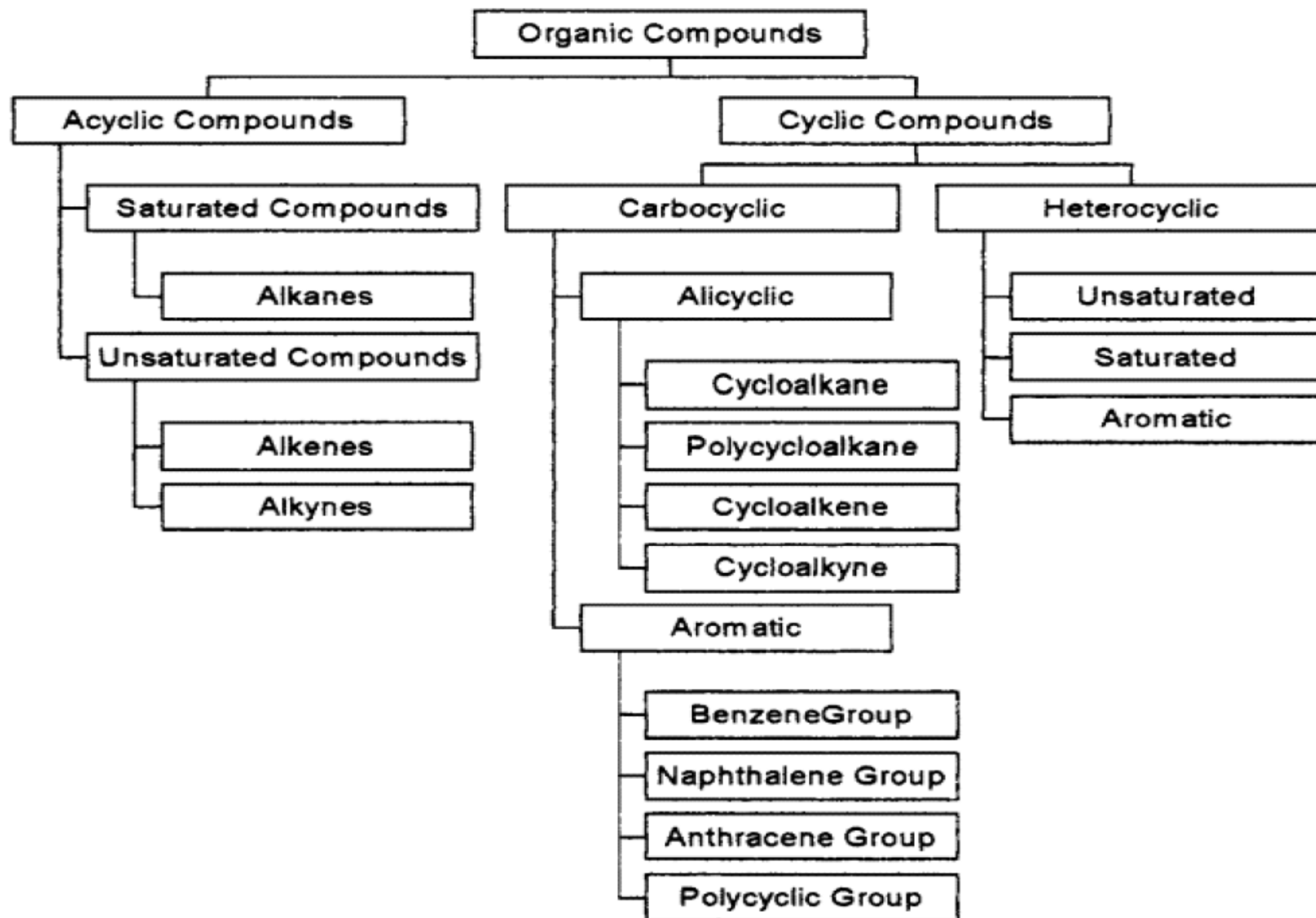


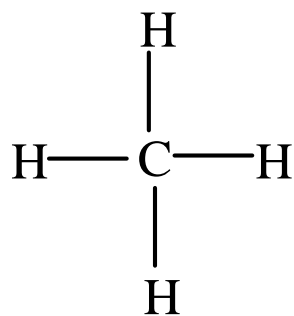
***CHM 102: Introductory
Organic Chemistry***

General Classification - Organic Compounds

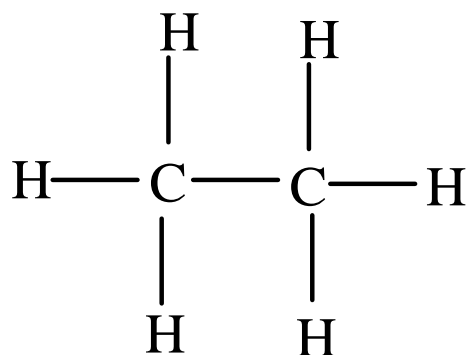


Hydrocarbon

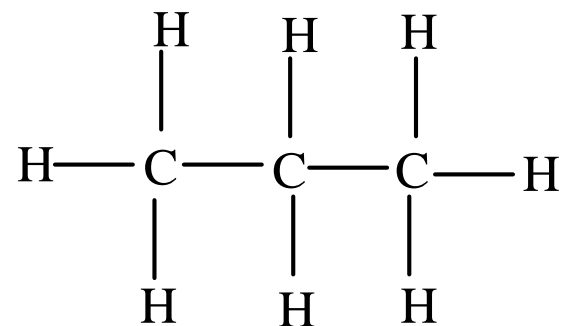
- ✓ **Alkane** is a hydrocarbon that has only single bonds. Alkanes has a general formula of C_nH_{2n+2} . An alkane in the shape of a ring is called a **cycloalkane**.
- ✓ **Alkene** is a compound that has at least one double bond. Alkene general formula is C_nH_{2n} .
- **Alkyne** is a compound that has at least one triple bond. A straight chain alkyne with one triple bond has the formula C_nH_{2n-2} .



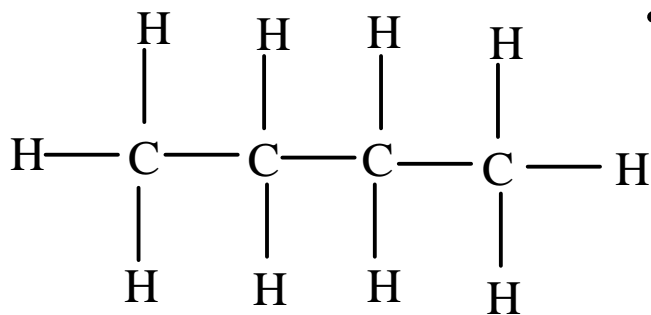
Methane (CH₄)



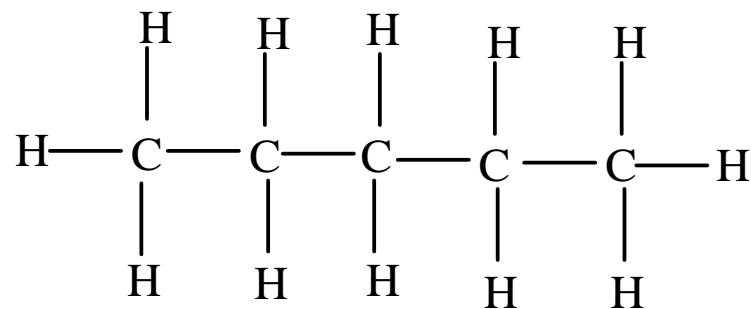
Ethane (CH₃-CH₃)



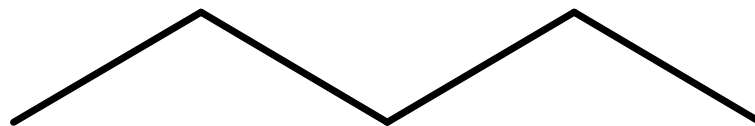
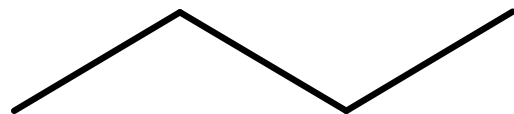
Propane (CH₃-CH₂-CH₃)



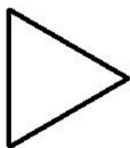
Butane (CH₃-CH₂-CH₂-CH₃)



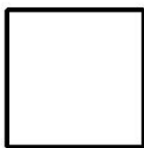
Pentane (CH₃-CH₂-CH₂-CH₂-CH₃)



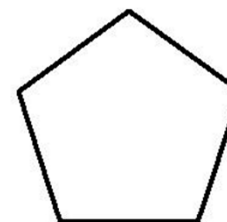
Cycloalkanes



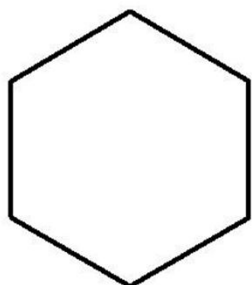
cyclopropane



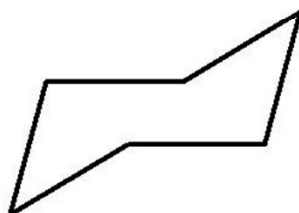
cyclobutane



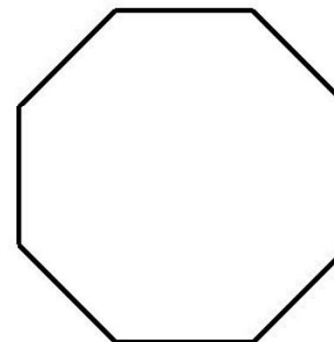
cyclopentane



cyclohexane



cyclohexane



cyclooctane

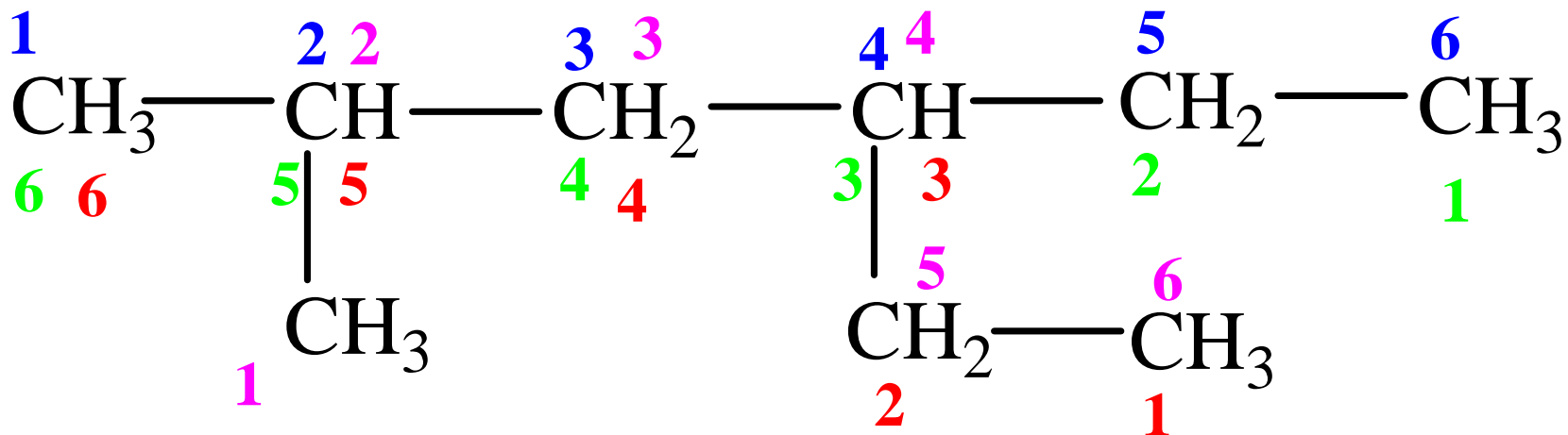
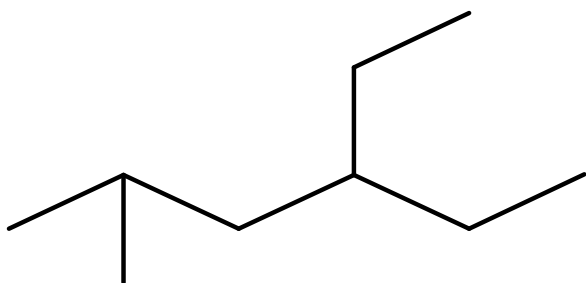
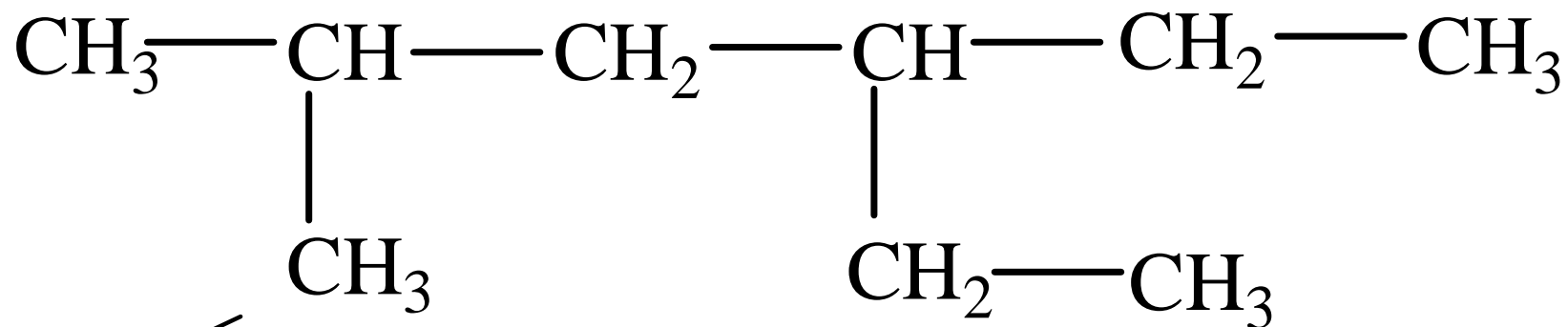
Name	Molecular formula	Name	Molecular formula
Methane	CH ₄	Undecane	C ₁₁ H ₂₄
Ethane	C ₂ H ₆	Dodecane	C ₁₂ H ₂₆
Propane	C ₃ H ₈	Tridecane	C ₁₃ H ₂₈
Butane	C ₄ H ₁₀	Tetradecane	C ₁₄ H ₃₀
Pentane	C ₅ H ₁₂	Pentadecane	C ₁₅ H ₃₂
Hexane	C ₆ H ₁₄	Hexadecane	C ₁₆ H ₃₄
Heptane	C ₇ H ₁₆	Heptadecane	C ₁₇ H ₃₆
Octane	C ₈ H ₁₈	Octadecane	C ₁₈ H ₃₈
Nonane	C ₉ H ₂₀	Nonadecane	C ₁₉ H ₄₀
Decane	C ₁₀ H ₂₂	Eicosane	C ₂₀ H ₄₂

Nomenclature of alkane

- ✓ Identify the parent chain (longest carbon chain) and the substituents (groups attached to the parent chain).
- ✓ Identify the 'branches' on the longest carbon chain and name them accordingly.
- ✓ Number the carbon atoms on the longest carbon chain to describe the positions of the branches – *use the lowest numbers possible*.
- ✓ Each substituent is given a name and a number. The number shows the carbon atom to which the substituent is attached.

- ✓ If the substituent appears more than once, the number of each carbon of the parent chain on which the substituent occur is given. In addition, the number of times in which the substituent occur is given by a prefix di-, tri-, tetra-, penta-, etc.
- ✓ If there are 2 or more substituent, they are listed in alphabetical order. (Ignore prefix like di-, tri-, tetra-, etc, or sec-, tert-, etc, when alphabetizing).

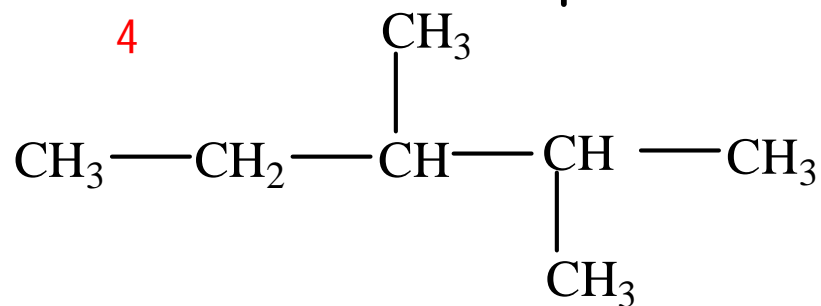
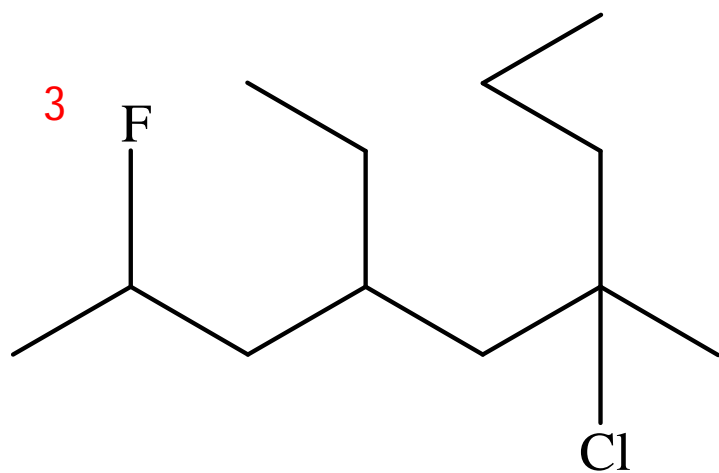
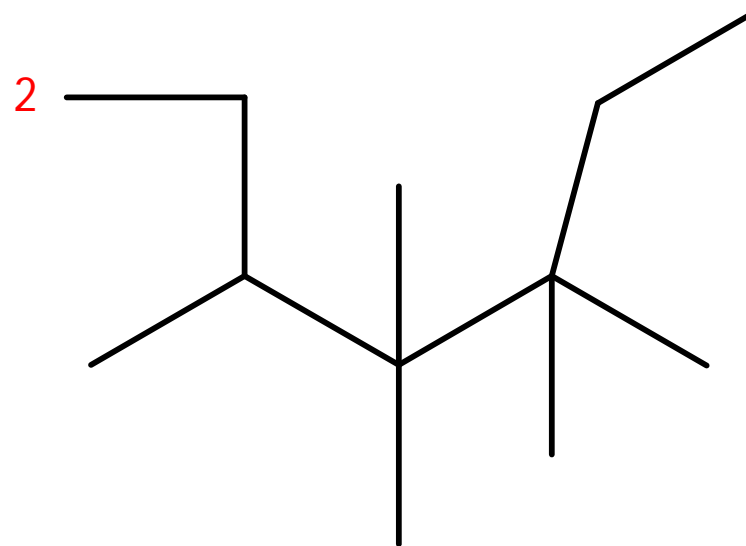
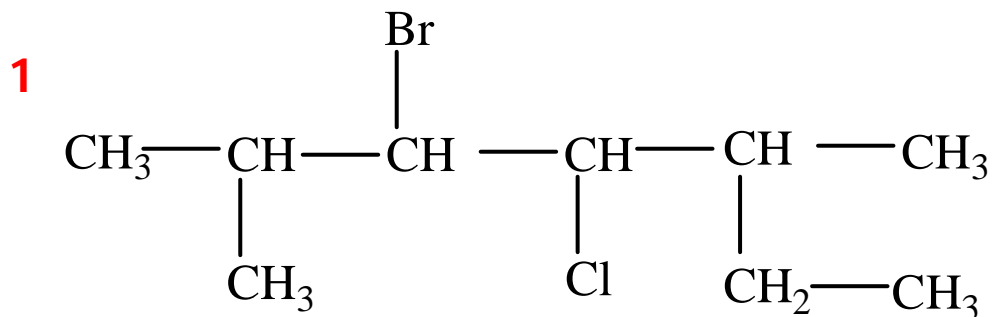
Exercise 1. Name the organic compounds below:



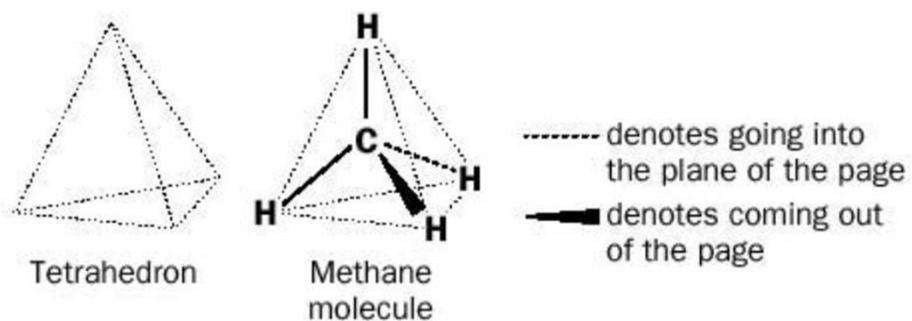
3-ethyl-5-methylhexane

(a) Write the structural formulae of: (i) 2-bromo-3-chloro-3-methylpentane (ii) 4-ethyl-2-methylheptane (iii) 2,2,5-trimethyloctane (iv) 2,3,4-trimethylheptane.

(b) Name the following organic compounds

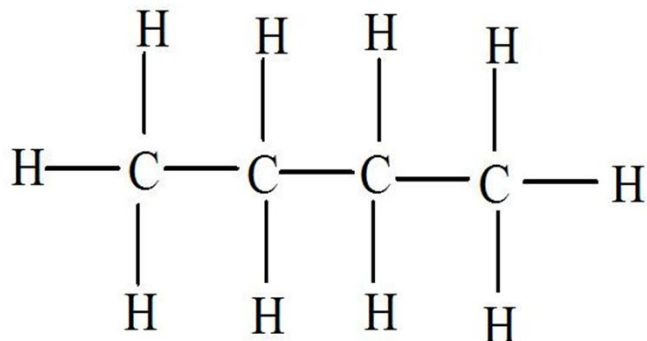


Shapes of alkane molecules

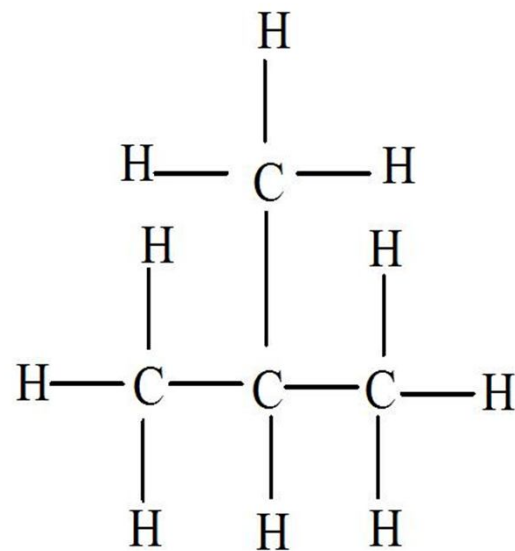


Structural isomerism in alkanes

Two or more compounds that have the same molecular formula but different orders of attachment of atoms are called structural isomer.



Butane
(bp -0.5°C)



2-methylpropane
(bp -11.2°C)

Show all the possible isomers of :

- 1) Pentane (C_5H_{12})
- 2) Hexane (C_6H_{14})

Preparation of alkane

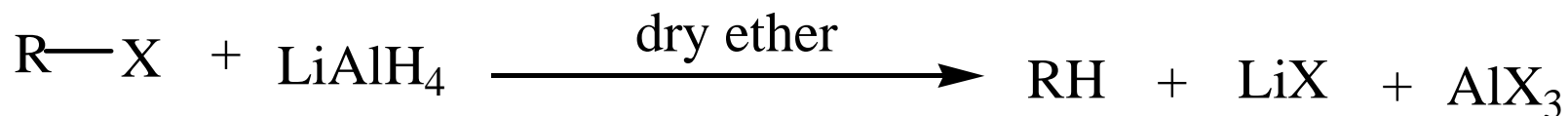
1. Wurtz reaction



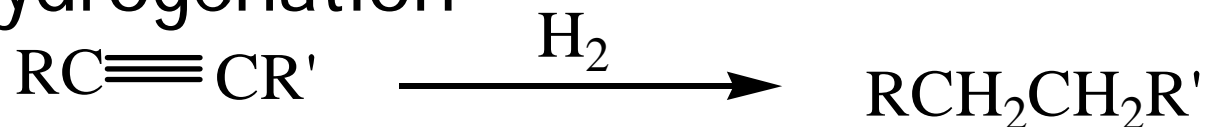
2. Grignard reduction



3. Reduction

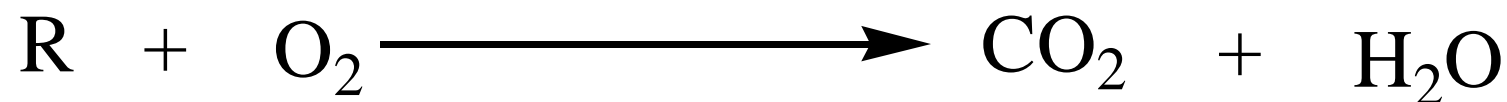


4. Hydrogenation



Reaction of alkane

1. Combustion



2. Halogenation



Reactivity X: $\text{Cl}_2 > \text{Br}$

H: $3^\circ > 2^\circ > 1^\circ > \text{CH}_3\text{-H}$

3. Free radical substitution



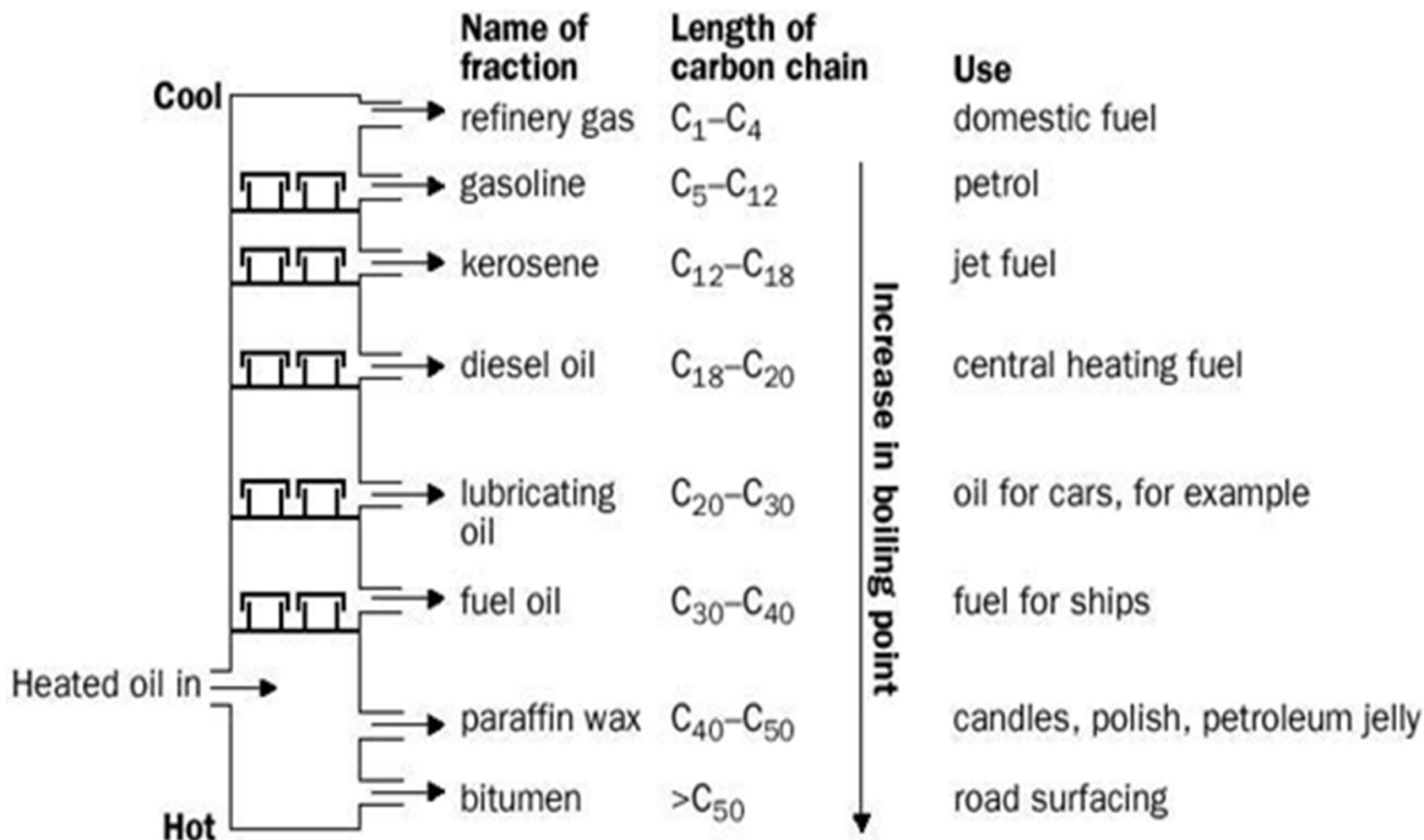
Sources of alkanes

- ✓ Alkanes are obtained from crude oil and natural gas.
- ✓ Natural gas contains 60–90% methane.
- ✓ Crude oil is a mixture of many carbon compounds with different chain lengths.
- ✓ The oil is therefore separated into groups of compounds with roughly the same chain length in an oil refinery.
- ✓ The technique that is used to refine the oil is called fractional distillation.

Fractional distillation of crude oil

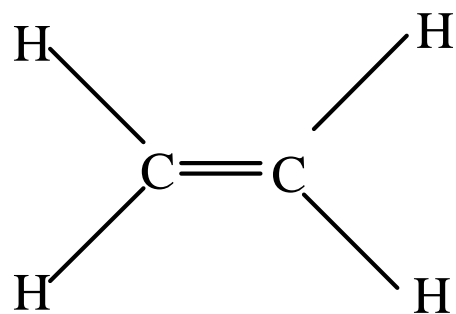
- ✓ The oil is heated and passed into a tall fractionating column.
- ✓ Compounds with large molecules and high boiling points are collected at the bottom of the tower, whereas the more volatile components, with smaller molecules, are collected near the top.
- ✓ Each group of compounds collected is called a fraction.
- ✓ Each fraction is still a complicated mixture, since it contains alkanes of a range of carbon numbers and isomers of each carbon number.
- ✓ In addition to alkanes, crude oil contains some cycloalkanes and aromatic compounds – the proportion of each present depends upon the source of the oil.

Fractionating column

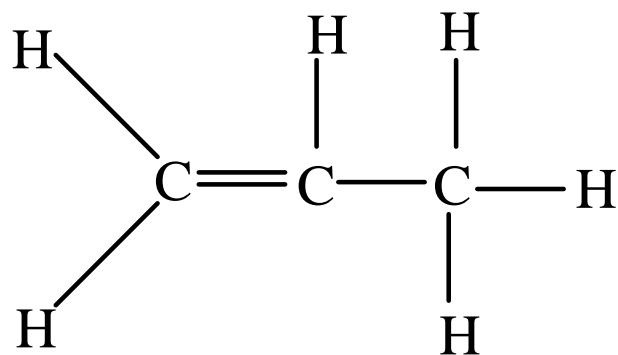


Alkenes

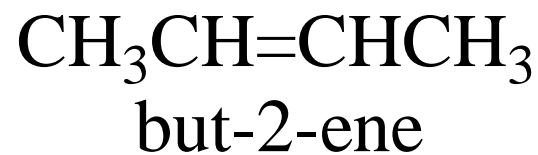
- ✓ Alkene molecules contain a double bond between carbon atoms.
- ✓ They have the general formula C_nH_{2n} and their names end in 'ene'.
- ✓ The first three (ethene, propene, and butene) are gases at 25°C.



ethene



propene

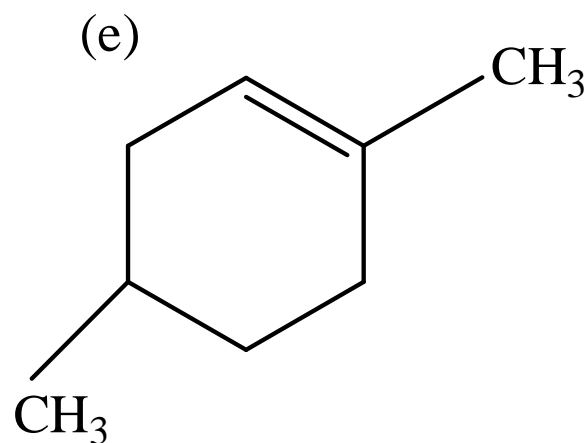
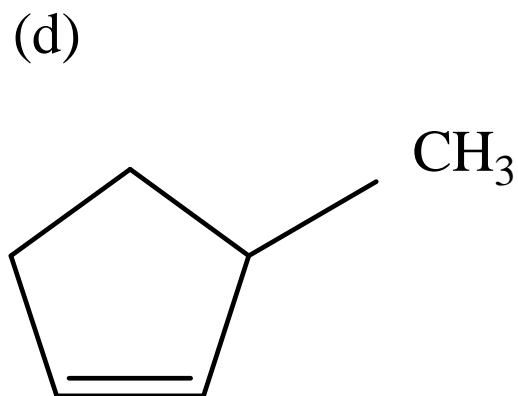
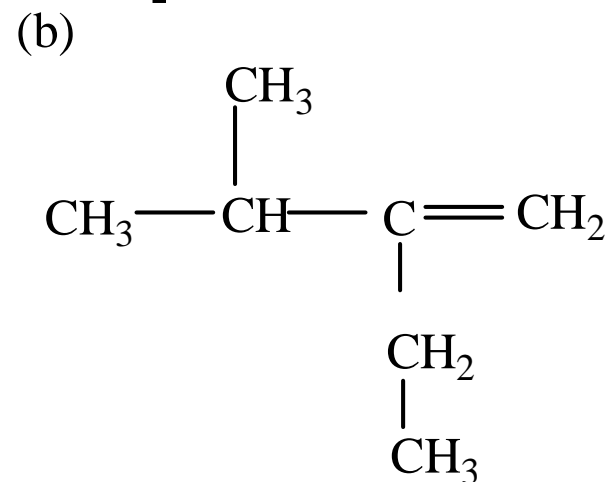
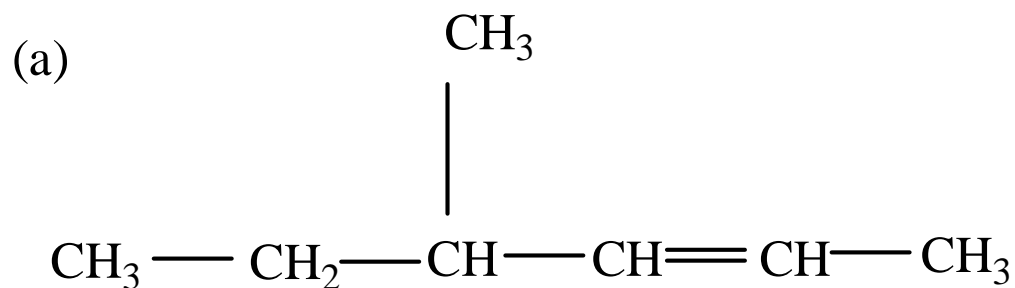


Nomenclature of Alkenes

- ✓ The IUPAC names of alkenes are formed by changing the **-an-** infix of the parent alk**ane** to **-en-**. Hence $\text{CH}_2=\text{CH}_2$ is named ethene and $\text{CH}_3\text{CH}=\text{CH}_2$ is named propene.
- ✓ According to the IUPAC system, the longest carbon chain that contains the double bond is numbered to give the carbon atoms of the double bond the lowest possible numbers.
- ✓ The location of the double bond is indicated by the number of the first carbon of the double bond. Branched or substituted alkenes are named in the same way as alkanes.
- ✓ The carbon atoms are numbered, substituent groups are located and named, the double bond is located, and the parent chain is named.

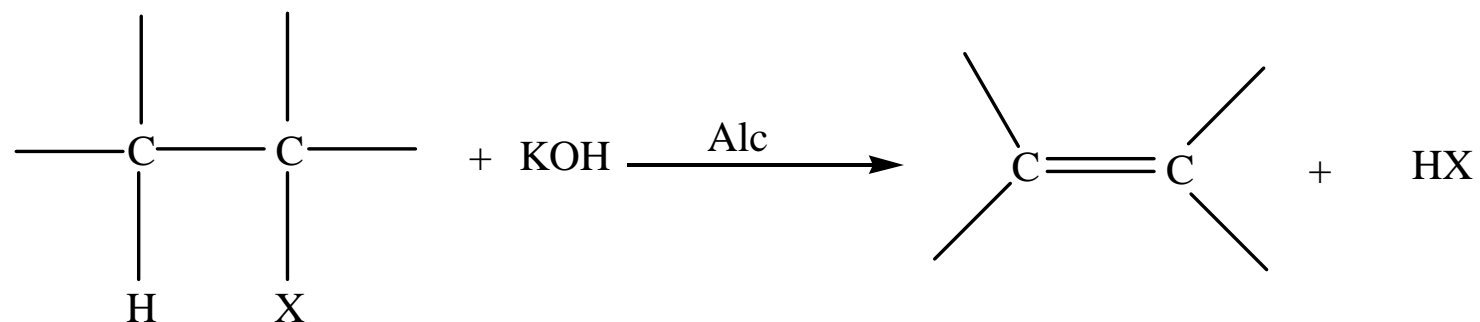
Exercise

Name the following compounds:



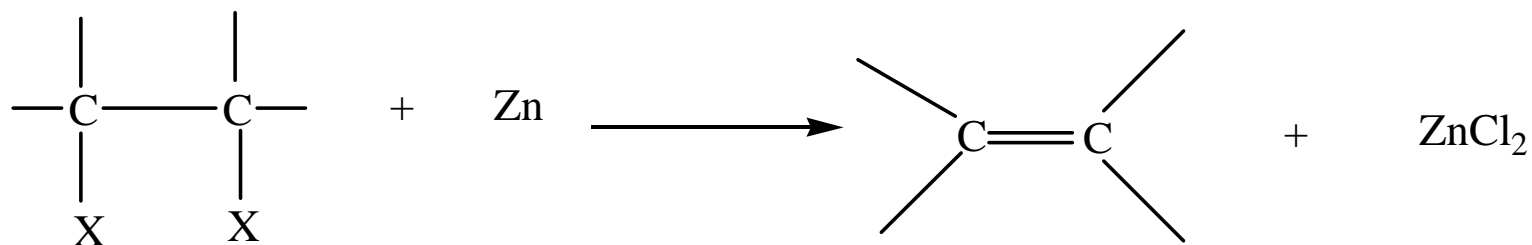
Preparation of Alkene

1. Dehydrogenation of alkylhalides

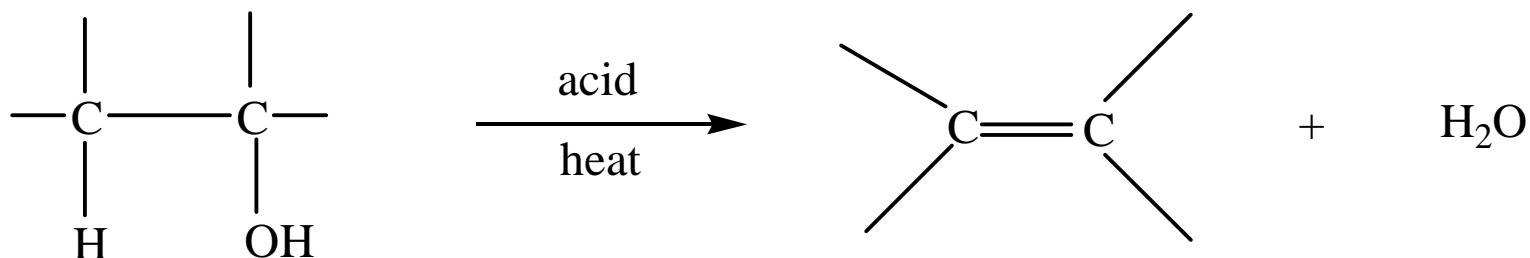


Ease of dehydrogenation: $3^\circ > 2^\circ > 1^\circ$

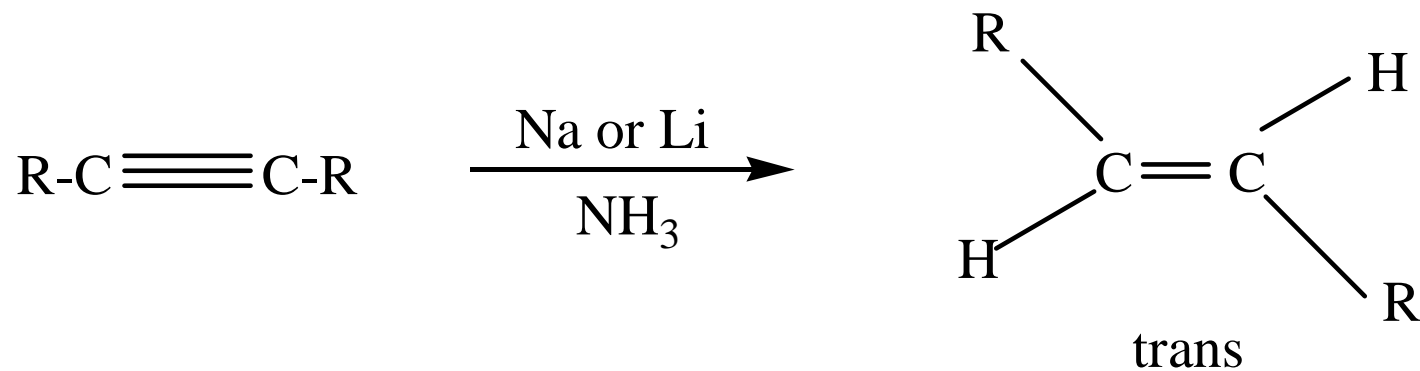
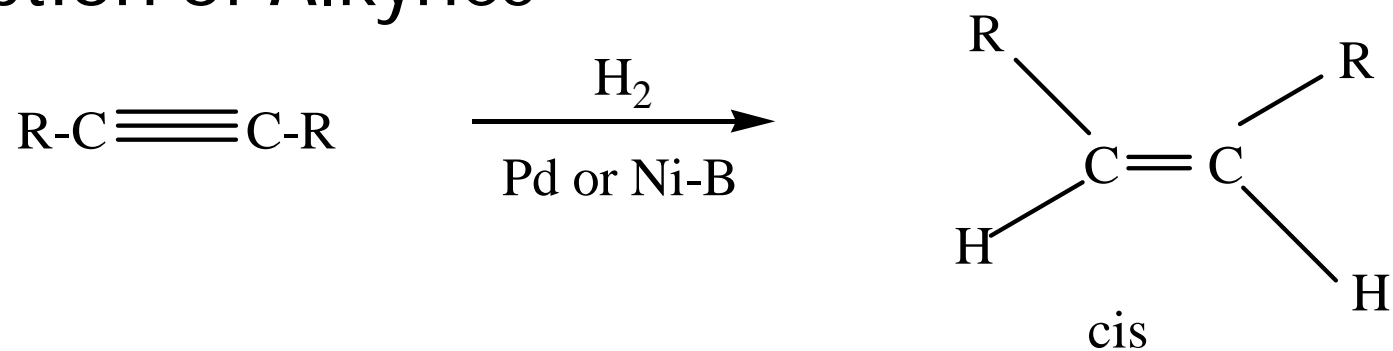
2. Dehalogenation of vicinal dihalides.



3. Dehydration of alcohol

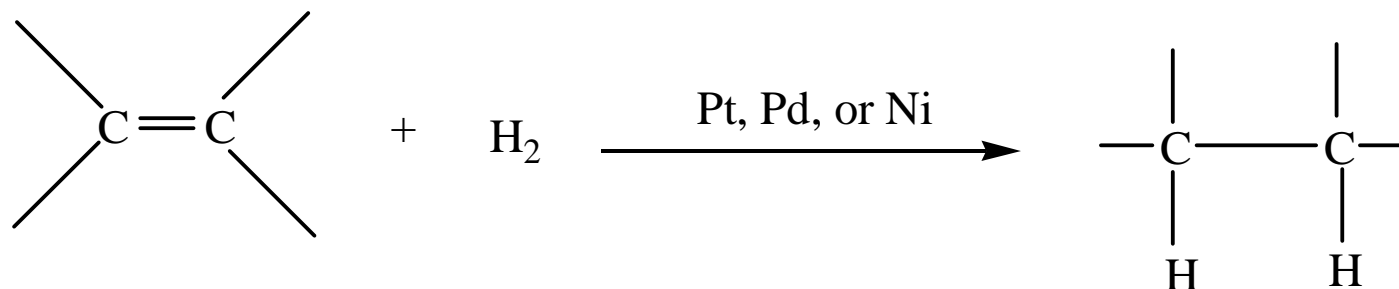


4. Reduction of Alkynes

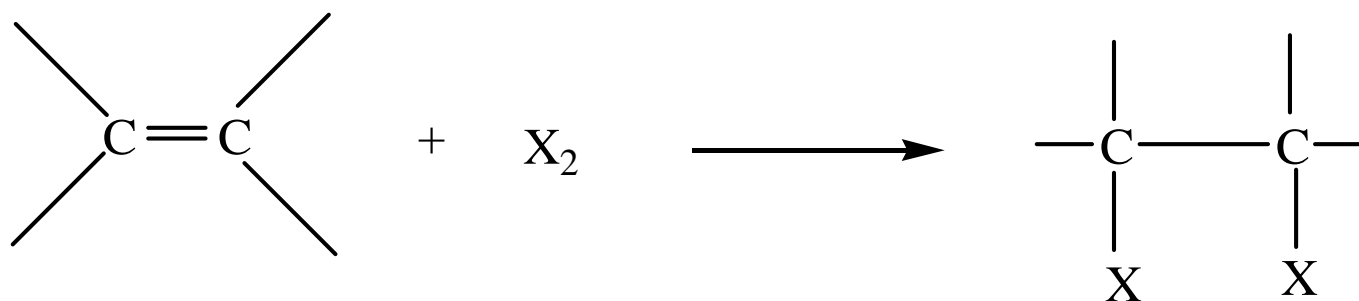


Reactions of alkene

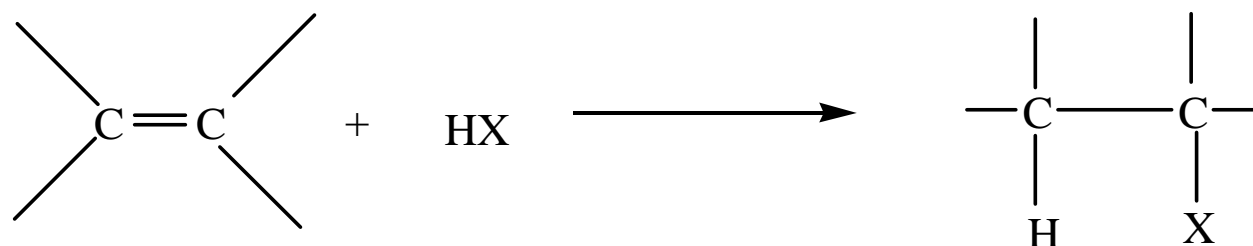
1. Hydrogenation



2. Halogenation

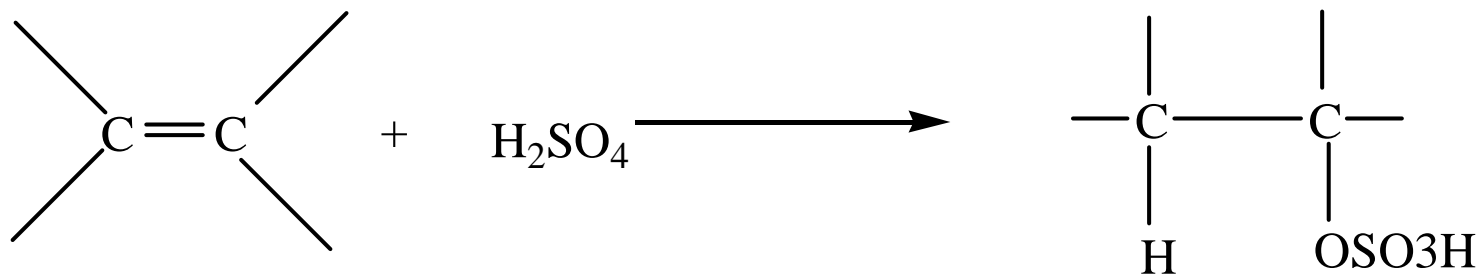


3. Addition of hydrogen halide.

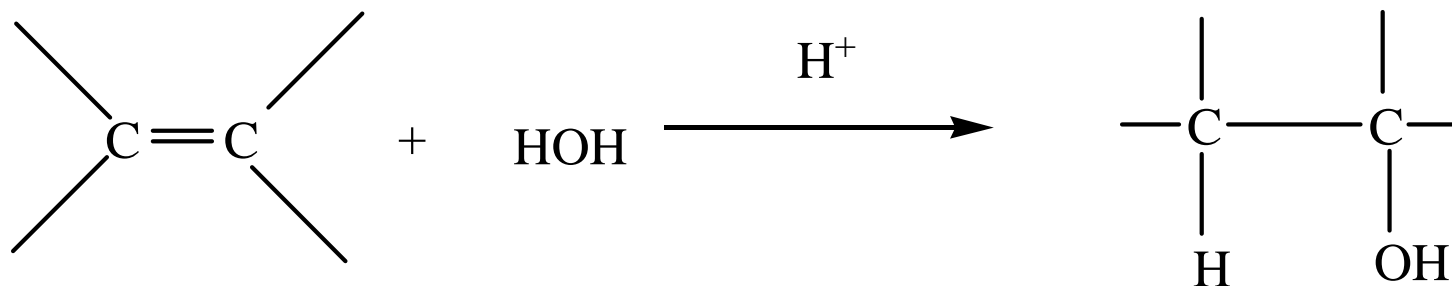


Markonikoff rule: The hydrogen of the acid attach itself to the carbon which already has the greatest number of hydrogen. In the presence of peroxide, HBr will undergo anti-Markovnikov addition.

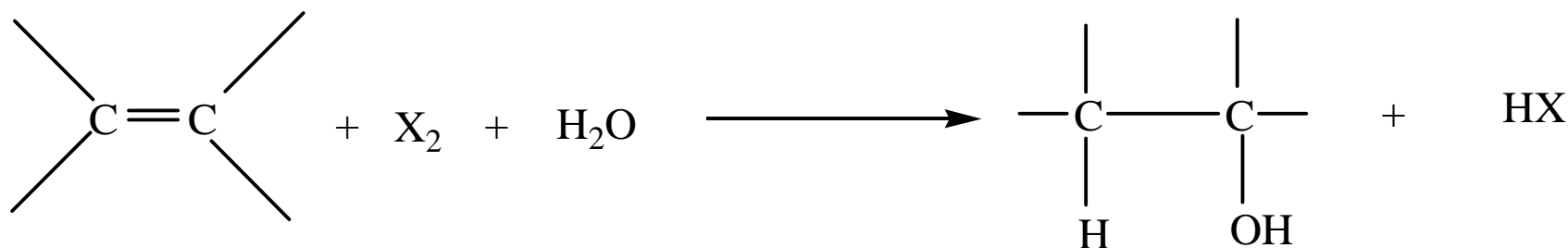
4. Addition of sulphuric acid



5. Addition of water

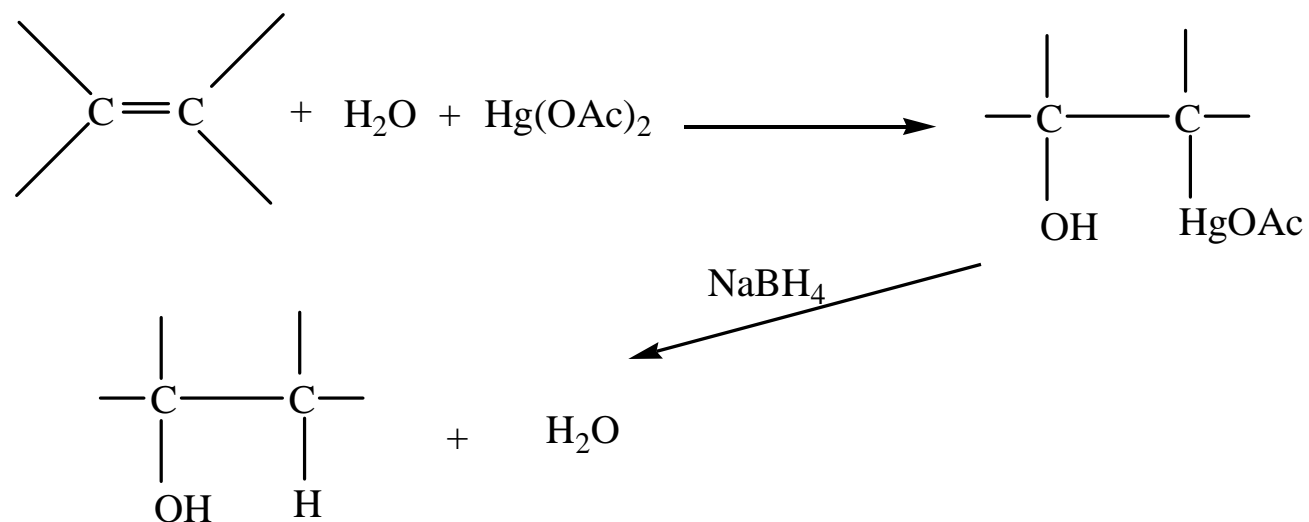


6. Halohydrin formation

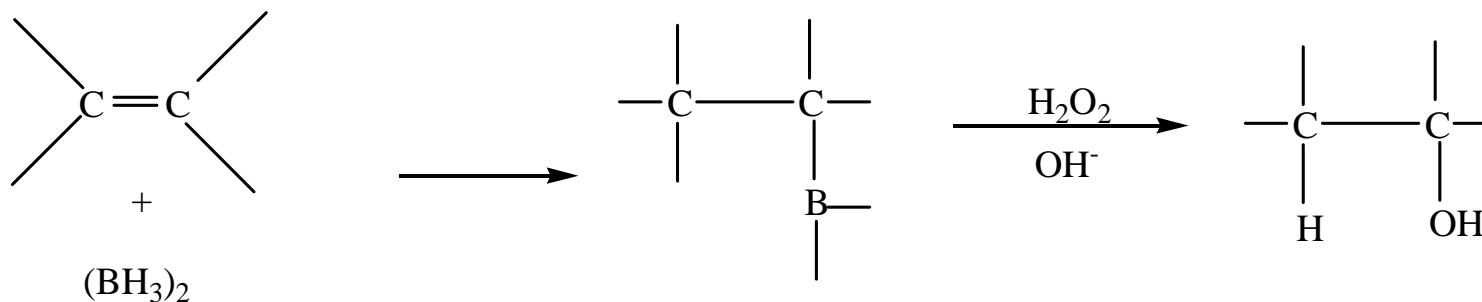


X = Cl, Br

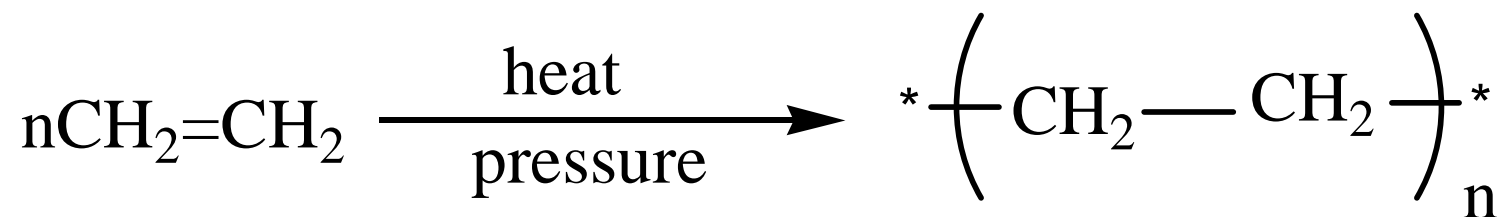
7. Oxymecuration – Demercuration



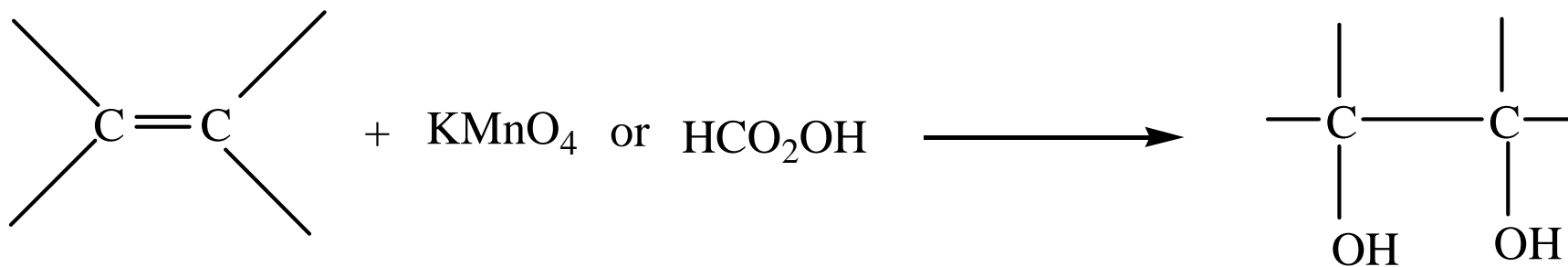
8. Hydroboration – Oxidation



8. Polymerisation



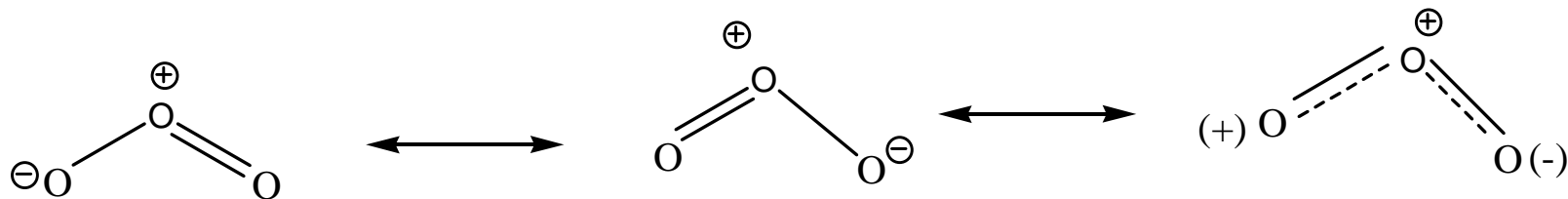
9. Hydroxylation



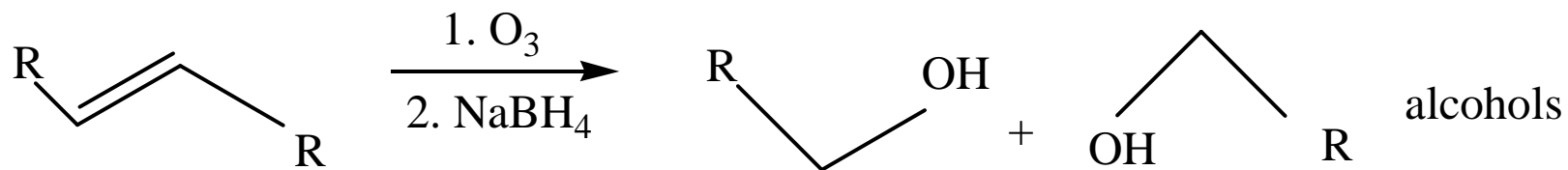
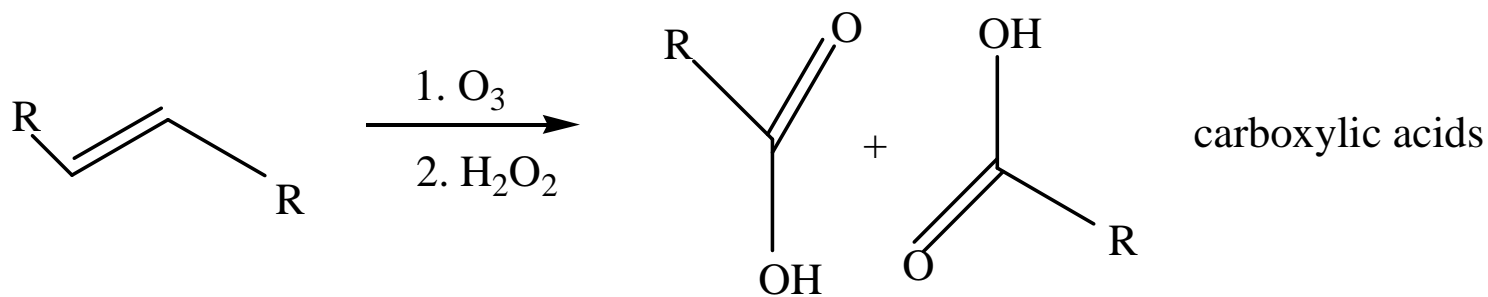
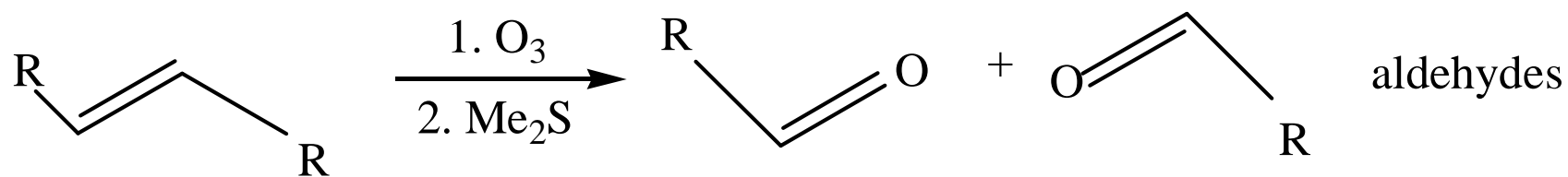
Ozonolysis

- ✓ Ozonolysis or ozonation is the cleavage of an alkene by ozone (O_3).
- ✓ It is a cycloaddition that destroys bonds
- ✓ ozone is a powerful oxidant and cleaves the alkene to make two carbonyl compounds.
- ✓ Ozone is a 1,3-dipole and does typical 1,3- dipolar cycloadditions with alkenes.

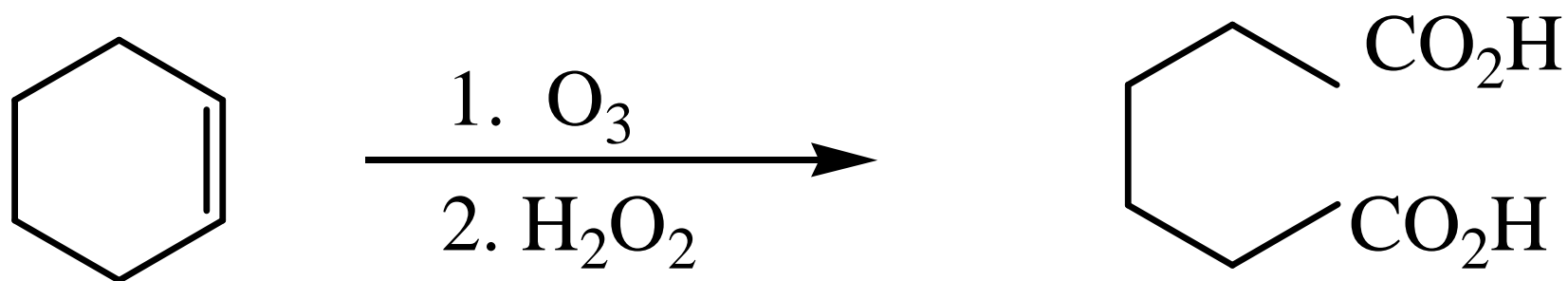
Structure of ozone:



Ozonolysis reactions



Ozonolysis of cyclohexenes is particularly useful as it gives 1,6-dicarbonyl compounds that are otherwise difficult to make.



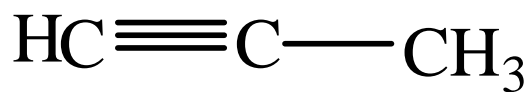
In the simplest case we get hexane 1,6-dioic acid (adipic acid) a monomer for nylon manufacture.

Alkynes

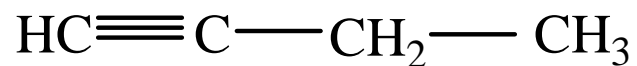
- ✓ General formula: C_nH_{2n-2}
- ✓ Presence of at least one triple bond



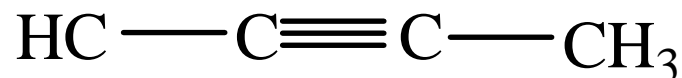
ethyne



propyne



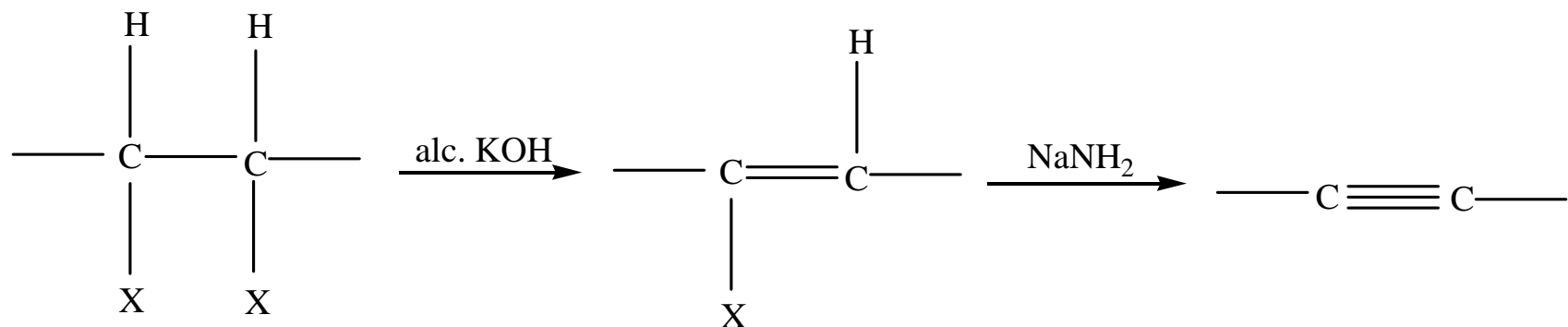
but-1-yne
(or 1-butyne)



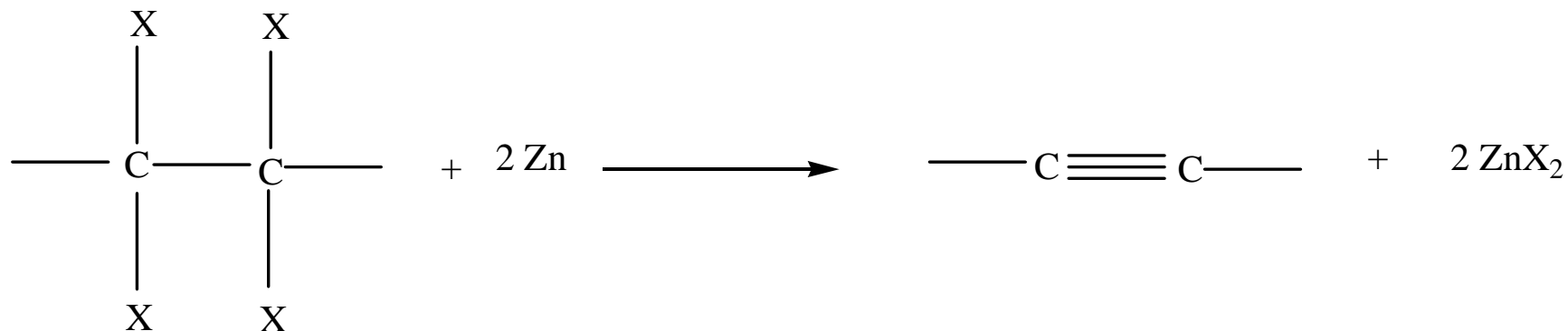
but-2-yne
(or 2-butyne)

Preparation of alkynes

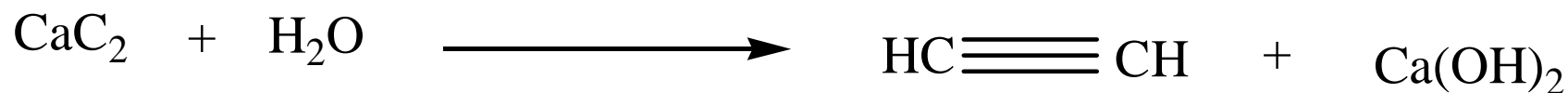
✓ Dehydrogenation of alkylhalide



✓ Dehalogenation of tetrahalides

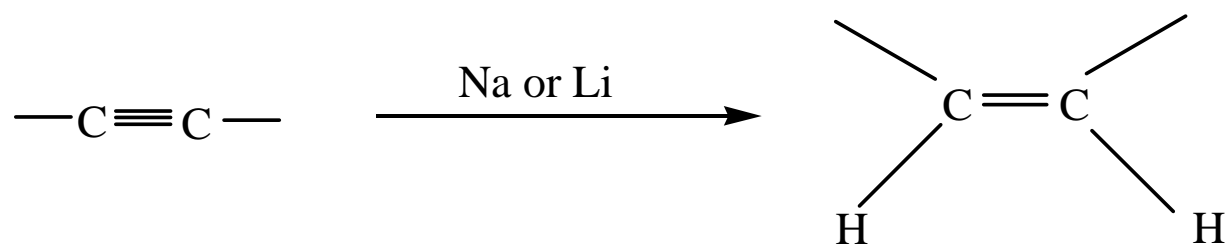
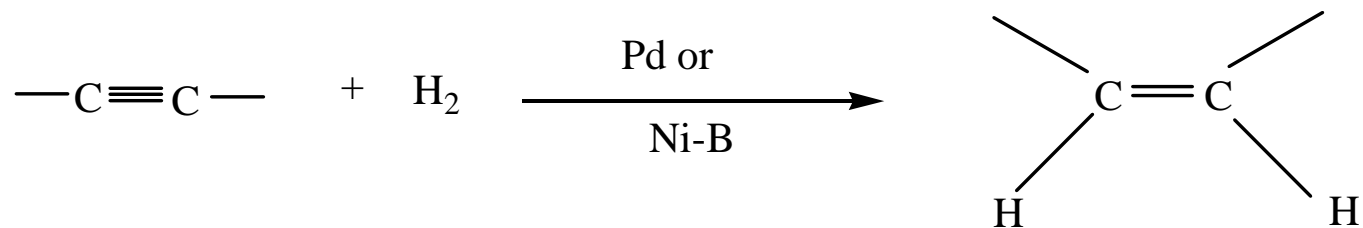


✓ Reaction of water and calcium carbide

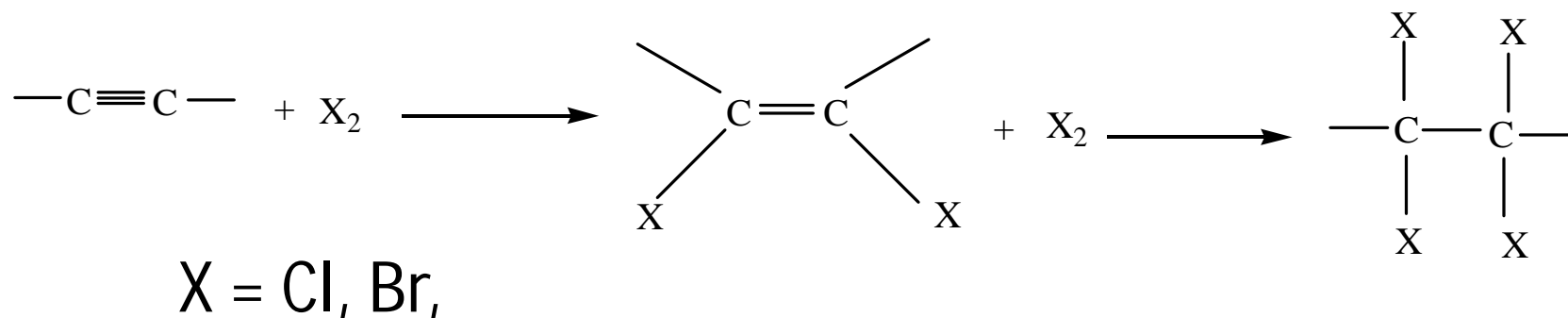


Reaction of alkynes

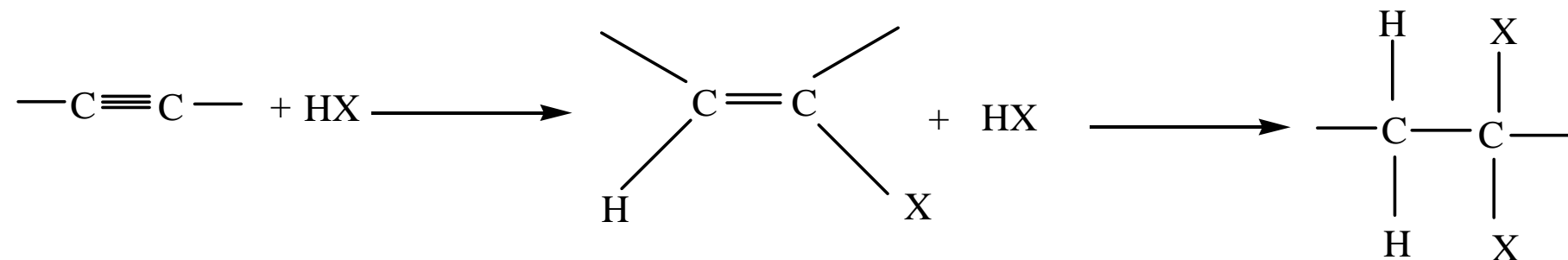
1. Hydrogenation



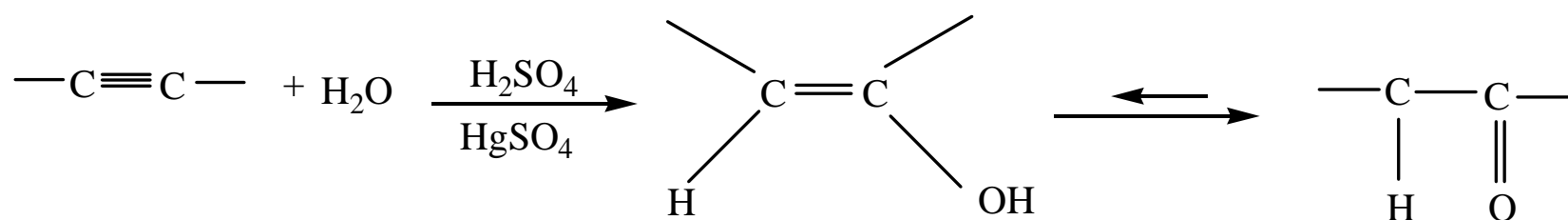
2. Halogenation



3. Addition of hydrogen halide



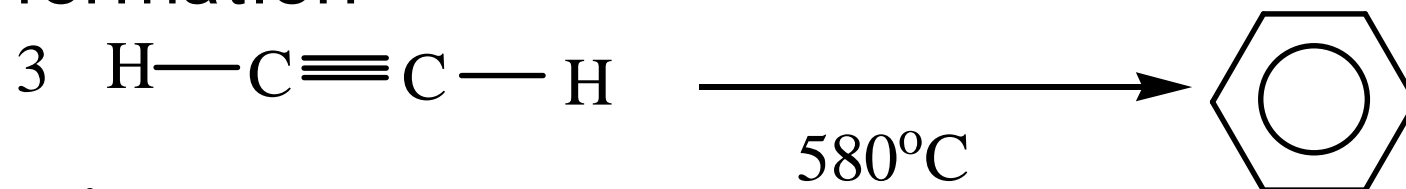
4. Addition of water (hydration)



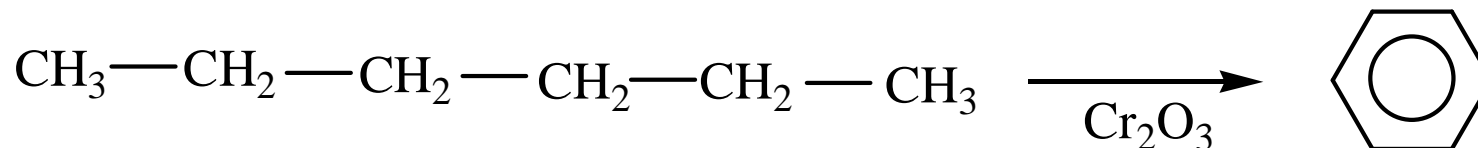
Benzene

Preparation of benzene

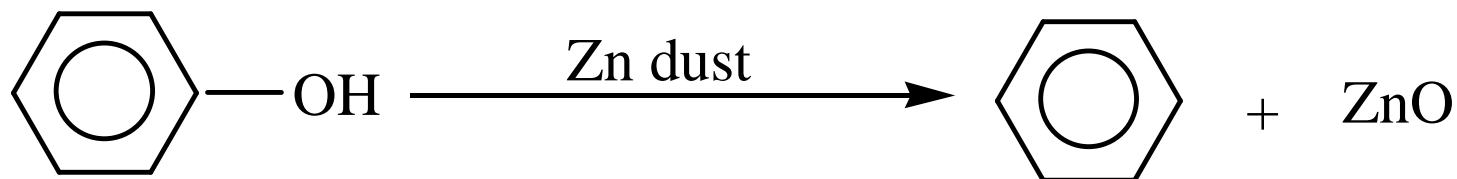
1. Ring formation



2. Cyclisation

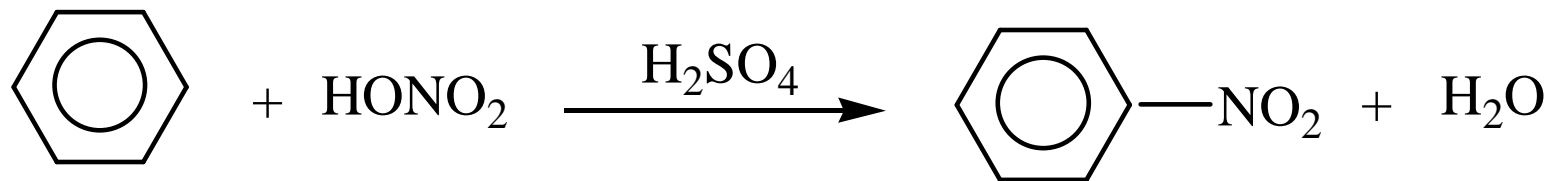


3. Elimination

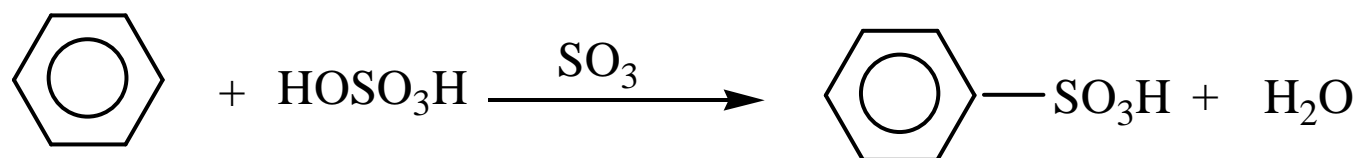


Reactions of benzene

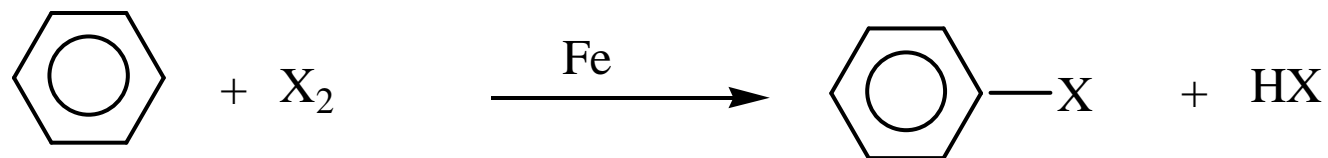
1. Nitration



2. Sulphournation

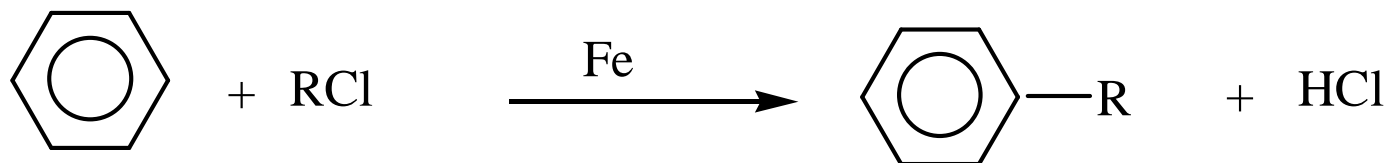


3. Halogenation

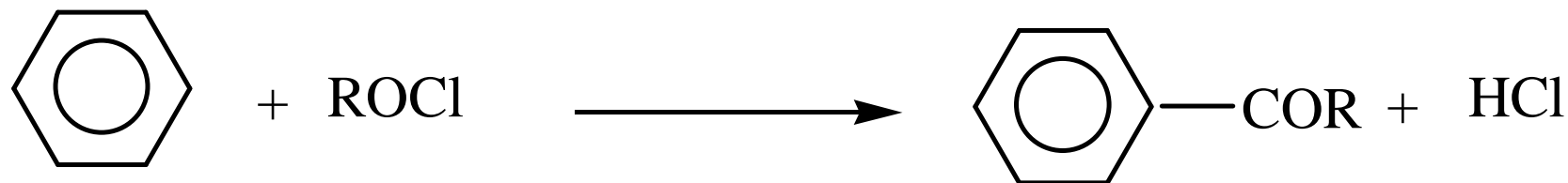


X = Cl, Br

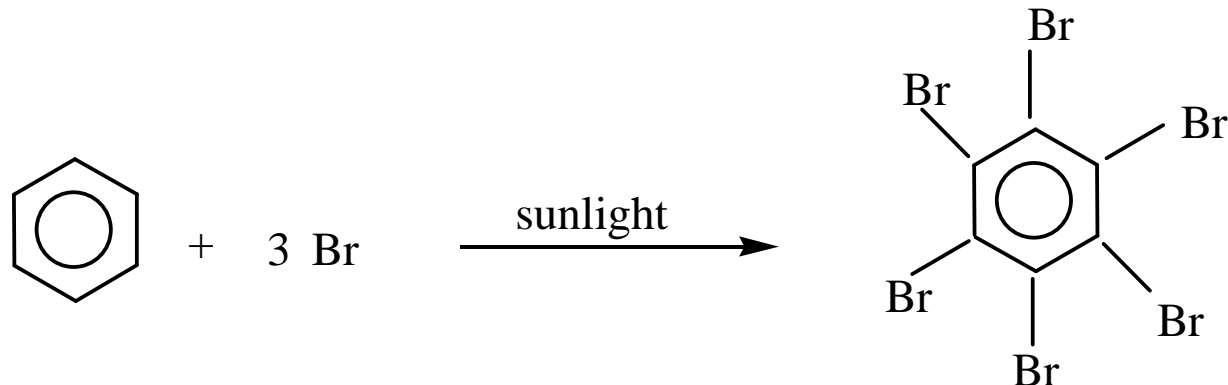
4. Friedel-Crafts Alkylation



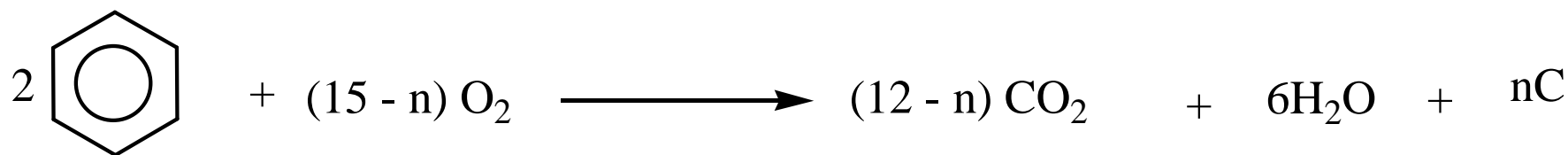
5. Friedel-Crafts acylation (also hydrogenation)



6. Bromination

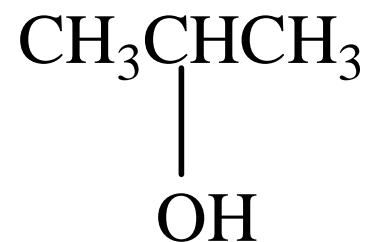


7. Combustion



Alcohols

General formula



ethanol

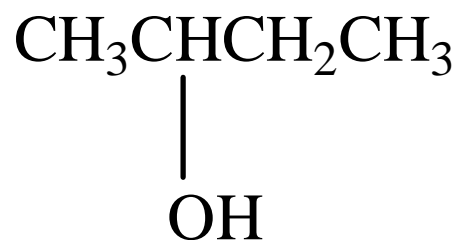


propan-1-ol
(or 1-propanol)

propan-2-ol
(or 2-propanol)



1-butanol
(or butan-1-ol)



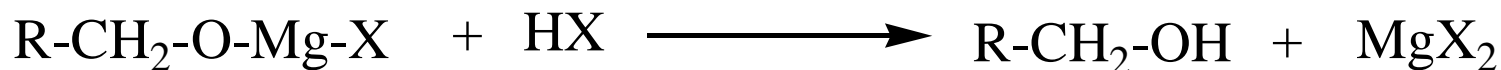
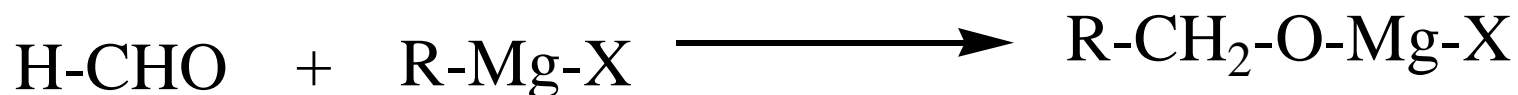
butan-2-ol
(or 2-butanol)

Preparation of Alcohols

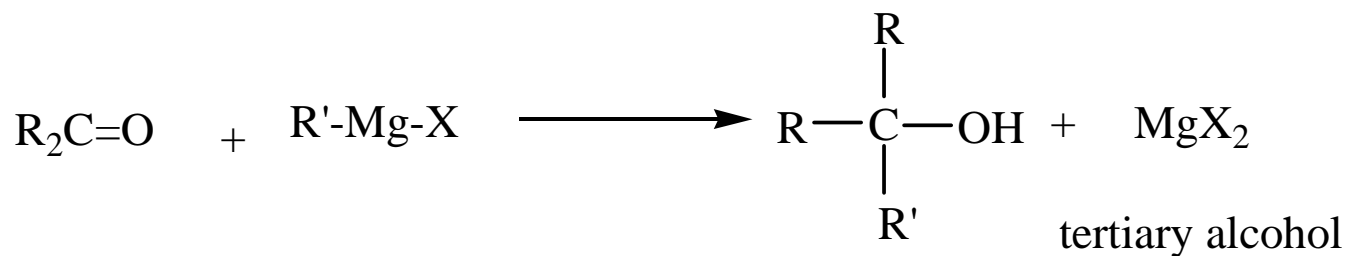
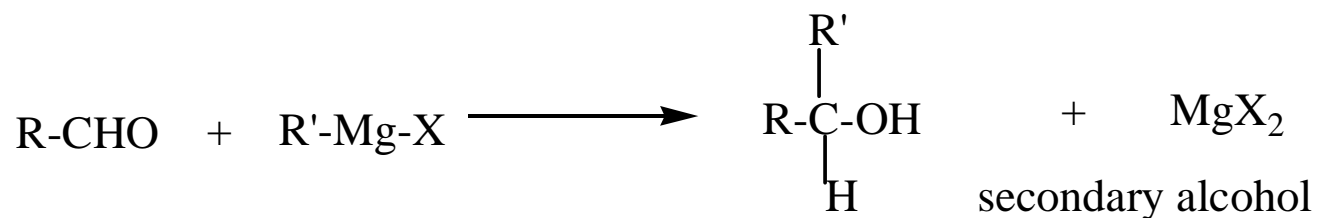
1. Addition of hydroxide



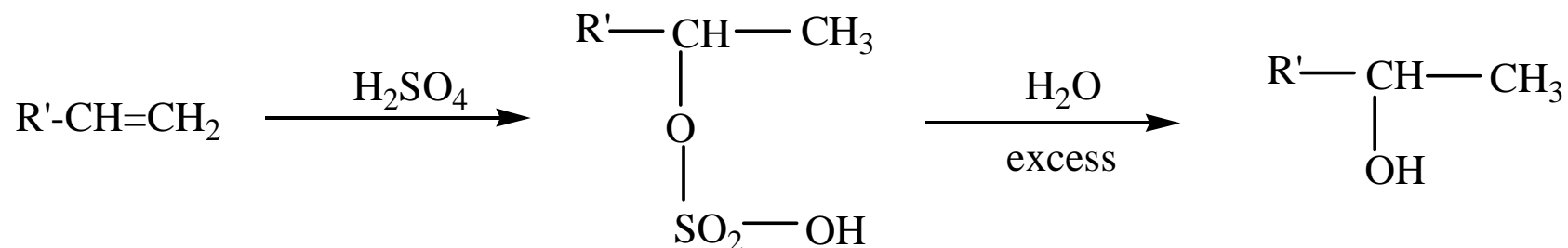
2. Grignads reagents



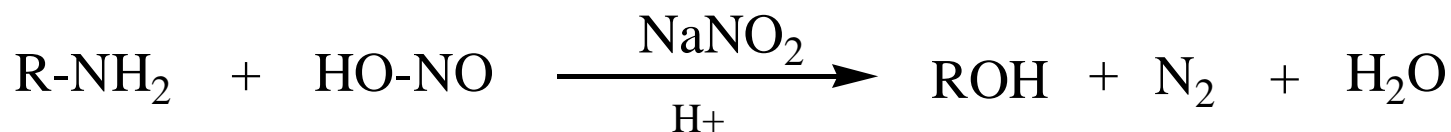
primary alcohol



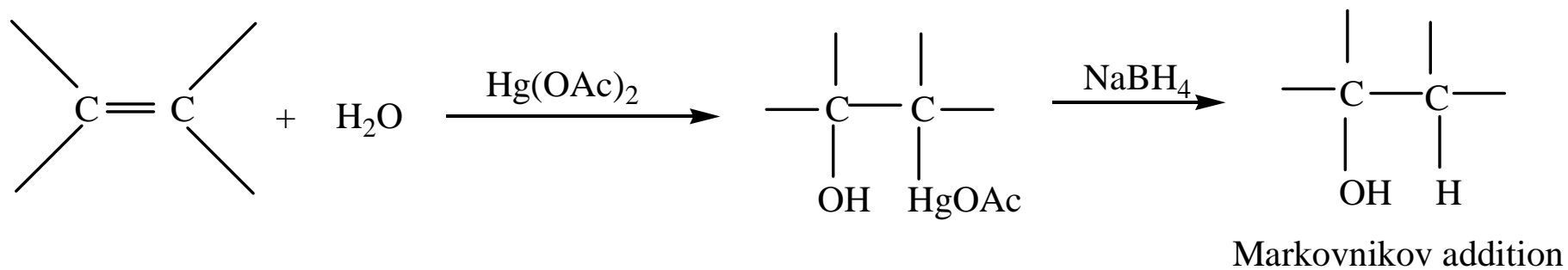
3. Hydration of alkenes



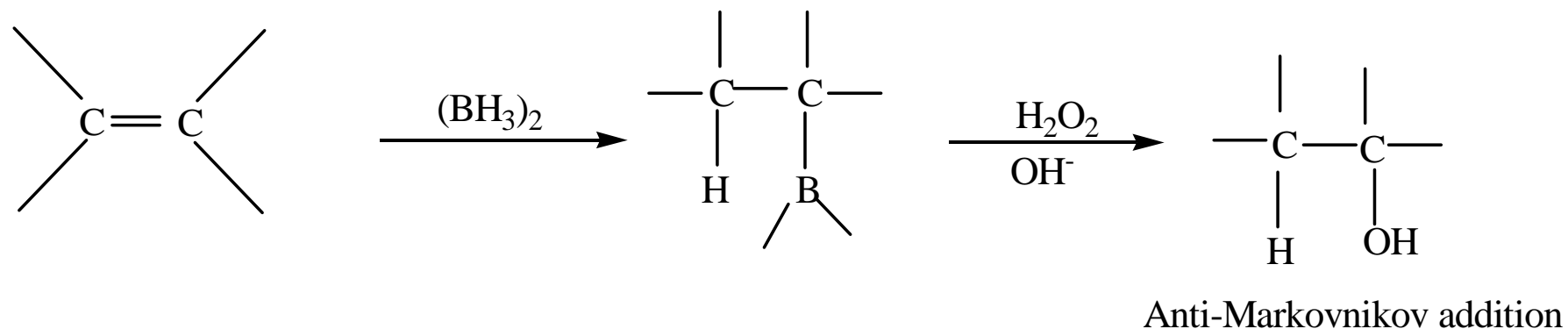
4. Reaction of amines with nitrous acid



5. Oxymecuration – Demecuration



6. Hydroboration – Oxidation



Reaction of Alcohols

1. Reaction with hydrogen halides



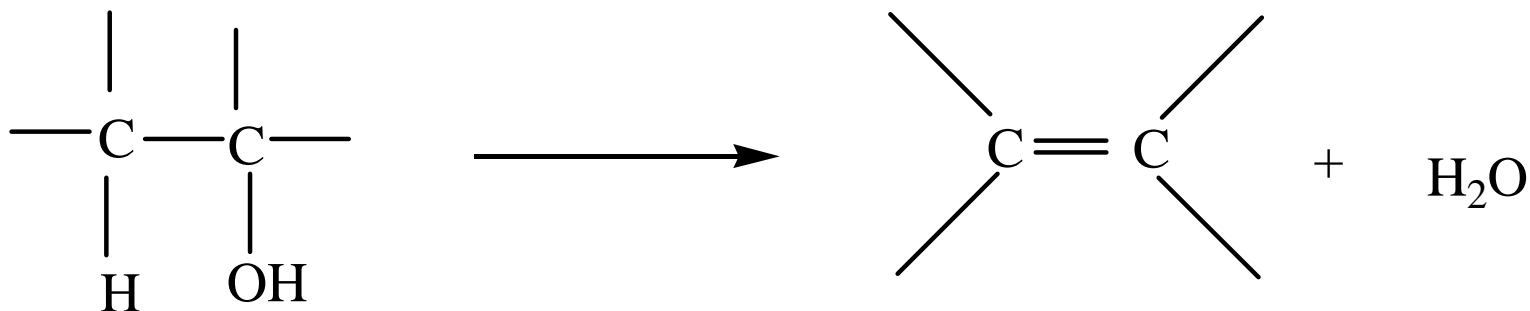
Reactivity of HX: $\text{HI} > \text{HBr} > \text{HCl}$

Reactivity of ROH: allyl, benzyl $> 3^\circ > 2^\circ > 1^\circ$

2. Reaction with Phosphorous trihalide



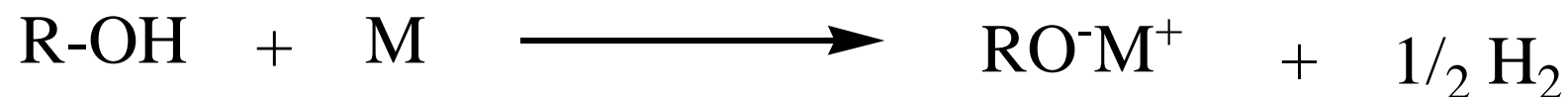
3. Dehydration



4. Ester formation



5. Reaction with active metals



6. Oxidation

