EXERCISES

Molecular Shapes; the VSEPR Model

9.11 CQ (a) An AB_2 molecule is described as linear, and the A—B bond length is specified. Does this information completely describe the geometry of the molecule? (b) The molecules BF_3 and SO_3 are both described as trigonal planar. Does this information completely define the bond angles of these molecules?

9.12 CQ (a) Methane (CH_4) and the perchlorate ion (ClO_4^-) are both described as tetrahedral. What does this indicate about their bond angles? **(b)** The NH_3 molecule is trigonal pyramidal. How many parameters need to be specified to define its geometry completely?

9.13 CQ (a) What is meant by the term *electron domain*? **(b)** Explain in what way electron domains behave like the balloons in Figure 9.5. Why do they do so?

9.14 CQ (a) How does one determine the number of electron domains in a molecule or ion? **(b)** What is the difference between a *bonding electron domain* and a *nonbonding electron domain*?

9.15 Describe the characteristic electron-domain geometry of each of the following numbers of electron domains about a central atom: **(a)** 3, **(b)** 4, **(c)** 5, **(d)** 6.

9.16 Indicate the number of electron domains about a central atom, given the following angles between them: (a) 120°, (b) 180°, (c) 109.5°, (d) 90°.

9.17 CQ What is the difference between the electron-domain geometry and the molecular geometry of a molecule? Use the water molecule as an example in your discussion.

9.18 CQ An AB_3 molecule is described as having a trigonal-bipyramidal electron-domain geometry. How many nonbonding domains are on atom A? Explain.

9.19 Give the electron-domain and molecular geometries of a molecule that has the following electron domains on its central atom: **(a)** four bonding domains and no nonbonding domains, **(b)** three bonding domains and two nonbonding domains, **(c)** five bonding domains and one nonbonding domain.

9.20 What are the electron-domain and molecular geometries of a molecule that has the following electron domains on its central atom? **(a)** Three bonding domains and no nonbonding domains, **(b)** three bonding domains and one nonbonding domain, **(c)** two bonding domains and three nonbonding domains.

9.21 Draw the Lewis structure for each of the following molecules or ions, and predict their electron-domain and molecular geometries: **(a)** PF_3, **(b)** CH_3^+, **(c)** BrF_3, **(d)** ClO_4^-, **(e)** XeF_2, **(f)** BrO_2^-.

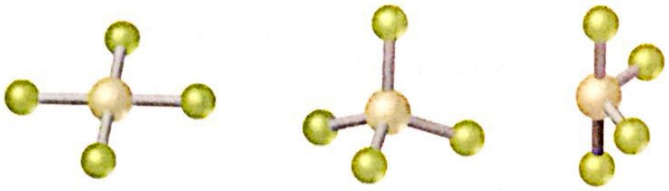
9.22 Give the electron-domain and molecular geometries for the following molecules and ions: **(a)** HCN, **(b)** SO_3^{2-}, **(c)** SF_4, **(d)** PF_6^-, **(e)** NH_3Cl^+, **(f)** N_3^-.

9.23 CQ The figure that follows shows ball-and-stick drawings of three possible shapes of an AF_3 molecule. **(a)** For each shape, give the electron-domain geometry on which the molecular geometry is based. **(b)** For each shape, how many nonbonding electron domains are there on atom A? **(c)** Which of the following elements will lead to an AF_3 molecule with the shape in (ii): Li, B, N, Al, P, Cl?

(d) Name an element A that is expected to lead to the AF_3 structure shown in (iii). Explain your reasoning.

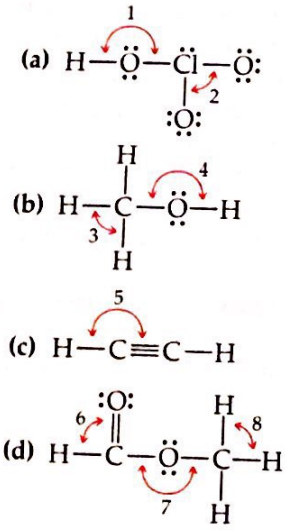
(i) (ii) (iii)

9.24 CQ The figure that follows contains ball-and-stick drawings of three possible shapes of an AF_4 molecule. **(a)** For each shape, give the electron-domain geometry on which the molecular geometry is based. **(b)** For each shape, how many nonbonding electron domains are there on atom A? **(c)** Which of the following elements will lead to an AF_4 molecule with the shape in (iii): Be, C, S, Se, Si, Xe? **(d)** Name an element A that is expected to lead to the AF_4 structure shown in (i).

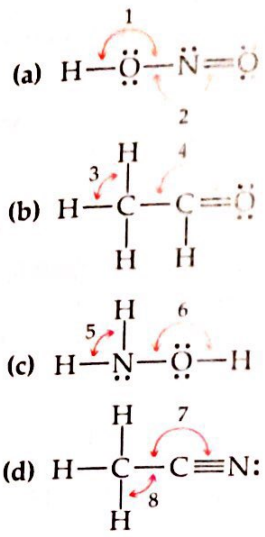


(i) (ii) (iii)

9.25 Give the approximate values for the indicated bond angles in the following molecules:



9.26 Give approximate values for the indicated bond angles in the following molecules:



9.27 CQ The three species NH_2^-, NH_3, and NH_4^+ have H—N—H bond angles of 105°, 107°, and 109°, respectively. Explain this variation in bond angles.

9.28 CQ Predict the trend in the F(axial)—A—F(equatorial) bond angle in the following AF_n molecules: PF_5, SF_4, and ClF_3.

9.29 CQ **(a)** Explain why BrF_4^- is square planar, whereas BF_4^- is tetrahedral. **(b)** In which of these molecules, CF_4 or SF_4, do you think the actual bond angle is closest to the ideal angle predicted by the VSEPR model? Explain briefly.

9.30 CQ **(a)** Explain why the following ions have different bond angles: ClO_2^- and NO_2^-. Predict the bond angle in each case. **(b)** Given that the spatial requirement of a nonbonding pair of electrons is greater than that of a bonding pair, explain why the XeF_2 molecule is linear and not bent.

Polarity of Polyatomic Molecules

9.31 CQ Does SO_2 have a dipole moment? If so, in which direction does the net dipole point?

9.32 CQ The PH_3 molecule is polar. How does this offer experimental proof that the molecule cannot be planar?

9.33 CQ **(a)** Consider the AF_3 molecules in Exercise 9.23. Which of these will have a nonzero dipole moment? Explain. **(b)** Which of the AF_4 molecules in Exercise 9.24 will have a zero dipole moment?

9.34 CQ **(a)** What conditions must be met if a molecule with polar bonds is nonpolar? **(b)** What geometries will give nonpolar molecules for AB_2, AB_3, and AB_4 geometries?

9.35 Predict whether each of the following molecules is polar or nonpolar: **(a)** CCl_4, **(b)** NH_3, **(c)** SF_4, **(d)** XeF_4, **(e)** CH_3Br, **(f)** GaH_3.

9.36 Predict whether each of the following molecules is polar or nonpolar: **(a)** IF, **(b)** CS_2, **(c)** SO_3, **(d)** PCl_3, **(e)** SF_6, **(f)** IF_5.