Hybridization

For this lab, please examine the following:

1) Molecules are bound by shared electrons.
2) Electrons exist in orbitals.
3) In methane, CH_4, the bond angles are 109.5° .
4) The p orbitals are 90° apart.

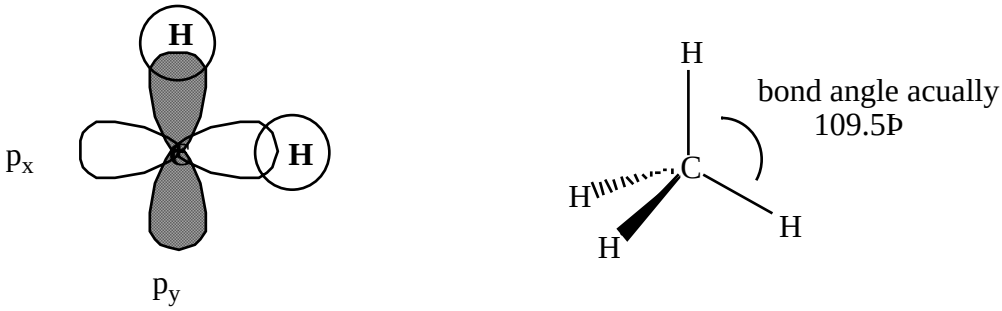


Figure 1: The bond angle is 109.5° instead of the 90° we would expect from looking at the p orbitals.

How can this be? If the electrons are shared they must be in overlapping orbitals but none of the orbitals are oriented at angles of 109° . The answer to this dichotomy is the creation of new orbitals that are oriented in the correct direction. The new orbitals are made from combinations of s, p and in some cases d orbitals.

Because hydrogen's valence electron is in the first shell, it cannot hybridize and so it only uses the s orbital. In the second shell, atoms can use their s or p orbitals. Atoms with valance electrons can use s, p and d orbitals. The hybridization choice depends on the number of areas of electron density around the atom. If there are three areas of electron density, for example, the atom will be sp^2 hybridized.

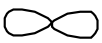
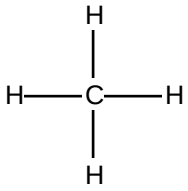
areas of electron density	hybridization	picture of an individual orbital	picture of the hybrids together
2	sp		
3	sp^2		
4	sp^3		

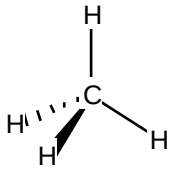
Figure 2: Pictures of the hybrid orbitals

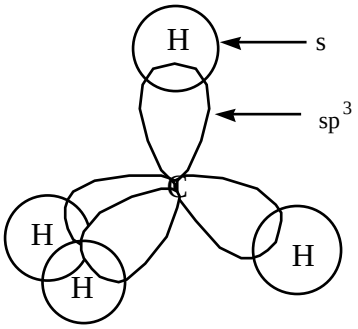
Please examine the hybridization scheme for carbon shown below. To make these new hybrids, the atom takes the same number of orbitals to make the hybrids. Note that the number of orbitals does not change, just type types. In a case where carbon is attached to three things there will be three areas of electron density and so it will use two p orbitals (p_x+p_y) and one s orbital to make three sp^2 orbitals leaving the p_z alone.

Areas of electron density	orbitals before hybridization	orbitals after hybridization	Bond angles
2	$s+p_x+p_y+p_z$	$2sp+p_y+p_z$	180°
3	$s+p_x+p_y+p_z$	$3sp^2+p_z$	120°
4	$s+p_x+p_y+p_z$	$4sp^3$	109.5°

In methane, the lewis structure shows 4 areas of electron density around the carbon. The VSEPR model shows the tetrahedral electron pair an molecular geometry. Examine the hybridization; each hydrogen is attached to the C through overlap of a sp^3 orbital of the carbon and the s orbital of the hydrogen.







Lewis Structure

VSEPR
e^- pr geom = tetrahedral
mol geom = tetrahedral
bond angles =109.5Þ

Valence Bond (VB)

A single bond involves only a sigma overlap of orbitals between nuclei. The double bond involved sharing 4 electrons. Like a single bond, 2 electrons are shared between the nuclei. The next two electrons must be shared above and below this area. We define the shared electrons between the nuclei as a σ bond. We define the shared electrons above and below this area as a π bond.

Pre-lab assignment:

1. Bring to lab scissors, scotch tape, a stapler and crayons or markers with 4 colors, preferably red, green, blue and yellow. You will probably want to bring your model sets.

2. Read the lab and chapter 1 of the book.

3. Prepare your notebook for data. For each molecule you will have a Lewis structure, a VSEPR model and a valence bond model. You will be working in groups but each person will be required to have a copy of pictures of all the molecules.

In lab:

1.You will be building models using Styrofoam balls, construction paper and toothpicks. I plan that you will color coordinate your orbitals as follows:

orbital	color
sp	pink
sp^2	blue
sp^3	yellow
s	white
p	green

Your models will show overlapping ¹ bonds etc.

This lab will involve **4** parts. The only thing that you will turn in to me next week is the answer to the question in part 4. Parts 1-3 will be graded in class.

Part 1. Split up into groups of three. Give each person in your group a letter from A-C.

Move from your group and find a person from another group with the same letter. Work with that person to prepare a presentation for your respective groups on 2 assignments.

Letter A: Draw and give the rationale for the Lewis structure, VSEPR Model and VB model for C_2H_6. Use colors in your drawings. Make a model using the model kits.

Make a model using the Styrofoam balls and draw and give the rationale for the Lewis structure, VSEPR Model and VB model for CH_2NH. Show all the correct hybridized orbitals. Use colors in your drawings.

Letter B: Draw and give the rationale for the Lewis structure, VSEPR Model and VB model for C_2H_4. Use colors in your drawings. Make a model using the model kits.

Make a model using the Styrofoam balls and draw and give the rationale for the Lewis structure, VSEPR Model and VB model for CO_2. Show all the correct hybridized orbitals. Use colors in your drawings.

Letter C: Draw and give the rationale for the Lewis structure, VSEPR Model and VB model for C_2H_2. Use colors in your drawings. Make a model using the model kits.

Make a model using the Styrofoam balls and draw and give the rationale for the Lewis structure, VSEPR Model and VB model for CH_2CCH_2. Show all the correct hybridized orbitals. Use colors in your drawings.

Part 2: In your group take turns presenting your information. During your presentation answer the questions:

1) How did you get that Lewis structure?
2) What is the geometry of the central atom (s) (electron pair geometry)?
3) What is the hybridization of each atom in each molecule?

Part 4. Find and name all the structural/constitutional isomers for C_6H_{14}.

(Homework)