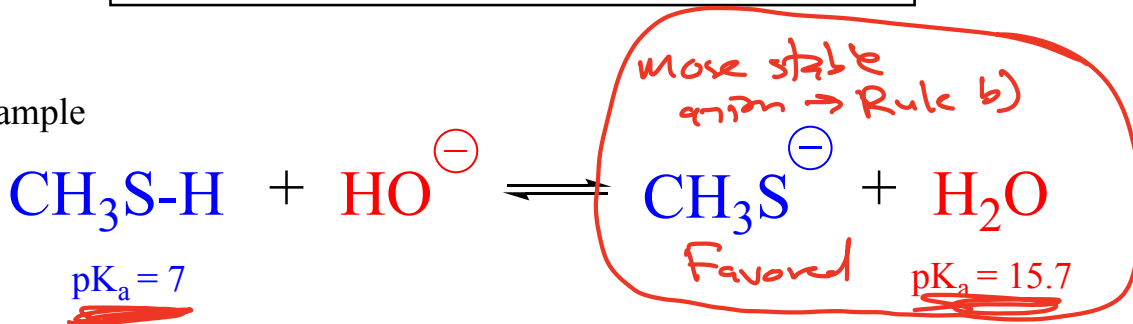


$$K_{\text{eq}} = 10^{(\text{pK}_a \text{H-B} - \text{pK}_a \text{H-A})}$$

Example



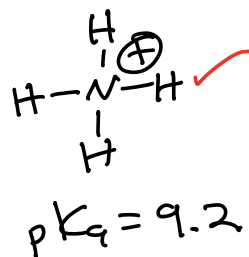
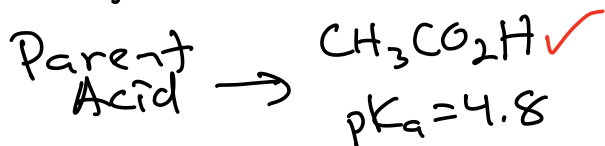
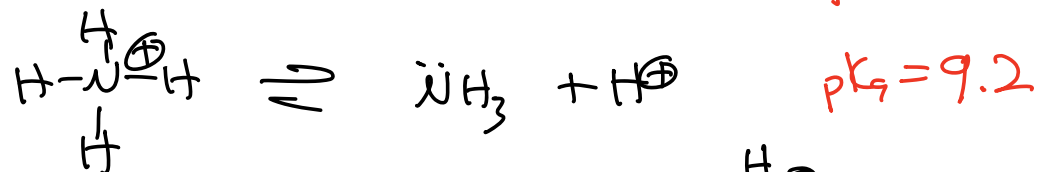
$$K_{\text{eq}} = 10^{(15.7 - 7.0)} = 10^{(8.7)}$$

New idea: How do  $pK_a$  and  $pH$  work together to determine predominant protonation states of acids?

An acid is mostly **protonated** at a  $pH$  that is **below** its  $pK_a$

An acid is mostly **deprotonated** at a  $pH$  that is **above** its  $pK_a$

Examples:



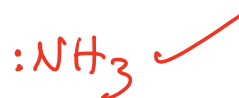
Forms Present at  $pH = 2.0$



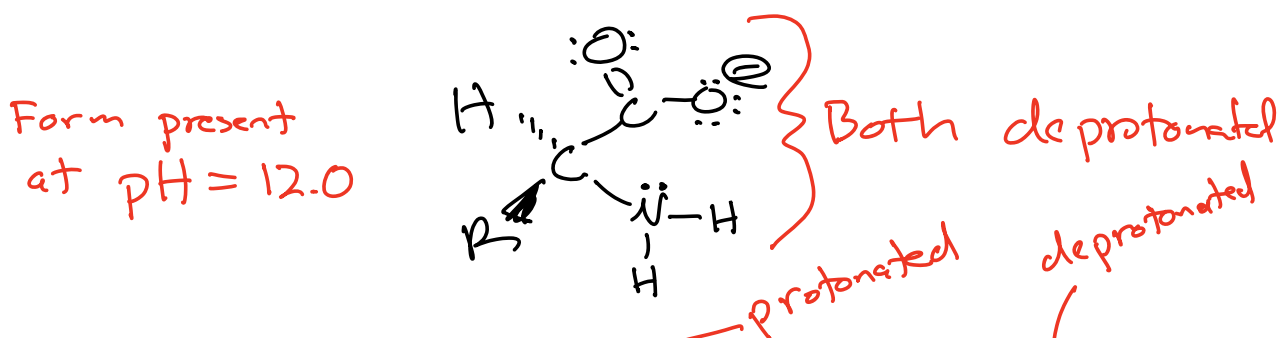
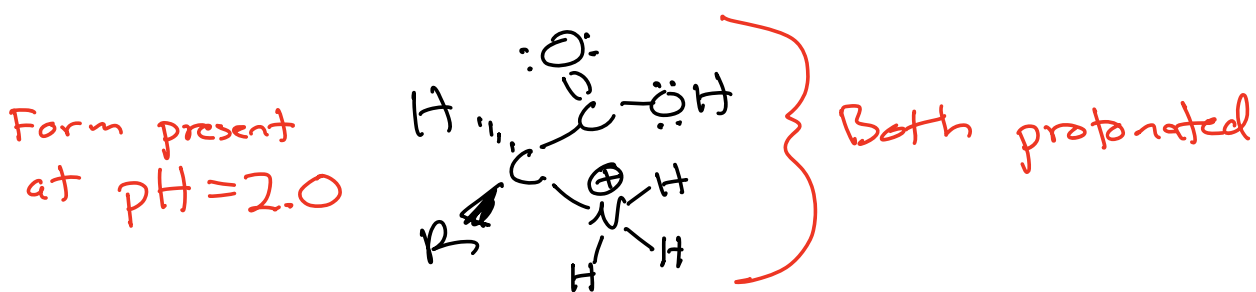
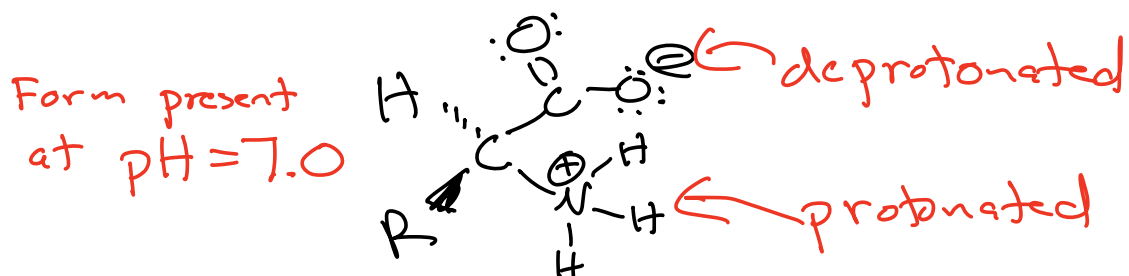
Forms Present at  $pH = 7.0$



Forms Present at  $pH = 12.0$




Application to important molecules  $\rightarrow$  amino acids  $\rightarrow$  same two groups we just saw



$\Rightarrow$  The  $-\text{CO}_2\text{H}$  and  $-\text{NH}_2$  forms are NEVER both present at any pH  $\rightarrow$  Not possible!!

Why doesn't anyone get this right?



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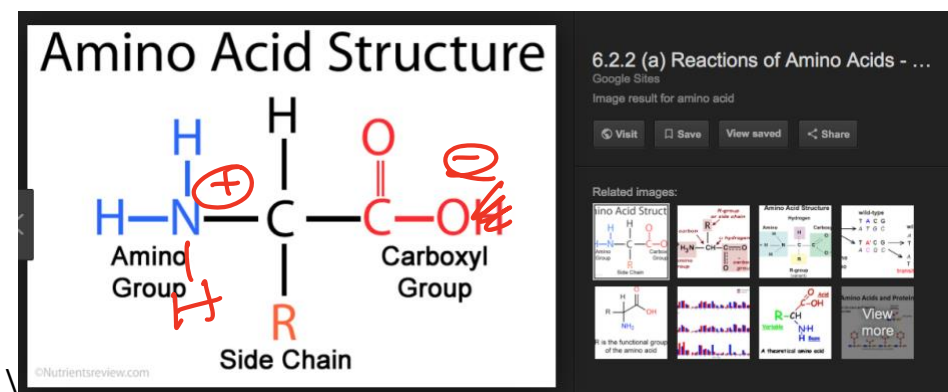
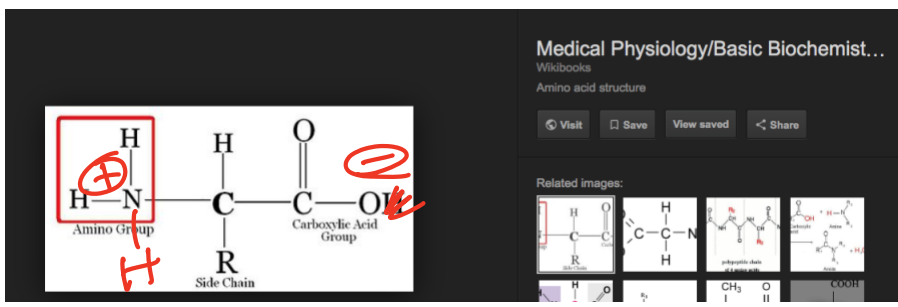
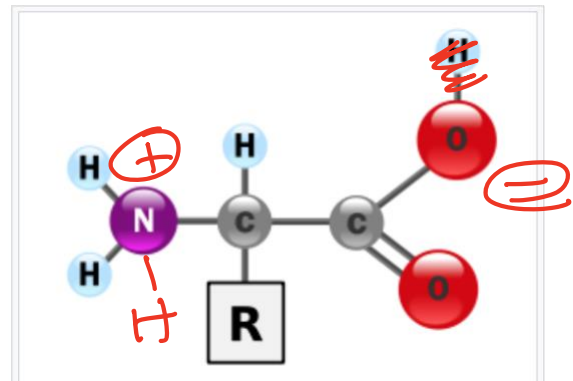
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# Amino acid

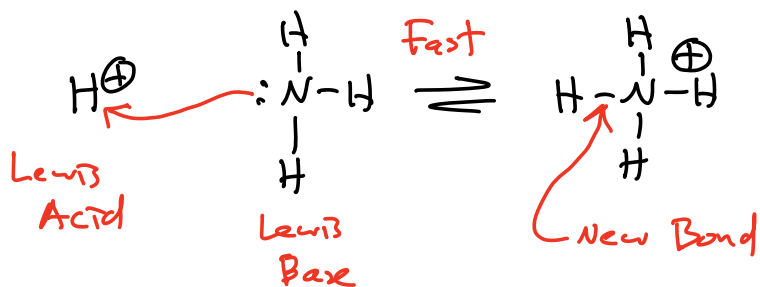
From Wikipedia, the free encyclopedia

*This article is about the class of chemicals. For the structures and properties of the standard proteinogenic amino acids, see Proteinogenic amino acid.*

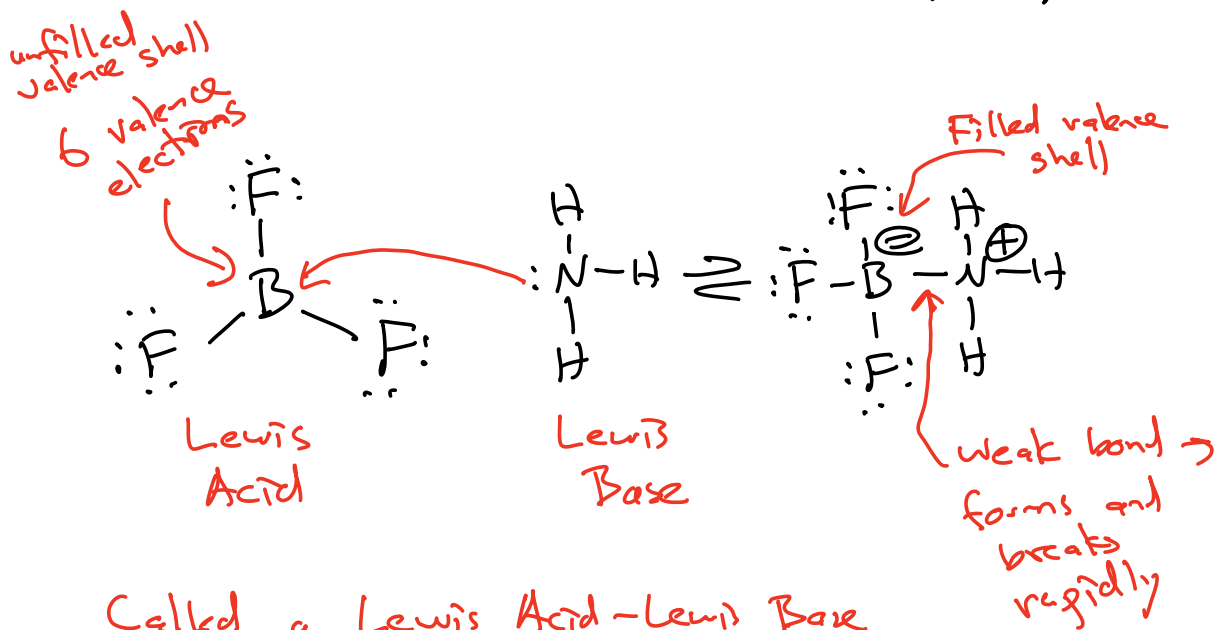
**Amino acids** are **organic compounds** containing **amine** (-NH<sub>2</sub>) and **carboxyl** (-COOH) functional groups, along with a **side chain** (R group) specific to each amino acid.<sup>[1][2][3]</sup> The key elements of an amino acid are **carbon** (C), **hydrogen** (H), **oxygen** (O), and **nitrogen** (N), although other elements are



Lewis Acid  $\rightarrow$  accepts an electron pair  
 Lewis Base  $\rightarrow$  donates an electron pair



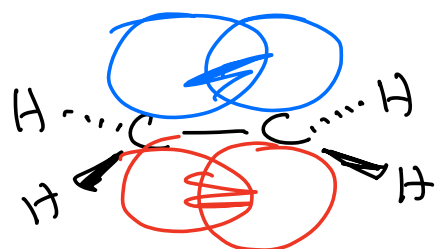
$\text{H}^{\oplus}$  can be thought of as a Lewis acid,  $\rightarrow$   
 but so can other species  $\rightarrow$  atoms with an incomplete valence shell  $\Rightarrow$  B, Al, Zn, Fe



Called a Lewis Acid-Lewis Base complex or "dative bond" or "coordinate covalent bond"



## Electronic Structure of Alkenes



$\pi$  bond  $\rightarrow$   
overlap of  
2p orbitals

## Consequences of $\pi$ bonds

1)  $\pi$  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

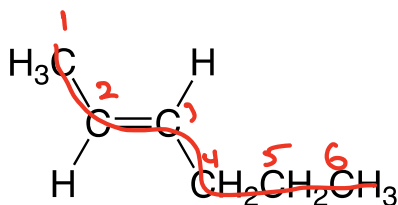
## Naming Alkenes

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.

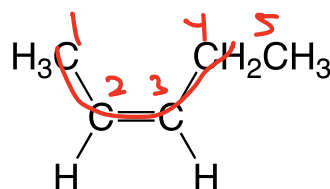
*cis/trans* nomenclature – older chemical nomenclature, but still used commonly in biochemistry – most useful when each  $sp^2$  atom of the double bond has an H atom.

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

same side



cis-2-pentene

NOT IUPAC

## Naming Alkenes

General Directions:

1. Locate longest continuous chain. ✓
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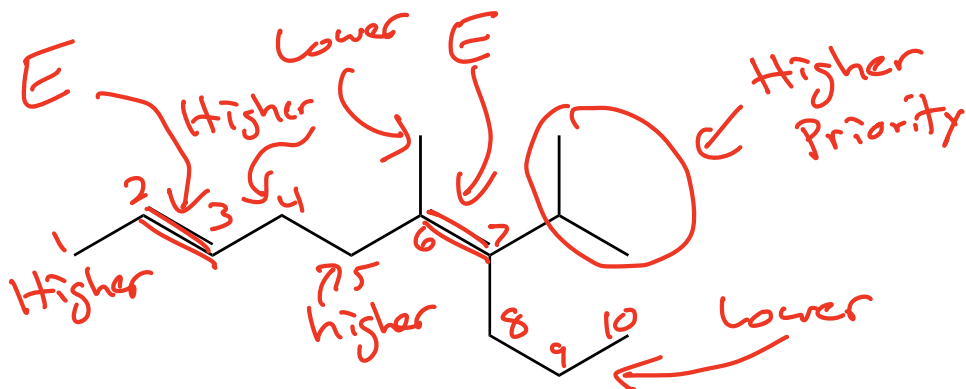
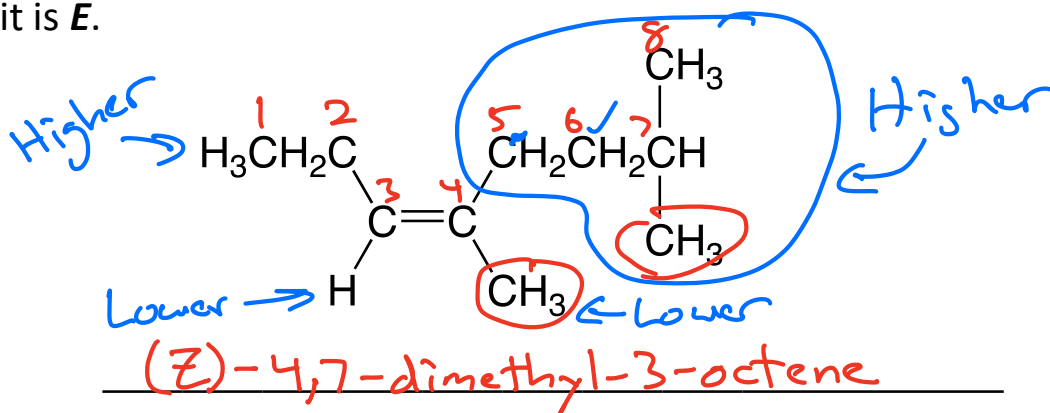
**E,Z nomenclature** - A general IUPAC nomenclature to names alkenes.



**Z** (zusammen) = same side, same side, same side

**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 same side 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**.

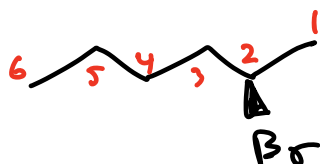
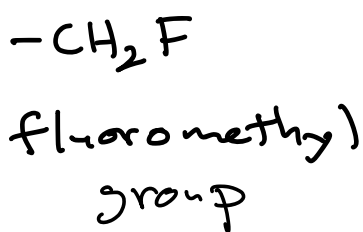
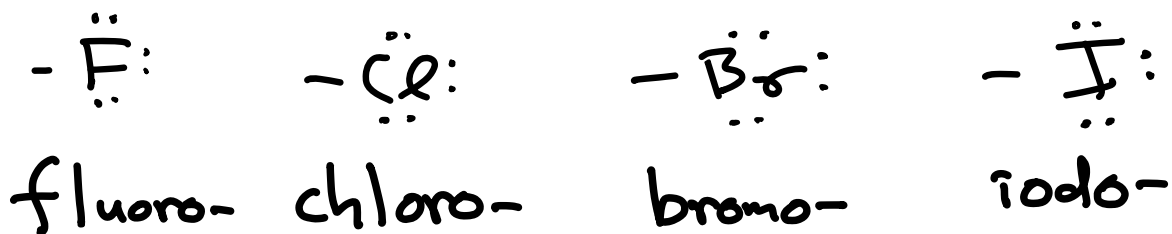


(2E,6E)-7-isopropyl-6-methyl-2,6-decadiene

or (2E,6E)-6-methyl-7-(1-methylethyl)-2,6-decadiene



Today's 1<sup>st</sup> Special Bonus Feature:  
Halogen Nomenclature

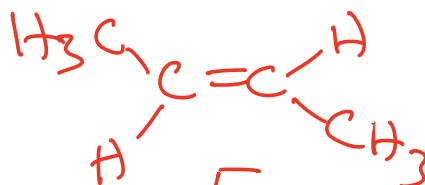
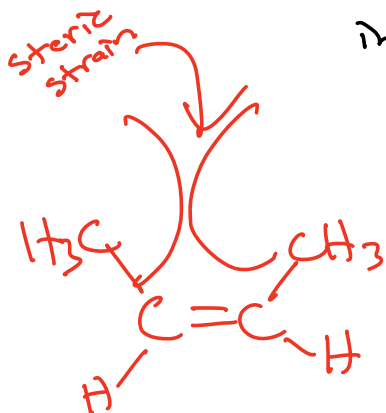


(R)-2-bromohexane

Today's 2<sup>nd</sup> Special Bonus Feature:  
Alkene Stability

Alkene stability

↳ Z (cis) groups will crash into each other causing steric strain



Z

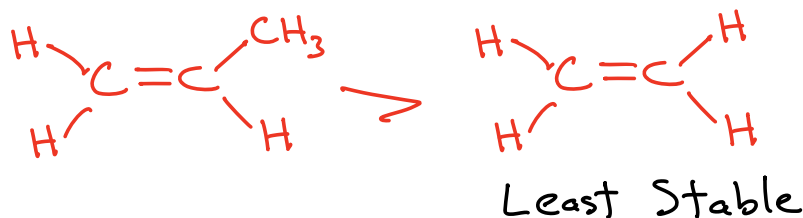
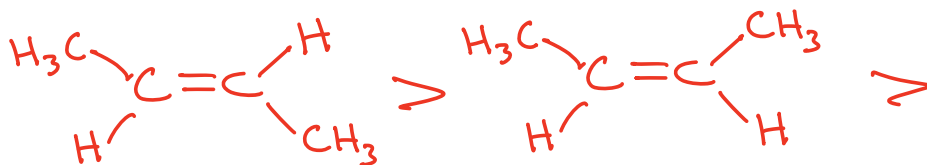
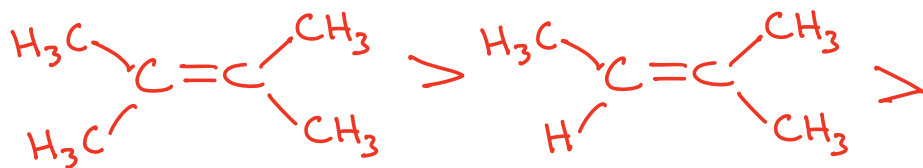
E  
No steriz strain

E alkenes are more stable than  
Z alkenes  $\Rightarrow$  due to steriz strain in Z alkenes

TIME CAPSULE  $\Rightarrow$  Zaitsev

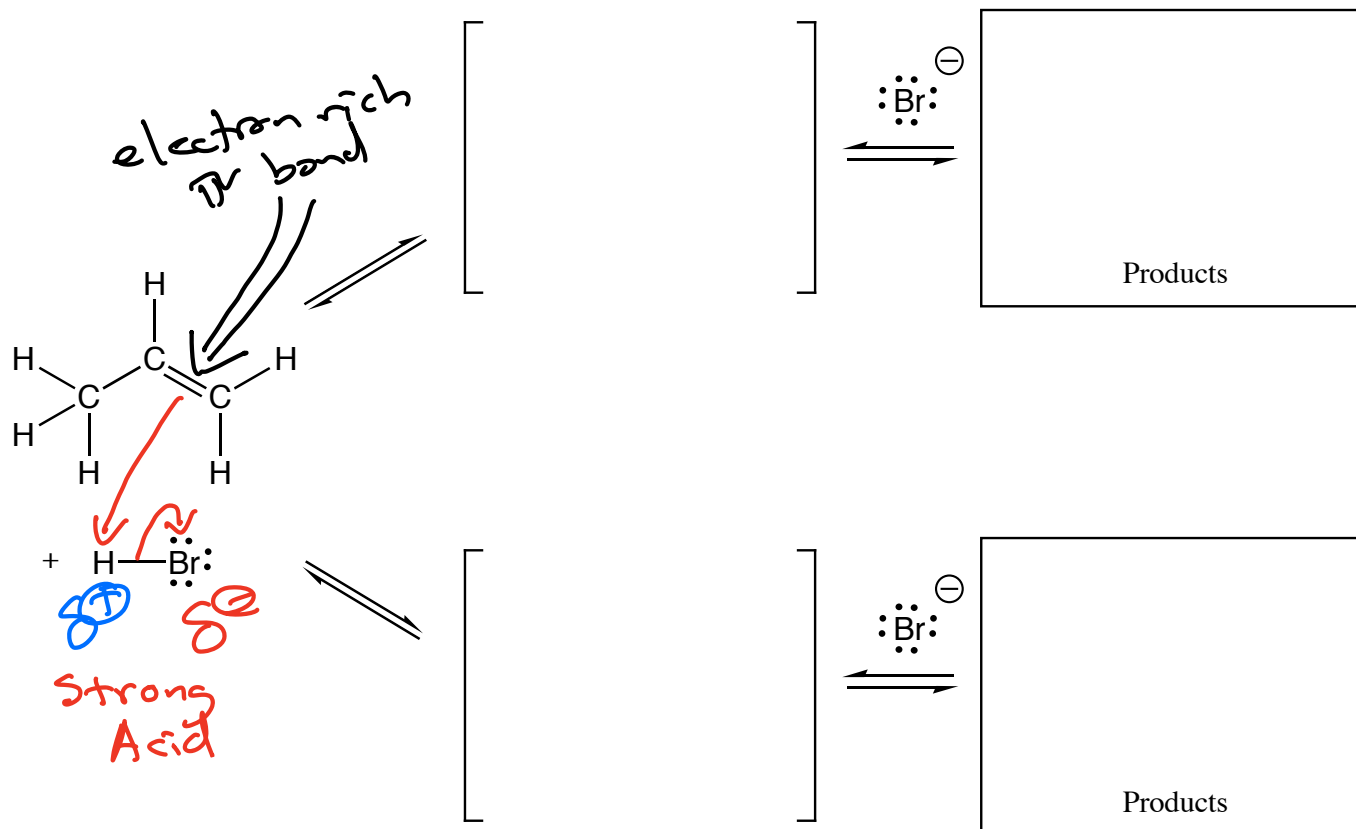
For reasons we do not explain  
MORE SUBSTITUTED ALKENES ARE  
MORE STABLE

Most Stable





## Addition of H-X to an Alkene

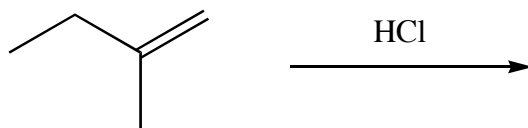


Summary:

Regiochemistry:

Stereochemistry:

Example:

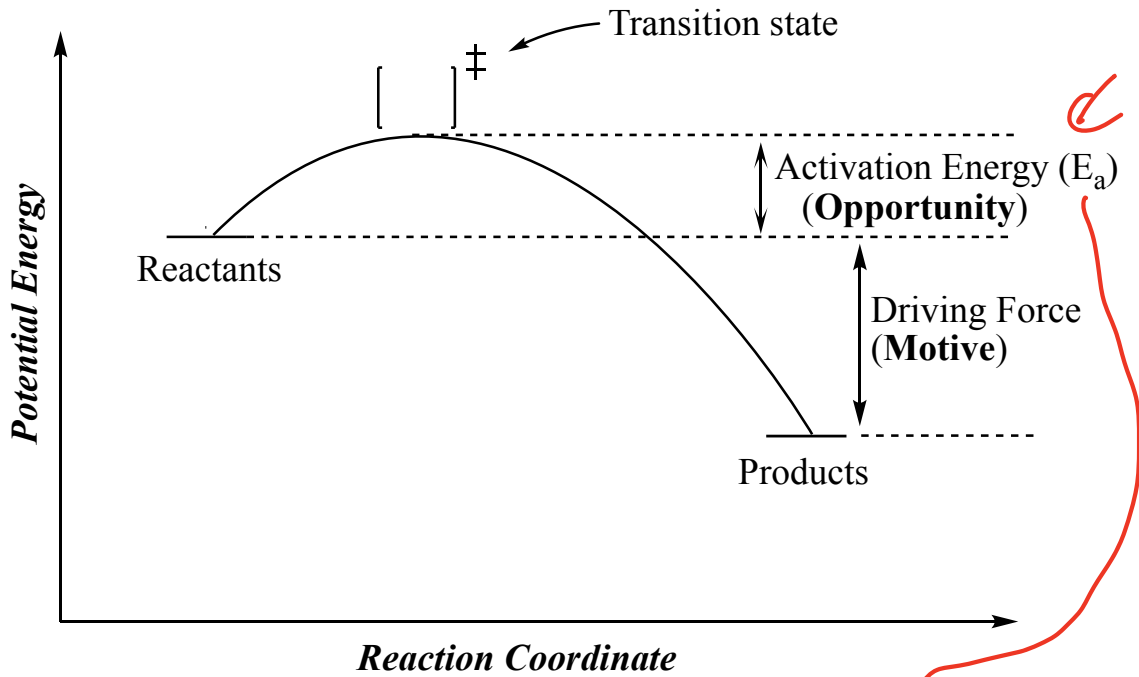


For a reaction to take place, you need both:

Motive  $\rightarrow$  thermodynamic driving force

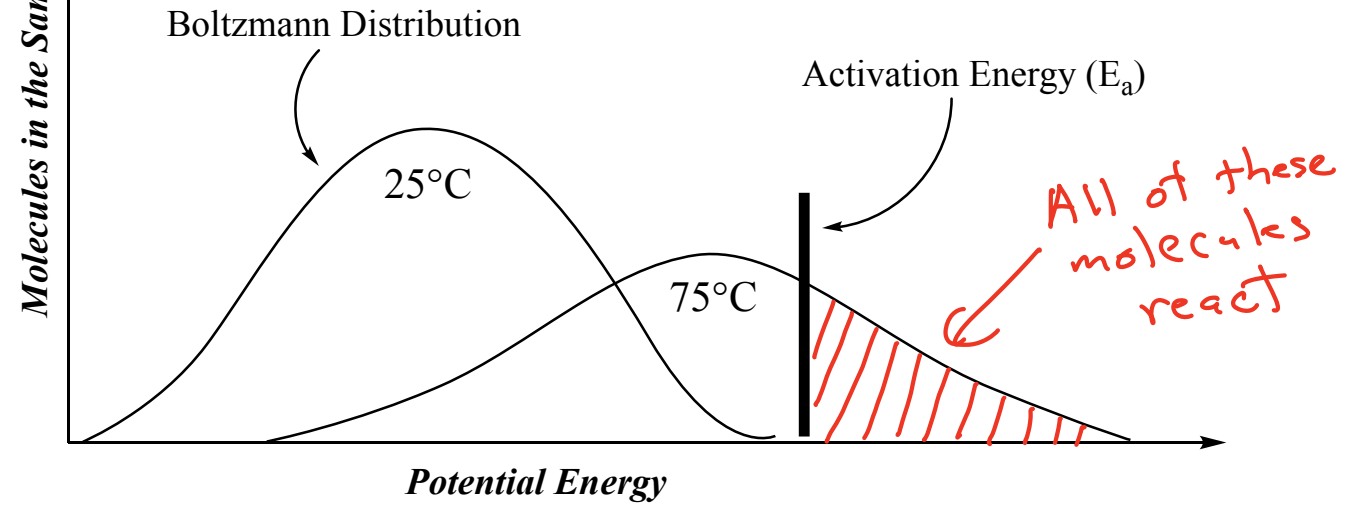
- 1) Make stronger bonds than you break
- 2) Formation of a weaker acid/base.
- 3) Entropy  $\rightarrow$  if you make a small gas molecule as a product.

Opportunity  $\rightarrow$  reasonable mechanism so that the activation energy of the reaction is not too high  
 $\Rightarrow$  movement of electrons



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

Increasing Temperature  $\rightarrow$  increases the number of molecules with enough energy to react











~~~~~