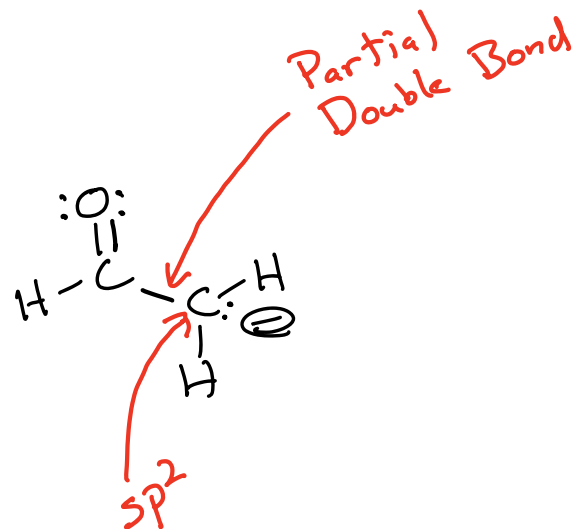
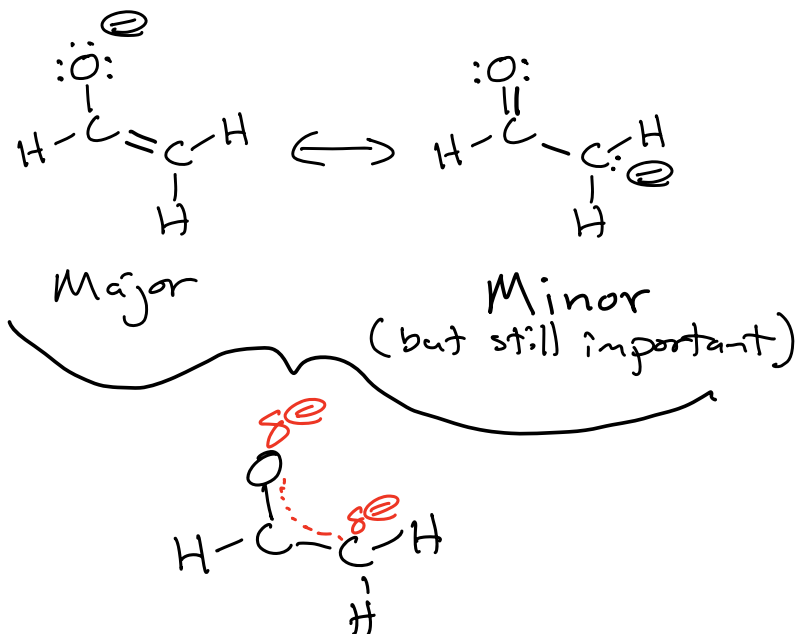






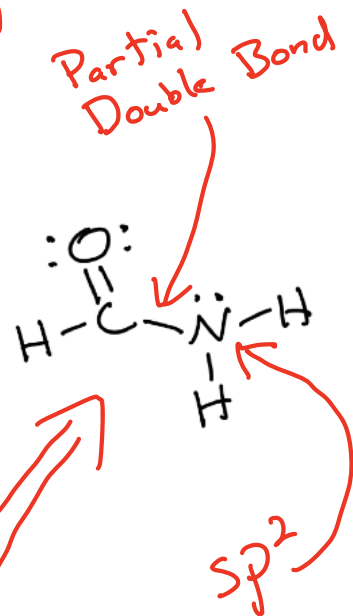
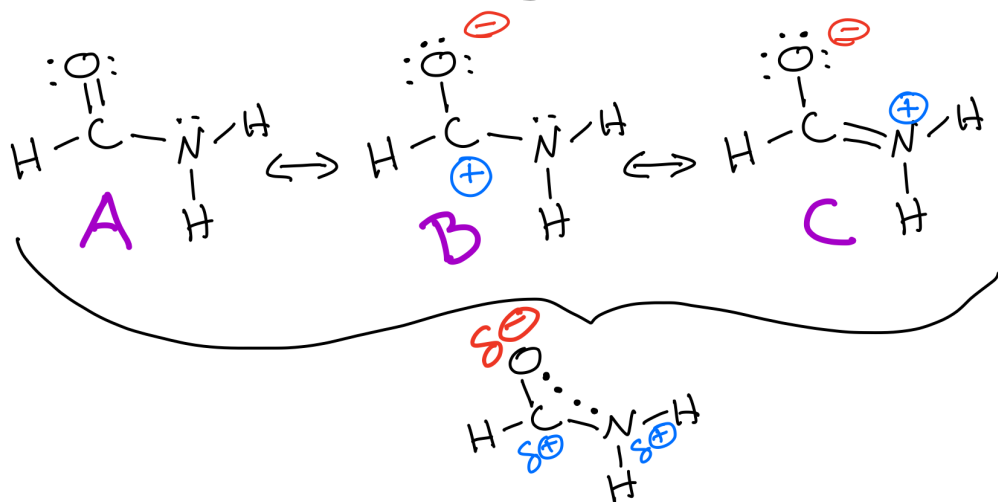


Enolate ion contributing structures



Amide contributing structures

Must consider all 3!



The partial double bond of the C-N bond does not rotate at room temperature so this adds considerable rigidity to protein chains $\rightarrow$ enables precise 3-dimensional folding and LIFE AS WE KNOW IT!!!

Look at the POTD for today!

Organic Chemistry 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. 8/26/26

You will learn the secret structural reason proteins, the most important molecular machines in our bodies, can support the chemistry of life. 9/9/26

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

You will learn how toothpaste works.

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.

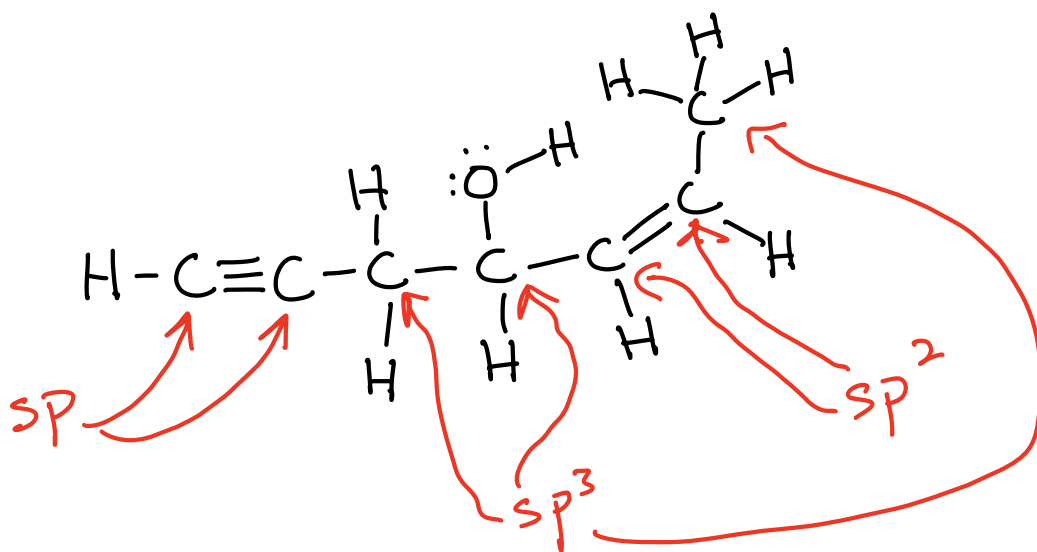
Survival skill in OChem

↳ Identify hybridization state of atoms in molecules

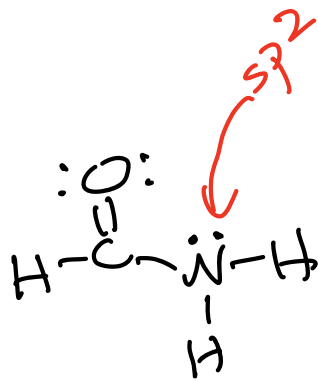
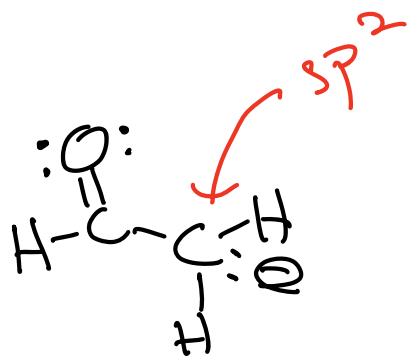
1) $sp^3 \rightarrow$ all sigma bonds and lone pairs

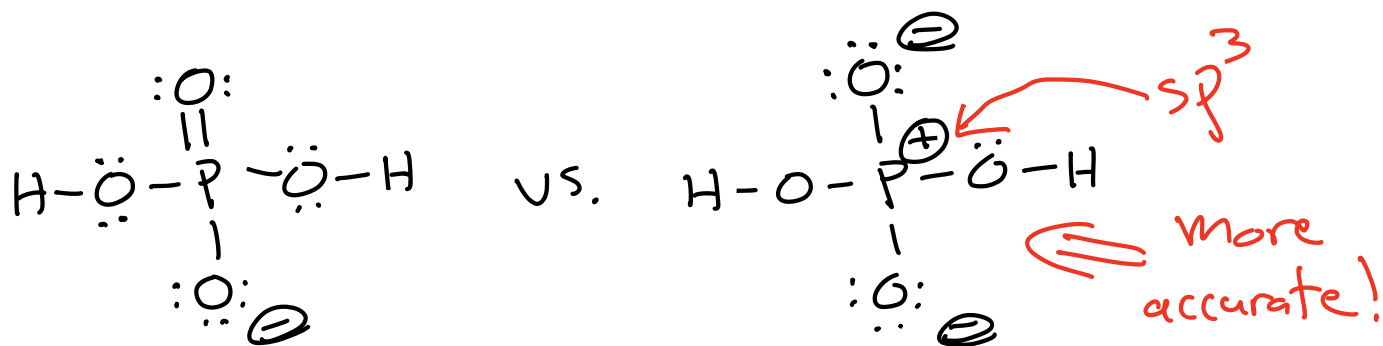
2) $sp^2 \rightarrow$ one pi bond and 3 sigma bonds/lone pairs

3) $sp \rightarrow$ two pi bonds and 2 sigma bonds/lone pairs



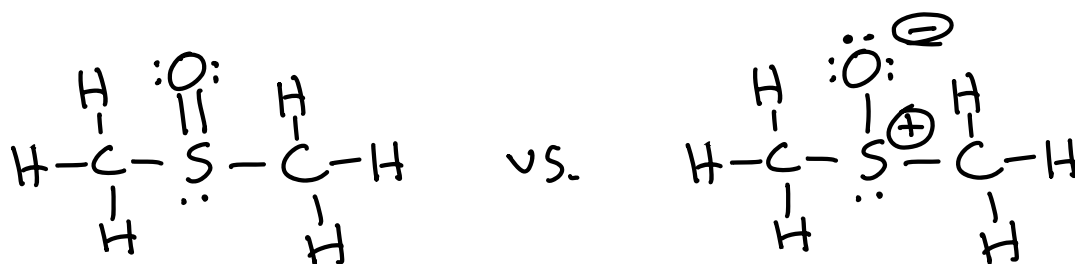
An atom counts as having a π bond if any significant contributing structure has a π bond $\Rightarrow$ part of a " π -way"





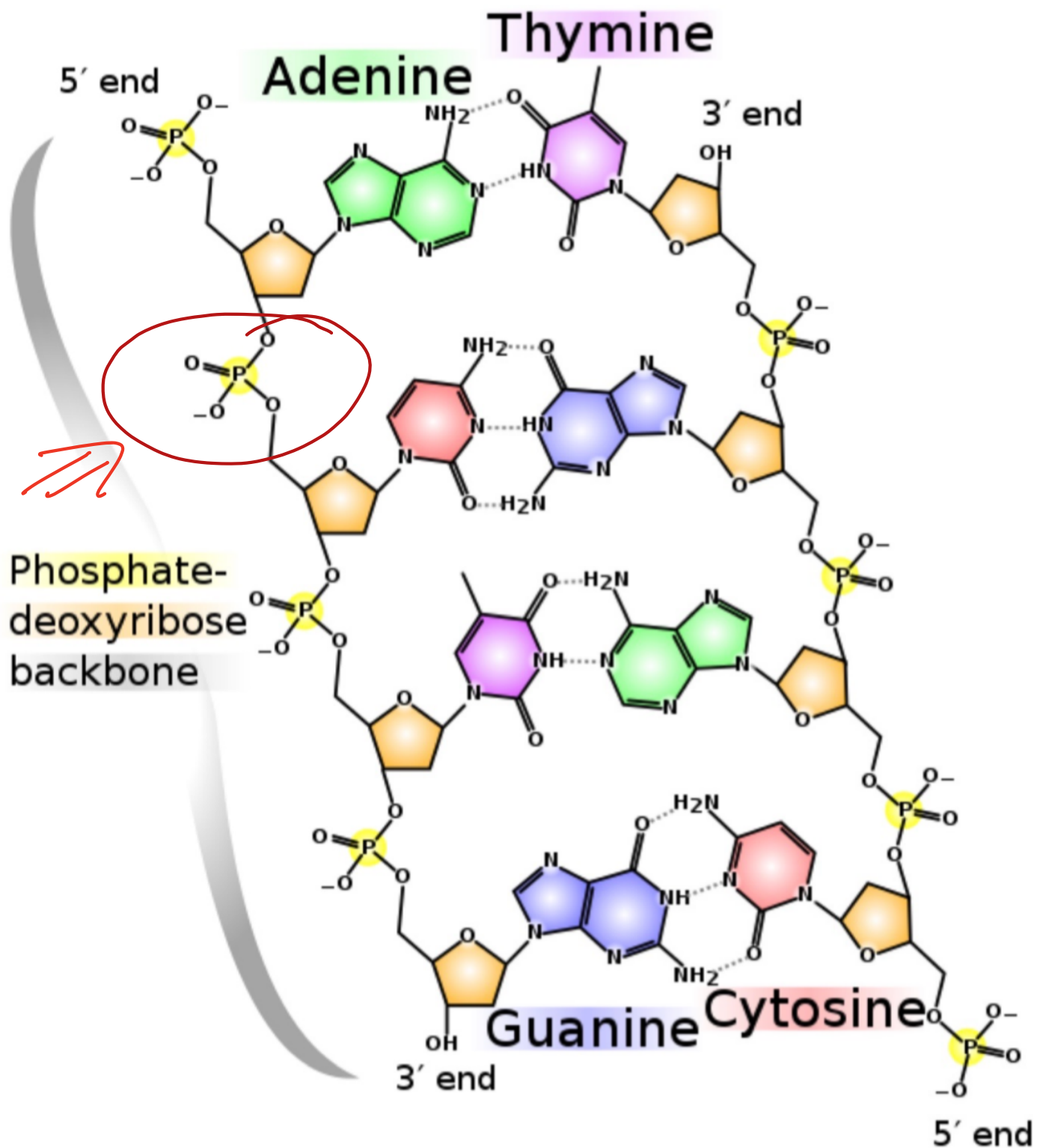
High level calculations found the d orbitals are too high in energy $\rightarrow$ not involved

However $\rightarrow$ because traditions are hard to change we still write it the "old" way even though it is not accurate!



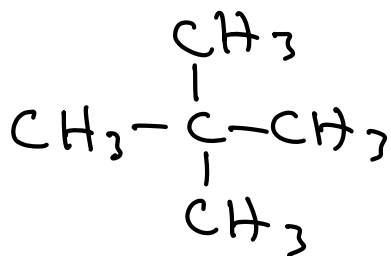
what we still draw

more accurate

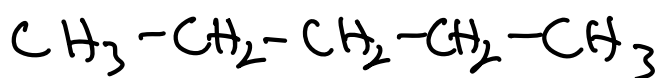
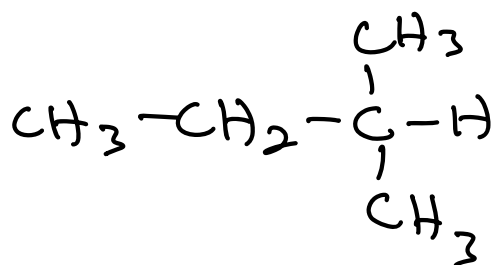


Chemical structure of DNA; hydrogen bonds shown as dotted lines





All of these
are



Constitutional isomers $\rightarrow$ same molecular formula but the atoms are connected to each other differently.

$\text{C}_4\text{H}_{10}\text{O} \rightarrow$ Constitutional Isomers



Nomenclature of molecules

2 systems → Common names → existed before systematic names

We will sometimes refer to these but you will never see them on an exam

IUPAC → systematic name process for structures

→ Molecules are named as the longest chain, with groups branching off the main

Step 1 → Memorize Tables 2.1–2.3 in the book

Add "ane" to indicate it is an alkane

Table 2.1 Names, Molecular Formulas, and Condensed Structural Formulas for the First 20 Alkanes with Unbranched Chains

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

Table 2.2 Prefixes Used in the IUPAC System to Show the Presence of 1 to 20 Carbon Atoms in an Unbranched Chain

Prefix	Number of Carbon Atoms	Prefix	Number of Carbon Atoms
meth-	1	undec-	11
eth-	2	dodec-	12
prop-	3	tridec-	13
but-	4	tetradec-	14
pent-	5	pentadec-	15
hex-	6	hexadec-	16
hept-	7	heptadec-	17
oct-	8	octadec-	18
non-	9	nonadec-	19
dec-	10	eicos-	20

Table 2.3 Names for Alkyl Groups with One to Five Carbons.
Common Names and Their Abbreviations Are Given in Parentheses

Name	Condensed Structural Formula	Name	Condensed Structural Formula
Methyl (Me)	$-\text{CH}_3$	1,1-Dimethylethyl (<i>tert</i> -butyl, <i>t</i> -Bu)	$\begin{array}{c} \text{CH}_3 \\ \\ -\text{CCH}_3 \\ \\ \text{CH}_3 \end{array}$
Ethyl (Et)	$-\text{CH}_2\text{CH}_3$		
Propyl (Pr)	$-\text{CH}_2\text{CH}_2\text{CH}_3$	Pentyl	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
1-Methylethyl (isopropyl, iPr)	$\begin{array}{c} -\text{CHCH}_3 \\ \\ \text{CH}_3 \end{array}$	3-Methylbutyl (isopentyl)	$\begin{array}{c} -\text{CH}_2\text{CH}_2\text{CHCH}_3 \\ \\ \text{CH}_3 \end{array}$
Butyl (Bu)	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	2-Methylbutyl	$\begin{array}{c} -\text{CH}_2\text{CHCH}_2\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$
2-Methylpropyl (isobutyl, iBu)	$\begin{array}{c} -\text{CH}_2\text{CHCH}_3 \\ \\ \text{CH}_3 \end{array}$	2,2-Dimethylpropyl (neopentyl)	$\begin{array}{c} \text{CH}_3 \\ \\ -\text{CH}_2\text{CCH}_3 \\ \\ \text{CH}_3 \end{array}$
1-Methylpropyl (<i>sec</i> -butyl, <i>s</i> -Bu)	$\begin{array}{c} -\text{CHCH}_2\text{CH}_3 \\ \\ \text{CH}_3 \end{array}$		

Step 2 $\rightarrow$ Identify the parent chain then number it.

longest continuous chain of C atoms

$\rightarrow$ Number the chain so that the first group (substituent) has the lower number *

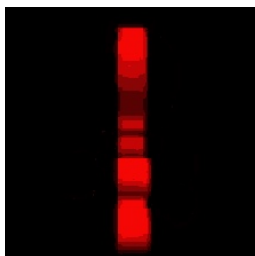
* if there is a "tie" on numbers use the lower number for the substituent that comes first in the alphabet

Step 3 → Name the substituents →
changing "ane" to "yl"
see Table 2.3

You can always use the common
names in Table 2.3

Ex. isopropyl or 1-methylethyl
are both OK

Step 4 → Alphabetize substituents and
list in alphabetical order

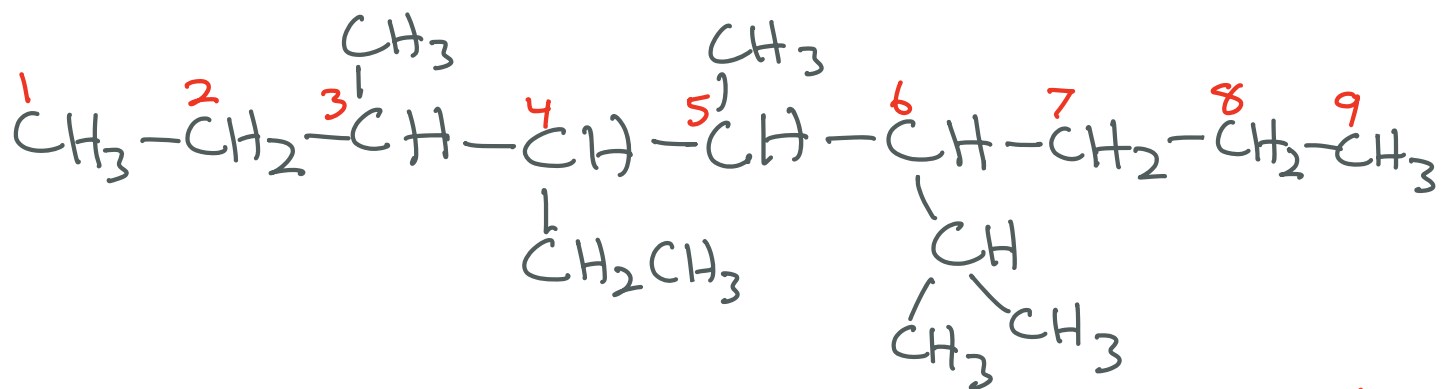


When more than one of the
same substituent is present
we use "di-, tri-, tetra-, penta-" to
indicate exactly how many

Do NOT consider di, tri,
tetra, etc. when alphabetizing

⇒ dimethyl counts as "M"

Putting it all together:



nonane → 9 carbons in the parent chain

dimethyl 3,5

ethyl 4

isopropyl 6

4-ethyl-6-isopropyl-3,5-dimethylnonane
or

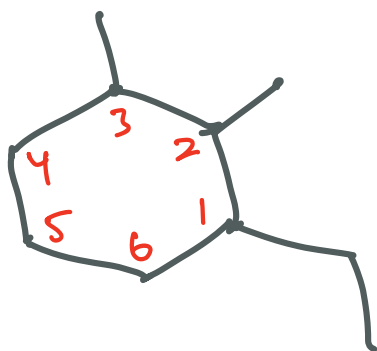
4-ethyl-3,5-dimethyl-6-(1-methylethyl)nonane

Cyclic Structures

Number the ring to give the lowest overall numbers (1,2,3 not 4,5,6).

If there is a tie the first substituent by alphabet gets the lower number

When there are more atoms in the ring compared to any of the substituents $\rightarrow$ the parent chain is the ring $\rightarrow$ add "cyclo" to the parent chain name



"in a ring" "6"

cyclohexane - parent

dimethyl 2,3

ethyl 1

1-ethyl-2,3-dimethylcyclohexane

IUPAC PROCEDURE FOR NAMING ALKANES

Before you begin you must:

- 1) Memorize alkane chain names (Table 2.1)
 - 2) Memorize substituent names (Tables 2.2 and 2.3)
- [I apologize on behalf of all chemists for the crazy names you have to memorize. I wish I knew an easier way, but I do not]

**START
HERE**

Locate Longest Continuous Carbon Chain and Count Number of Carbon Atoms. Find the Alkane Name that Corresponds to the Chain (ex. heptane, dodecane, etc.) and Write this Down Leaving Room in Front of the Name for More Writing. If There are Alkane Branches Continue, if Not You are Done. Go Have a Party.

Number the Main Chain Such that the First Substituent Will Be Branching Off from the Lowest Numbered Carbon (this is not as hard as it sounds since there are only two choices on which way to number, choose the origin as being closest to the first branch point). If There are Substituents in Equivalent Positions from Either End, the Lower Number Goes to the One that Comes First in Alphabetical Order.

Does Branch have Branching ?

No Branching
On Branch
Itself

Yes, Branch Has
Branches Of Its Own

- 1) Count the Number of Carbon Atoms in The Chain
- 2) Find the Name Corresponding to that Chain Length
- 3) Change the Suffix from *ane* to *yl*. This is Name of the Branch .

- 1) Does Entire Branch Group Have a Trivial Name? (isopropyl, isobutyl, neopentyl etc.)

Yes

No

Write Number of Main Chain Carbon at Branch Point then a Dash (-) Followed by Name of Branch All Preceding Original Main Chain Name as One Word

Use Same Rules as for the Rest of Alkane: Pick Longest Continuous Chain, Name Branches Including Numbers But Use Parentheses Around Branch Name
Ex. 6-(2,3-dimethylbutyl)dodecane

ADDITIONAL RULES

1) If a Molecule Contains Two of the Same Branching Alkyl Groups Use the Prefix *di*, if Three Use *tri*, if Four Use *tetra*, if Five Use *penta*, if Six Use *hexa* etc.

Ex. 2,3,4-trimethylhexane

2) If Structure Contains a Ring That Has More Carbon Atoms Than Any Other Open Chain, the Main Chain is the Ring and is Named by Adding *cyclo* to the Name of the Alkane with the Same Number of Carbon Atoms as the Ring. The Rest is the Same as for Normal Alkane Except You Need to Keep the Total Numbers as Small as Possible When Numbering.

Ex. 1,2-dimethylcyclohexane

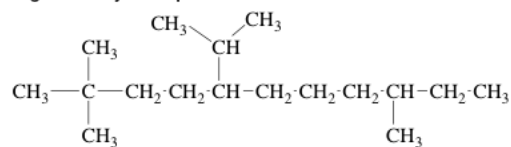
3) If More Than One Branch, List Them in Alphabetical Order, NOT Numerical Order.

Ex. 5-ethyl-3,4-diisopropyl-7-methyldecane

4) DO NOT Include the Italicized Prefixes *n*-, *sec*-, and *tert*- OR the Multiplying Prefixes *di*, *tri*, *tetra*, etc. When Alphabetizing Simple Substituents. All Other Prefixes (*iso*, *neo*, etc.) are Included When Alphabetizing Simple Substituents. No Need to Argue, I Did Not Invent These Rules!

Ex. 5-*tert*-butyl-2-methyldecane

Big Old Hairy Example:



5-Isopropyl-2,2,9-trimethylundecane

What you need to know

Important concept → Energy and stability are relative terms that are related to each other → "relative" because they need comparisons to make sense

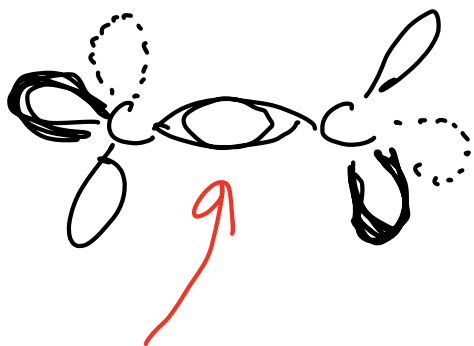
A molecule with higher energy is less stable

A molecule with lower energy is more stable

Strain → in molecules raises energy and decreases stability

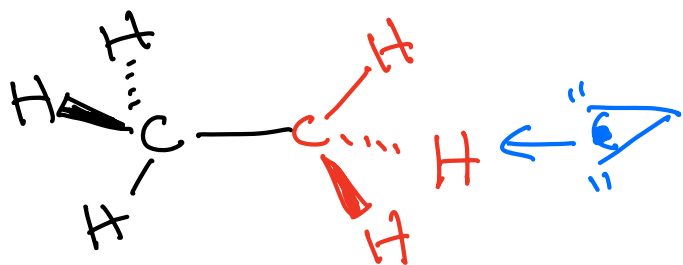
⇒ Molecules are found predominantly in their lowest energy (most stable) form.

Carbon-Carbon sigma bonds rotate rapidly at room temperature

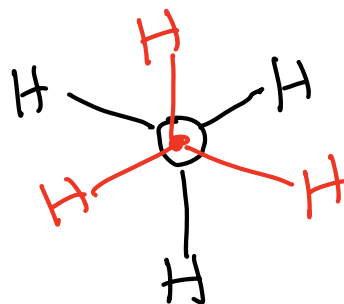


σ (cylindrical)
bond can rotate

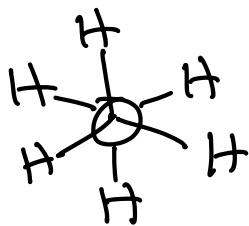
It does not set weaker as it rotates



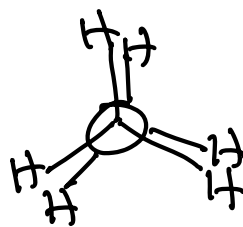
Newman Projection



Two extremes



More stable



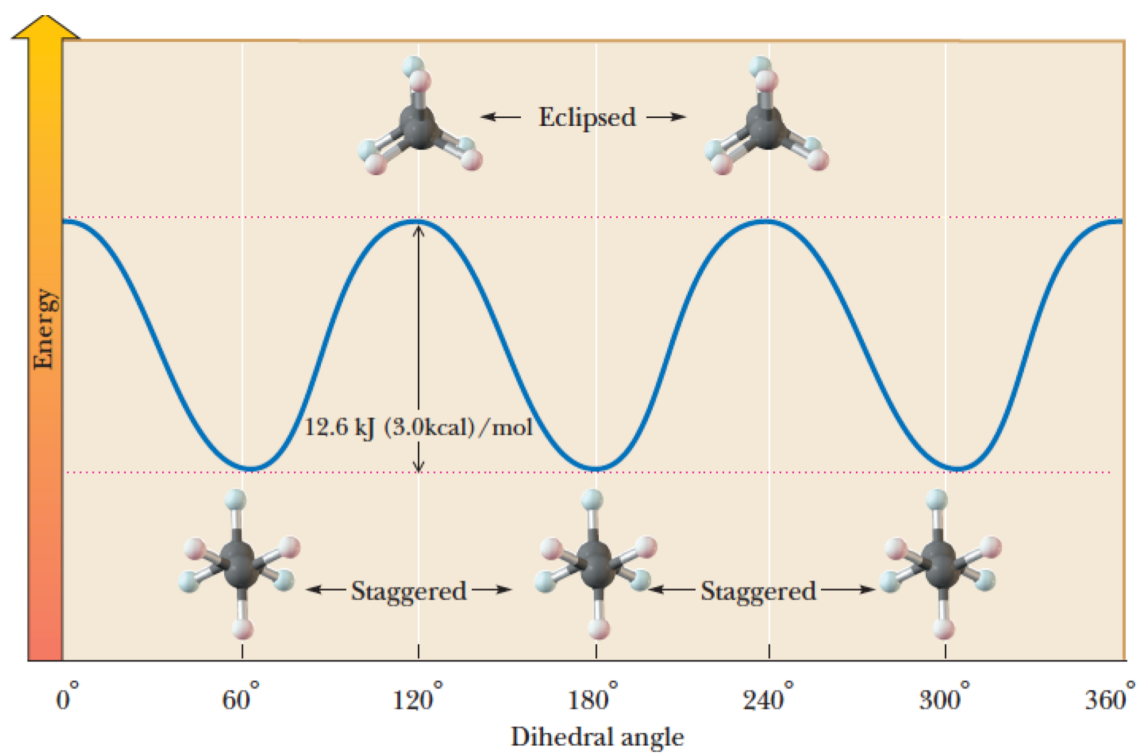
Less Stable

Torsional Strain $\rightarrow$ a complex effect based on

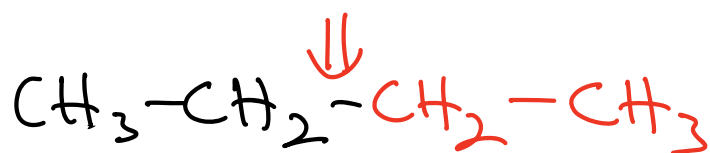
TIME
CAPSULE

$\Downarrow$
we will discuss
in Chpt. 6

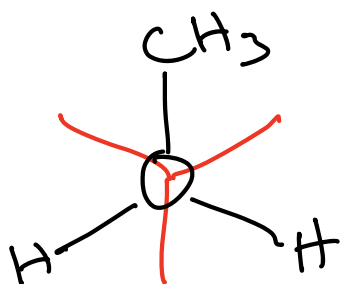
that introduces
strain unless the H
atoms are in the
staggered geometry



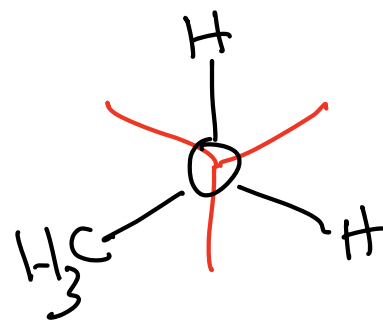
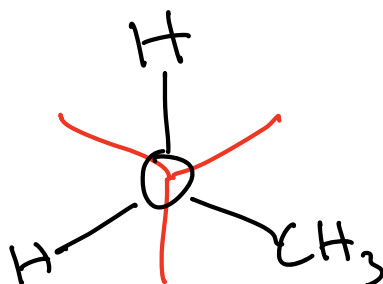
Butane $\rightarrow$ 3 different staggered conformations



Looking down
the central
 C-C bond

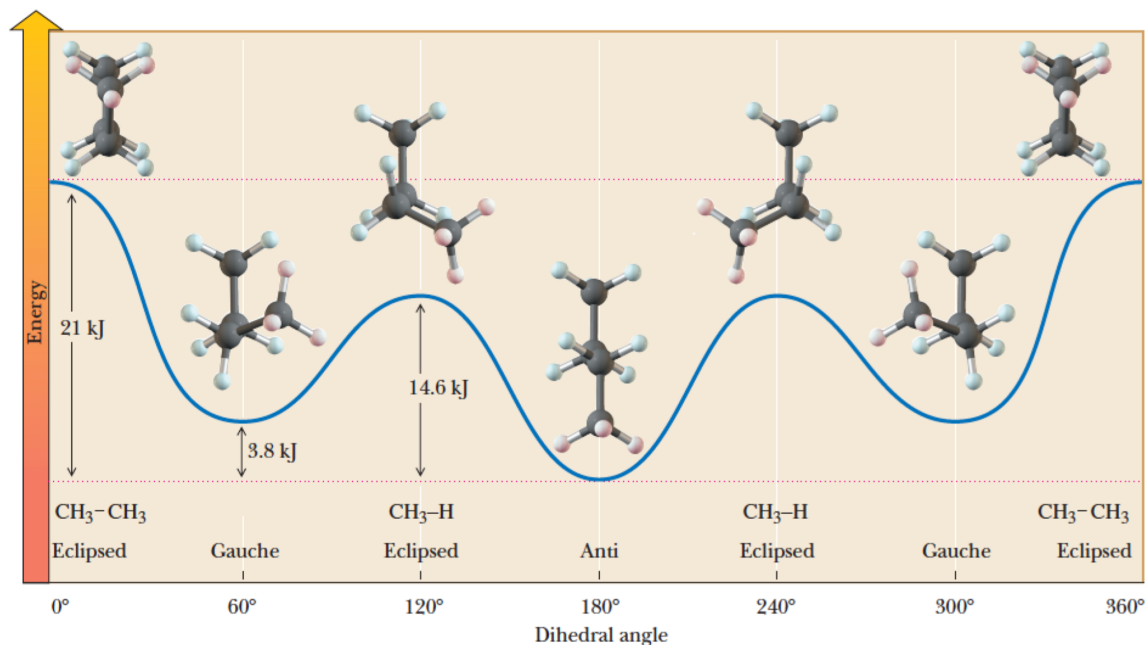


Anti



Gauche

Steric strain $\rightarrow$



Important consequence $\Rightarrow$ for longer alkanes

