



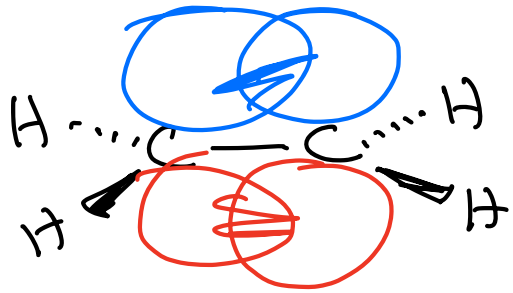








Electronic Structure of Alkenes



Consequences of π bonds

1) π bonds cannot rotate

2) Electron density is above and below the bond axis so it is "available" to react with electron deficient atoms/molecules

Like a Lewis base

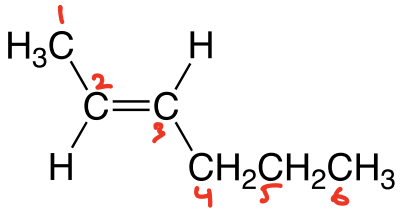
Naming Alkenes

General Directions:

1. Locate longest continuous chain.
2. Number the chain so the double bond gets the lowest possible number.
3. For the parent chain name, use "-ene" not "-ane" as suffix and place a number to indicate the location of the double bond before the main chain name.
4. Make the suffix "-adiene" , "-atriene", etc. if multiple double bonds are present.

***cis/trans* nomenclature** – older chemical nomenclature, but still used commonly in biochemistry – most useful when each sp^2 atom of the double bond has an H atom.

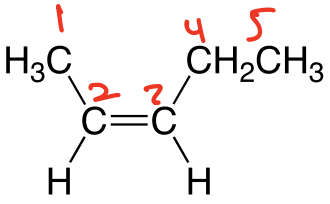
1. Track the longest chain through the double bond
   a. ***cis*** if whole main chain is on the same side of the double bond.
   b. ***trans*** if chain emerges on opposite sides of the double bond.



trans-2-hexene

or

trans-hex-2-ene



cis-2-pentene

or

cis-pent-2-ene

NOT IUPAC but still used by everyone ☹

Naming Alkenes

General Directions:

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4. Make the suffix "-adiene" , "-atriene", etc. if multiple double bonds are present.

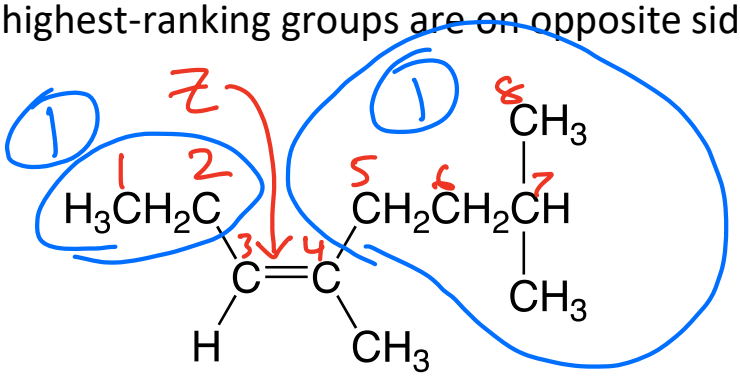
***E,Z* nomenclature** - A general IUPAC nomenclature to names alkenes.



Z (zusammen) = *zame zide, zame zide, zame zide*

E (entgegen) = opposite side

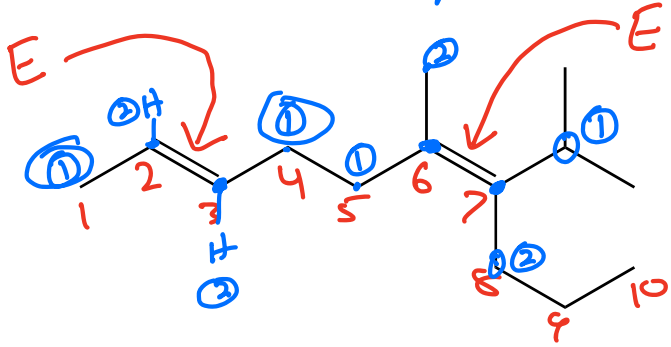
5. On each carbon of the double bond rank the two groups according to the Cahn, Ingold, Prelog priority rules (*R* vs. S rules).
6. If both of the highest-ranking groups are on the zame zide of the double bond it is ***Z***.
7. If both of the highest-ranking groups are on opposite sides of the double bond it is ***E***.



(Z)-4,7-dimethyl-3-octene

or

(Z)-4,7-dimethyloct-3-ene



(2E,6E)-7-isopropyl-6-methyl-2,6-decadiene

or

(2E,6E)-7-isopropyl-6-methyldeca-2,6-diene

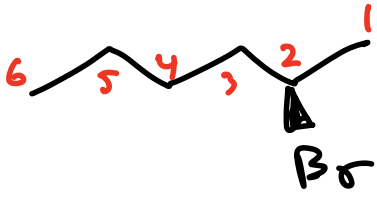
Today's Special Bonus Feature:
Halogen Nomenclature



fluoro- chloro- bromo- iodo-

$-CH_2F$

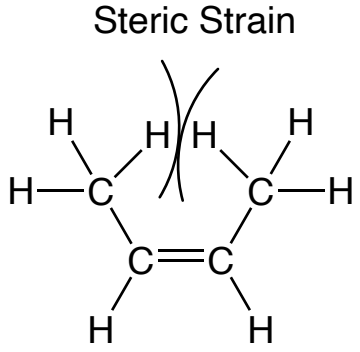
fluoromethyl group



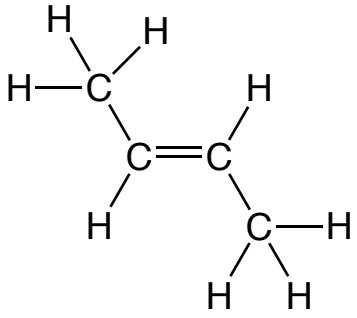
(R)-2-bromohexane

Special Alkene Bonus: Important material you will need to know!

Alkene stability part 1: Z (cis) groups larger than H atoms will crunch into each other causing steric strain.



Z

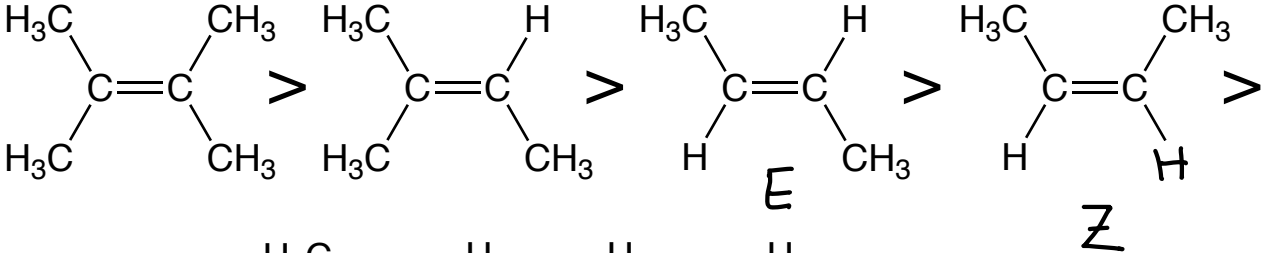


E

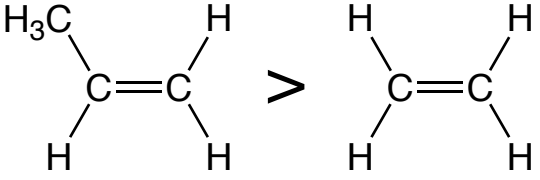
(no steric strain)

Alkene stability part 2: For reasons we are not able to tell you, more substituted alkenes have more stable (stronger) pi bonds than alkenes with more H atoms on their sp^2-hybridized C atoms (despite there being steric strain present in the most substituted alkenes).

Strongest Pi Bond



E Z

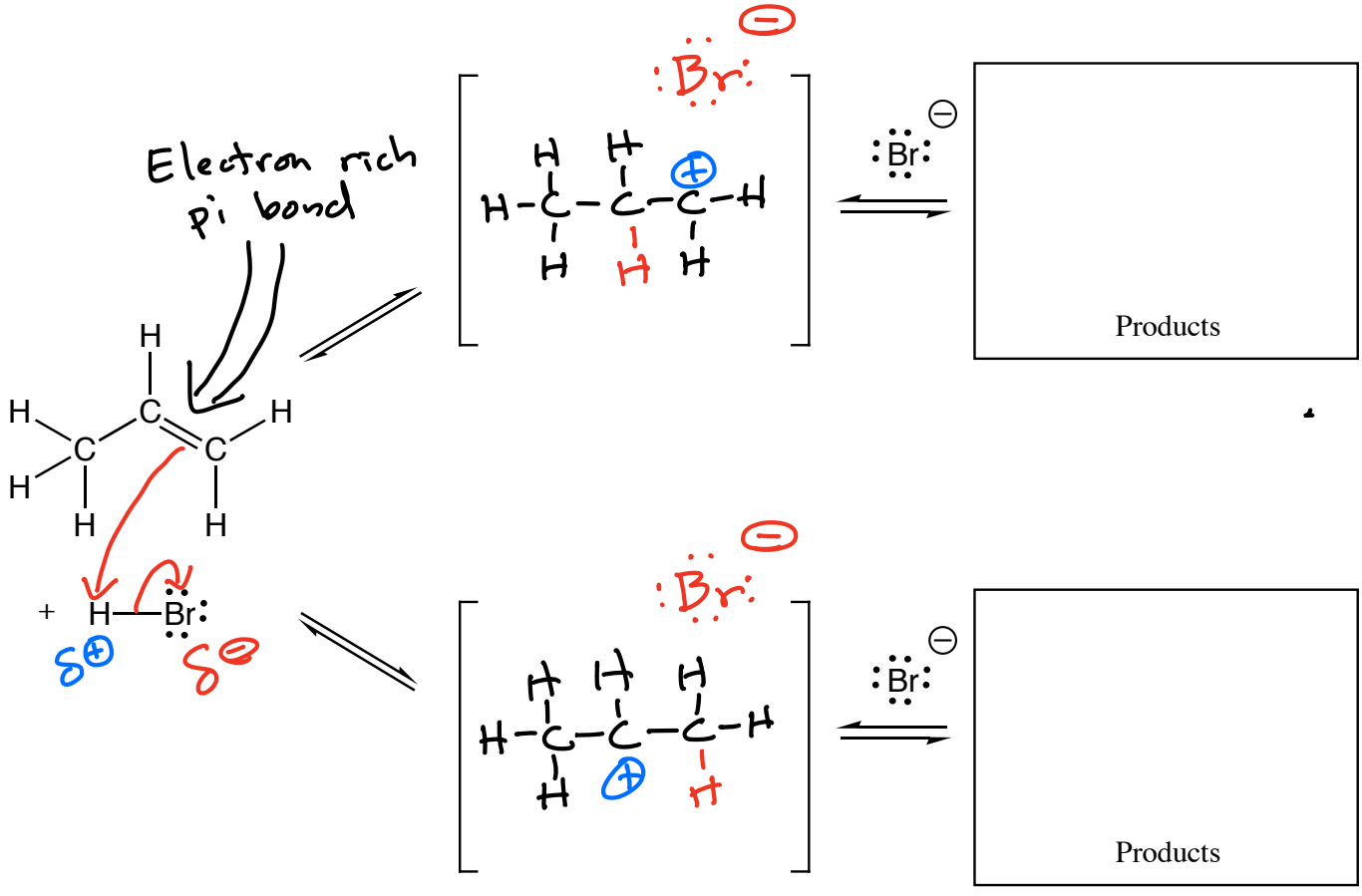


Weakest Pi Bond



Time Capsule: Zaitsev's rule follows this trend!!

Addition of H-X to an Alkene

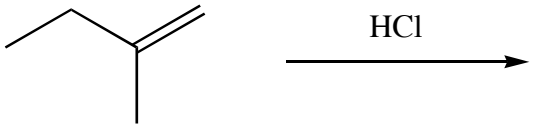


Summary:

Regiochemistry:

Stereochemistry:

Example:



For a reaction to take place, you need both:

Motive → thermodynamic driving force

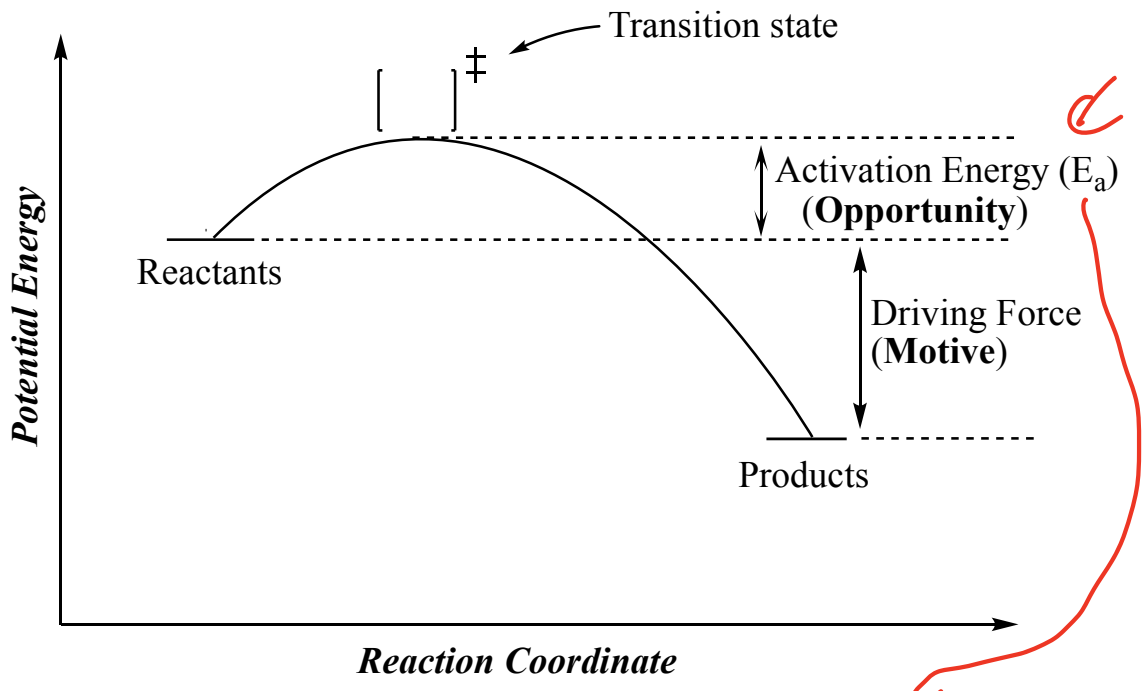
1) Make stronger bonds than you break

2) Formation of a weaker acid (or base)

3) Entropy → if you make a gas molecule (H_2, N_2)

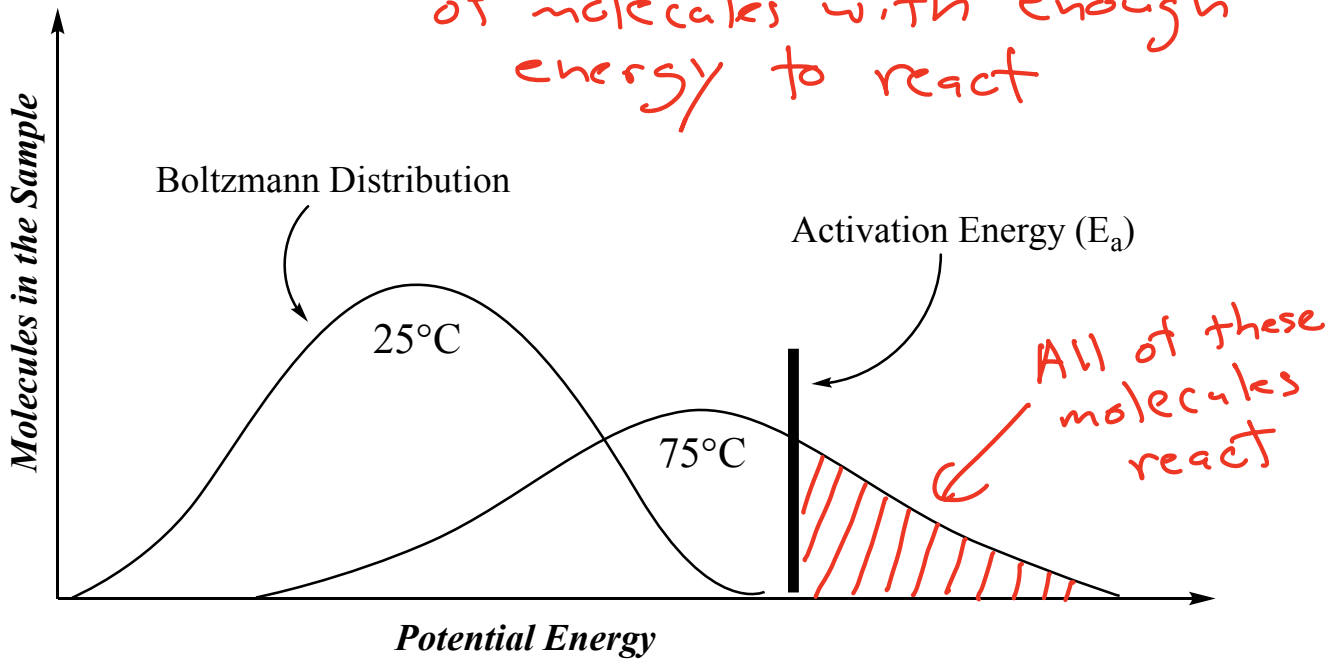
Opportunity → reasonable mechanism so that activation energy is not too high

⟹ movement of electrons

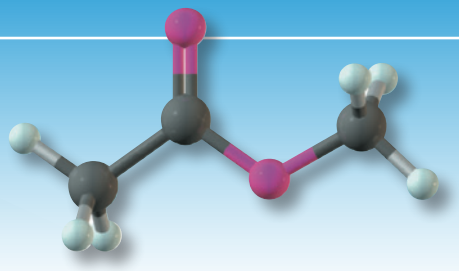


$$k = \text{reaction rate} = Ae^{-E_a/RT}$$

Increasing Temperature → increases the number of molecules with enough energy to react



Appendix 3



Bond Dissociation Enthalpies

Bond dissociation enthalpy (BDE) is defined as the amount of energy required to break a bond homolytically into two radicals in the gas phase at 25°C.

$$A—B \rightarrow A^{\cdot} + B^{\cdot} \qquad \Delta H^0 \text{ [kJ (kcal)/mol]}$$

Bond	ΔH^0	Bond	ΔH^0	Bond	ΔH^0
H—H bonds		**C—C multiple bonds**		**C—Br bonds**	
H—H	435 (104)	CH_2=CH_2	727 (174)	CH_3—Br	301 (72)
D—D	444 (106)	HC≡CH	966 (231)	C_2H_5—Br	301 (72)
				$(CH_3)_2CH$—Br	309 (74)
X—X bonds		**C—H bonds**		$(CH_3)_3C$—Br	305 (73)
F—F	159 (38)	CH_3—H	439 (105)	CH_2=$CHCH_2$—Br	247 (59)
Cl—Cl	247 (59)	C_2H_5—H	422 (101)	C_6H_5—Br	351 (84)
Br—Br	192 (46)	$(CH_3)_2CH$—H	414 (99)	$C_6H_5CH_2$—Br	263 (63)
I—I	151 (36)	$(CH_3)_3C$—H	405 (97)		
		CH_2=CH—H	464 (111)	**C—I bonds**	
H—X bonds		CH_2=$CHCH_2$—H	372 (89)	CH_3—I	242 (58)
H—F	568 (136)	C_6H_5—H	472 (113)	C_2H_5—I	238 (57)
H—Cl	431 (103)	$C_6H_5CH_2$—H	376 (90)	$(CH_3)_2CH$—I	238 (57)
H—Br	368 (88)	HC≡C—H	556 (133)	$(CH_3)_3C$—I	234 (56)
H—I	297 (71)			CH_2=$CHCH_2$—I	192 (46)
		C—F bonds		C_6H_5—I	280 (67)
O—H bonds		CH_3—F	481 (115)	$C_6H_5CH_2$—I	213 (51)
HO—H	497 (119)	C_2H_5—F	472 (113)		
CH_3O—H	439 (105)	$(CH_3)_2CH$—F	464 (111)	**C—N single bonds**	
C_6H_5O—H	376 (90)	C_6H_5—F	531 (127)	CH_3—NH_2	355 (85)
				C_6H_5—NH_2	435 (104)
O—O bonds		**C—Cl bonds**			
HO—OH	213 (51)	CH_3—Cl	351 (84)	**C—O single bonds**	
CH_3O—OCH_3	159 (38)	C_2H_5—Cl	355 (85)	CH_3—OH	385 (92)
$(CH_3)_3CO$—$OC(CH_3)_3$	159 (38)	$(CH_3)_2CH$—Cl	355 (85)	C_6H_5—OH	468 (112)
		$(CH_3)_3C$—Cl	355 (85)		
C—C single bonds		CH_2=$CHCH_2$—Cl	288 (69)		
CH_3—CH_3	378 (90)	C_6H_5—Cl	405 (97)		
C_2H_5—CH_3	372 (89)	$C_6H_5CH_2$—Cl	309 (74)		
CH_2=CH—CH_3	422 (101)				
CH_2=$CHCH_2$—CH_3	322 (77)				
C_6H_5—CH_3	435 (104)				
$C_6H_5CH_2$—CH_3	326 (78)				

<u>Organic Chemistry</u> is the study of carbon-containing molecules.

This class has two points.

The first point of the class is to understand the organic chemistry of living systems. We will teach you how to think about and understand the most amazing things on the planet!!

Water is essential for life, you will learn why water has such special properties. 8/27/25

You will learn the secret structural reason proteins, the most important molecular machines in our bodies, can support the chemistry of life. 9/10/25

You will learn why when you take Advil for pain, exactly half of what you take works, and the other half does nothing. 9/24/25

You will learn how toothpaste works. 10/6/25

You will learn how a single chlorofluorocarbon refrigerant molecule released into the atmosphere can destroy many, many ozone molecules, leading to an enlargement of the ozone hole.

You will learn how medicines like Benadryl, Seldane, and Lipitor work.

You will learn how Naloxone is an antidote for an opioid overdose.

You will learn why Magic Johnson is still alive, decades after contracting HIV.

You will learn how MRI scans work.

The second point of organic chemistry is the synthesis of complex molecules from simpler ones by making and breaking specific bonds.

You will learn how to understand movies of reaction mechanisms like alkene hydration.

You will learn reactions that once begun, will continue reacting such that each product molecule created starts a new reaction until all the starting material is used up.

You will learn reactions that can make antifreeze from vodka.

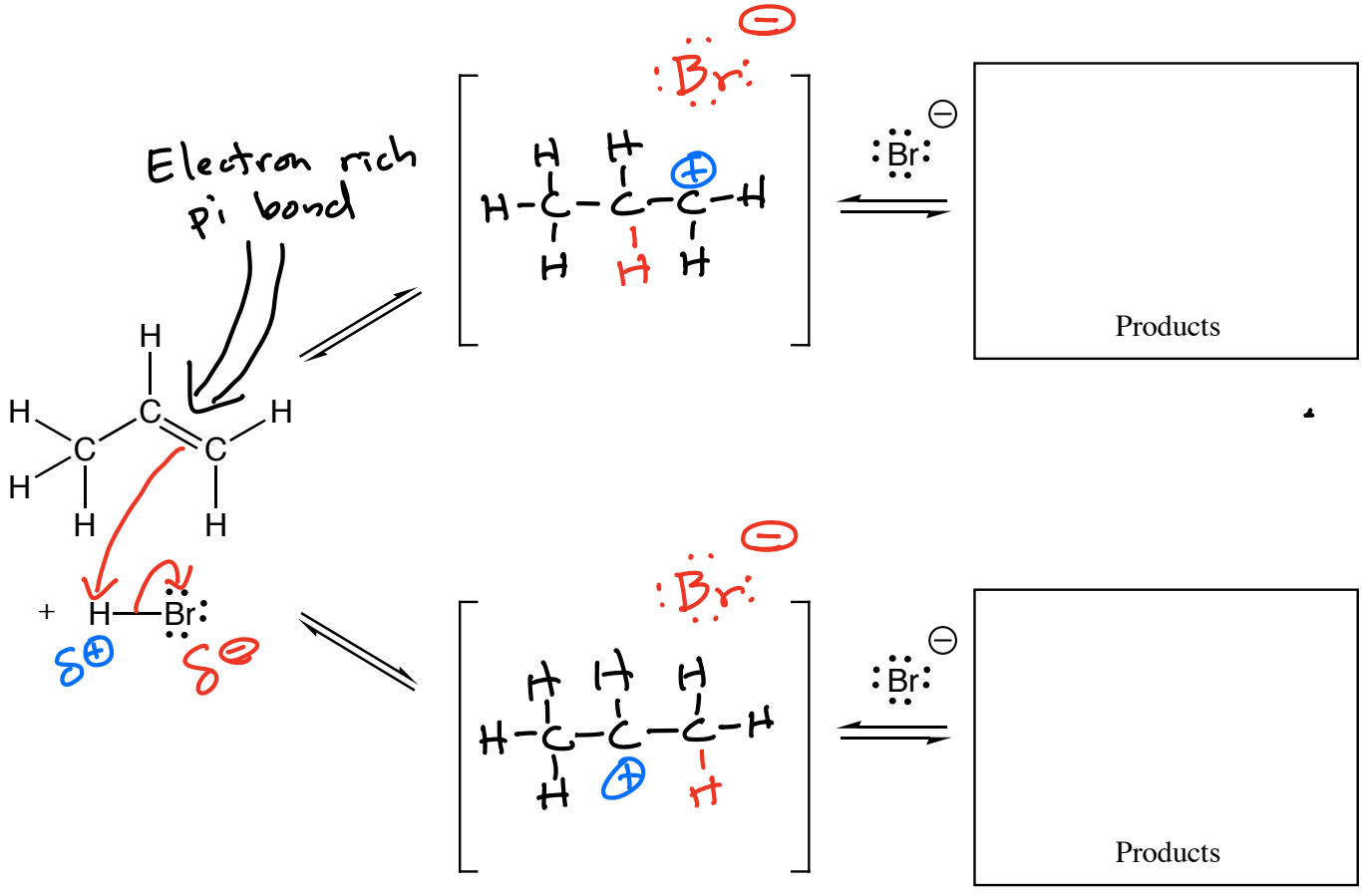
You will learn a reaction that can make nail polish remover from rubbing alcohol.

You will learn how to look at a molecule and accurately predict which atoms will react to make new bonds, and which bonds will break during reactions.

You will learn how to analyze a complex molecule's structure so that you can predict ways to make it via multiple reactions starting with less complex starting molecules.

Addition of H-X to an Alkene

Cl, Br, I (not F)

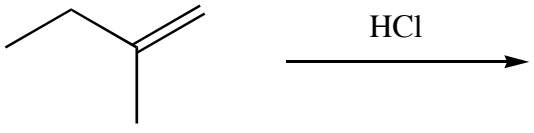


Summary:

Regiochemistry:

Stereochemistry:

Example:



Mechanisms → movement of electrons and and atoms in chemical reactions

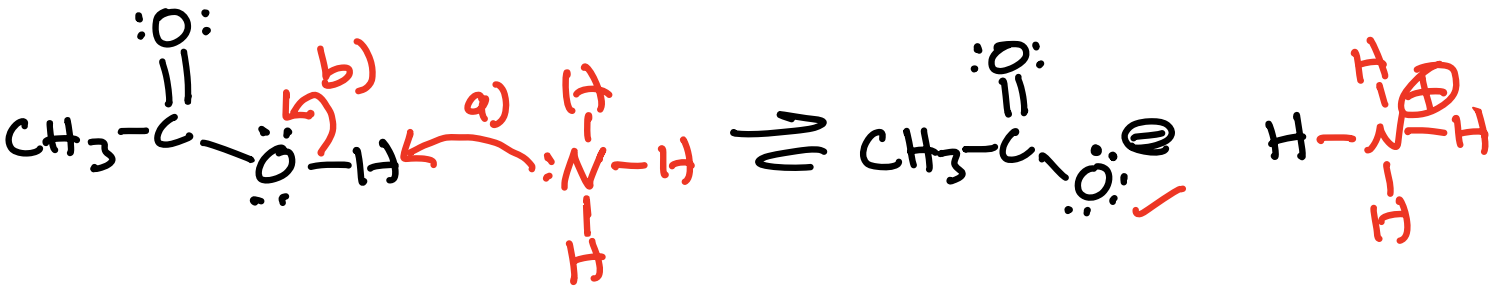
1) Arrows in reaction mechanisms move electrons.

2) Arrows in reaction mechanisms, DO NOT move atoms

3) Arrows start at an electron source → lone pair or a pi bond on an electron rich species OR a bond that must break

and end at an electron sink → an atom that can accept a new pair of electrons

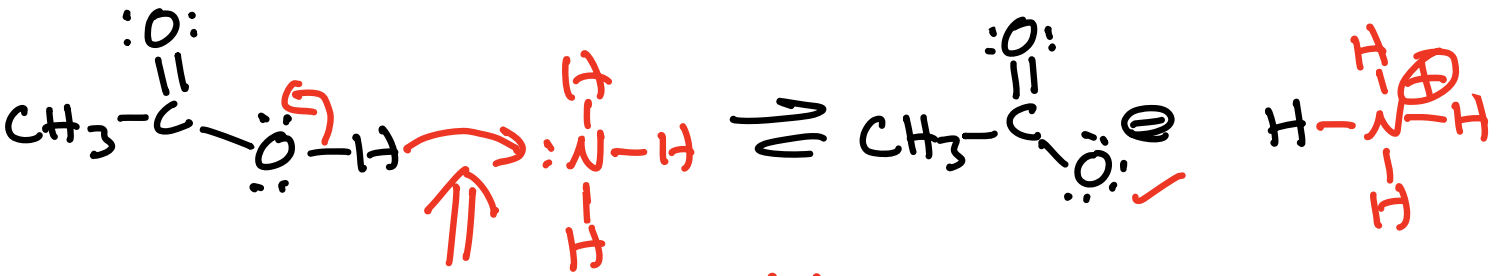
4) Breaking a bond will occur to overfilling the valence shell of an atom.



a) → lone pair on N atom makes a new bond to H

b) → OH sigma bond breaks to prevent overfilling the valence shell of H

Mistake to avoid → moving an atom with an arrow



WRONG!! → Move the electrons with an arrow not an H atom!

Nucleophile → electron rich species that has an electron rich π bond or a lone pair that takes part in a bond forming step

↓

analogous to a Lewis base

Ex.  , 

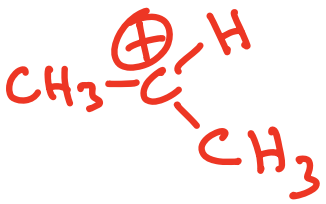
Electrophile → electron deficient species that contains an atom that serves as a sink for an arrow from an nucleophile

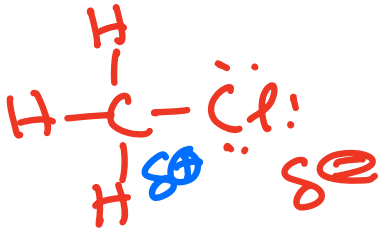
OR

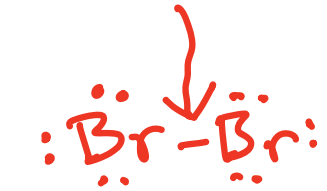
a molecule that has a weak bond

↓

analogous to a Lewis acid

Ex. Full ⊕ 

Partial ⊕ 

Weak bond 

The 4 Most Important Mechanistic Elements

The following are expressed from the point of view of the carbon-containing molecule taking part in a reaction

1) **Make a bond** between a nucleophile and electrophile.
   ⇒ A nucleophile and electrophile are both present and a bond can be made.

2) **Break a bond** to give stable molecules or ions.
   ⇒ None of the other possibilities are likely and the fragments produced are relatively stable

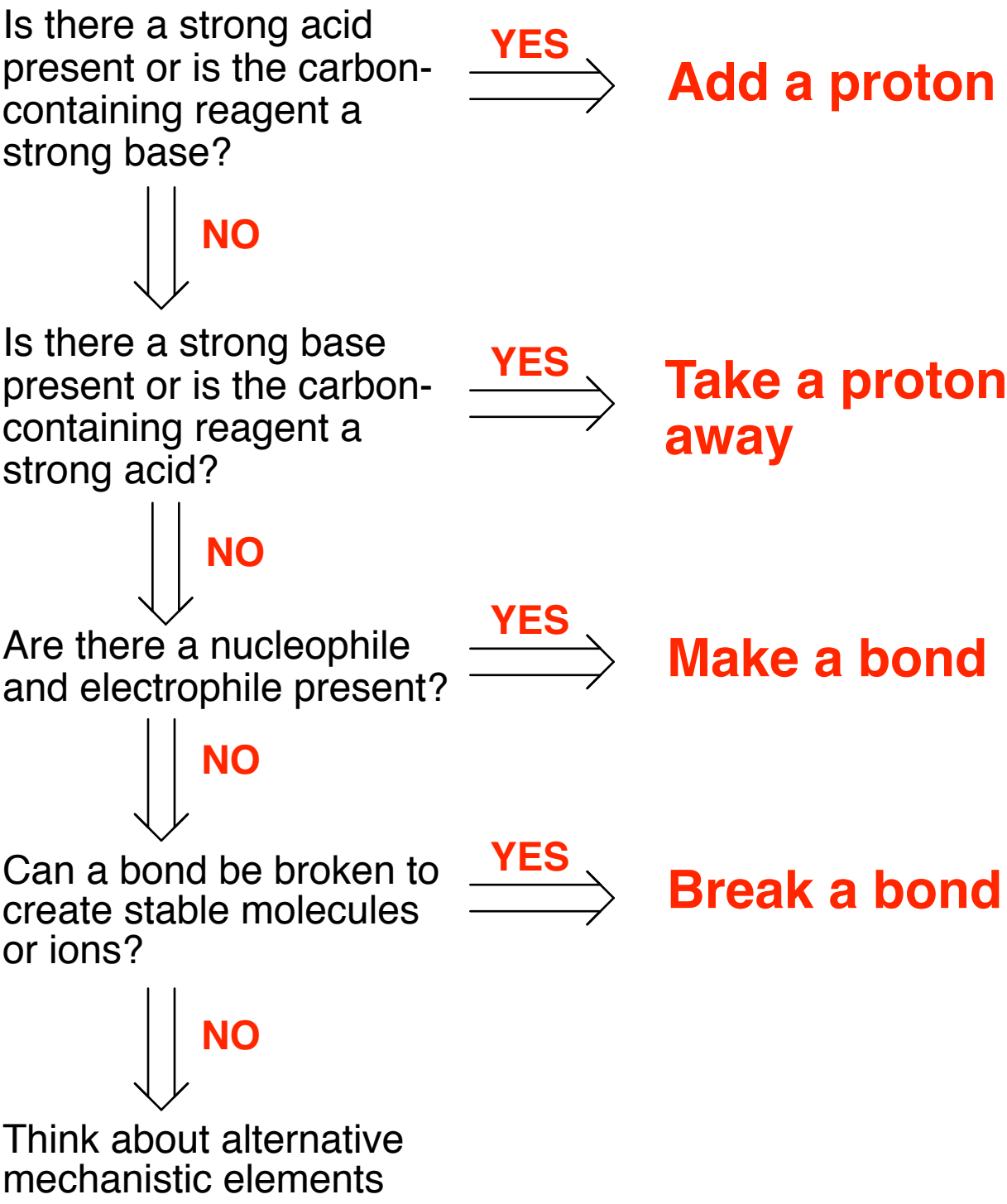
3) **Add a proton**
   ⇒ Acid is present or the molecule is a strong base.

4) **Take a proton away**
   ⇒ Base is present or the molecule is a strong acid.

Notice → 1) is the reverse of 2) and 3) is the reverse of 4) .... and vice versa

Mechanism Summary

The following questions and mechanistic elements are described from the point of view of the carbon-containing reagent, written in the form of a flowchart.



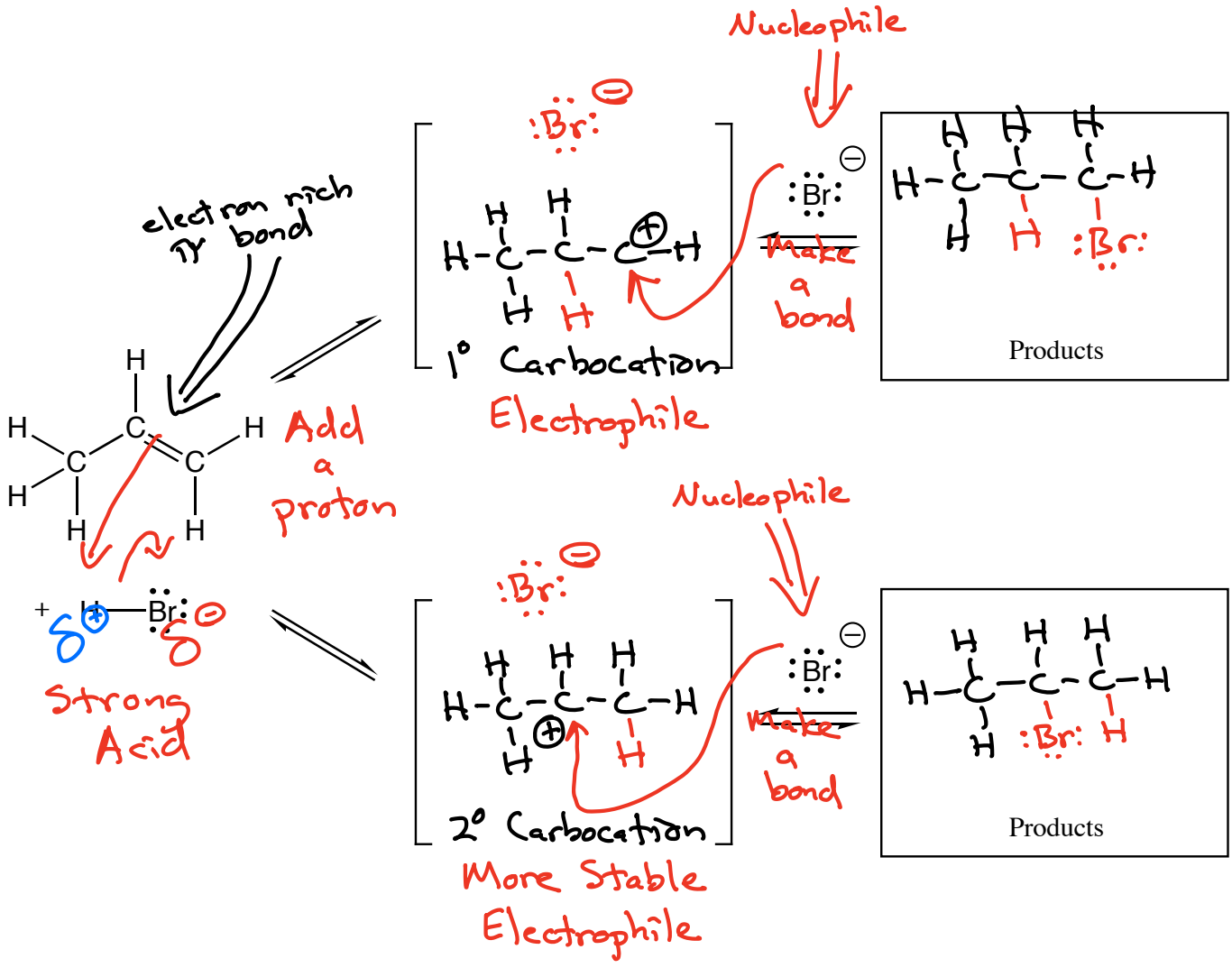


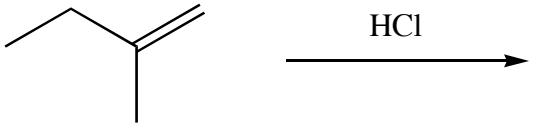


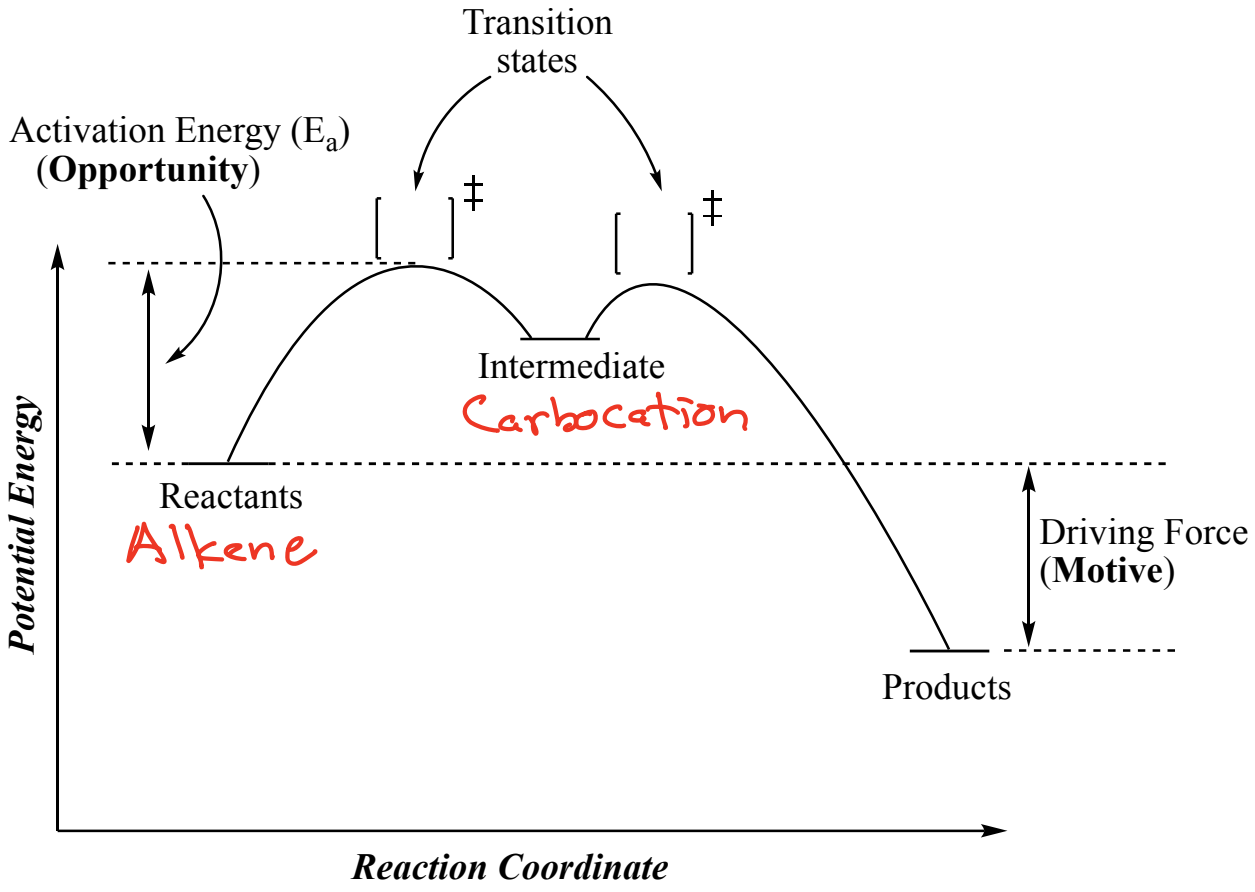


Addition of H-X to an Alkene

X = Cl, Br, I but not F



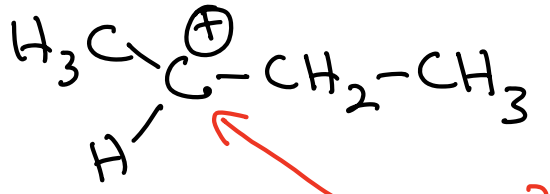
Summary:
Regiochemistry:
Stereochemistry:
Example: 



During reactions we often encounter intermediates → relatively high energy species that are formed between reactants and products

When alkenes react with H-X → carbocation intermediate

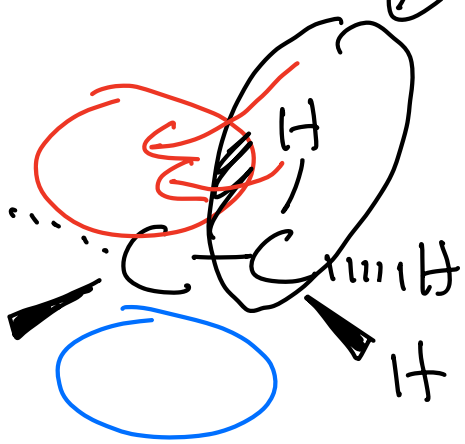
Carbocations → positive charge on a carbon atom



sp^2 hybridized with an empty 2p orbital

Alkyl groups stabilize carbocations by 2 different mechanisms

1) Hyperconjugation → overlap of adjacent σ bonding electron density with the empty 2p orbital of a carbocation



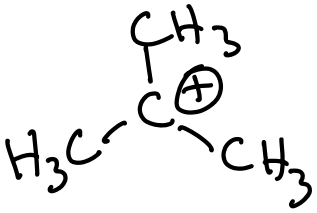
delocalizes the ⊕ charge

Some electron density of the C–H σ bond is pulled into the empty 2p orbital (red arrows in the figure)

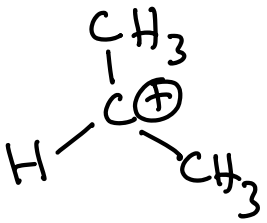
2) Inductive effect → the electron density is drawn through the σ bonds to the C⊕

↳ The C⊕ is very electronegative!

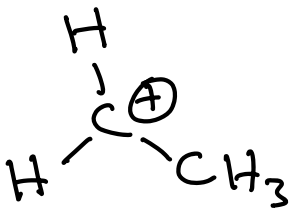
Carbocation stability → the more C atoms bonded to the C⊕ the more stable



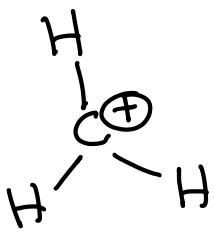
3° (tertiary)



2° (secondary)



1° (primary)



methyl

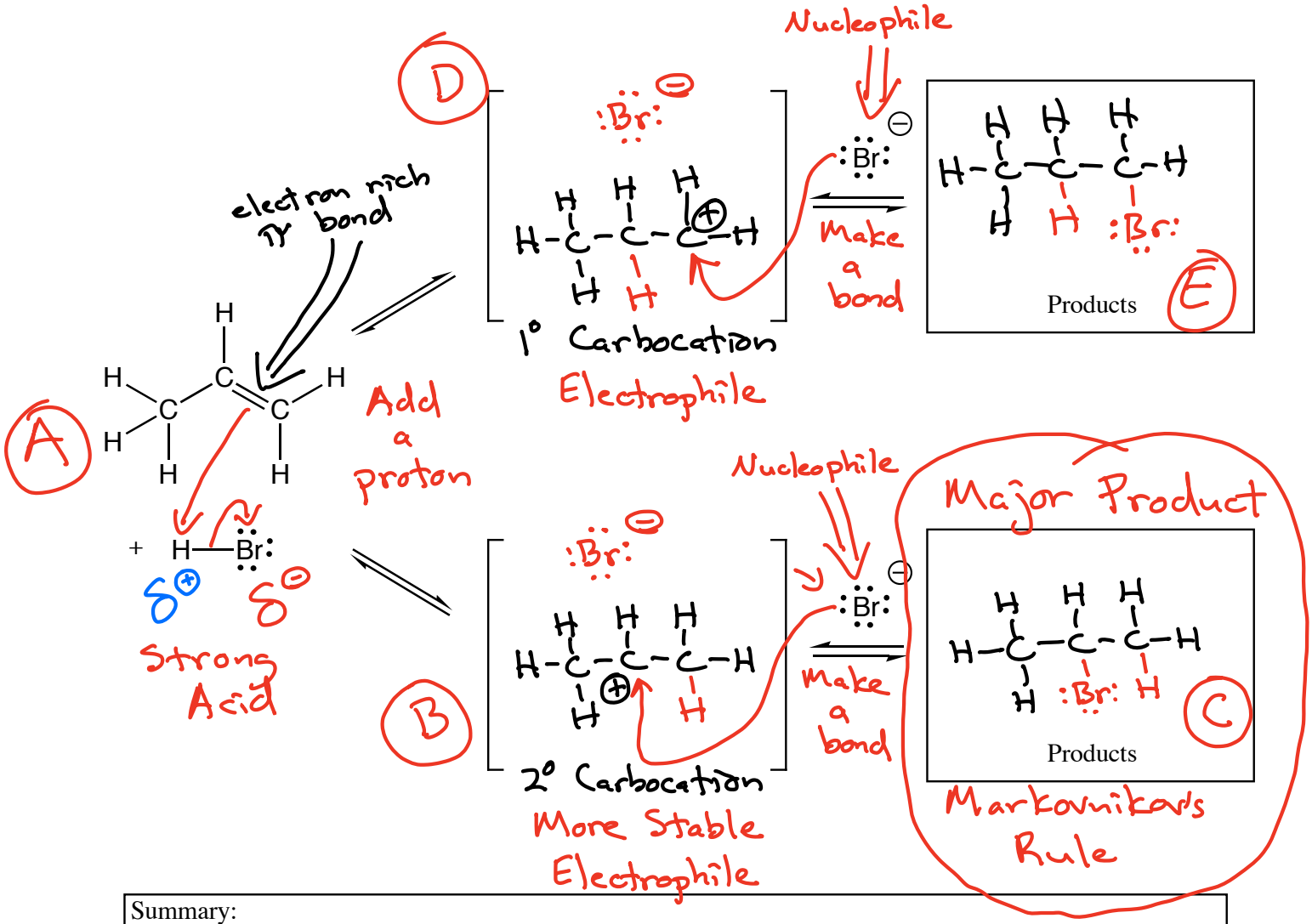
Hyperconjugation stabilization

Inductive effect stabilization

Carbocation Stability

Addition of H-X to an Alkene

X = Cl, Br, I but not F

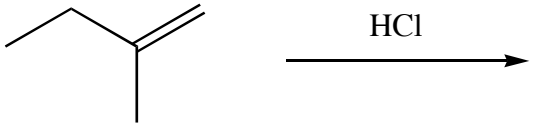


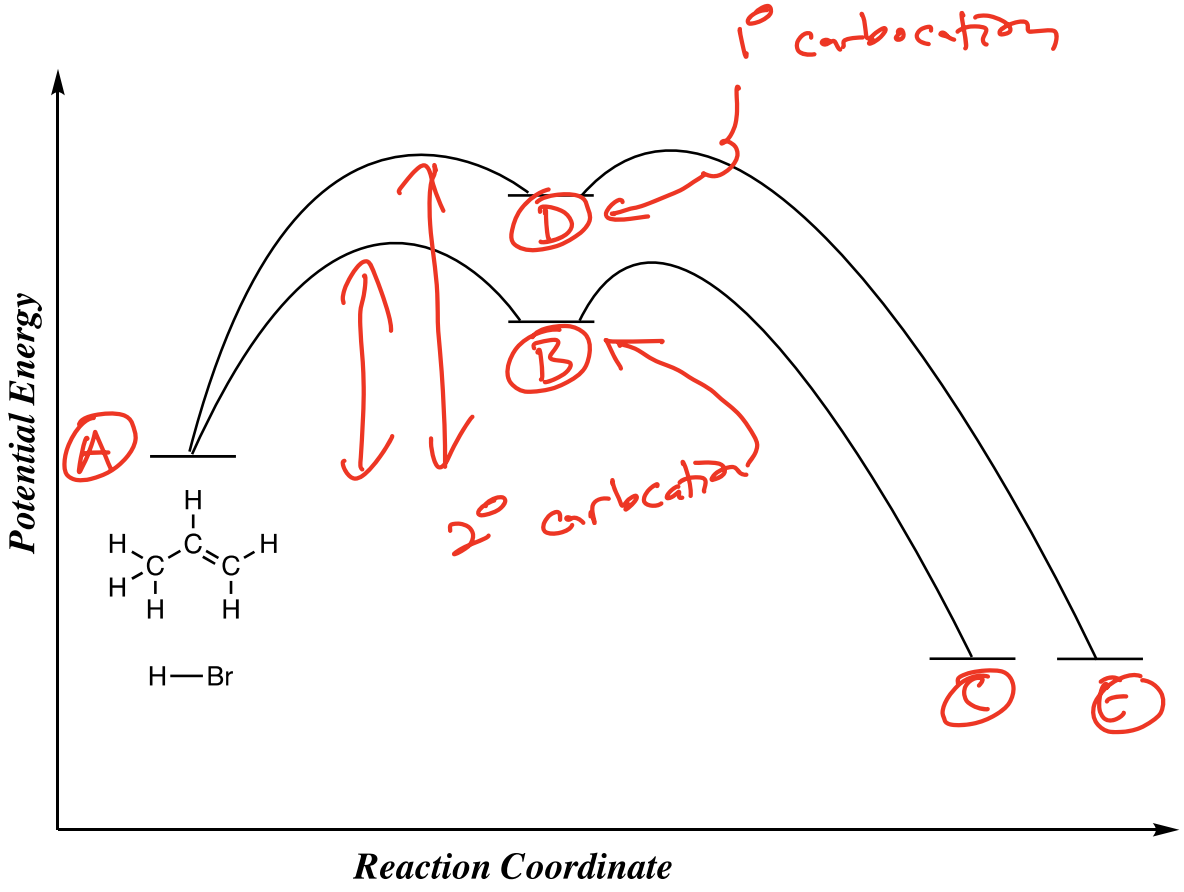
Summary:

Regiochemistry:

Stereochemistry:

Example:





Creation of (B) has a lower energy barrier and it forms faster → We get more (C) product