# Bond Shape Clues

Use oxidation numbers and electron groups to predict molecular properties.

**CHE.4.4** "Use models and oxidation numbers to predict the type of bond, shape of the compound, and the polarity of the compound."

NAME _____ DATE _____

## 1 READ AND MARK

Read it twice

**YOUR JOB** Write 1 beside a rule for bond type, 2 beside a rule for molecular shape, and 3 beside a rule for polarity; underline the sample details you need to use those rules.

### What a Formula Can Reveal

1. Bonding gives clues about what a substance can do. A metal with a nonmetal usually forms ions in a repeating lattice, as magnesium oxide, MgO, does. Two nonmetals usually share electrons in covalent bonds, as in methane, $CH_4$. Oxidation numbers track assigned electrons; they do not always describe real charges. In a neutral formula, the oxidation numbers add to zero. A Group 1 metal has oxidation number +1, fluorine always has -1, and chlorine usually has -1 when bonded to a less electronegative atom. These numbers help you check a formula, but the elements' identities help you classify bonding.

2. A covalent molecule has a shape set by electron groups around its central atom. Each single, double, or triple bond counts as one group; each lone pair counts as one group. Two bonding groups and no lone pairs give a linear molecule, such as carbon dioxide, $CO_2$. Three bonding groups and no lone pairs give a trigonal planar molecule. Four groups give a tetrahedral electron arrangement: four bonds make a tetrahedral molecule, three bonds and one lone pair make a trigonal pyramidal molecule, and two bonds and two lone pairs make a bent molecule. Ionic lattices have no single molecule to assign a molecular shape.

3. A bond's dipole points toward the atom that attracts its shared electrons more strongly. Equal polar bonds cancel in symmetric linear or trigonal planar molecules with matching outer atoms, but not in bent or trigonal pyramidal molecules. Consider four unclassified samples. LiF pairs a metal with a nonmetal. In $CS_2$, carbon makes two double bonds to sulfur and has no lone pairs. In $OF_2$, oxygen has two bonds to fluorine and two lone pairs. In $PCl_3$, phosphorus has three bonds to chlorine and one lone pair. Carbon-sulfur bonds are nearly nonpolar; oxygen-fluorine and phosphorus-chlorine bonds are polar toward the halogen.

## 2 ANSWER WITH EVIDENCE

Use the passage

1. Use oxidation numbers and element types to predict the bond type in LiF. Can you assign LiF a molecular shape? Explain.

2. Predict the bond type, molecular shape, and overall polarity of $CS_2$. Use its bonding groups to explain the shape.

3. Use oxygen's bonds and lone pairs to predict the shape and overall polarity of $OF_2$.

4. Find the oxidation numbers of phosphorus and chlorine in $PCl_3$. Then predict its bond type, shape, and molecular polarity.

## 3 YOUR TURN

Your own words

Analyze $BCl_3$, which has boron at the center, three B-Cl bonds, no lone pairs on boron, and bonds polarized toward chlorine. In three sentences, give the oxidation numbers, bond type, molecular shape, and overall polarity, and explain whether the bond dipoles cancel.

ANSWER KEY

# Bond Shape Clues



## PART 1 · READ AND MARK

Write 1 beside a rule for bond type, 2 beside a rule for molecular shape, and 3 beside a rule for polarity; underline the sample details you need to use those rules. Accept any marking that follows this job and points at the right text.

## PART 2 · ANSWERS

| # | QUESTION | ANSWER |
|---|---|---|
| 1 | Use oxidation numbers and element types to predict the bond type in LiF. Can you assign LiF a molecular shape? Explain. | **Lithium is +1 and fluorine is -1. LiF is ionic because it contains a metal and a nonmetal. Its lattice has no single molecule with a molecular shape.** |
| 2 | Predict the bond type, molecular shape, and overall polarity of $CS_2$. Use its bonding groups to explain the shape. | **$CS_2$ is covalent and linear because carbon has two bonding groups and no lone pairs. The molecule is nonpolar.** |
| 3 | Use oxygen's bonds and lone pairs to predict the shape and overall polarity of $OF_2$. | **Oxygen has two bonds and two lone pairs, so $OF_2$ is bent. Its polar bonds do not cancel, making the molecule polar.** |
| 4 | Find the oxidation numbers of phosphorus and chlorine in $PCl_3$. Then predict its bond type, shape, and molecular polarity. | **Phosphorus is +3, and each chlorine is -1. $PCl_3$ is covalent and trigonal pyramidal. Its polar bonds do not cancel, so the molecule is polar.** |

## PART 3 · YOUR TURN (SAMPLE ANSWER)

Boron has oxidation number +3, and each chlorine has -1. $BCl_3$ has polar covalent bonds and a trigonal planar shape. Its bond dipoles cancel in this symmetric shape, so the molecule is nonpolar.

Accept equivalent explanations that distinguish polar bonds from overall molecular polarity. For LiF, accept an explanation that an ionic lattice does not have a molecular shape.