Orbital Hybridization

Unit: Covalent Bonding & Molecular Geometry

MA Curriculum Frameworks (2016): HS-PS1-2

Mastery Objective(s): (Students will be able to…)

- Determine the hybridization of the central atom in simple molecules.

Success Criteria:

- VSEPR shapes show the correct number of lone pairs in the correct locations and correct bond angles.
- Hybridization is correct (sp, sp^2 or sp^3).

Tier 2 Vocabulary: hybrid

Language Objectives:

- Explain how electron clouds change shape.

Notes:

orbital: the name for one of the spaces around an atom where electrons are.

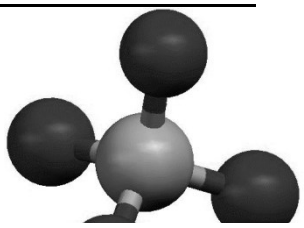
hybrid orbital: an orbital whose shape is a hybrid of the shapes of different types of orbitals (such as a cross between an s-orbital and a p-orbital).

It is tempting to think of electrons as well-behaved particles that stay within the rigid boundaries defined by their energy levels. However, electrons are actually tiny charged particles moving randomly at speeds close to the speed of light. Because of their energies and the energies of the nuclei and the other electrons around them, they bounce around within a specific area. If that area is the shared electrons in a covalent bond, the region has a different shape than the electrons of an unbonded atom.

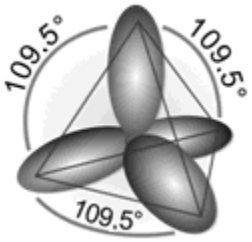
When atoms form covalent bonds, the electrons occupy the space between the two atoms. The space where the bonding electrons are is still called an orbital, even though its shape is now *different* from the shapes of the orbitals in the s, p, d, or f sub-levels of a single atom.

Use this space for summary and/or additional notes:

Recall that molecules with four electron clouds (tetrahedral, trigonal pyramidal, or bent with single bonds, like H_2O), are based on a tetrahedral VSEPR shape:

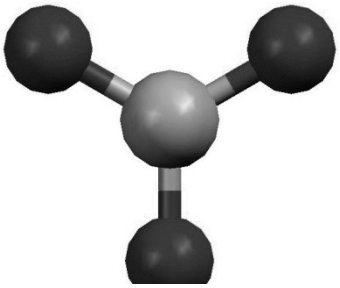


The shape of the orbitals surrounding the central atom is the shape determined by the four electron clouds. It looks like the following:

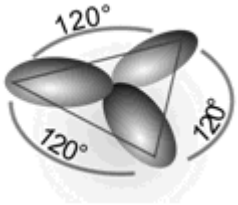


If we wanted to create four orbitals like this one by reshaping the *s* and *p* orbitals of an atom's valent shell, we would need to start with one *s* and three *p* orbitals. We therefore call this bonding orbital an ***sp*^{3} hybrid orbital**, because it looks like a hybrid made from the one *s* and three *p* orbitals.

Similarly, molecules with three electron clouds are based on the trigonal planar VSEPR shape:



This hybrid orbital would come from one s and two p orbitals, and would be called an ***sp*^{2} hybrid orbital**:



Finally, the hybrid orbital from one *s* and one *p* orbital is indeed called an ***sp* hybrid orbital**.

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Summary of VSEPR Shapes for Hybrid Orbitals

Hybridization	VSEPR Shape(s)	Bond Angles
sp^3	tetrahedral	109.5°
	trigonal pyramidal,	107.5°
	bent	104.5°
sp^2	trigonal planar	120°
	bent	118°
sp	linear	180°

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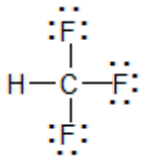
Homework Problems

For each of the following molecules, draw the Lewis structure. Then build a model of the molecule, and use your model to determine the shape of the electron clouds, and the shape of the molecule.

Formula	Hybrid-ization	Lewis Structure	# of Electron Clouds around Central Atom	VSEPR shape
CHF_3	sp^3		4	tetrahedral
SCl_2				
SiO_2				
PH_3				
CH_2O				

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Formula	Hybrid-ization	Lewis Structure	# of Electron Clouds around Central Atom	VSEPR shape
C_2H_2				
HCN				
NO_3^-				
BF_3				

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