Shapes in Space

Use electron domains to predict molecular shape

CHE.2.d "Develop and use models based on valence shell electron pair repulsion (VSEPR) theory to predict the shape of a molecule up to four electron domains around the central atom."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Circle each molecule's formula and underline the clues about its central atom's bonds and lone pairs so you can model its electron domains.

Why Molecules Have Shape

1. A fizzy drink releases carbon dioxide, while water condenses on the outside of its cold glass. These molecules are tiny, but their shapes affect how they interact with other substances. To predict a shape, start with a central atom and count its electron domains. A domain is one region of electron density around that atom: a single, double, or triple bond counts as one domain, and each lone pair counts as one domain. In VSEPR theory, domains repel one another and spread out as far as they can. Draw domains first, then use the positions of atoms to name the molecular shape.

2. With two domains, the domains point in opposite directions; a molecule with two bonded atoms and no central lone pairs is linear. Three domains spread out in a plane. If all three are bonds, the molecular shape is trigonal planar; if two are bonds and one is a lone pair, the shape is bent. Four domains spread out in three dimensions. Four bonds make a tetrahedral molecular shape. Three bonds and one lone pair make a trigonal pyramidal shape, while two bonds and two lone pairs make a bent shape. Lone pairs take up space but do not appear as atoms in a molecular shape.

3. Now consider molecules you might encounter in a kitchen or chemistry lab. In carbon dioxide, CO_2, carbon is central and has a double bond to each oxygen, with no lone pairs on carbon. In boron trifluoride, BF_3, boron is central with three single bonds to fluorine and no lone pairs on boron. In ammonia, NH_3, nitrogen has three single bonds to hydrogen and one lone pair. In water, H_2O, oxygen has two single bonds to hydrogen and two lone pairs. In methane, CH_4, carbon has four single bonds to hydrogen and no lone pairs.

2 ANSWER WITH EVIDENCE

Use the passage

1. In CO_2, how many electron domains surround carbon, and what molecular shape do they predict?

2. Model the domains around boron in BF_3. How many are there, and what molecular shape do they predict?

3. How do the domains around nitrogen in NH_3 lead to its molecular shape?

4. How do the domains around oxygen in H_2O lead to its molecular shape?

3 YOUR TURN

Your own words

Draw a VSEPR model of CH_4 with carbon at the center, showing its bonds and any lone pairs on carbon. Name its molecular shape and explain your prediction in one sentence.

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PART 1 · READ AND MARK

Circle each molecule's formula and underline the clues about its central atom's bonds and lone pairs so you can model its electron domains. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	In CO_2, how many electron domains surround carbon, and what molecular shape do they predict?	**Carbon has two domains, one for each double bond. CO_2 is linear.**
2	Model the domains around boron in BF_3. How many are there, and what molecular shape do they predict?	**Boron has three bonding domains and no lone pairs. BF_3 is trigonal planar.**
3	How do the domains around nitrogen in NH_3 lead to its molecular shape?	**Nitrogen has four domains: three bonds and one lone pair. NH_3 is trigonal pyramidal.**
4	How do the domains around oxygen in H_2O lead to its molecular shape?	**Oxygen has four domains: two bonds and two lone pairs. H_2O is bent.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Model: C at the center with four C–H bonds pointing toward the corners of a tetrahedron and no lone pairs on C. Shape: tetrahedral. The four bonding domains spread apart to reduce repulsion.

Accept sketches that show four bonds around carbon in a three-dimensional arrangement, even if students use different drawing conventions. The explanation should connect four bonding domains and no lone pairs to a tetrahedral shape.