



@chem31phys

Dr. P. Abdul Wahab

Chem 121

Chapter 20 Unsaturated Hydrocarbons

Lectures 17 and 18

Hein * Best * Pattison * Arena



Chapter Outline

20.1 Bonding in Unsaturated Hydrocarbons

20.2 Nomenclature of Alkenes

20.3 Geometric Isomerism in Alkenes

20.4 Cycloalkenes

20.5 Preparation and Physical Properties of Alkenes

20.6 Chemical Properties of Alkenes

20.7 Alkynes: Nomenclature and Preparation

20.8 Physical and Chemical Properties of Alkynes

Unsaturated hydrocarbons enhance our standard of living ; here are some examples

1. Polyethylene plastic bags and bottles
2. Polystyrene Styrofoam cups
3. Plastic wraps
4. Essential oils in plants contain multiple bonds between carbon atoms.
 - Cosmetics, medicines, flavorings, perfumes
5. Hydrocarbons also form rings of carbon atoms (aromatics)
 - Detergents, insecticides, and dyes

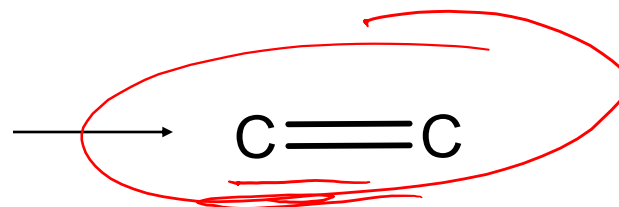


20.1 Bonding in Unsaturated Hydrocarbons

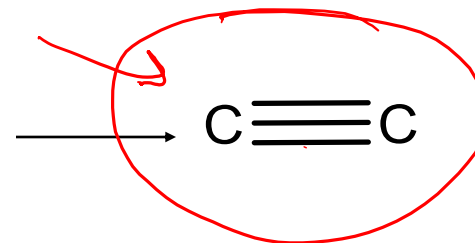


Types of Unsaturated Hydrocarbons

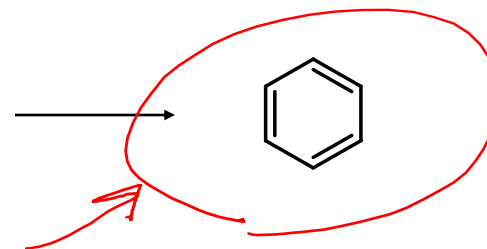
- **Alkenes** contain carbon-carbon double bonds.

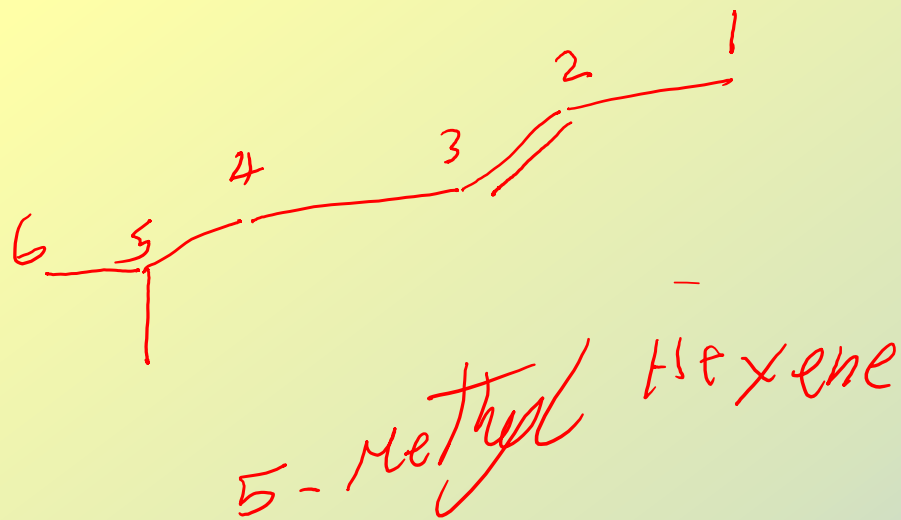
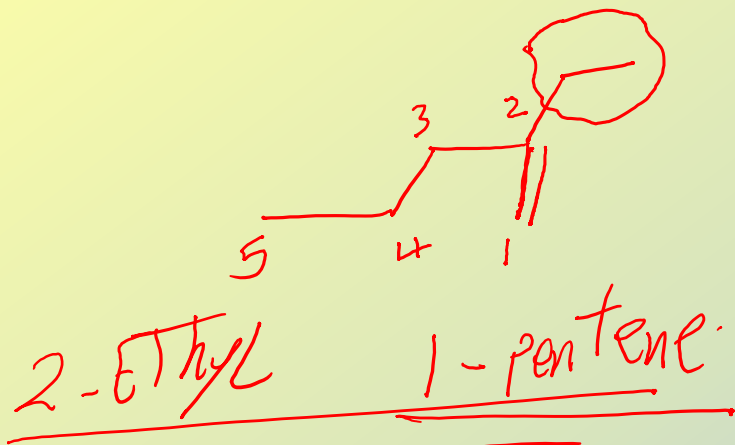
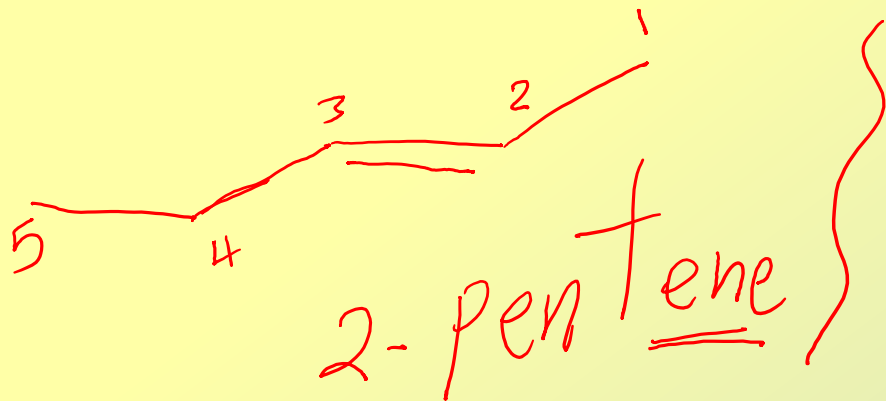


- **Alkynes** contain carbon-carbon triple bonds.



- **Aromatic compounds** contain benzene rings.





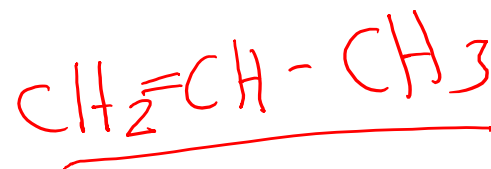
20.2 Nomenclature of Alkenes

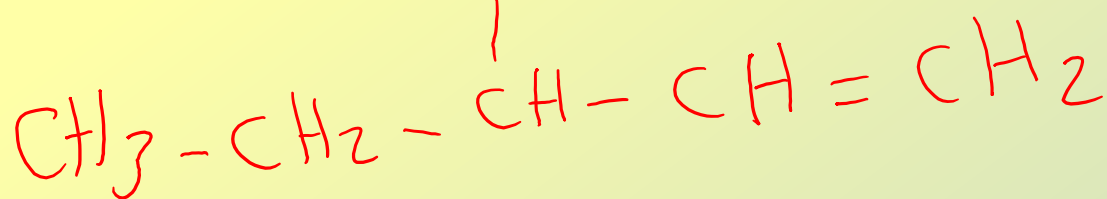
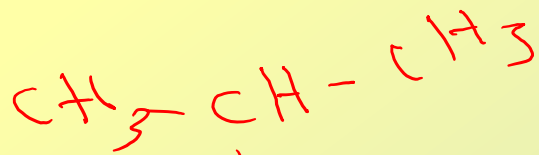


IUPAC Rules for Naming Alkenes

1. Identify the longest chain containing the C=C bond.

2. Name the parent alkane and change the ane ending to -ene.

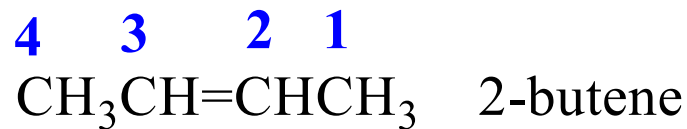
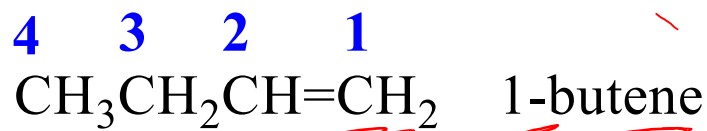




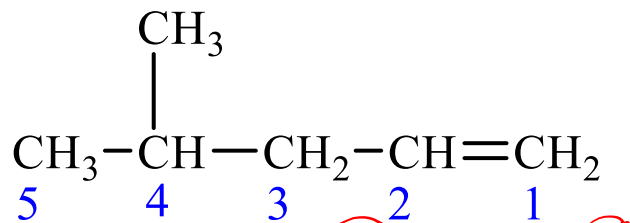
@chem31phys

IUPAC Rules for Naming Alkenes

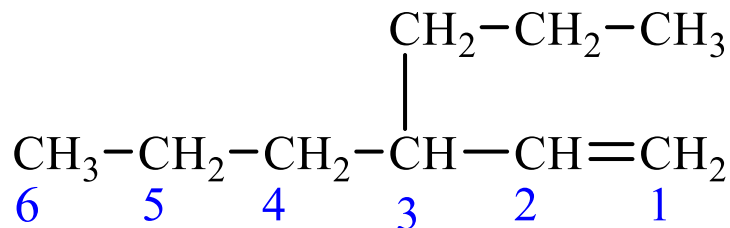
3. Number the carbon chain and double bond as shown below..



4. Number and name branch chains as alkyl groups as shown below.



4-methyl-1-pentene



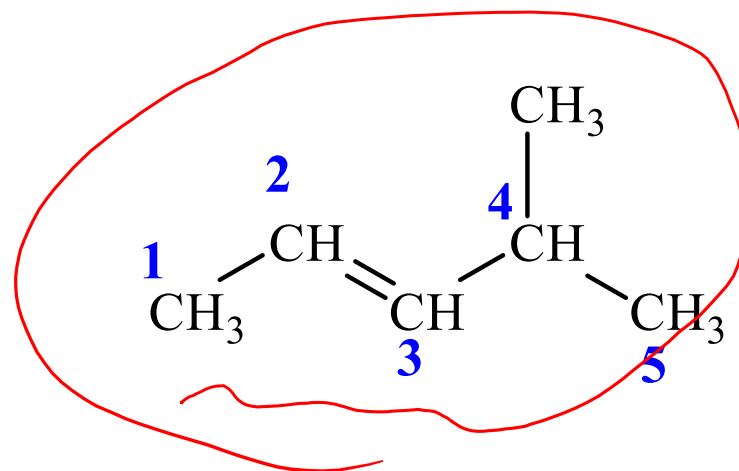
3-propyl-1-hexene

What is the structural formula of 4-methyl-2-pentene?



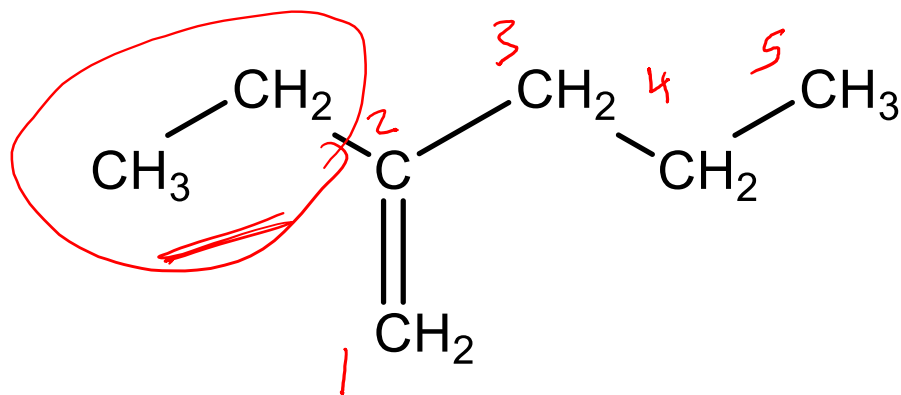
The name indicates:

- Five carbons in the longest chain
- A double bond between carbons 2 and 3
- A methyl group on carbon 4



Name this compound

- Longest chain containing C=C is 5 carbons



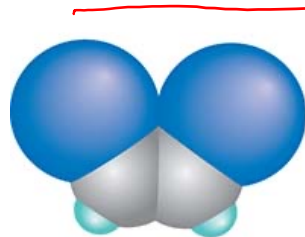
- This compound is 2-ethyl-1-pentene

20.3 Geometric Isomerism in Alkenes

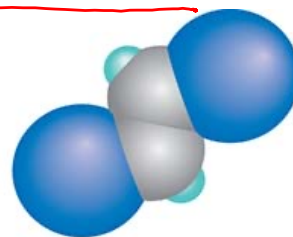


Geometric Isomerism in Alkenes

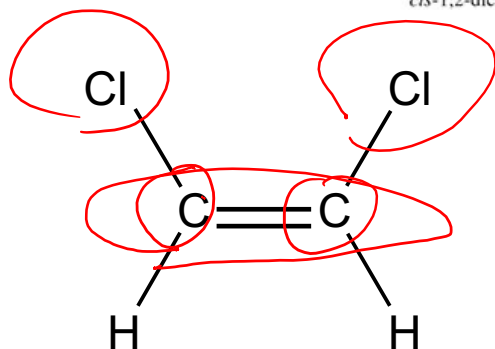
Alkenes that have the same molecular formula and the same connectivity between atoms but different spatial orientation of the atoms are called geometric isomers or cis-trans isomers.



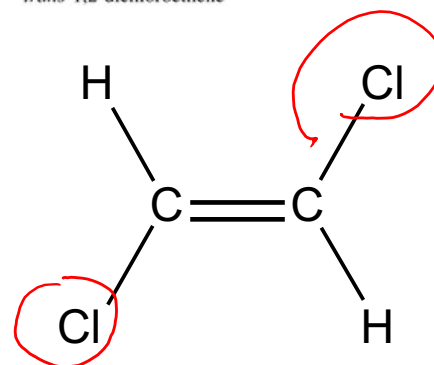
cis-1,2-dichloroethene



trans-1,2-dichloroethene



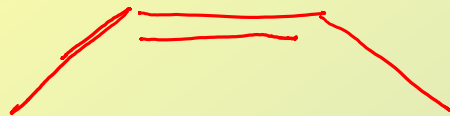
cis-1,2-dichloroethene
(bp = 60.1 C)



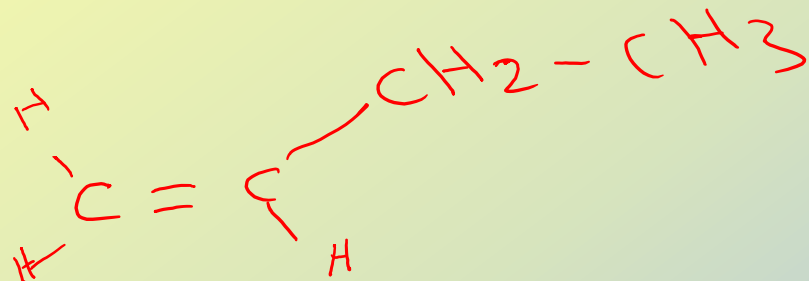
trans-1,2-dichloroethene
(bp = 48.4 C)



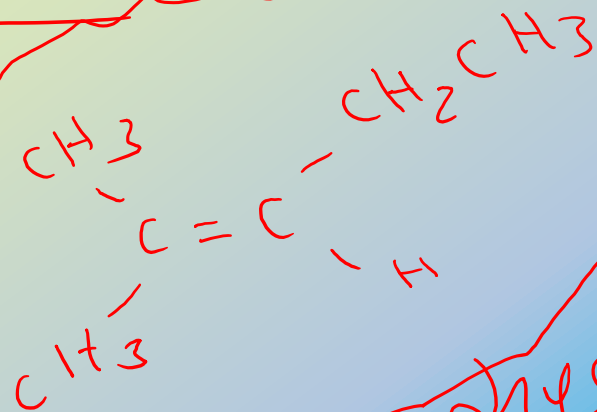
cis-2-Butene



trans-2-Butene

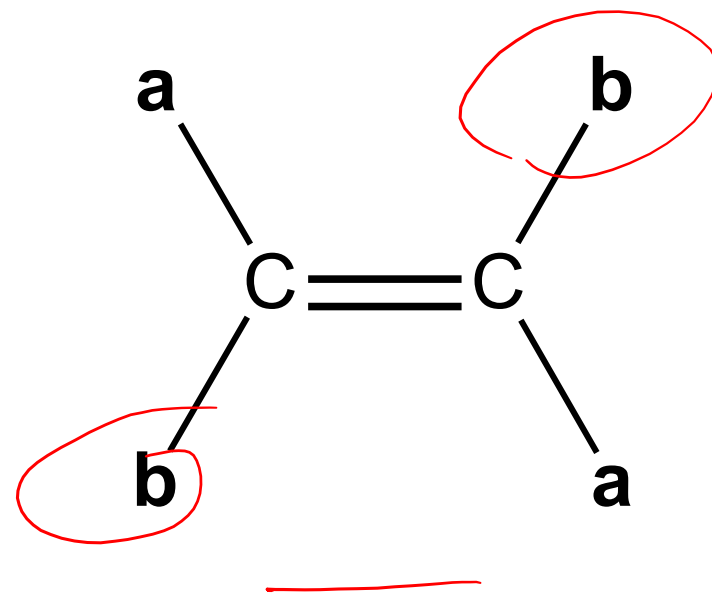
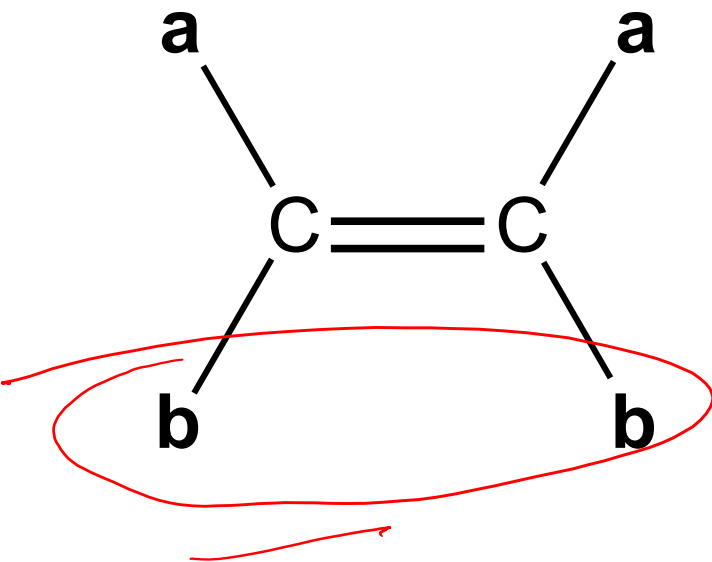


1-Butene

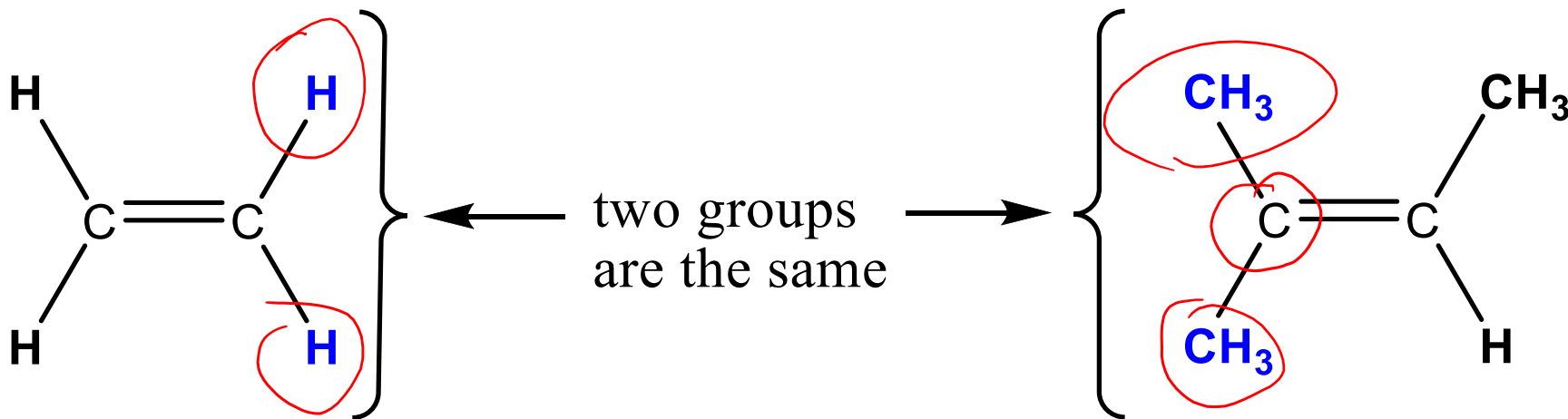


@chem31phys

Alkenes with the a/b pattern shown here will show **cis-trans isomerism**.



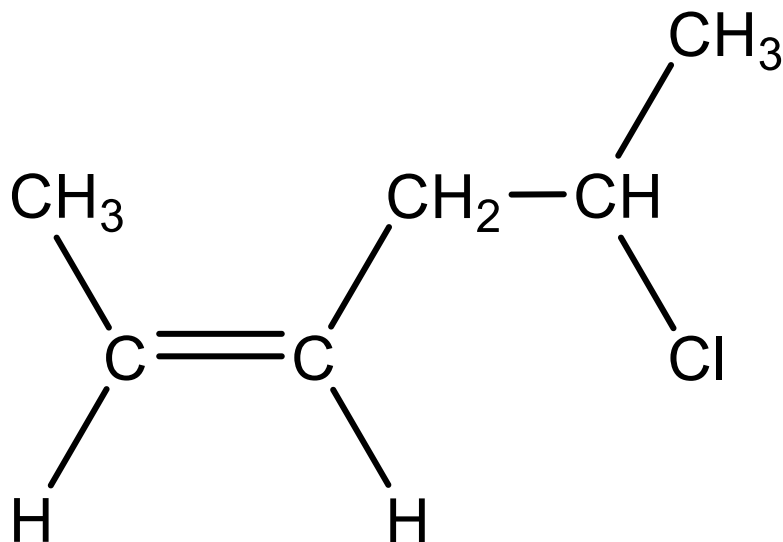
If a C=C carbon has two identical groups as shown here, then cis-trans isomerism will not occur in an alkene.

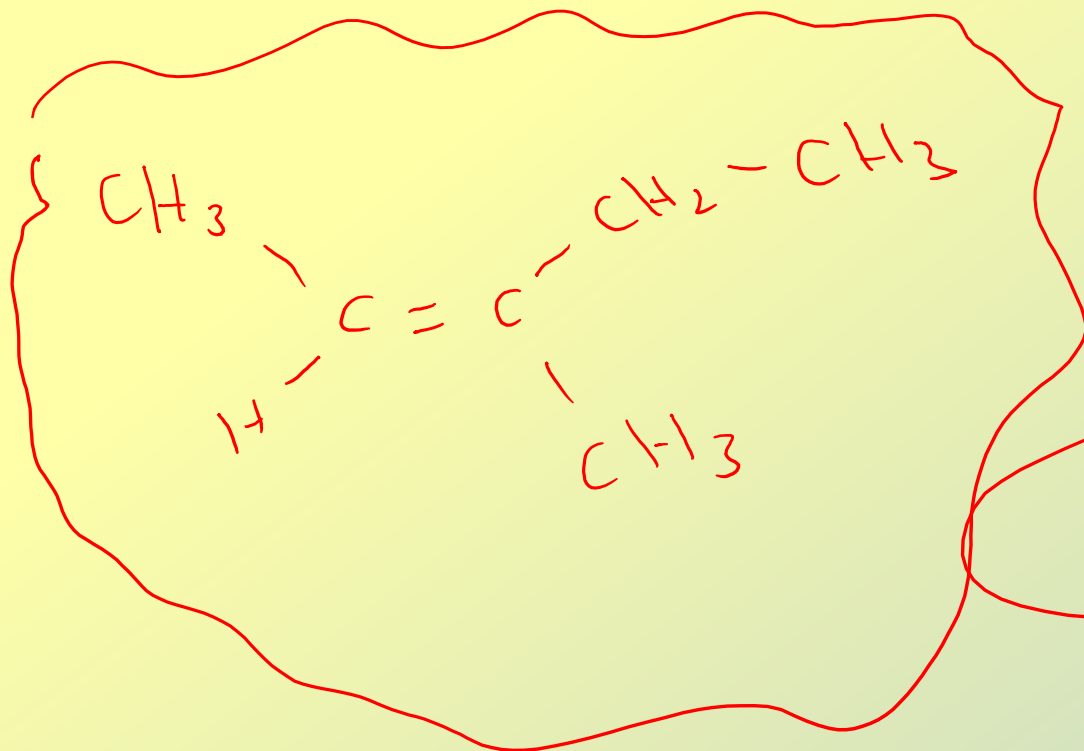


Practice Problems

(1) Draw the chemical structure of *cis*-5-chloro-2-hexene

This compound contains 6 carbons with a C=C between carbons 2 and 3, and a Cl atom on carbon 5.



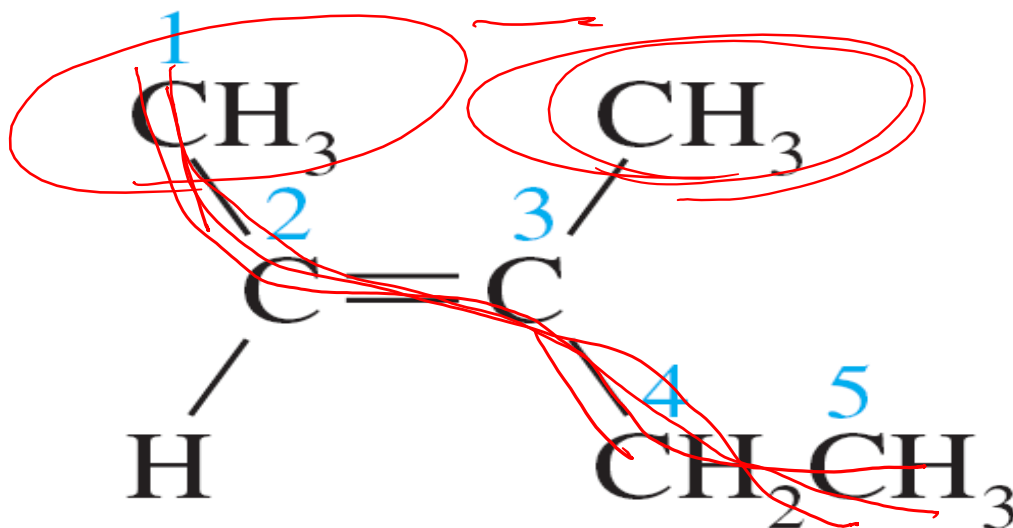


Name

Cis, trans

@chems1phys

(2) Is this the cis or trans isomer of 3-methyl-2-pentene?



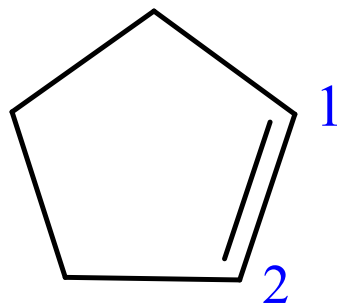
This is trans-3-methyl-2-pentene because the methyl and ethyl groups in the pentene chain are trans to each other.

20.4 Cylcoalkenes

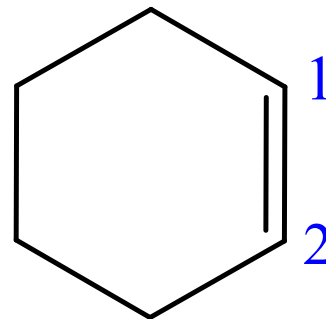


Cycloalkenes

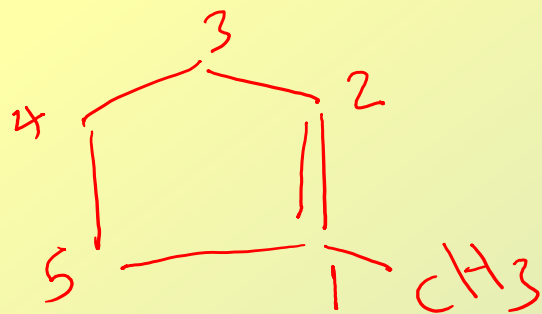
- Cycloalkenes are cyclic compounds with a C=C bond in the ring.
- The carbons of the double bond are assigned numbers 1 and 2 as shown here.



cyclopentene

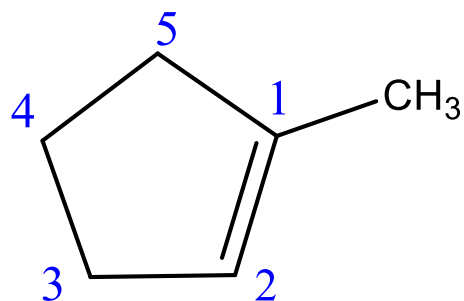


cyclohexene

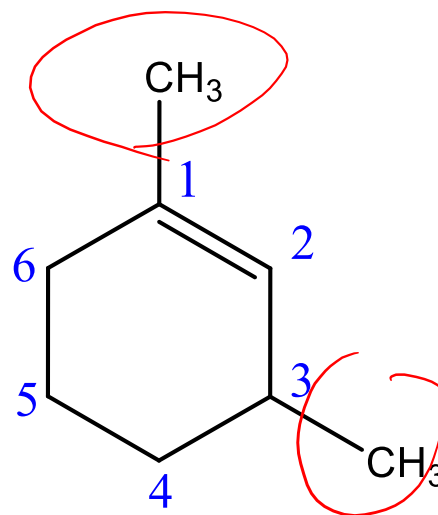


1-methyl cyclopentene

Examples of Cycloalkenes



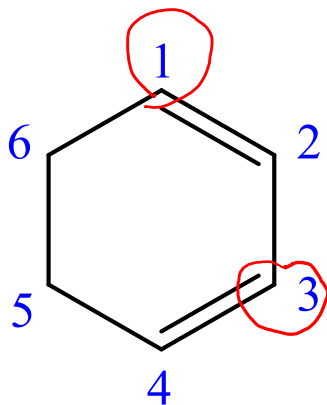
1-methylcyclopentene



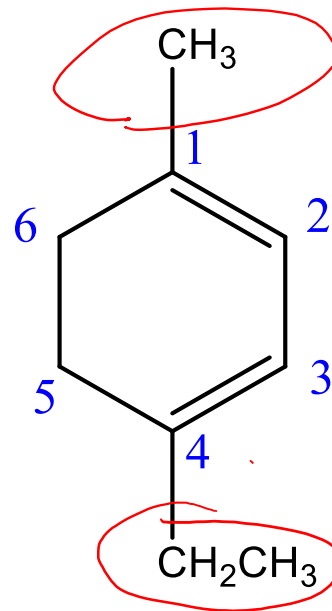
1,3-dimethylcyclohexene

Examples of Cycloalkadienes

1,3-cyclohexadiene



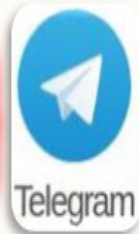
1,3-cyclohexadiene



4-ethyl-1-methyl-1,3-cyclohexadiene

دعواتي للجميع بالتفوق والنجاح

أبو عبد الله محمد



@Chem31Phys

@Chem31Phys

عبدالرحمن

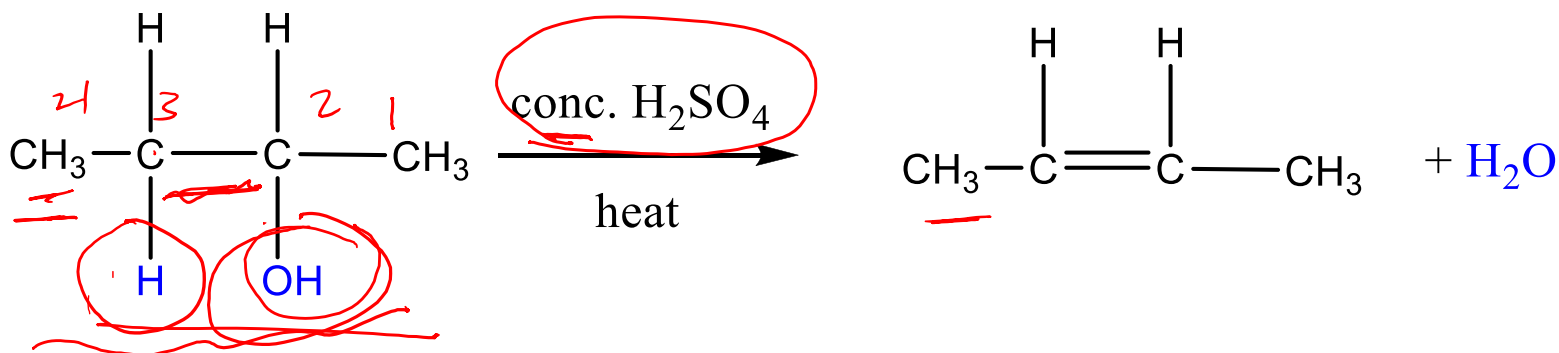
20.5 Preparation and Physical Properties of Alkenes

20.6 Chemical Properties of Alkenes



Methods for Preparing Alkenes

- Dehydration of Alcohols (*elimination of H₂O from a molecule*)

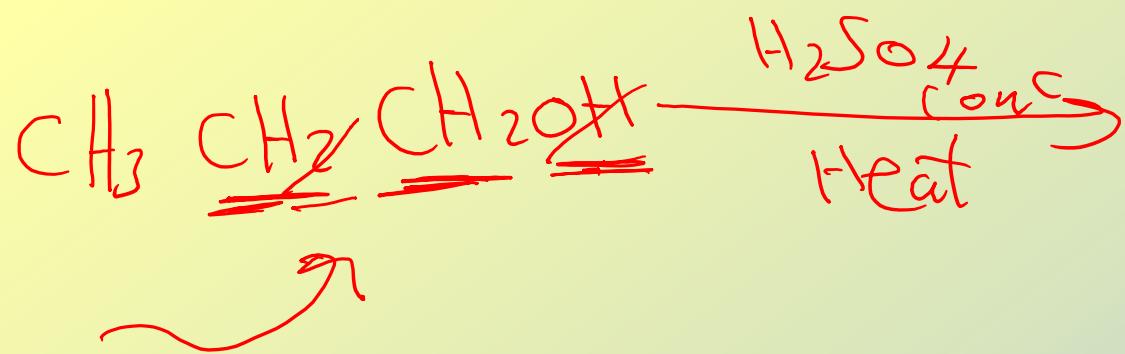
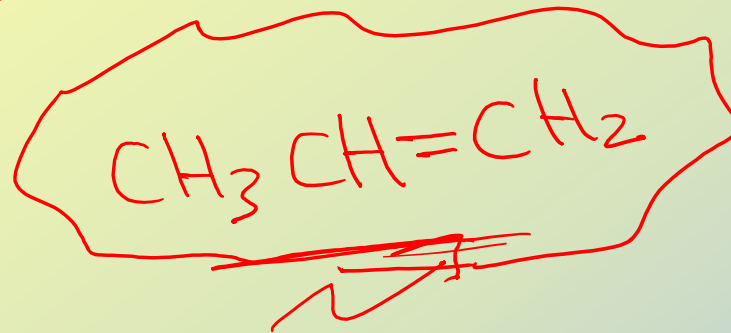


The reaction is catalyzed by an acid .

R-OH

Chemistry

PhyS



like dissolve like

Physical Properties of Alkenes

The physical properties of alkenes are similar to alkanes. They are **nonpolar and insoluble in water but soluble in organic solvents.**

Table 20.1 Physical Properties of Alkenes

Molecular formula	Structural formula	IUPAC name	Density (g/mL)	Melting point (°C)	Boiling point (°C)
C ₂ H ₄	CH ₂ =CH ₂	Ethene	—	-169	-104
C ₃ H ₆	CH ₃ CH=CH ₂	Propene	—	-185	-48
C ₄ H ₈	CH ₃ CH ₂ CH=CH ₂	1-Butene	0.595	-185	-6
C ₄ H ₈	(CH ₃) ₂ C=CH ₂	2-Methylpropene	0.594	-14	-7
C ₅ H ₁₀	CH ₃ (CH ₂) ₂ CH=CH ₂	1-Pentene	0.641	-138	30

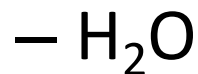
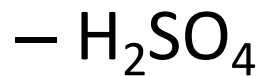
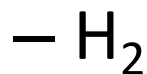
1- Butene

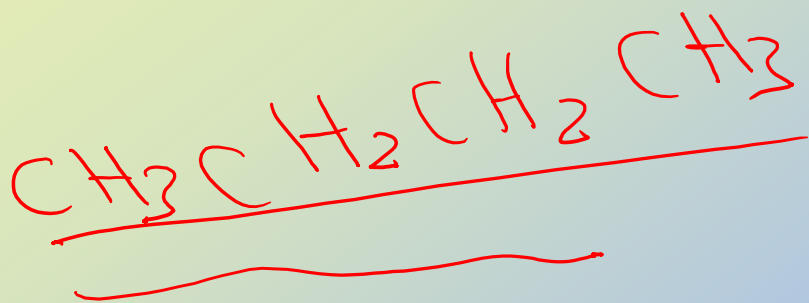
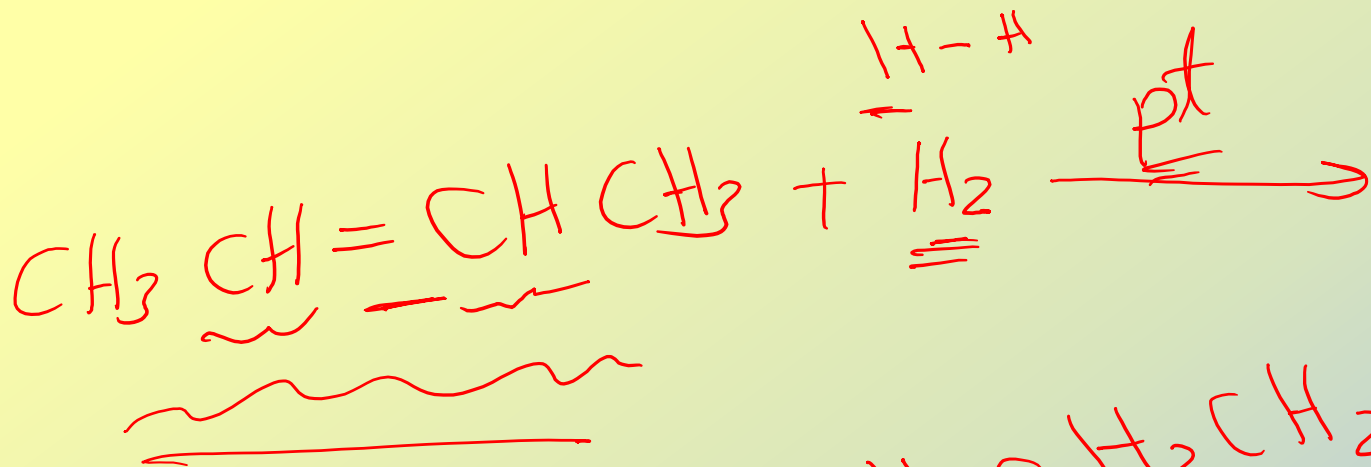
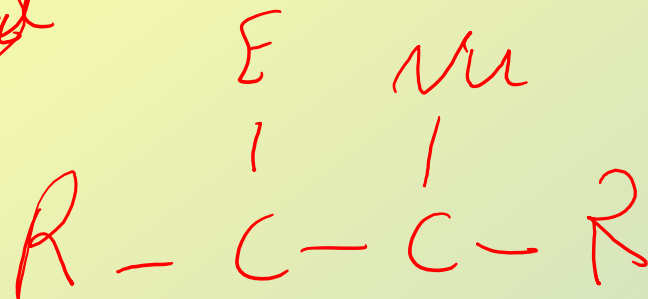
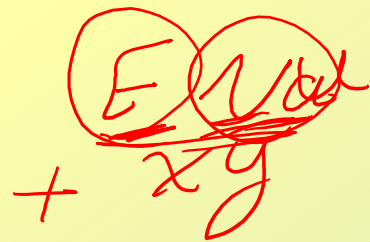
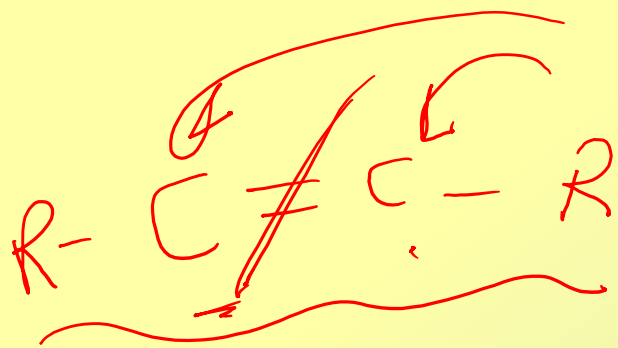
2- Butene

@ Chem 3 ip hys

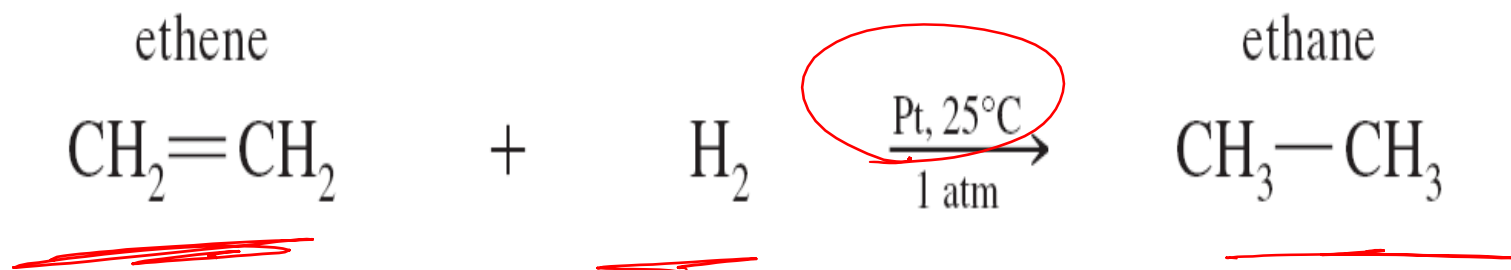
Chemical Properties of Alkenes (20.6)

Alkenes undergo addition reactions at the C=C bond with these reactants:



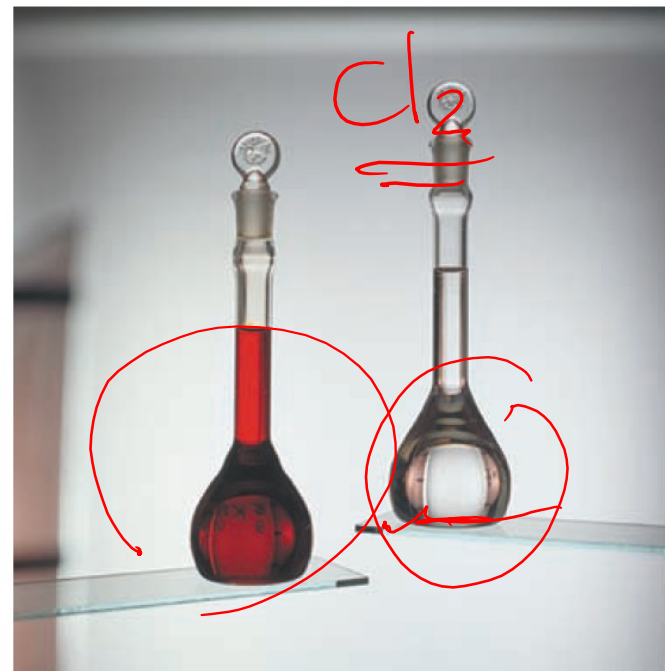
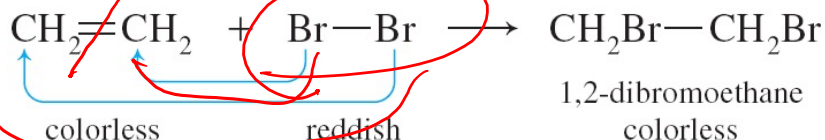
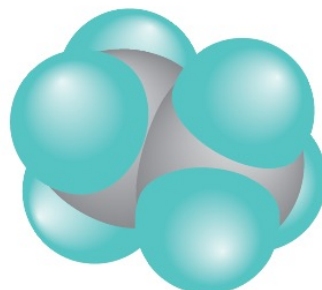
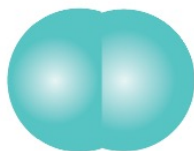
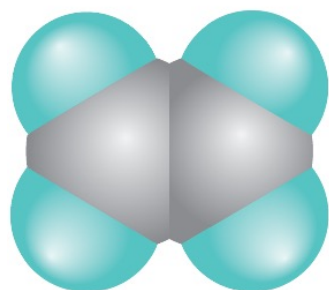


Addition of H₂ (*Hydrogenation*)

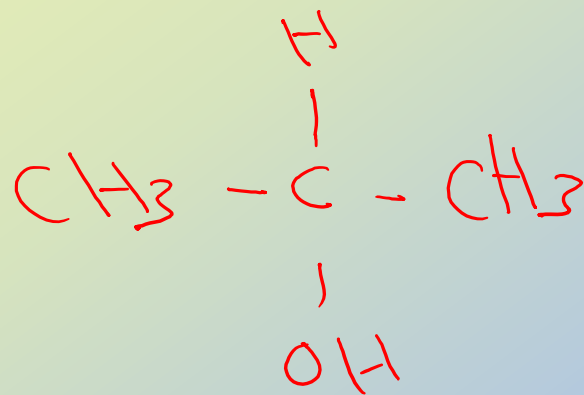
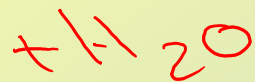
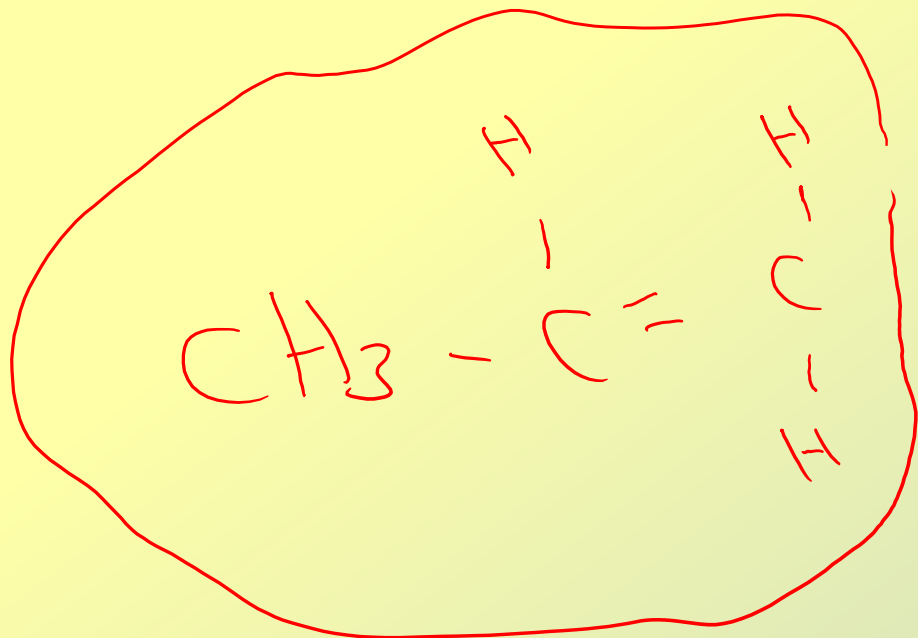


Addition of X₂

Br₂

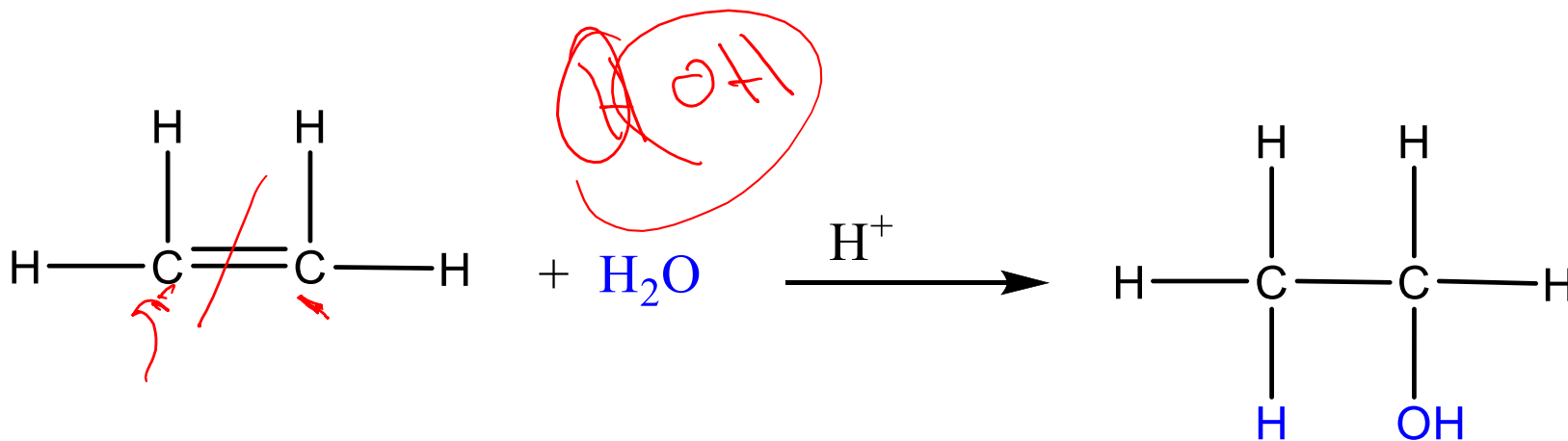


Bromine changes from a red-orange (*flask on the left*) to colorless when added to an alkene as shown in the flask on the right.

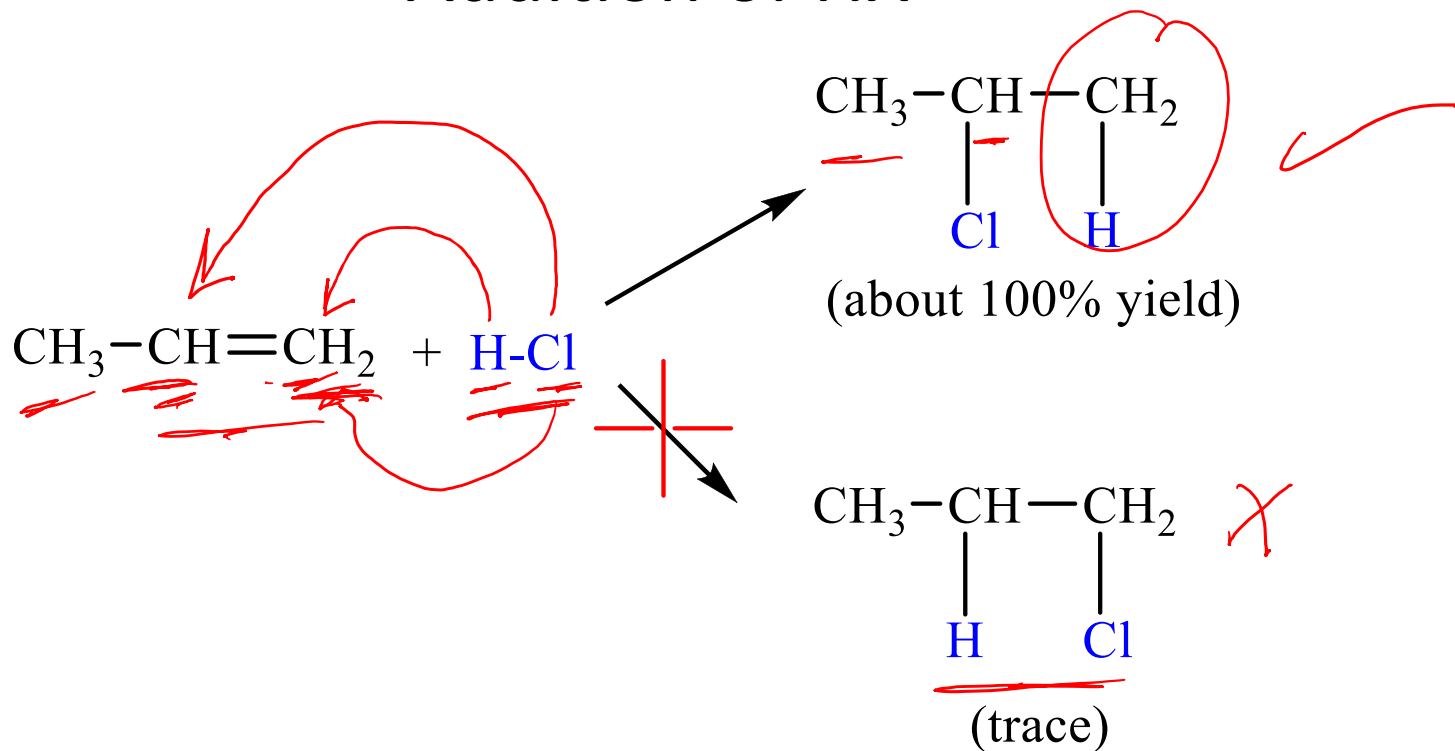


2-propanol

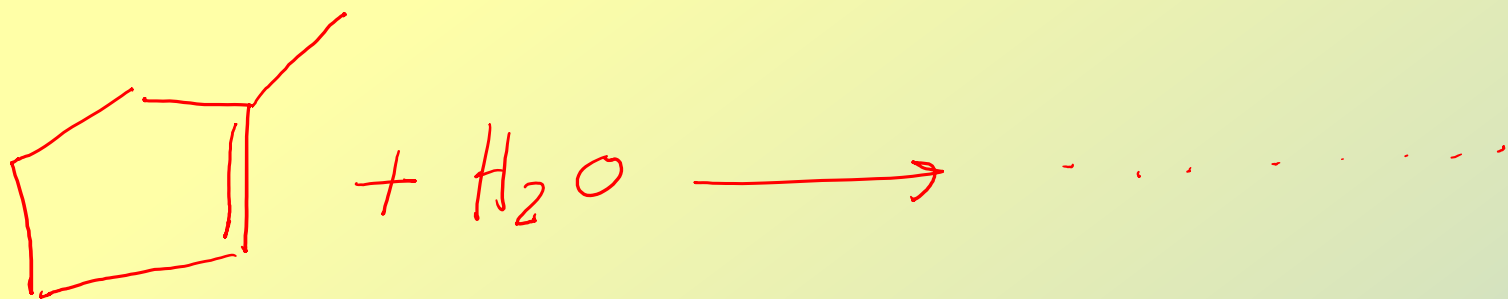
Addition of H₂O



Addition of HX



Notice how only one product of the two possible products is produced. This occurs because addition reactions involving unsymmetrical alkenes follow Markovnikov's rule.



@Chem 3, phys

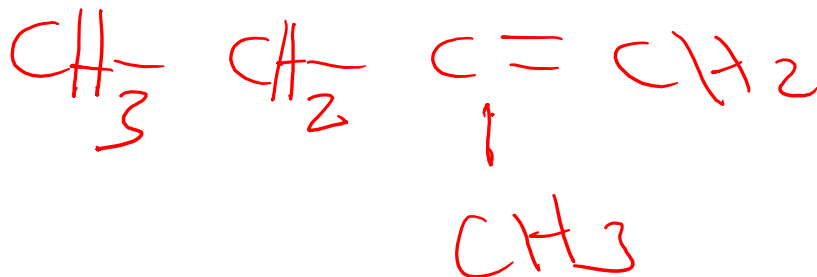
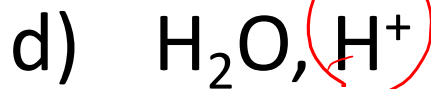
What is Markovnikov's rule?

It is a rule that states the H of HX adds to the C=C carbon with the most hydrogens.

This rule can be explained by a reaction mechanism (i.e. *the specific steps from reactants to products*).

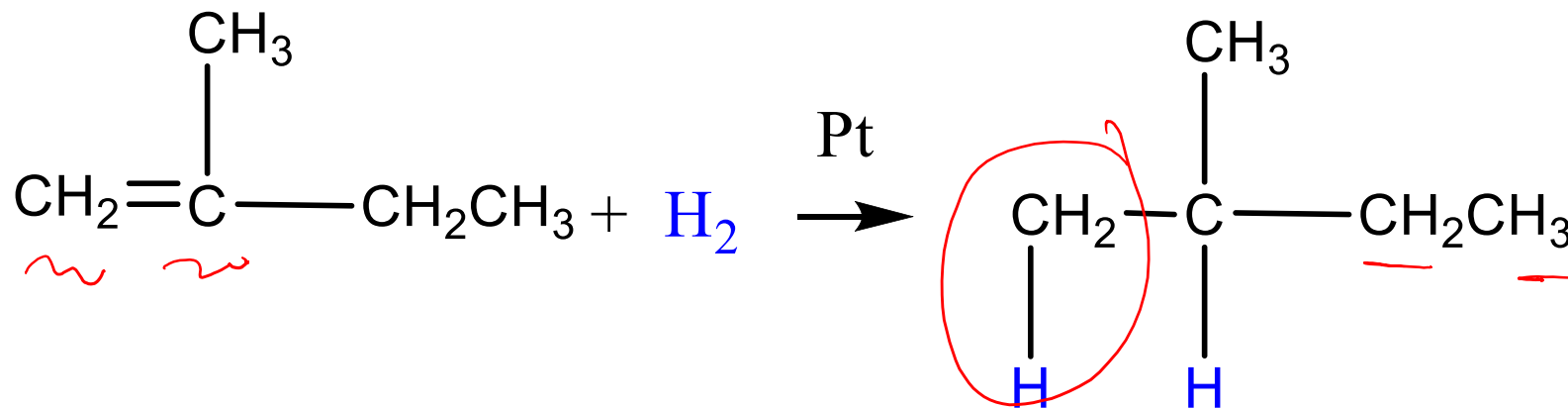
Practice Problem

Predict the major products formed when 2-methyl-1-butene reacts with:

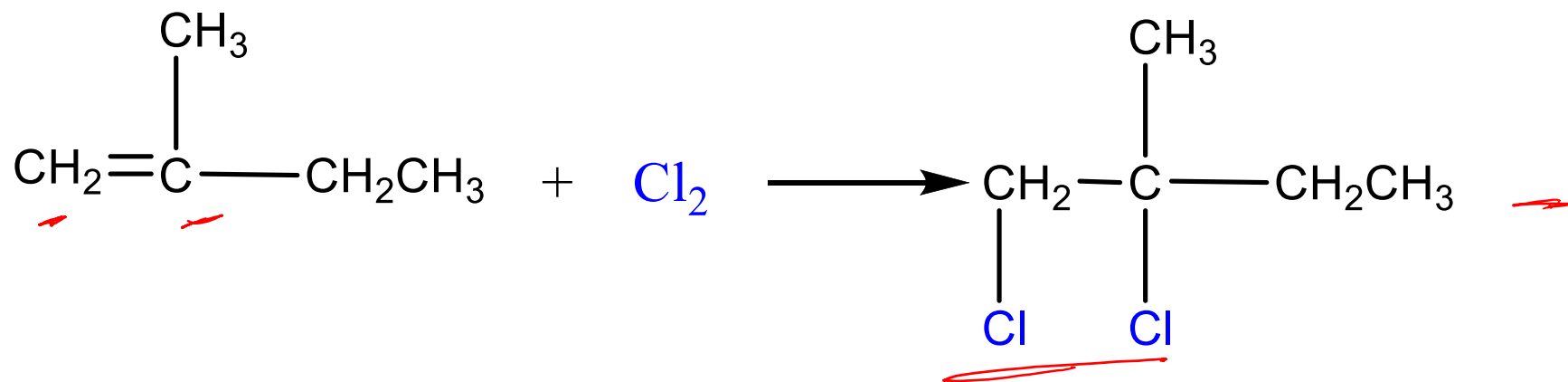


@chem311phys

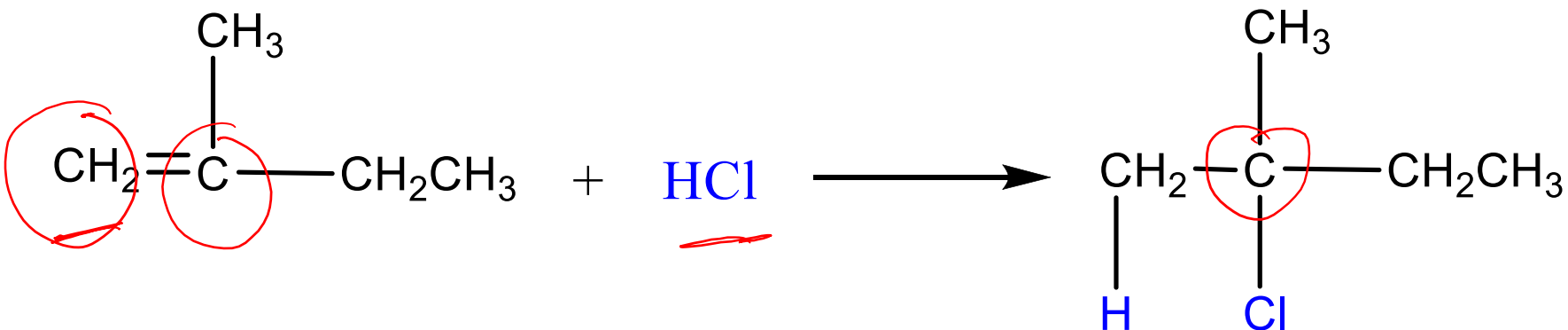
2-methyl-1-butene + H₂, Pt/25 °C



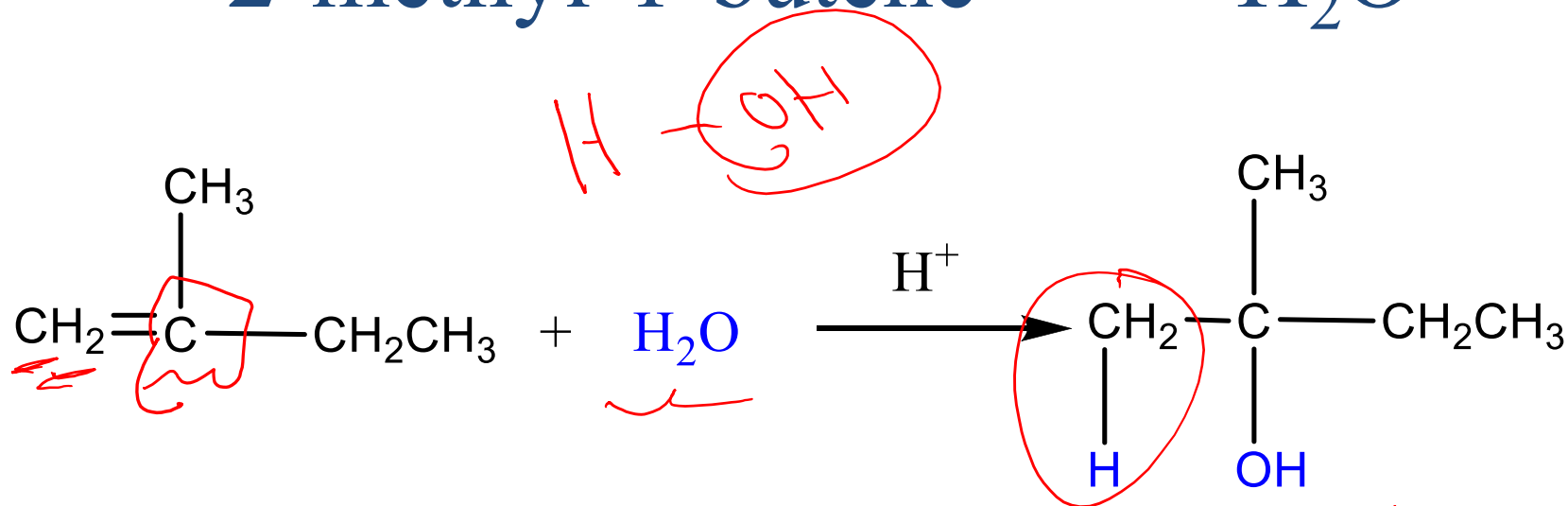
2-methyl-1-butene + Cl₂



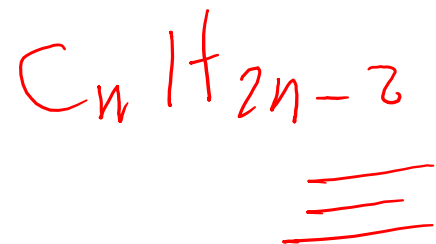
2-methyl-1-butene + HCl



2-methyl-1-butene + H₂O



2-methyl
2-Butanol



20.7 Alkynes: Nomenclature and Preparation

20.8 Physical and Chemical Properties of Alkynes



IUPAC Rules for Naming Alkynes

Naming alkynes is the same as naming alkenes except the suffix -yne indicates the C≡C bond.

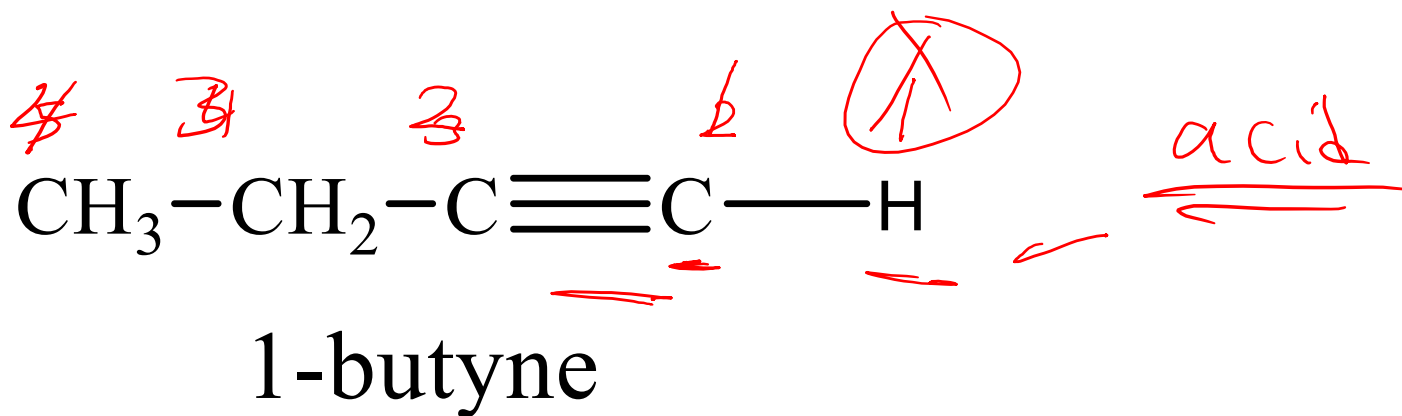


Table 20.2 Nomenclature for Some Common Alkynes

Molecular formula	Structural formula	IUPAC name
C_2H_2	$H-C \equiv C-H$	Ethyne*
C_3H_4	$CH_3-C \equiv C-H$	Propyne
C_4H_6	$CH_3CH_2-C \equiv C-H$	1-Butyne
C_4H_6	$CH_3-C \equiv C-CH_3$	2-Butyne

*Ethyne is commonly known as acetylene.

Physical Properties of Acetylene



Ethyne

Acetylene

- is a colorless gas
- has little odor when pure.
- is insoluble in water
- is a gas at normal temperature and pressure.
- is subject to explosive decomposition

1 atm

25

H_2O

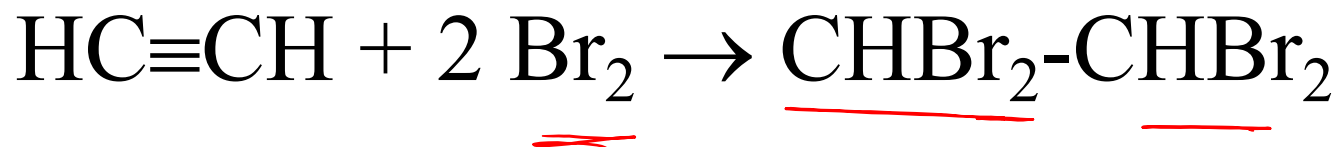
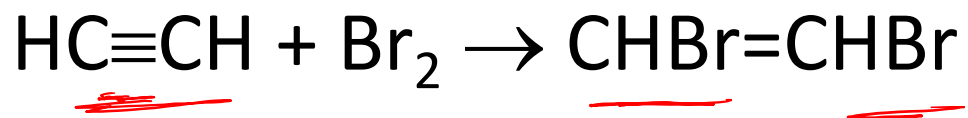
$T = 25^\circ \text{C}$ 1 atm

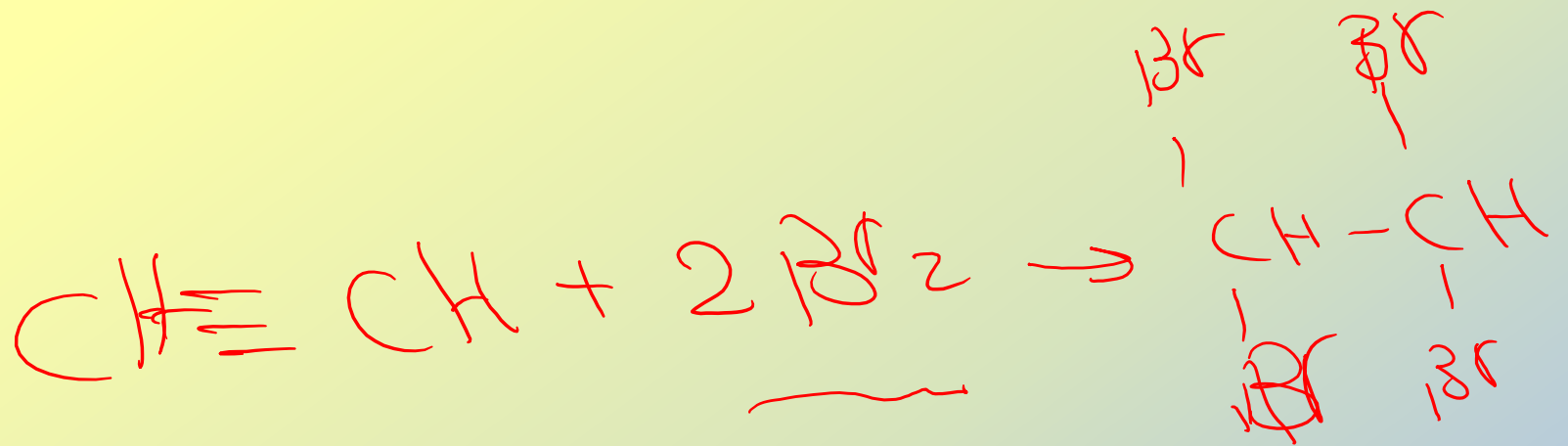
Chemical Properties of Alkynes (20.8)

Alkynes undergo addition reactions similar to those of alkenes. They also react with:

- Cl_2 and Br_2
- HCl and HBr

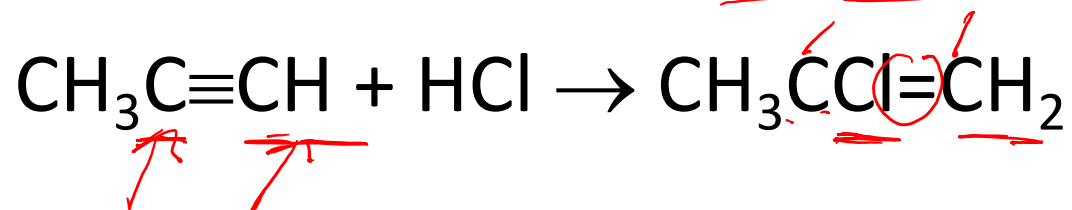
Bromination of Acetylene

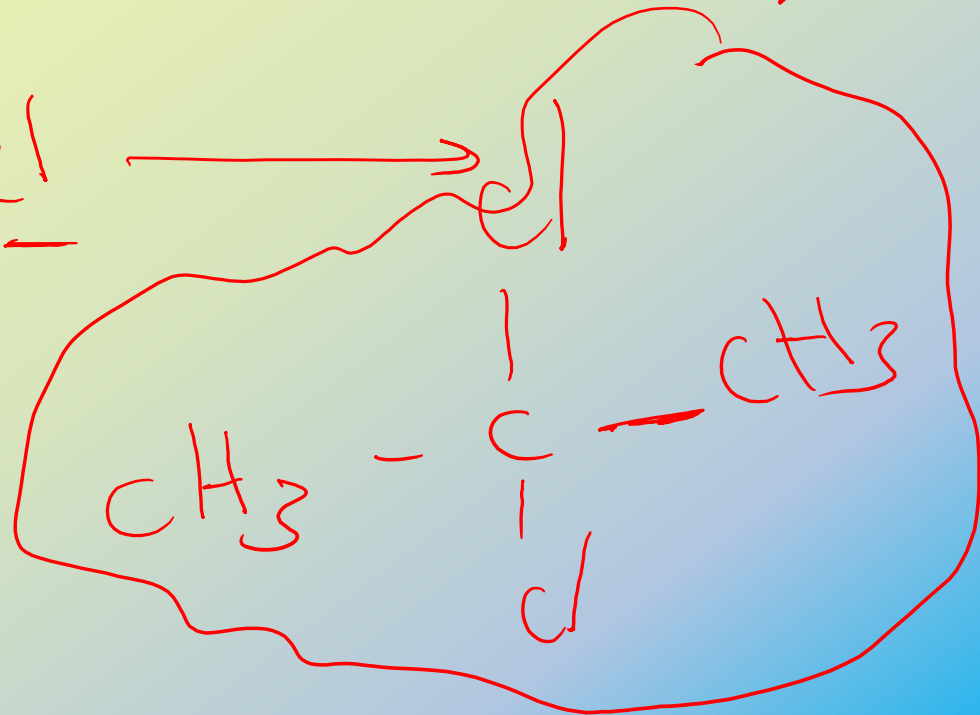
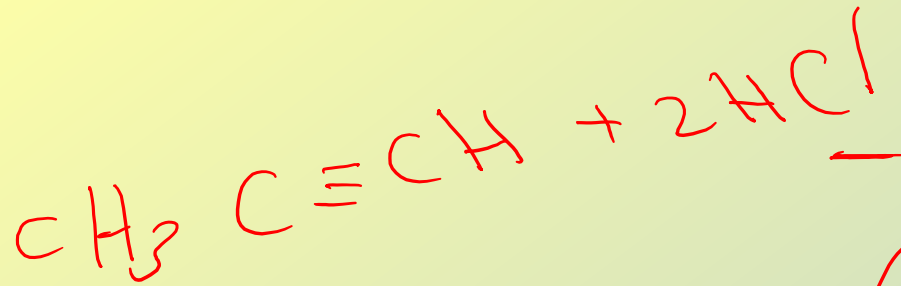
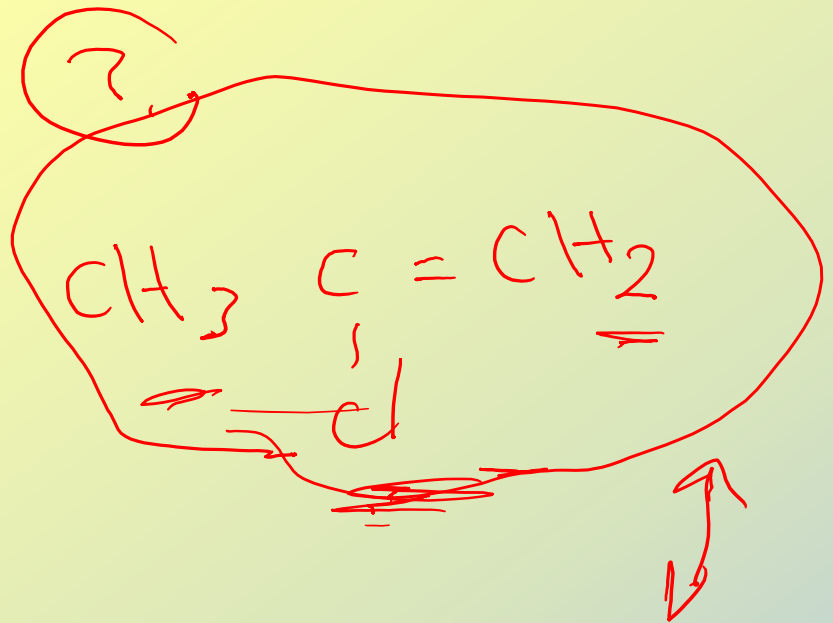
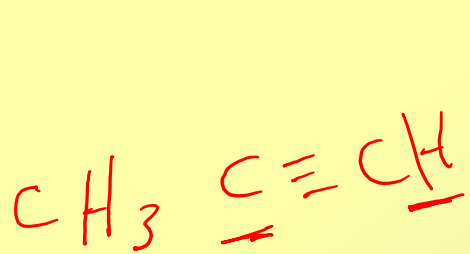




HCl Addition to Unsymmetrical Alkynes

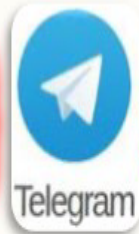
This addition also follows Markovnikov's rule:





دعواتي للجميع بالتفوق والنجاح

أبو عبد الله محمد



@Chem31Phys