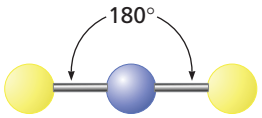
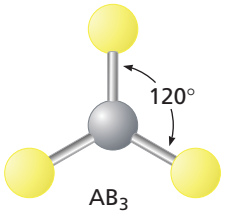


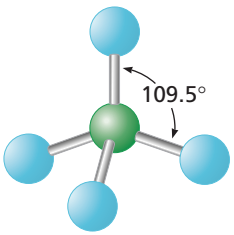

$AB_2$

**(a)** Beryllium fluoride, $BeF_2$




$AB_3$

**(b)** Boron trifluoride, $BF_3$




$AB_4$

**(c)** Methane, $CH_4$

**FIGURE 21** Ball-and-stick models show the shapes of (a) $AB_2$, (b) $AB_3$, and (c) $AB_4$ molecules according to VSEPR theory.

on opposite sides of the beryllium atom, 180° apart. Thus, all three atoms lie on a straight line. The molecule is linear.

If we represent the central atom in a molecule by the letter *A* and we represent the atoms bonded to the central atom by the letter *B*, then according to VSEPR theory, $BeF_2$ is an example of an $AB_2$ molecule, which is linear. Can you determine what an $AB_3$ molecule looks like? The three A—B bonds stay farthest apart by pointing to the corners of an equilateral triangle, giving 120° angles between the bonds. This trigonal-planar geometry is shown in **Figure 21b** for the $AB_3$ molecule boron trifluoride, $BF_3$.

The central atoms in $AB_4$ molecules follow the octet rule by sharing four electron pairs with B atoms. The distance between electron pairs is maximized if each A—B bond points to one of four corners of a tetrahedron. This geometry is shown in **Figure 21c** for the $AB_4$ molecule methane, $CH_4$. The same figure shows that in a tetrahedral molecule, each of the bond angles formed by the A atom and any two of the B atoms is equal to 109.5°.

The shapes of various molecules are summarized in **Table 5.** B can represent a single type of atom, a group of identical atoms, or a group of different atoms on the same molecule. The shape of the molecule will still be based on the forms given in the table. However, different sizes of B groups distort the bond angles, making some bond angles larger or smaller than those given in the table.

## SAMPLE PROBLEM E

**Use VSEPR theory to predict the molecular geometry of boron trichloride, $BCl_3$.**

**SOLUTION**

First write the Lewis structure for $BCl_3$. Boron is in Group 13 and has three valence electrons.

$$\cdot\dot{B}\cdot$$

Chlorine is in Group 17, so each chlorine atom has seven valence electrons.

$$:\ddot{Cl}:$$

The total number of available valence electrons is therefore $24e^-$ ($3e^-$ from boron and $21e^-$ from chlorine). The following Lewis structure uses all $24e^-$.

$$\begin{array}{c} :\ddot{Cl}: \\ :\ddot{Cl}:\dot{B}:\ddot{Cl}: \end{array}$$

This molecule is an exception to the octet rule because in this case B forms only three bonds. Boron trichloride is an $AB_3$ type of molecule. Therefore, according to VSEPR theory, it should have trigonal-planar geometry.