# Where Pulls Point

Use bond pulls and shape to predict molecular polarity

**CHE.2.e** "Construct an explanation of the polarity of a molecule based on electronegativity data and molecular geometry."

NAME _____ DATE _____

## 1 READ AND MARK

Read it twice

**YOUR JOB** Underline the sentence that tells you which way a bond dipole points, circle the electronegativity values in paragraph 2, and number the four shape descriptions so you can use both kinds of evidence.

### The Shape of a Pull

1. A molecule can have polar bonds without having an overall positive or negative charge. A polar bond forms when one atom pulls shared electrons more strongly than the other. Electronegativity measures that pull: the larger the difference, the stronger the bond dipole. A bond dipole points toward the more electronegative atom. To predict molecular polarity, consider both these arrows and the molecule's three-dimensional shape. For example, HCN has a straight H-C-N arrangement. Its electronegativity values are H 2.20, C 2.55, and N 3.04. Both bond dipoles point toward the nitrogen end, so HCN is polar.

2. Now consider four molecules with different shapes. In $H_2O$, oxygen sits at the center of a bent arrangement with two hydrogen atoms. In $CO_2$, carbon is centered between two oxygen atoms in a straight line. In $BF_3$, boron and three fluorine atoms form a flat, triangular arrangement with fluorine atoms spaced evenly around boron. In $NH_3$, nitrogen sits at the peak of a triangular pyramid with three hydrogen atoms below it. The electronegativity values are H 2.20, O 3.44, C 2.55, B 2.04, F 3.98, and N 3.04. Use these numbers to determine which bonds have unequal pulls.

3. Bond dipoles add like forces in different directions, so shape matters as much as bond strength. When arrows balance, the molecule has no net dipole; when they do not, it is polar. Do not decide from electronegativity differences alone, since the same kinds of bonds can give different results in different shapes. For another case to investigate, $CH_2Cl_2$ has a central carbon bonded to two hydrogen atoms and two chlorine atoms in a tetrahedral arrangement. Chlorine's electronegativity is 3.16; carbon and hydrogen values appear above. In a tetrahedron, the four bonds point toward different corners in three dimensions.

## 2 ANSWER WITH EVIDENCE

Use the passage

1. Is $H_2O$ polar or nonpolar? Use the electronegativity values to identify the direction of its bond dipoles, then explain what its shape does to them.

2. Is $CO_2$ polar or nonpolar? Explain how its electronegativity values and shape lead to your answer.

3. The B-F bonds in $BF_3$ have a large electronegativity difference. Does that make the molecule polar? Explain using its shape.

4. Predict whether $NH_3$ is polar or nonpolar. Identify the more electronegative atom in each bond and explain whether the dipoles cancel.

## 3 YOUR TURN

Your own words

In three sentences, explain whether $CH_2Cl_2$ is polar. State which way its bond dipoles point, explain how its tetrahedral shape affects them, and compare the result with one molecule from Part 2.

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## PART 1 · READ AND MARK

Underline the sentence that tells you which way a bond dipole points, circle the electronegativity values in paragraph 2, and number the four shape descriptions so you can use both kinds of evidence. Accept any marking that follows this job and points at the right text.

## PART 2 · ANSWERS

| # | QUESTION | ANSWER |
|---|---|---|
| 1 | Is $H_2O$ polar or nonpolar? Use the electronegativity values to identify the direction of its bond dipoles, then explain what its shape does to them. | **$H_2O$ is polar. Each O-H bond dipole points toward oxygen because O is more electronegative than H. In the bent shape, the dipoles do not cancel.** |
| 2 | Is $CO_2$ polar or nonpolar? Explain how its electronegativity values and shape lead to your answer. | **$CO_2$ is nonpolar. Each C-O bond dipole points toward oxygen, but the equal dipoles point in opposite directions in the linear molecule and cancel.** |
| 3 | The B-F bonds in $BF_3$ have a large electronegativity difference. Does that make the molecule polar? Explain using its shape. | **No. The B-F bond dipoles point toward fluorine, but the three equal dipoles are spaced evenly around boron in a flat triangular shape and cancel. $BF_3$ is nonpolar.** |
| 4 | Predict whether $NH_3$ is polar or nonpolar. Identify the more electronegative atom in each bond and explain whether the dipoles cancel. | **$NH_3$ is polar. Nitrogen is more electronegative than hydrogen, so the N-H bond dipoles point toward nitrogen. They do not cancel in the triangular pyramidal shape.** |

## PART 3 · YOUR TURN (SAMPLE ANSWER)

The C-Cl bond dipoles point toward chlorine, while the C-H bond dipoles point toward carbon. In the tetrahedral shape, the two chlorine atoms and two hydrogen atoms occupy different corners, so the bond dipoles do not cancel and $CH_2Cl_2$ is polar. Like bent $H_2O$, it has a net dipole because its bond dipoles do not balance.

Accept explanations that correctly use electronegativity to establish bond dipole directions and geometry to establish whether those dipoles cancel. Students do not need to calculate electronegativity differences.