Alkenes

multiple carbon-carbon double bonds result when hydrogen atoms are removed from alkanes

Alkenes

hydrocarbons containing at least one carbon-carbon double bond

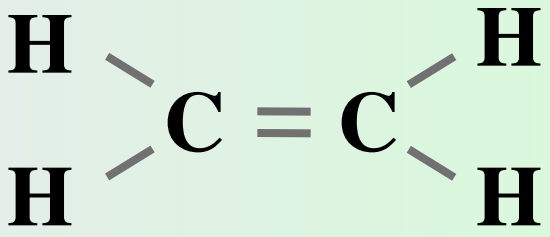
C_nH_{2n}

sp^2 hybridization

Ethene

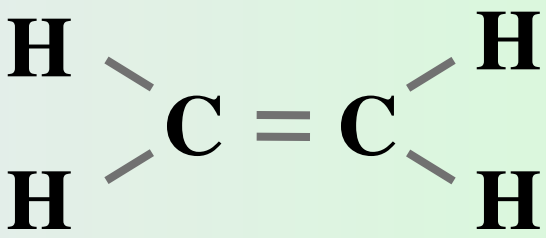
Ethylene

C_2H_4



Alkenes

Ethene C_2H_4



these molecules are said to be unsaturated

unsaturated: more hydrogen can be added to the molecule

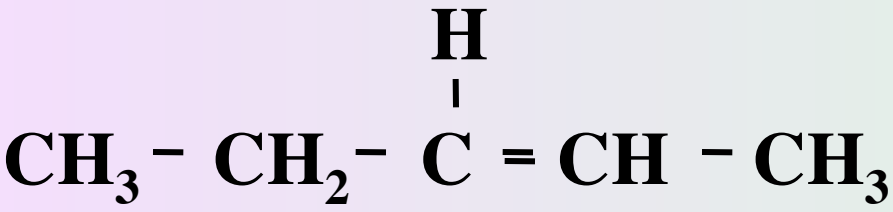
Alkene Nomenclature

The root hydocarbon ends in *-ene* rather than *-ane*.

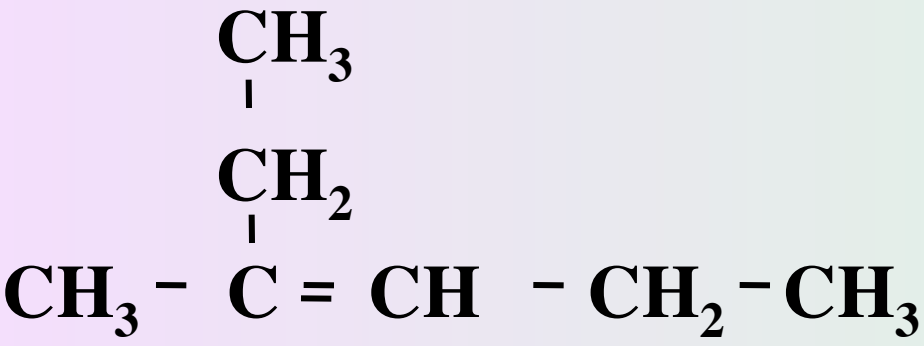
The location of the carbon-carbon double bond is indicated by the lowest numbered carbon atom involved in the double bond.

$CH_2 = CH_2 - CH_2 - CH_3$	1-Butene
$CH_3 - CH = CH - CH_3$	2-Butene

Example



2-pentene

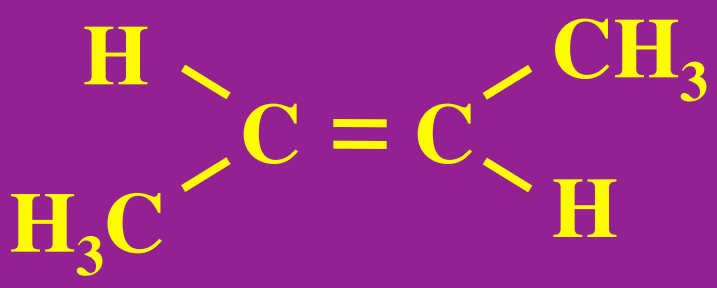


3-methyl-3-hexene

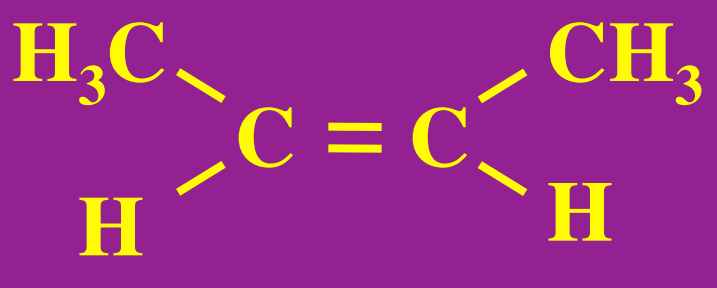
Conformations of Alkenes

rotation around the carbon-carbon double bond is highly restricted but not impossible

thus alkenes exhibit *cis-trans* isomerism



***trans*-2-Butene**



***cis*-2-Butene**

the two H atoms are across from each other

the two H atoms are on the same side

Conformations of Alkenes

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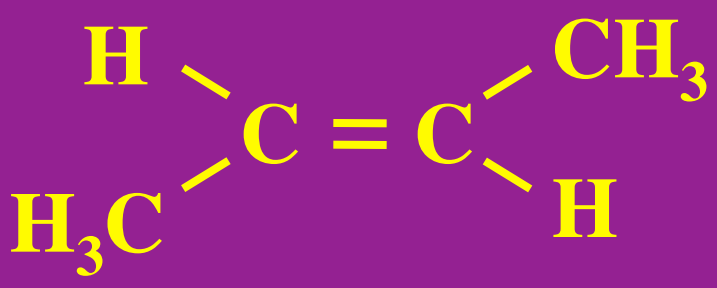
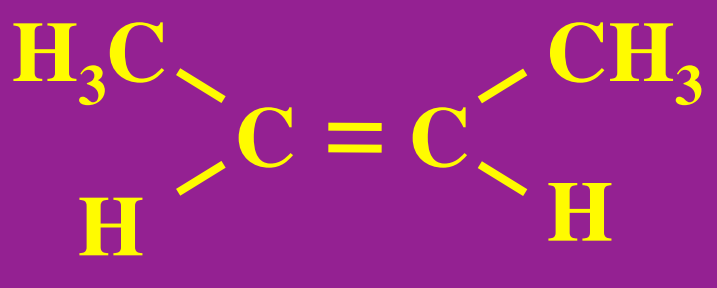


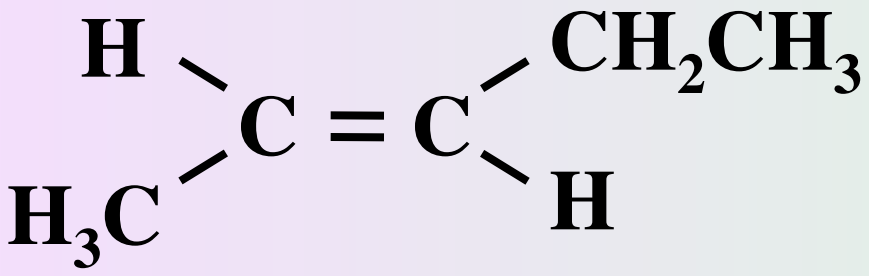
***trans*-2-Butene**



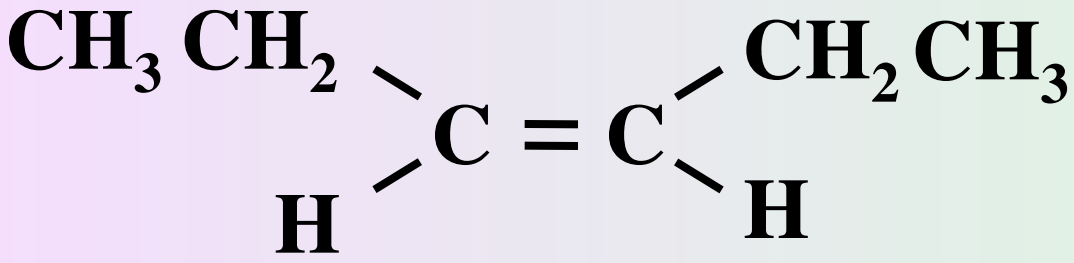
***cis*-2-Butene**

less steric strain

Example



trans-2-pentene

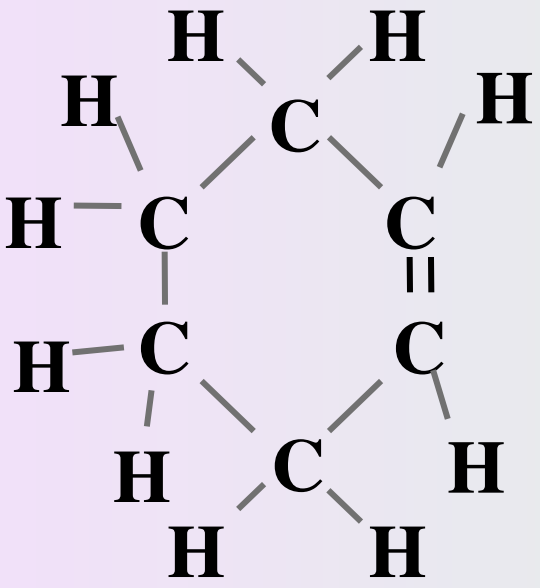


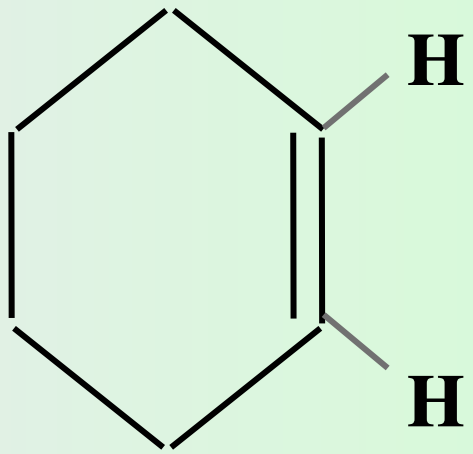
cis-3-hexene

Cycloalkenes

Alkenes formed into rings

All cycloalkenes are assumed to be *cis*

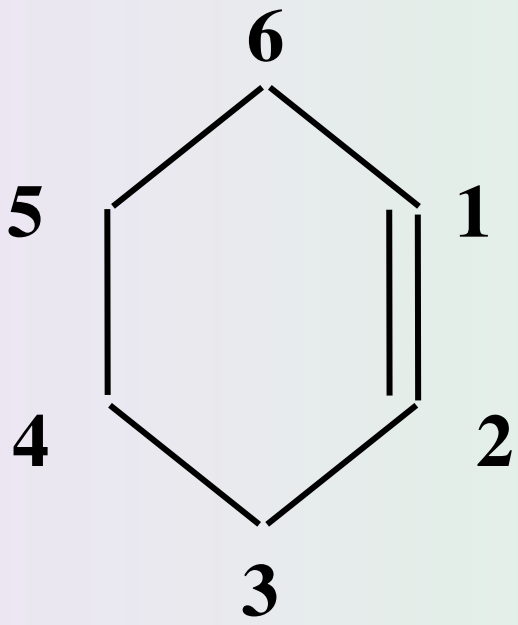




cyclohexene

Cycloalkenes

When the chain contains more than three carbon atoms, a number is used to give the location of the double bond



Cycloalkenes

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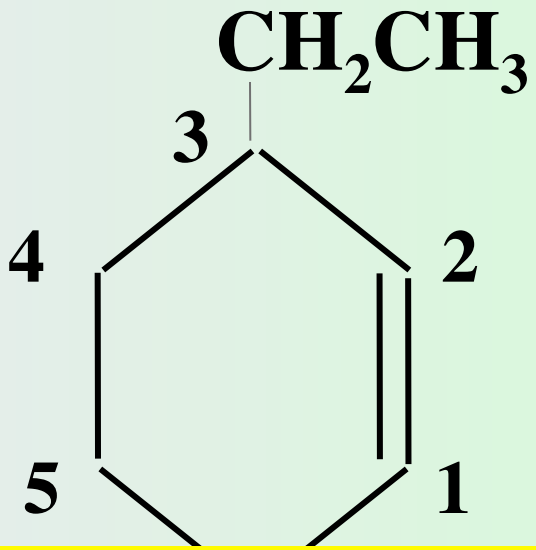
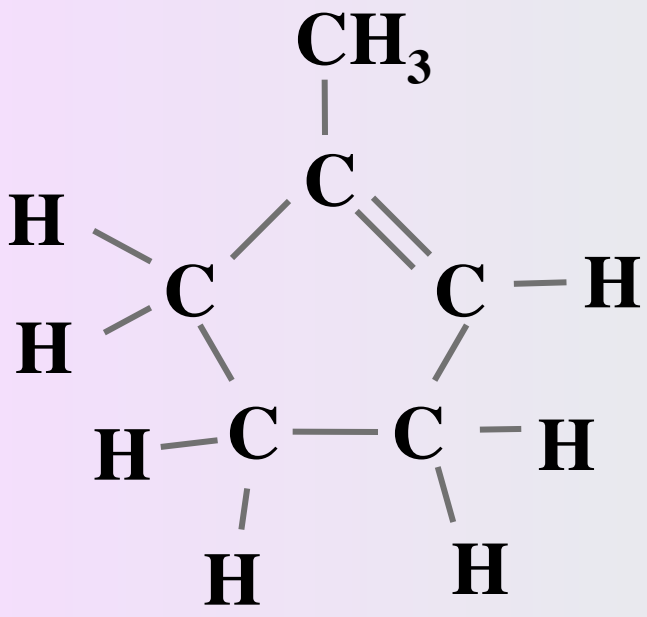


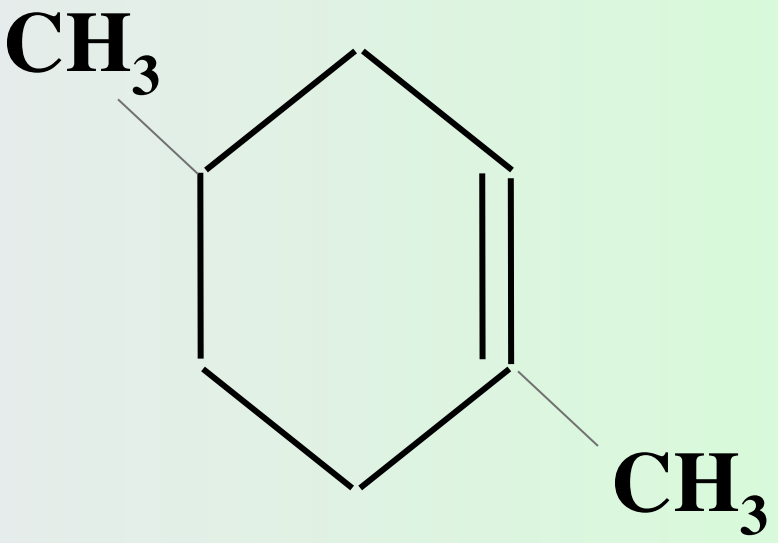
3-Ethylcyclohexene

Cycloalkenes are assumed to have the double bond at the one position

Example

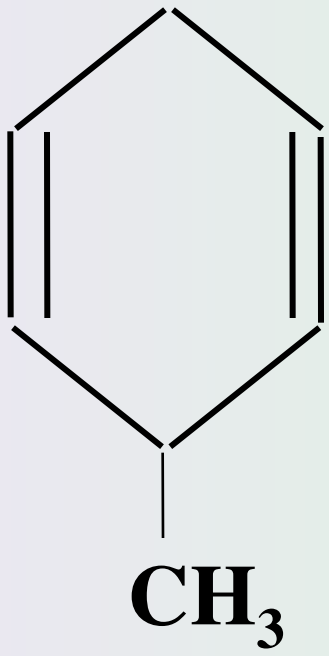


1-methylcyclopentene



1,4-dimethylcyclohexene

Example



3-methyl-1,4-cyclohexene

Some Chemical Reactions involving Alkenes

addition reactions

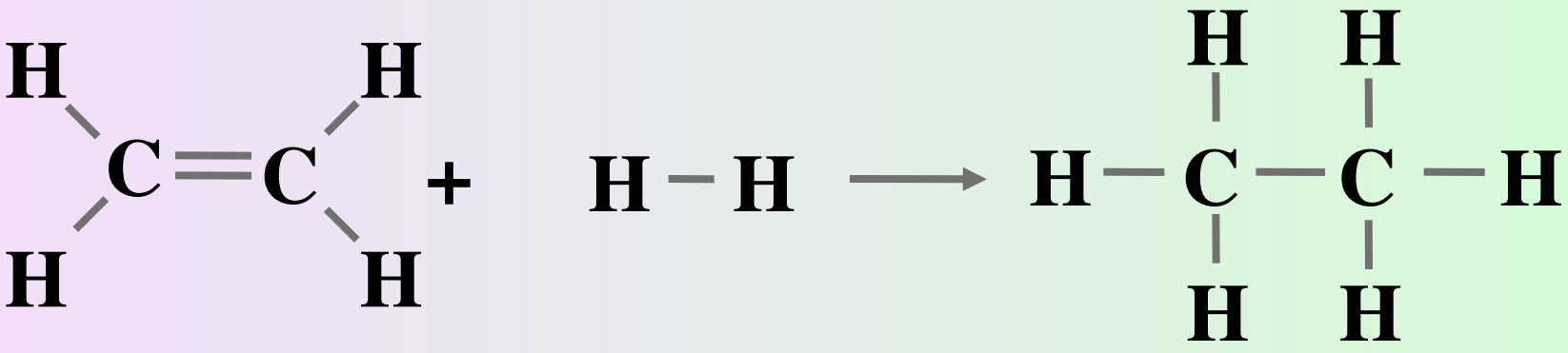
- **hydrogenation**
- **with halogens**
- **with hydrogen halides**

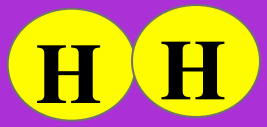
Hydrogenation of ethylene

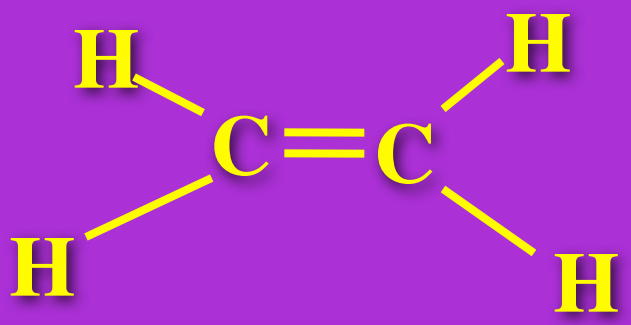
Addition Reaction

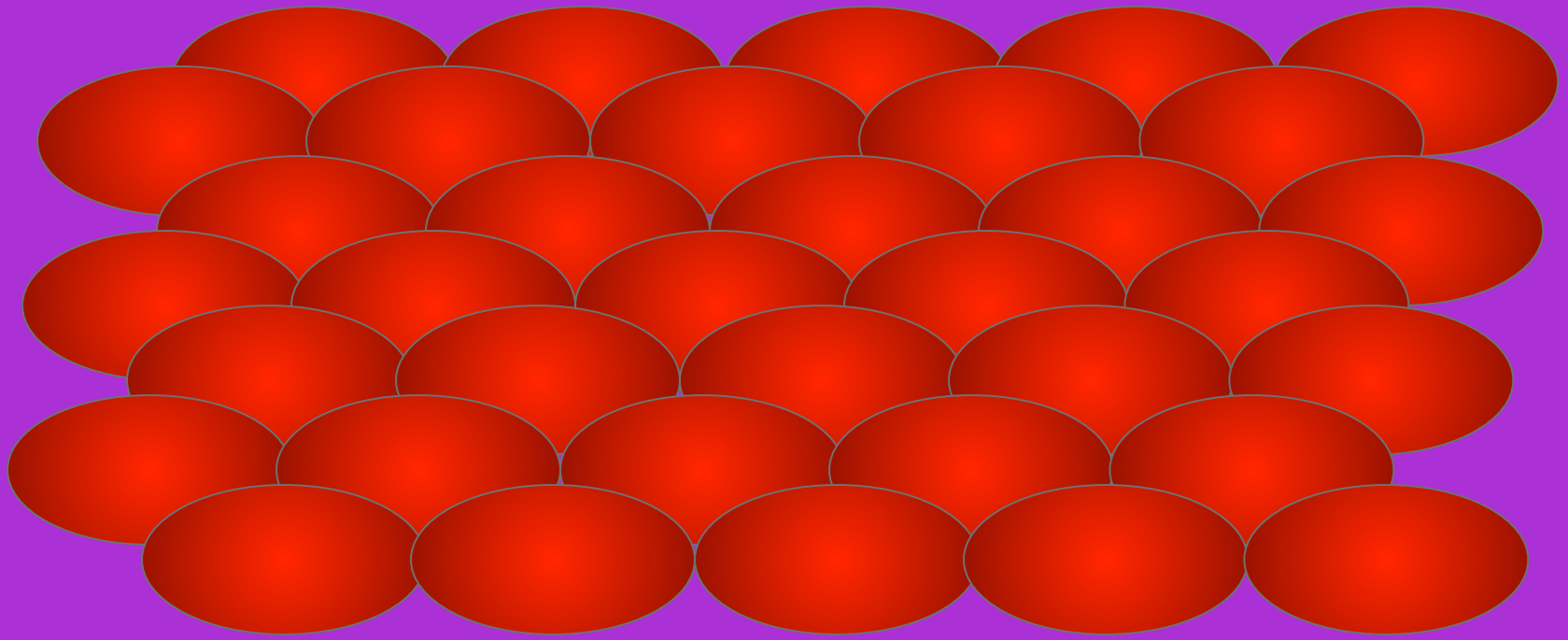
Exothermic ΔE° **= -136 kJ/mol**

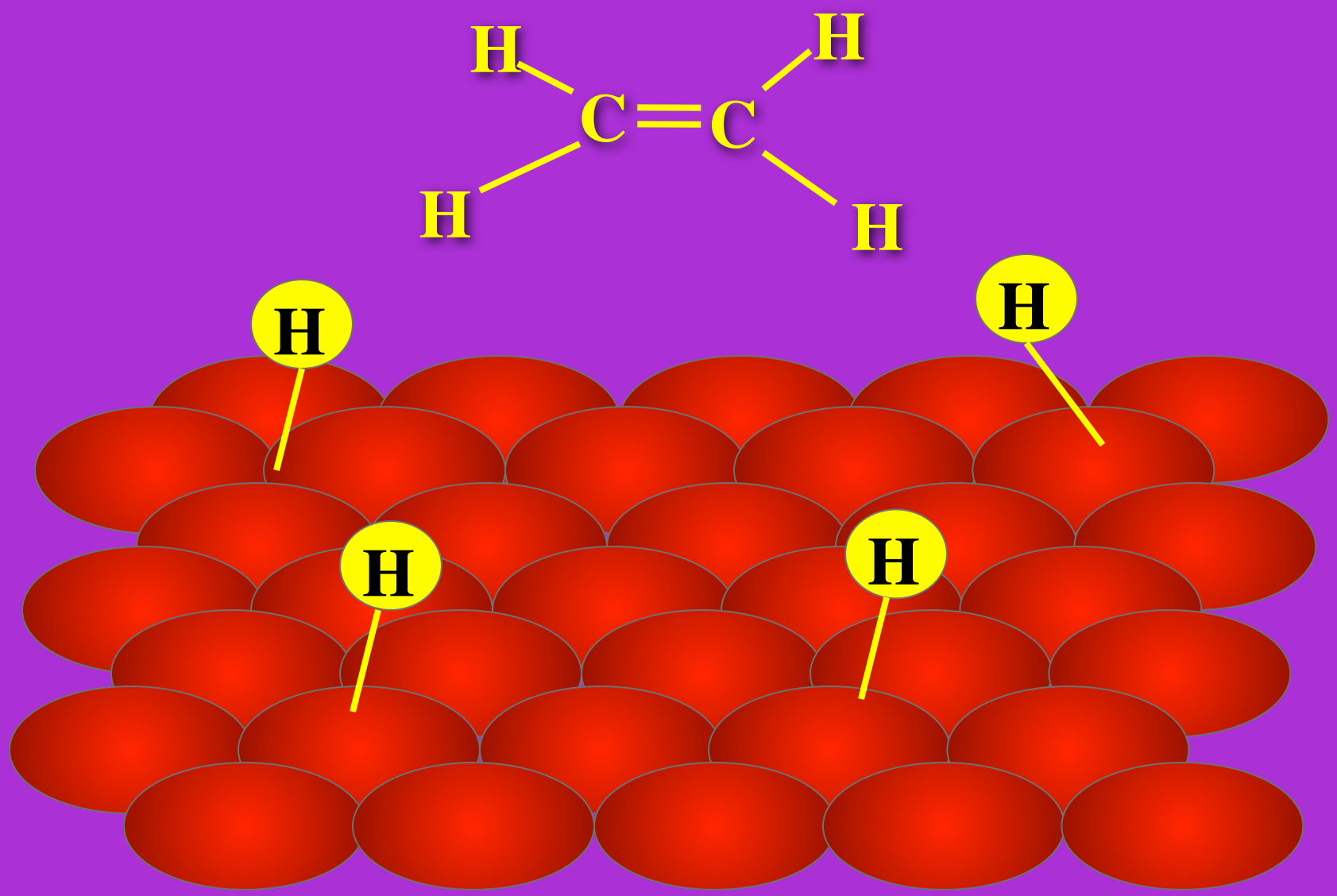
catalyzed by finely divided Pt,Pd, Rh, Ni

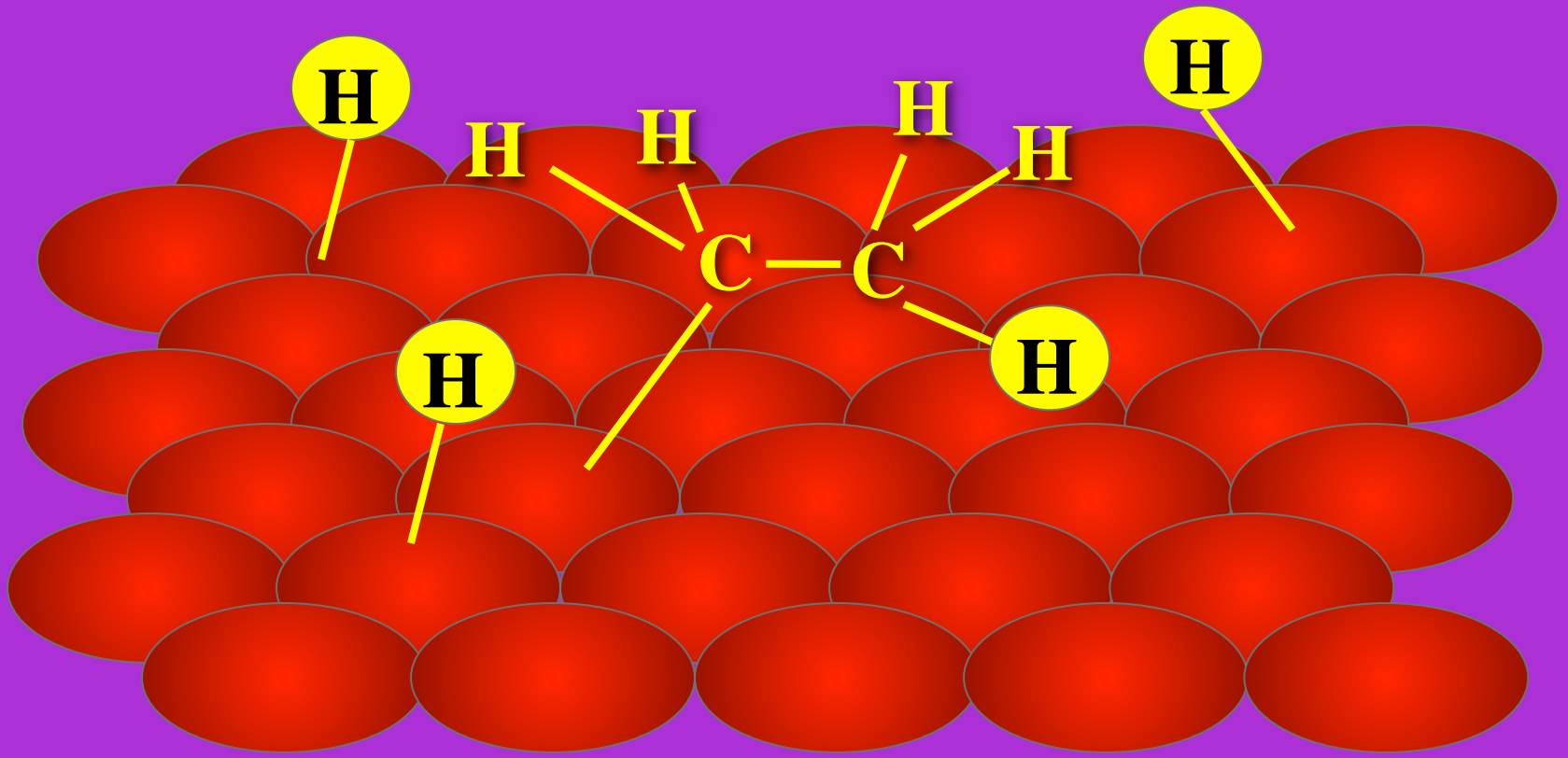


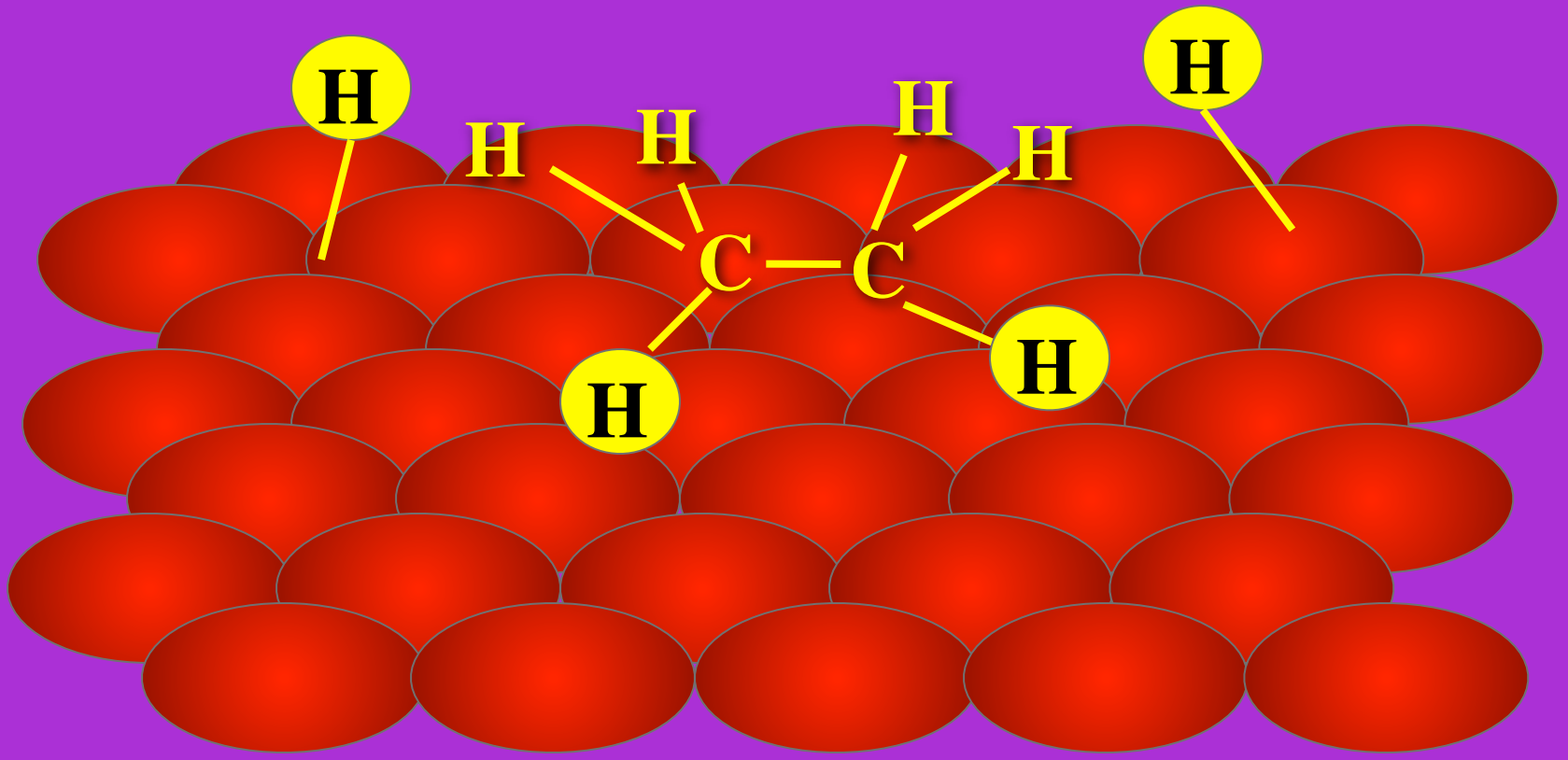

H
H

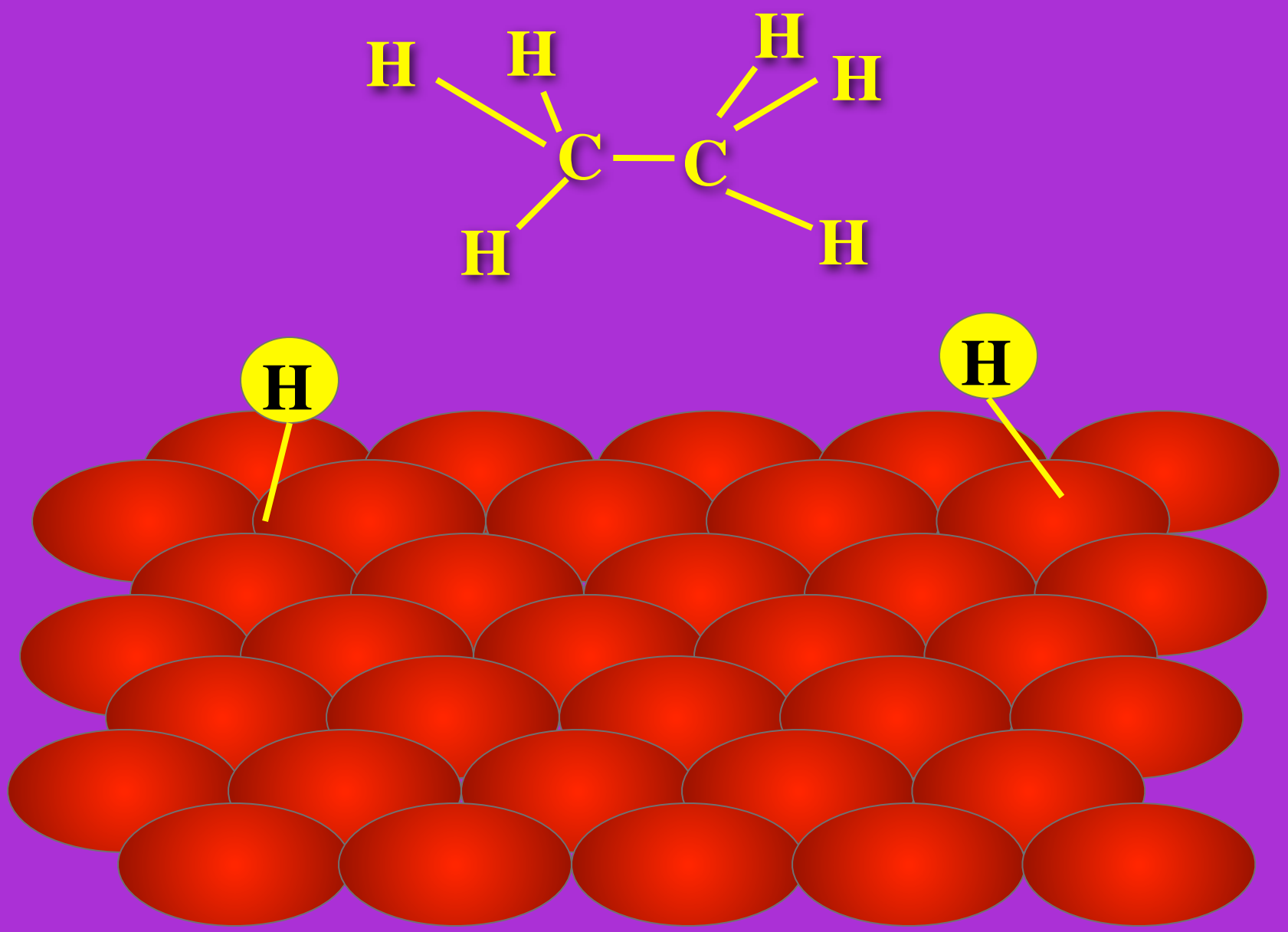

H
H
C
C
H
H




H
H
C
C
H
H
H
H
H
H


H
H
H
H
H
H
H
C
C
H
H

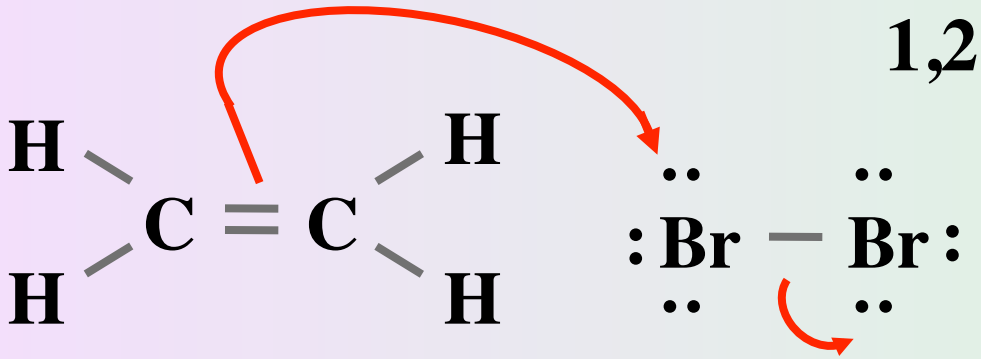

H
H
H
H
H
H
H
C
C
H
H

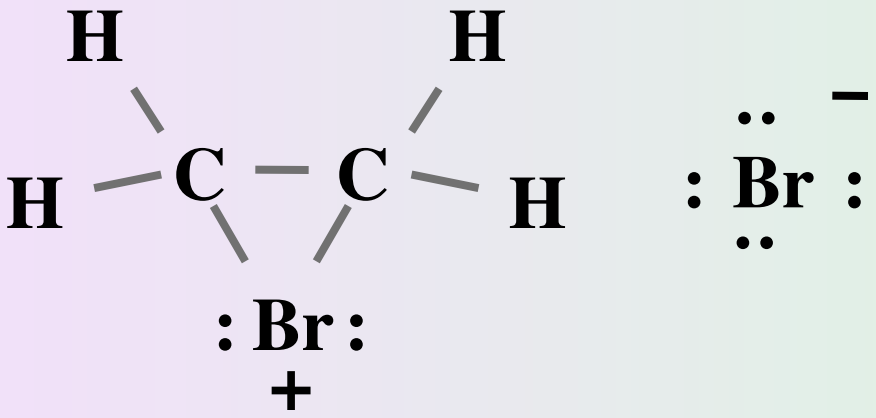

H
H
H
H
C
C
H
H
H
H

Reactions with Halogens

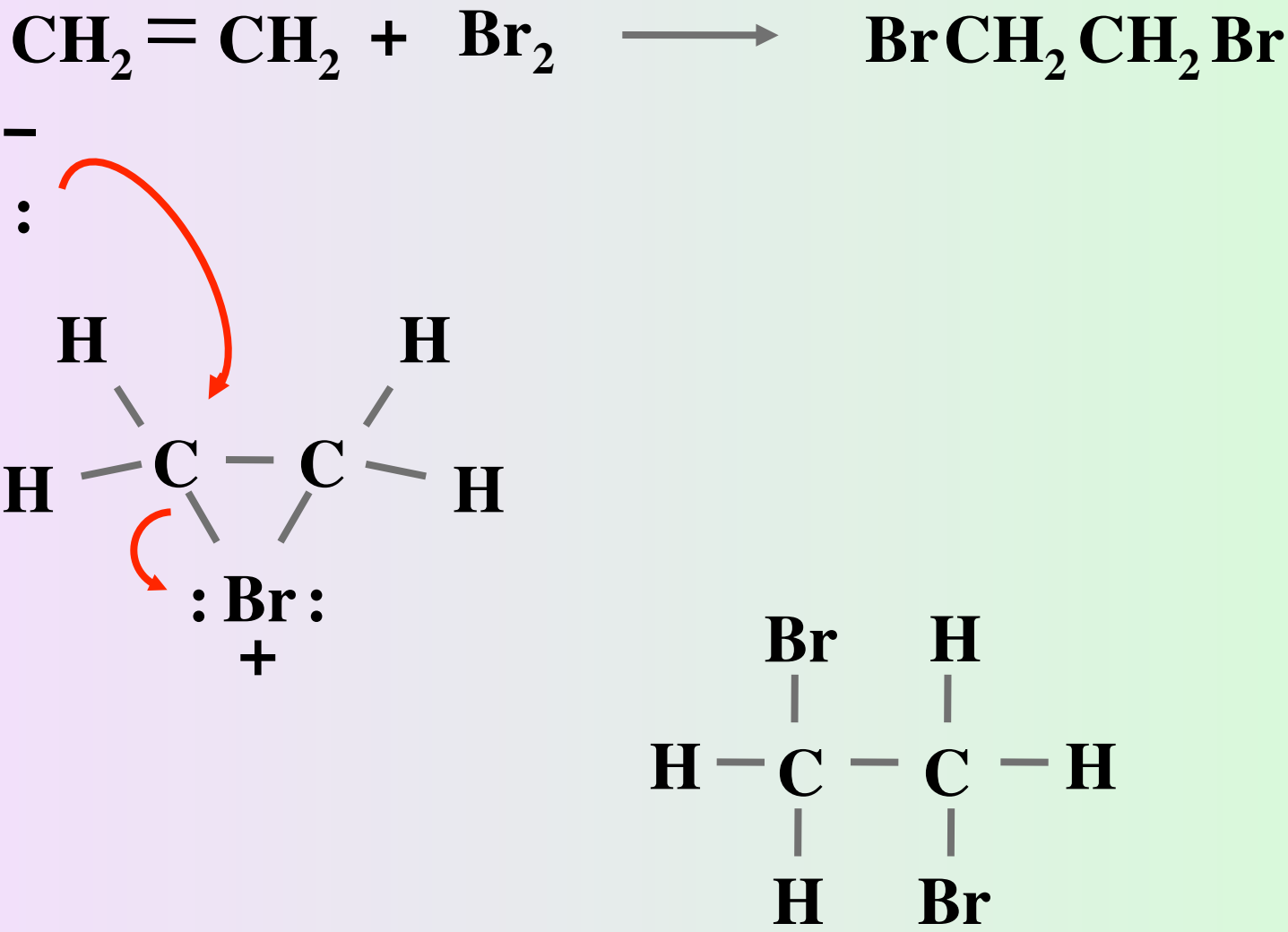
$CH_2CH_2 + Br_2 \longrightarrow BrCH_2CH_2Br$

1,2-dibromoethane





Reactions with Halogens



Reactions with Hydrogen Halides

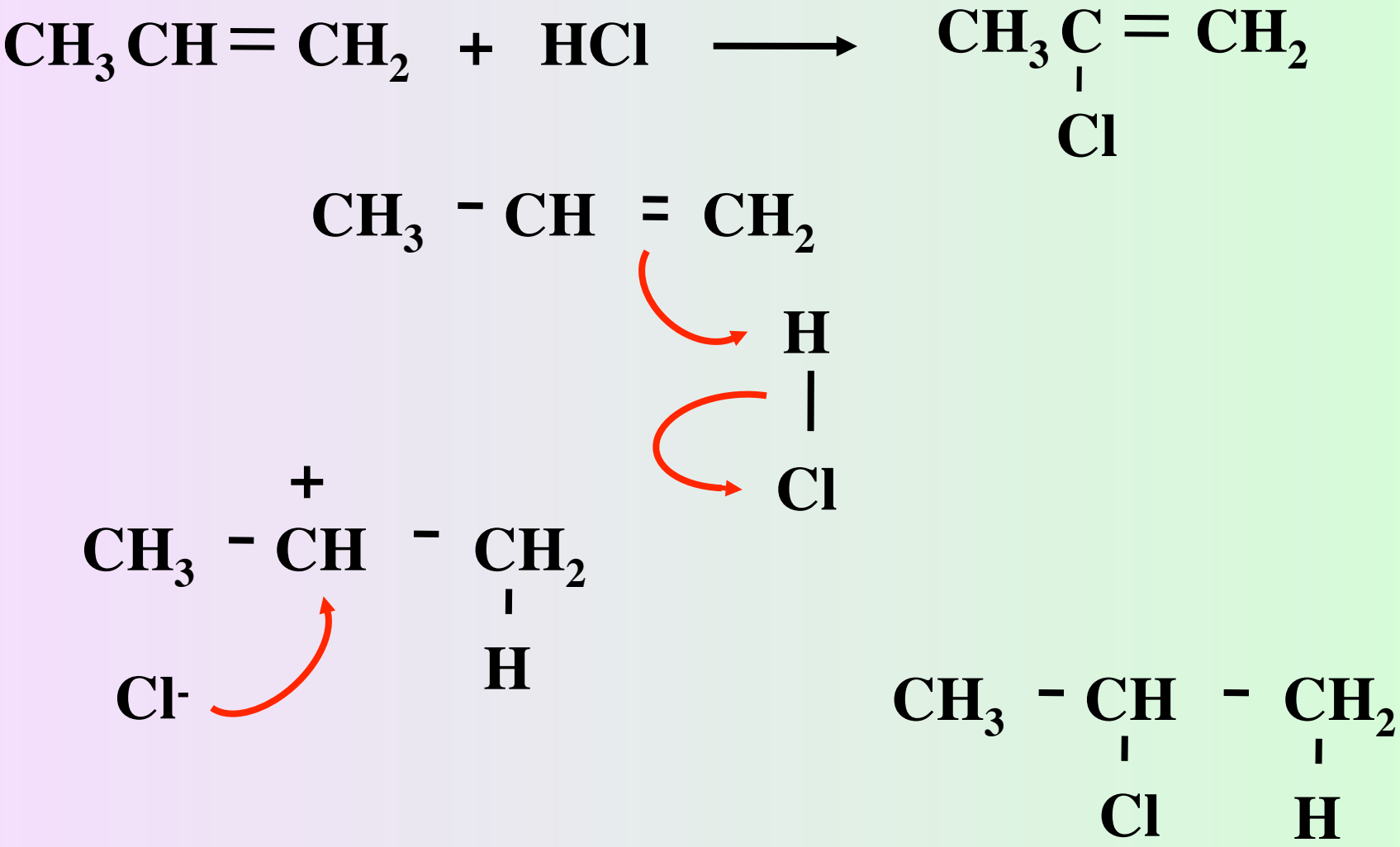
the addition of a hydrogen halide to an unsymmetrical alkene two products are possible

1-chloropropane

Occurs 80% of the time

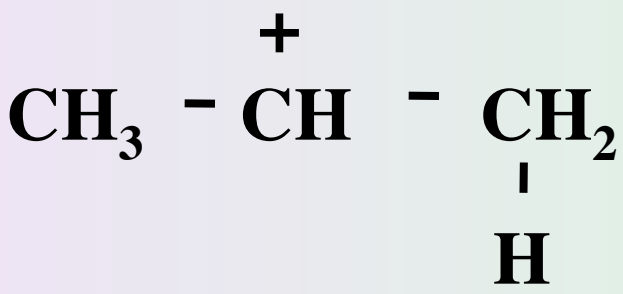
2-chloropropane

Reactions with Hydrogen Halides



Markovnikov's rule

an unsymmetrical reagent adds to an unsymmetrical double bond in the direction that places the positive part of the reagent on the carbon of the double bond that has the greater number of hydrogen substitutents



alkyl groups are electron- releasing creating a more stable carbocation

thus favoring secondary carbocation formation over primary

Alkynes

Alkynes

hydrocarbons containing at least one carbon-carbon triple bond

C_nH_n **sp hybridization**

Ethyne C_2H_2 $H-C\equiv C-H$

Alkyne Nomenclature

alkynes involves the use of -yne as a suffix to replace the -ane of the parent molecule

$CH \equiv C - CH_2 - CH_3$	1-Butyne
$CH_3 - C \equiv C - CH_3$	2-Butyne

number from the end closer to the carbon bearing the triple

Chemical properties of Ethyne (Acetylene)

the positive free energy of formation of acetylene refers to its relative instability

$$2C + H_2 \longrightarrow HC \equiv CH$$

$$\Delta G^\circ \qquad 209 \text{ kJ/mol}$$

Chemical Reactions and Ethyne (Acetylene)

Due to its high heat of combustion acetylene has many industrial uses

$$2\,(HC \equiv CH) + 5O_2 \longrightarrow 4CO_2 + 2H_2O$$

$$\Delta H^\circ \qquad -2599.2\ \text{kJ}$$

Chemical Reactions and Ethyne (Acetylene)

Addition reactions

with hydrogen halides

halogens

hydrogenation

occur much the same as with alkenes