Office Hours: M 1:30pm – 3:00pm
(in Park 169) W 11:00am – 12:00pm
or by appointment (email me)
or just email me with questions!

TA Hours: TBD

Q-center: https://www.brynmawr.edu/inside/offices-services/q-center/q-center-schedule

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Bonding, Hybridization, and VSEPR Geometry

9/2/2026

Bond polarity

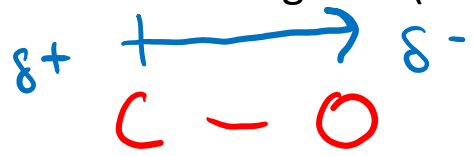
TABLE 1.1 ELECTRONEGATIVITY VALUES OF SOME COMMON ELEMENTS

Increasing electronegativity →

			H 2.1			
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8						Br 2.8

↑ Increasing electronegativity

Bond polarity is shown with a crossed arrow pointing toward the more Electronegative (EN) atom.



$|\Delta EN| = 1.0$

polar bond

Partial charges (δ) depict unequal distribution of electrons in a bond.

For an individual bond between two atoms…. (from Gen Chem)

If ΔEN < 0.5 → bond is *nonpolar* – e^- are shared equally

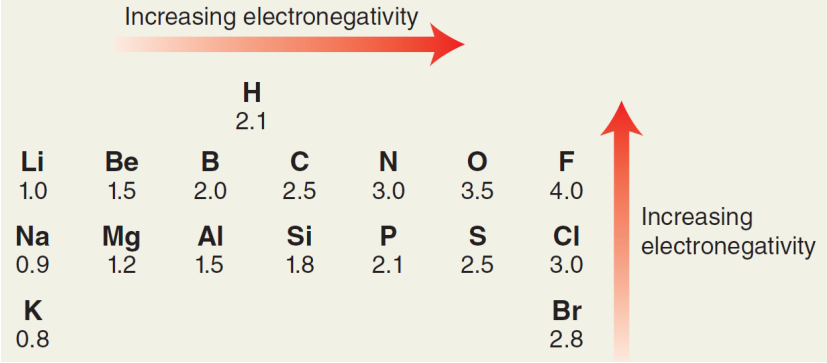
If ΔEN is between 0.5 and 1.7 → bond is *polar* δ+ & δ-

If ΔEN > 1.7 → "bond" is *ionic* & e^- are not shared! + −

Bond polarity (for Organic Chemists)

- Organic chemists characterize bonds + polarity between Carbon & Friends based more on observed properties than Pauling Scale EN values.

TABLE 1.1 ELECTRONEGATIVITY VALUES OF SOME COMMON ELEMENTS



"Pauling Scale" electronegativity (EN)

Common **nonpolar** *bonds*:

C – C , H – H , C – H

(anything w/ itself)

Common **polar** *bonds*:

C – O , C – N , C – X

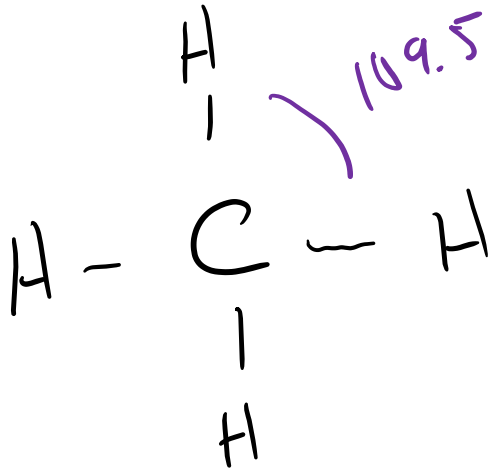
X = halogen (F, Cl, Br, I)

- Formal charge/octet – prediction about stability/plausibility of structure
- **VSEPR** – predictions about geometry

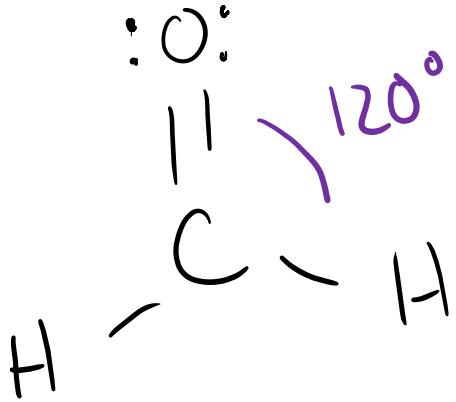
↳ Valence Shell e⁻ pair repulsion

↳ e⁻ groups spread out as much as possible

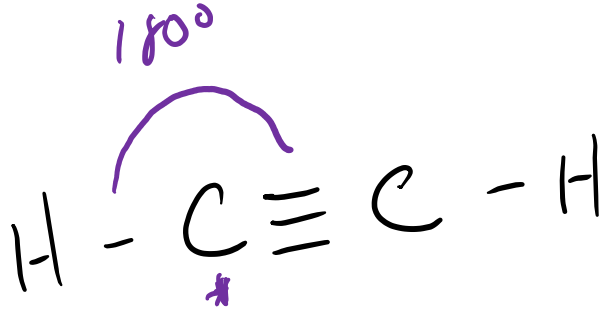
Give approximate bond angles around each C, and "name" the molecule's geometry



tetrahedral



trigonal planar



linear

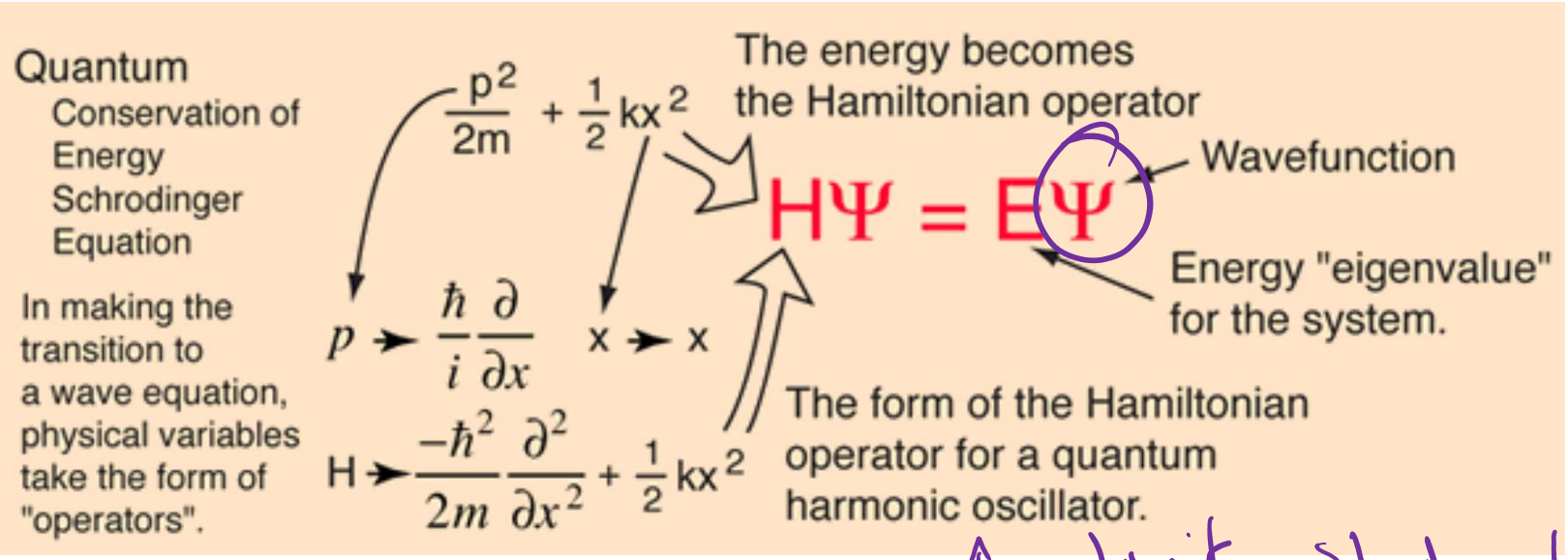
- *Very* simplistic model of "where electrons are" in a molecule

Atomic orbitals

- What is an orbital? where e^- are found in an atom / molecule
- Recall from Gen Chem that the energy of electrons is quantized and not continuous – e^- exist only @ certain specific energy levels, never between
- Visualized as 3D probability density maps: region or "shape" where an electron is most likely to be found, if it's at a certain energy. + some probability
- An orbital holds a maximum of $2e^-$
- Cool story and all, but where do these shapes of orbitals come from? P chem !!

The Schrödinger equation

- Electrons have both wave- and particle-like nature
- Schrödinger modeled electron as a 3D standing wave around nucleus
- Quantized energy levels of orbitals come from this model
  as do their corresponding 3D "shapes" at each energy level!



Ψ^2 = probability function

orbital shape is graph of Ψ^2

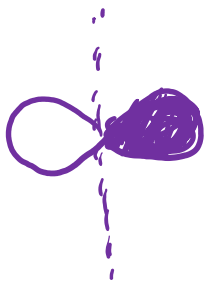
↑ don't study this (yet)

Solutions to the Schrödinger equation for Hydrogen

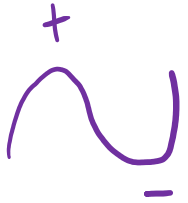
Orbital shapes:

s sphere

p peanut



node = ∅ e^- density



d ~~d~~

f ~~f~~

not in this course

[Visualizer of solutions for Hydrogen orbitals]

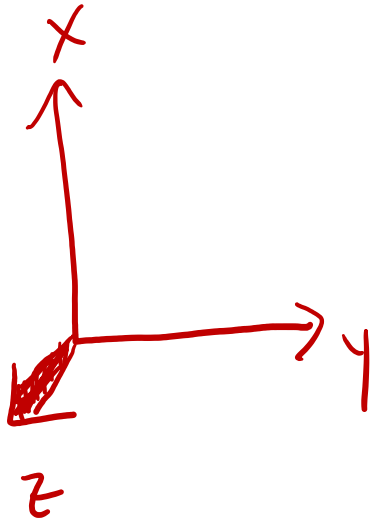
More about p orbitals

occur in a set of three degenerate orbitals.

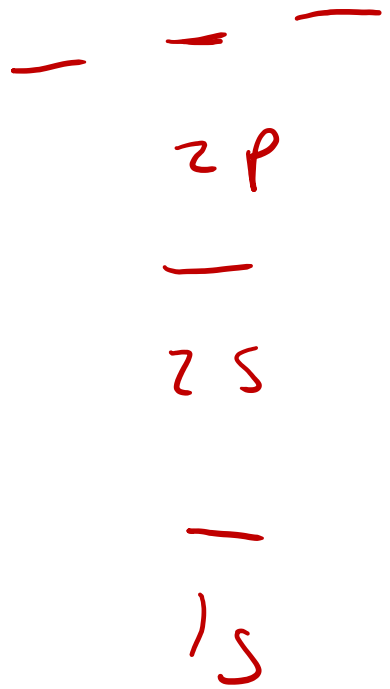
↓ same energy

that are mutually orthogonal

all 90° to each other



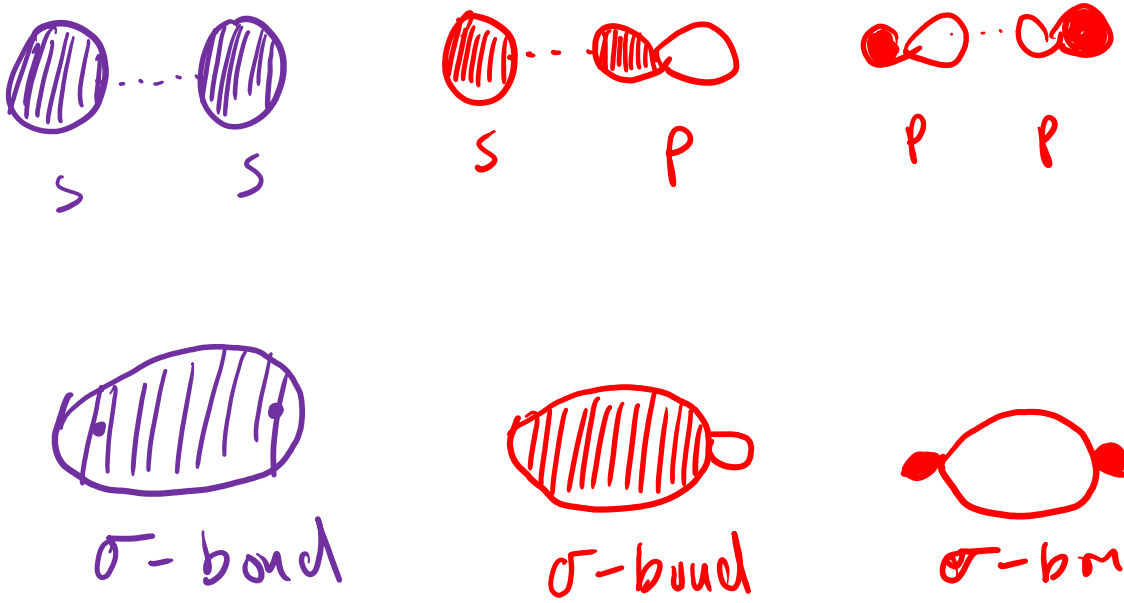
z axis is coming toward you



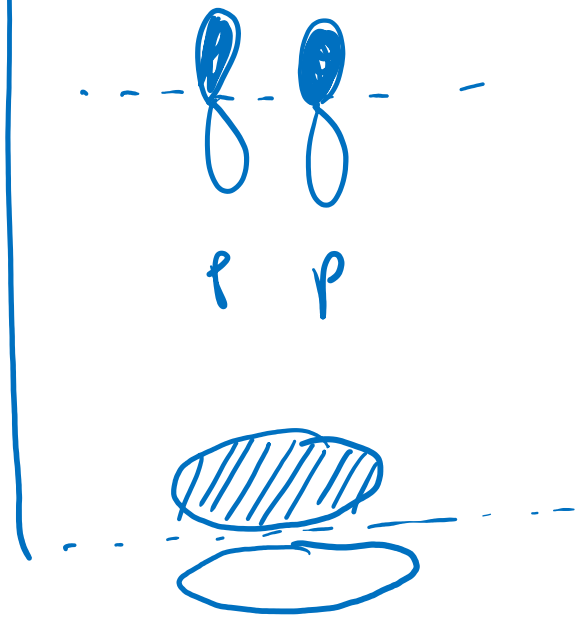
Valence Bond Theory

- Bonding is a result of overlap of orbitals between two atoms
- Two important flavors of overlap in this class:

σ (sigma) 1 "lobe" overlapping



π (pi) 2 lobes overlapping



O = O

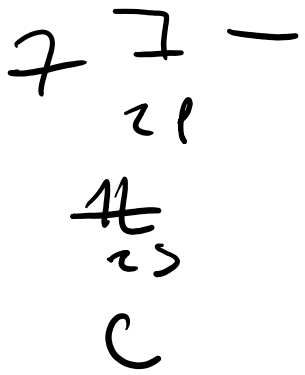
↓

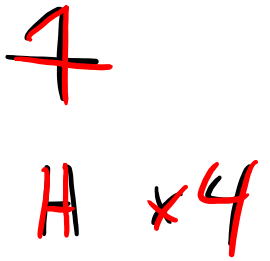
1 σ-bond + 1 π-bond

σ-bond is stronger and ~~weaker~~ than π-bond!

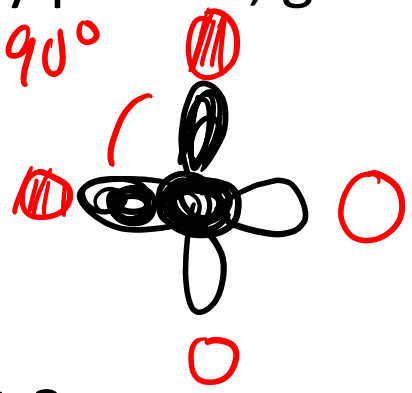
Geometry of CH_4 (methane)

Valence electron configurations of C and H:





What bond angles does Valence Bond theory predict, given the orbitals involved that can overlap?



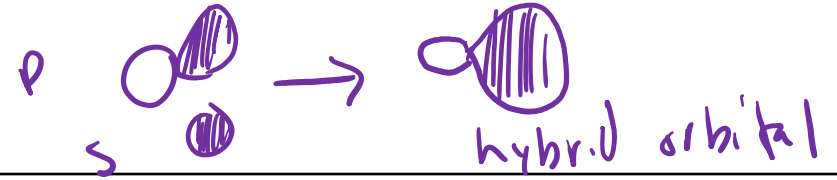
What bond angle does VSEPR predict for CH_4?

109.5°

Valence Bond theory needs an adjustment!

Hybridized atomic orbitals

General idea: within one atom, the orbitals involved in sigma bonding or containing lone-pairs ***MIX*** (hybridize) to get <u>new atomic orbital shapes</u> that are **<u>degenerate</u>**.



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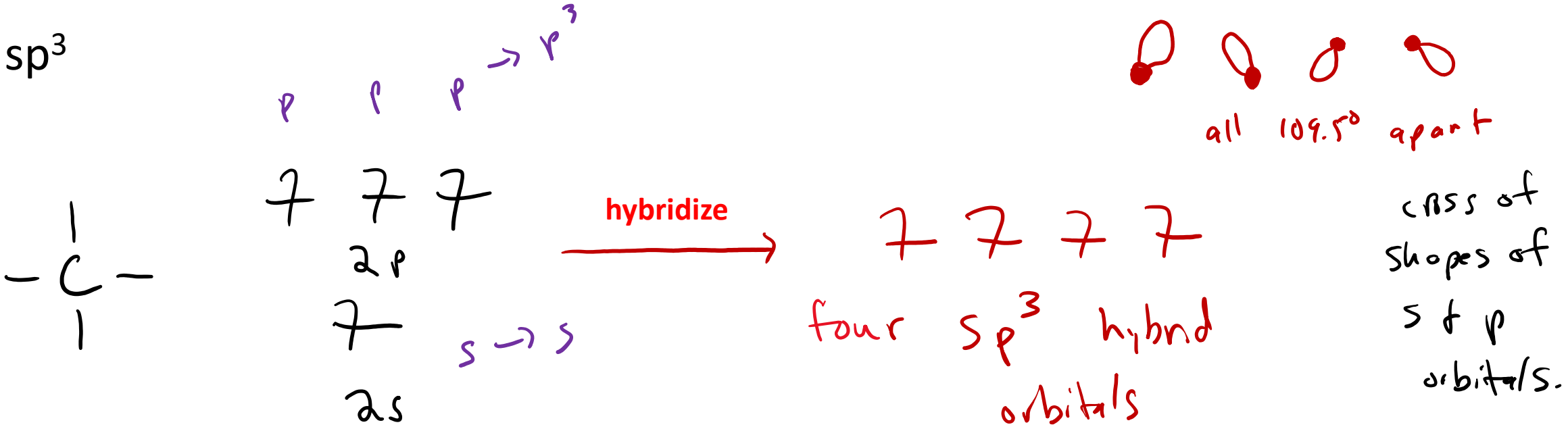
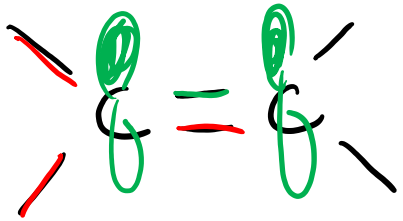
sp^3



sp²

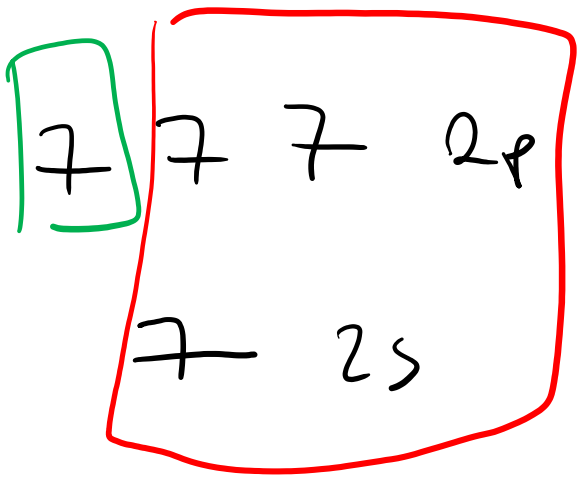


used in π bond

1

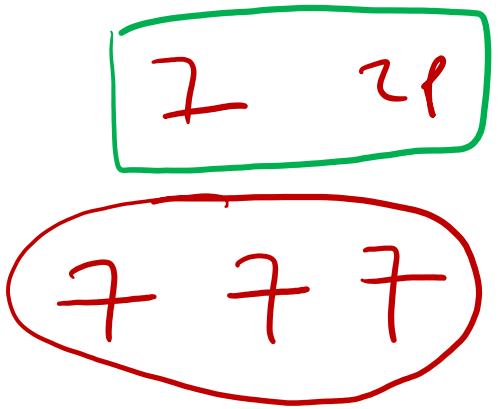
p

p → p²



s → s

hybridize



120° apart

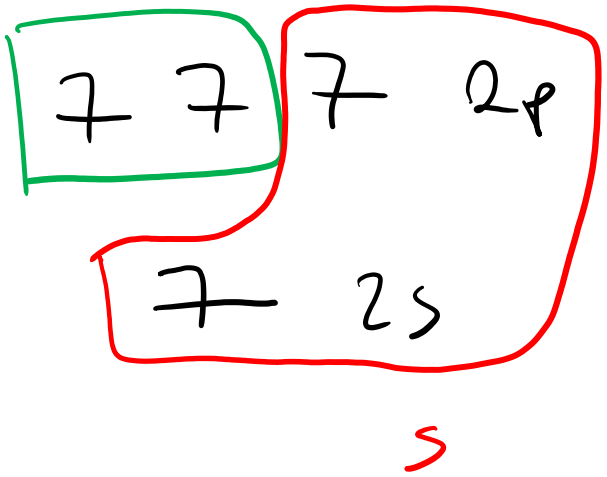
three sp^2 hybrid orbitals

---

sp

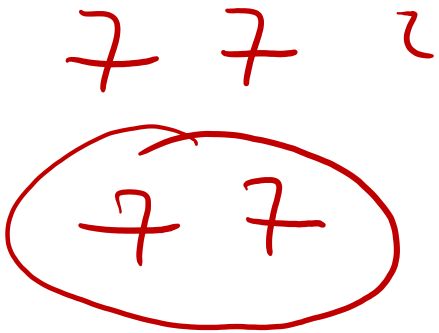
used in π bond

p



s

hybridize



180° apart

two sp hybrid orbitals

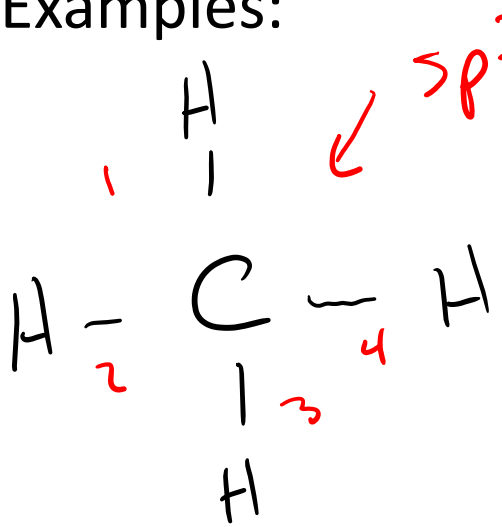
TL;DR for hybridization

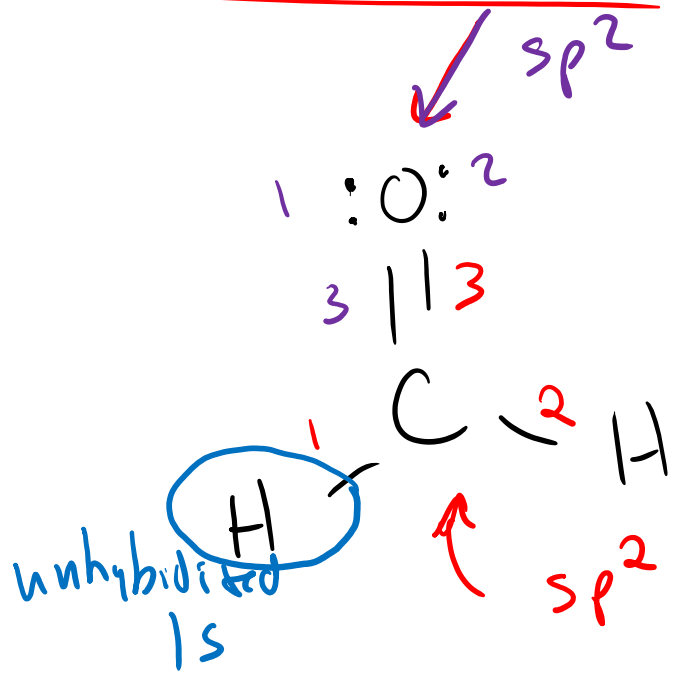
- Count the number of **electron groups** around an atom
  a double or triple bond only counts as **one group** (one σ-bonds)
  each lone pair counts as **one group**

# of lone pairs + sigma bonds ☆

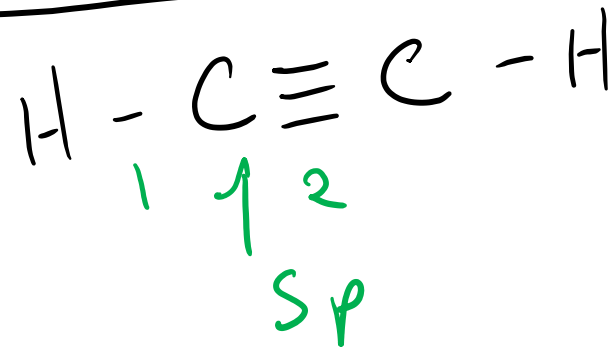
- Number of groups = the total number of *letters* in the hybridization label.

Examples:





sppp → sp3 4
spp → sp2 3
sp 2



Poll

MCAT Question

Identify the hybridization of the carbon atom and the oxygen atom indicated by the arrows.

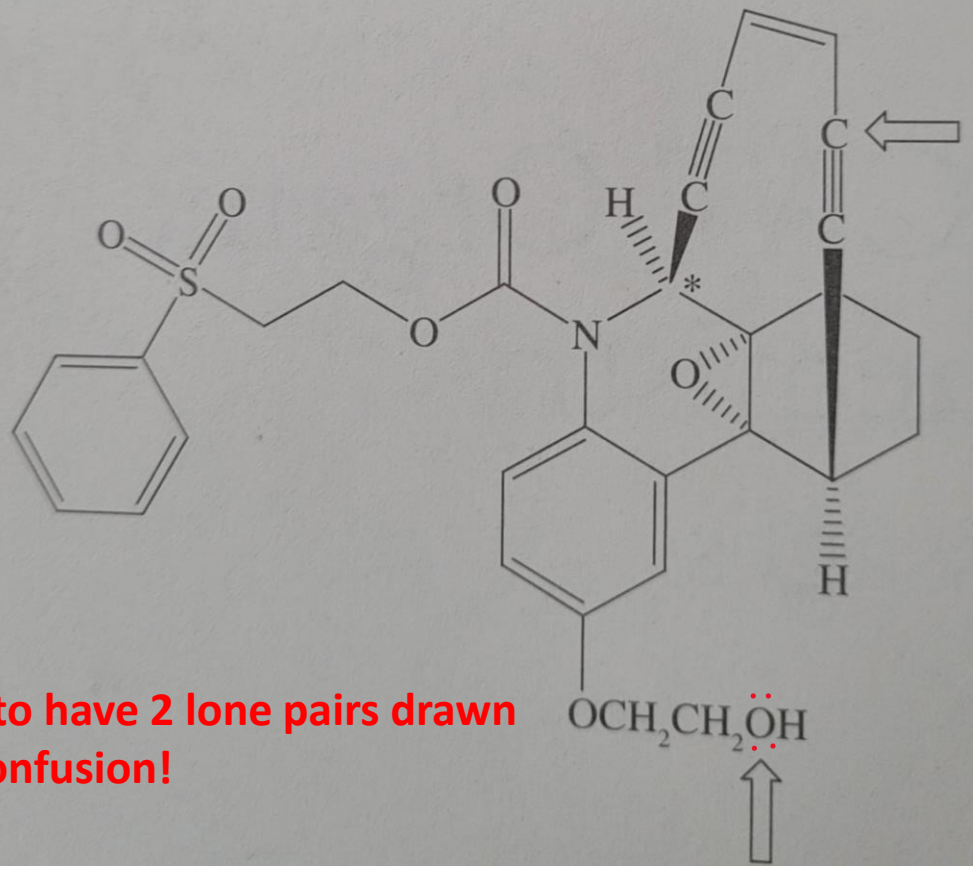
A. C: *sp*, O: sp^2

B. C: *sp*, O: sp^3

C. C: sp^2, O: sp^3

D. C: sp^3, O: sp^3

Recent research has demonstrated that there is a class of DNA-cleaving molecules that are referred to as *enediynes*. These compounds are known as enediynes because they contain a continuous six-carbon unit in which there is one double bond and two triple bonds. These DNA-cleaving molecules appear to be quite potent and, most importantly, selective in regards to anticancer activity. The following molecule has proven to be one of the more potent of these enediyne molecules:



This O was meant to have 2 lone pairs drawn in…sorry for any confusion!

pollev.com/timcook653 or text timcook653 to 22333 or use android/iphone app

Poll

MCAT Question

How many π-bonds does this molecule have?

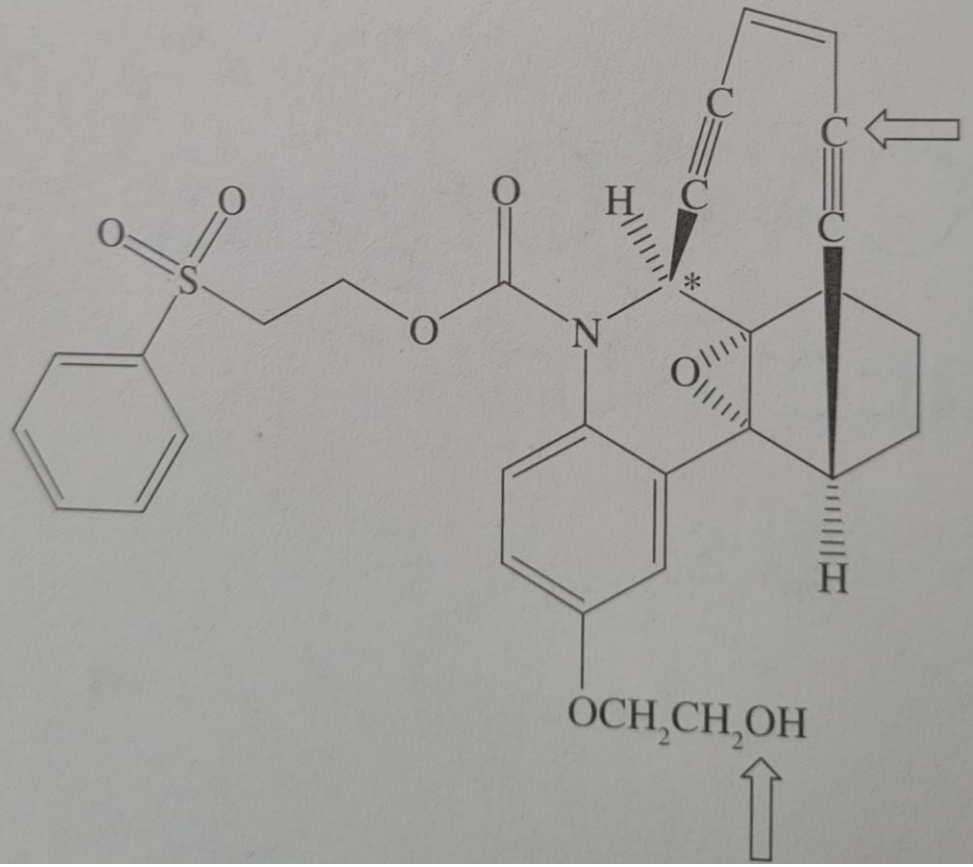
A. 12

B. 13

C. 14

D. 15

Recent research has demonstrated that there is a class of DNA-cleaving molecules that are referred to as *enediynes*. These compounds are known as enediynes because they contain a continuous six-carbon unit in which there is one double bond and two triple bonds. These DNA-cleaving molecules appear to be quite potent and, most importantly, selective in regards to anticancer activity. The following molecule has proven to be one of the more potent of these enediyne molecules:



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