

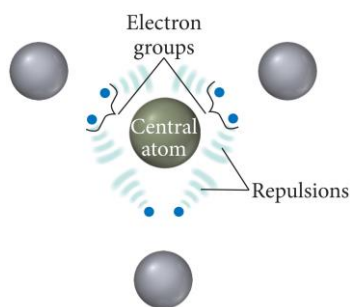
This chapter goes into the structure of molecules and the reasons behind the geometries of the structures. These concepts are part of Big Idea 2 in the AP Chemistry curriculum. Bond orders are part of Big Idea 5. Concepts not in the curriculum include hybridizations with d orbitals and memorizing molecular orbital filling order.

### 10.1 Artificial Sweeteners: Fooled by Molecular Shape

1. Explain what processes must occur for us to taste something sweet

### 10.2 VSEPR Theory: The Five Basic Shapes

2. What does VSEPR stand for and what is this theory based on?



3. Using the figure above, explain what determines the geometry of a molecule.

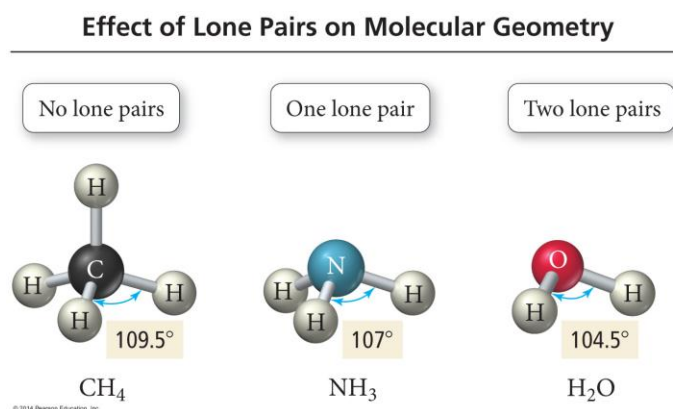
4. Fill in the following table:

Number of Electron Groups on Central atom	Example Molecule	Basic Name of the Shape	Bond Angle(s)	Basic Drawing of the shape
2				
3				
4				
5				
6				

- Explain why the bond angles in formaldehyde are not the predicted  $120^\circ$  for a trigonal planar structure.
- Draw the Lewis structure for methane. Using methane as an example, explain why the Lewis structure gives an incomplete picture of the geometric structure of the molecule. Include a 3D diagram of methane, showing its geometrical shape, in your answer.

### 10.3 VSEPR Theory: The Effects of Lone Pairs

Use the following diagram in answering questions 7-9



- When lone electron pairs are presented on a central atom in a simple molecule, why are the electron geometries different from the molecular geometries.?
- Explain why a tetrahedral electron geometry with one lone pair on the central atom does not show  $109.5^\circ$  angles. Use a 3D drawing in your answer.
- Explain why a tetrahedral electron geometry with two lone pair on the central atom does not show  $109.5^\circ$  angles. Use a 3D drawing in your answer.
- Explain how the electron geometries with five electron groups form molecular shapes with the following numbers of lone pairs. Use diagrams in your answers.  
**1 lone pair:**

**2 lone pairs:**

**3 lone pairs:**

11. Explain how the electron geometries with six electron groups form molecular shapes with the following numbers of line pairs. Use diagrams in your answers.

**1 lone pair:**

**2 lone pairs:**

12. Fill in the table below:

Number of Electron Groups	Number of Lone Pairs on Central Atom	Name of Electron Geometry	Name of Molecular Geometry	Example	Drawing
4					
4					
5					
5					
5					
6					
6					

**10.4 VSPER: Predicting Molecular Geometries** (note that you will not be expected to draw in three dimensions on the AP exam, but you should still be familiar with these conventions)

13. In a three-dimensional (3-D) model how do you indicate (i) a bond in the plane of the paper, (ii) and bond going into the page, and (iii) a bond coming out of the page? Include a diagram in your answer.

14. Using a 3-D model, draw the basic model of each of the following:

Linear:

Trigonal Planar:

Bent:

Tetrahedral:

Trigonal  
Pyramidal:

Trigonal  
Bipyramidal:

Seesaw:

Octahedral:

Square Planar:

### 10.5 Molecular Shape and Polarity

15. Compare  $\text{CCl}_4$  to  $\text{CH}_2\text{Cl}_2$ . Explain how to determine if a molecule is polar or not.

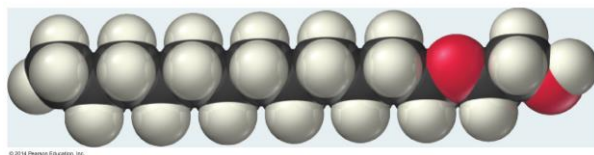
16. Why is it important to be able to determine the polarity of a molecule? What properties does it explain?

17. How can a molecule have polar bonds and be nonpolar? Provide an example.

18. Explain how phosphine,  $\text{PH}_3$ , can have nonpolar P-H bonds and be a polar molecule?

19. What are the unique properties of soap that allow it to clean off oil in a water environment?

20. On the following diagram indicate which end will dissolve in water and which end will dissolve in fats and oils. Refer to page 442 for the coloring in this molecule.



## 10.6 Valence Bond Theory: Hybridization of Atomic Orbitals

21. What is a hybridized orbital?
22. In valence bond theory, what determines the shape of the molecule?
23. Explain how the Lewis model and the valence bond theory differ in their description of a chemical bond.

## 10.7 Valence Bond Theory: Hybridization of Atomic Orbitals

24. How do hybrid orbitals differ from atomic orbitals?
25. How is the number of hybrid orbitals determined?
26. Using a diagram, explain why a central atom such as carbon in  $\text{CCl}_4$  is  $sp^3$  hybridized and the molecule forms a tetrahedral shape.
27. Using a diagram, explain why a central atom with  $sp^2$  hybridization forms a trigonal planar shape.
28. What types of orbitals and hybrid orbitals compose a double bond? A triple bond?
29. Draw the Lewis structure and the valence bond diagram for  $\text{CO}_2$ , showing the location of sigma bonds and pi bonds. Explain the difference between a sigma bond and a pi bond.
30. Using a diagram, explain why  $sp$  hybridization is linear in shape.

### Self-Assessment Answers

- |          |          |          |           |           |
|----------|----------|----------|-----------|-----------|
| 1. _____ | 4. _____ | 7. _____ | 10. _____ | 13. _____ |
| 2. _____ | 5. _____ | 8. _____ | 11. _____ | 14. _____ |
| 3. _____ | 6. _____ | 9. _____ | 12. _____ | 15. _____ |