Exercises 7

Exercise 7.1
Predict the VSEPR geometry and polarity for the following molecules:

a) BeH_2 b) BrF_3 c) $SeBr_2$ d) BrF_2^-
e) IF_5 f) SO_2 g) $SiCl_4$ h) O_3
i) PCl_3 j) SBr_4 k) ICl_3 l) SbF5
m) $SeCl_6$ n) XeF_4 o) $AlBr_3$

Solutions
a) AX_2 (non polar) b) AX_3E_2 (polar) c) AX_2E_2 (polar) d) AX_2E_3 (non polar)
e) AX_5E (polar) f) AX_2E (polar) g) AX_4 (non polar) h) AX_2E (polar)
i) AX_3E (polar) j) AX_4E (polar) k) AX_3E_2 (polar) l) AX_5 (non polar)
m) AX_6 (non polar) n) AX_4E_2 (non polar) o) AX_3 (non polar)

Exercise 7.2
Place the following molecules or ions in order of *decreasing* bond length:
(a) the CO bond in CO, CO_2, CO_3^{2-}
(b) the SO bond in SO_2, SO_3, SO_3^{2-}
(c) the CN bond in HCN, CH_2NH , CH_3NH_2.
Explain your reasoning.

Solutions
(a) CO_3^{2-} (all bonds in a resonance structure have the same length. The length of the bond is shorter than a single bond, but longer than a double bond) > CO_2 (has two double bonds) > CO (has a triple bond). Multiple bonds are shorter than single bonds.
(b) SO_3^{2-} (negative charges increase repulsion in the molecule) > SO_2 (partial double bond character due to resonance) > SO_3 (sulfur atom forms double bond with each oxygen)
(c) CH_3NH_2 (single bond) > CH_2NH (double bond) > HCN (triple bond).

Exercise 7.3
What geometry can we expect for the following molecules: $BeCl_2$, BF_3, ClF_3, XeF_4 and SF_6?

Solutions
- $BeCl_2$, VSEPR AX_2 model ⇒ linear.
- BF_3, VSEPR AX_3 model ⇒ trigonal planar.
- ClF_3, VSEPR model AX_3E_2 ⇒ T-shaped. If chlorine forms 3 bonds, it has two free pairs left.
- XeF_4, VSEPR model AX_4E_2 ⇒ square planar. Similarly, when Xe forms 4 bonds, it is left with two lone pairs.
- SF_6, VSEPR model AX_6 ⇒ octahedral.

Exercise 7.4
Which do you predict to have the strongest CX bond, where X is a halogen: (a) CF_4 , (b) CCl_4, or (c) CBr_4? Explain.

Solution (a) CF_4 has the strongest C–X bond.

As we move down the halogen group in the periodic table—from fluorine to chlorine to bromine—the atomic radius of the halogen atoms increases. An increased atomic radius leads to weaker bonds.

Exercise 7.5

Which do you predict to have the strongest CN bond: (a) $NHCH_2$, (b) NH_2CH_3, or (c) HCN? Explain.

Solution: (c) HCN has the strongest bond.

Bond strength trends are opposite to bond length trends. The triple bond in (c) means there are more electrons binding the atoms together, when compared to the double bond in in (a) and single bond in (b).