From Dots to Shape

Use electron models to predict bonds and molecular shapes.

CHE.4.1 "Develop and use models (e.g., Lewis dot, 3-D ball-stick, 3-D printing, or simulation programs such as PhET) to predict the type of bonding between atoms and the shape of simple compounds."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline facts about outer electrons, circle clues about ionic and covalent bonding, and number each shape rule by its number of bonding groups. Use your marks to build models for the questions.

What a Model Can Predict

1. Imagine shrinking a model until each ball is an atom. A Lewis dot model places outer electrons around element symbols. Paired dots can show shared electrons, while brackets and charges can show transferred electrons. In lithium fluoride, a lithium atom gives its one outer electron to fluorine. The resulting ions attract, so the bond is ionic. Nonmetals usually share electrons instead. A carbon tetrachloride molecule has carbon joined to four chlorine atoms by shared pairs, so its bonds are covalent. A ball-and-stick model can then turn those connections into a prediction about the molecule's three-dimensional shape.

2. To build an unfamiliar Lewis model, count outer electrons before drawing bonds. Hydrogen has one and usually makes one bond. Carbon has four and usually makes four bonds. Nitrogen has five and usually makes three bonds, leaving one lone pair. Oxygen has six and usually makes two bonds, leaving two lone pairs. Magnesium has two outer electrons and can lose both to reach a stable arrangement; an oxygen atom can gain two. Magnesium is a metal, while carbon, nitrogen, oxygen, and hydrogen are nonmetals. These facts help you decide whether a model needs charged ions or shared pairs.

3. Next, look at the groups of electrons around the central atom of a covalent molecule. A single bond or a double bond counts as one bonding group; each lone pair is another group. Electron groups spread out because they repel one another. Two bonding groups and no lone pairs give a linear molecule. Three bonding groups and no lone pairs give a trigonal planar molecule. Three bonding groups and one lone pair give a trigonal pyramidal molecule. Two bonding groups and two lone pairs give a bent molecule. Four bonding groups and no lone pairs give a tetrahedral molecule.

2 ANSWER WITH EVIDENCE

Use the passage

1. For MgO, predict the bonding type. Describe the charged particles your Lewis model would show and explain how they form.

2. For CO_2, show the bond connections in a Lewis model using words or symbols. Predict the molecule's shape and explain your choice.

3. For NH_3, predict the bonding type and three-dimensional shape. What does your Lewis model show around nitrogen?

4. For H_2O, predict the shape from a Lewis model. Why do its two bonds not make the molecule linear?

3 YOUR TURN

Your own words

Draw a Lewis dot model of CH_2O in the box. Write two sentences that predict its bonding type and three-dimensional shape, and explain how your model supports both predictions.

ANSWER KEY

From Dots to Shape

PART 1 · READ AND MARK

Underline facts about outer electrons, circle clues about ionic and covalent bonding, and number each shape rule by its number of bonding groups. Use your marks to build models for the questions. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	For MgO, predict the bonding type. Describe the charged particles your Lewis model would show and explain how they form.	**Ionic. Magnesium loses two electrons to become Mg^{2+}; oxygen gains them to become O^{2-}. A Lewis model shows the charged ions rather than a shared pair.**
2	For CO_2, show the bond connections in a Lewis model using words or symbols. Predict the molecule's shape and explain your choice.	**O=C=O, with two lone pairs on each oxygen. Carbon has two bonding groups and no lone pairs, so the molecule is linear.**
3	For NH_3, predict the bonding type and three-dimensional shape. What does your Lewis model show around nitrogen?	**The bonds are covalent. Nitrogen has three bonds to hydrogen and one lone pair, giving the molecule a trigonal pyramidal shape.**
4	For H_2O, predict the shape from a Lewis model. Why do its two bonds not make the molecule linear?	**The molecule is bent. Oxygen has two bonds and two lone pairs, not two bonds and no lone pairs.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Lewis sketch: H-C(=O(··)(··))-H
The bonds are covalent because all the atoms are nonmetals. Carbon has three bonding groups and no lone pairs, so the molecule is trigonal planar.

Accept equivalent Lewis drawings, including lines for shared electron pairs. For CH_2O, check for two C-H single bonds, one C=O double bond, and two lone pairs on oxygen.