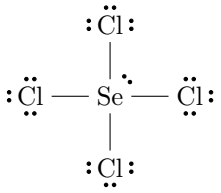
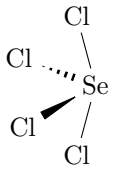
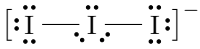
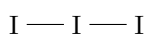
1/21: I) Do the following (VSEPR) problems from your text (Miessler et al. (2014)): Chapter 3: #8, 9f-i, 20, 29.

3.8 Give Lewis dot structures and sketch the shapes of the following:

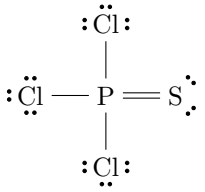
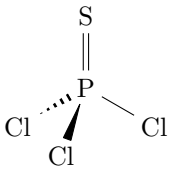
a. $SeCl_4$

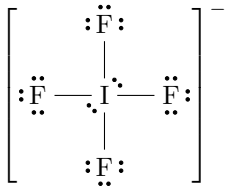
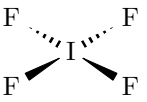
b. I_3^-

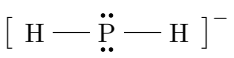
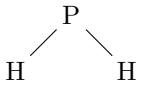
c. $PSCl_3$

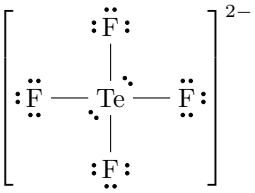
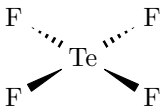
d. IF_4^-

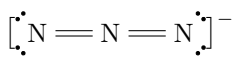
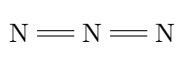
e. PH_2^-

f. TeF_4^{2-}

g. N_3^-

h. $SeOCl_4$

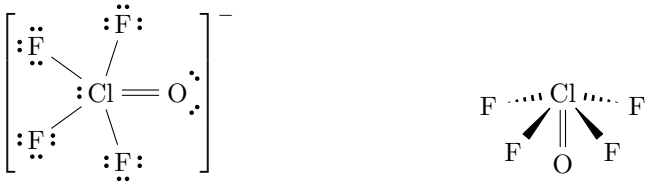
i. PH_4^+

3.9 Give Lewis dot structures and sketch the shapes of the following.

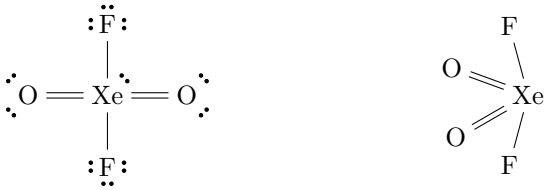
f. $IO(OH)_5$

g. $SOCl_2$

h. $ClOF_4^-$ [1]

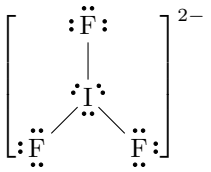


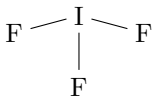
i. XeO_2F_2



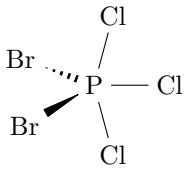
[1]Note that it is unclear whether the equatorial fluorines will be bent away from the lone pair and toward the oxygen, or the other way around. Hence, I arbitrarily chose to show them pointed away from the lone pair.

3.20 Predict and sketch the structure of the (as yet) hypothetical ion $IF_3{}^{2-}$.





3.29 Sketch the most likely structure of PCl_3Br_2 and explain your reasoning.



Answer. Bromine is more electropositive than chlorine. Thus, by Bent's rule, the bromines will bond to the hybrid orbitals with greater s-character (the equatorial sp^2 ones) first. □

II) Assign the symmetry point group to the 13 ions and molecules in problems #8, 9f-i in Chapter 3 of your text.

3.8

a. $SeCl_4$

Answer. Not low or high symmetry. Has a C_2 axis. No perpendicular C_2 axes. No σ_h. Has two perpendicular σ_v planes.
Therefore, $SeCl_4$ is of the C_{2v} point group. □

b. I_3^-

Answer. I_3^- is of the $D_{\infty h}$ point group. □

c. $PSCl_3$

Answer. Not low or high symmetry. Has a C_3 axis. No perpendicular C_2 axes. No σ_h. Has three σ_v planes all offset by 60°.
Therefore, $PSCl_3$ is of the C_{3v} point group. □

d. IF_4^-

Answer. Not low or high symmetry. Has a C_4 axis. Has 4 perpendicular C_2 axes. Has σ_h.
Therefore, IF_4^- is of the D_{4h} point group. □

e. PH_2^-

Answer. Not low or high symmetry. Has a C_2 axis. No perpendicular C_2 axes. No σ_h. Has two perpendicular σ_v planes.
Therefore, PH_2^- is of the C_{2v} point group. □

f. TeF_4^{2-}

Answer. Not low or high symmetry. Has a C_4 axis. Has 4 perpendicular C_2 axes. Has σ_h.
Therefore, TeF_4^{2-} is of the D_{4h} point group. □

g. N_3^-

Answer. N_3^- is of the $D_{\infty h}$ point group. □

h. $SeOCl_4$

Answer. Not low or high symmetry. Has a C_2 axis. No perpendicular C_2 axes. No σ_h. Has two perpendicular σ_v planes.
Therefore, $SeOCl_4$ is of the C_{2v} point group. □

i. PH_4^+

Answer. PH_4^+ is of the T_d point group. □

3.9

f. $IO(OH)_5$

Answer. Not low or high symmetry. Has a C_4 axis. No perpendicular C_2 axes. No σ_h. Has two perpendicular σ_v planes and two perpendicular σ_d planes.
Therefore, $IO(OH)_5$ is of the C_{4v} point group. □

g. $SOCl_2$

Answer. $SOCl_2$ is of the C_s point group. □

h. $ClOF_4^-$

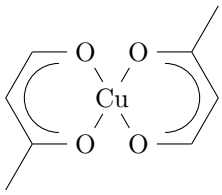
Answer. Not low or high symmetry. Has a C_4 axis. No perpendicular C_2 axes. No σ_h. Has two perpendicular σ_v planes and two perpendicular σ_d planes.
Therefore, $ClOF_4^-$ is of the C_{4v} point group. □

i. XeO_2F_2

Answer. Not low or high symmetry. Has a C_2 axis. No perpendicular C_2 axes. No σ_h. Has two perpendicular σ_v planes.
Therefore, XeO_2F_2 is of the C_{2v} point group. □

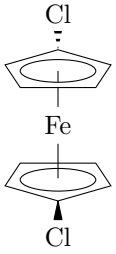
III) Assign the symmetry point group of the following molecules and objects. Ignore the H atoms in (a), (e), and (g). Note that (e) has pseudooctahedral geometry and (g) is square-planar.

a) The molecule pictured below.



Answer. Not low or high symmetry. Has a C_2 axis. No perpendicular C_2 axes. Has a σ_h.
Therefore, the above molecule is of the C_{2h} point group. □

b) The molecule pictured below.



Answer. Not low or high symmetry. Has a C_2 axis. No perpendicular C_2 axes. Has a σ_h
Therefore, the above molecule is of the C_{2h} point group. □

c) $POCl_3$

Answer. Not low or high symmetry. Has a C_3 axis. No perpendicular C_2 axes. No σ_h. Has three σ_v planes all offset by 60°.
Therefore, $POCl_3$ is of the C_{3v} point group. □

d) Tennis ball (including the seam)

Answer. Not low or high symmetry. Has a C_2 axis. Has 2 perpendicular C_2 axes. No σ_h. Has two perpendicular σ_d planes.
Therefore, a tennis ball is of the D_{2d} point group. □

e) *trans*-$[CrCl_2(H_2O)_4]^+$

Answer. Not low or high symmetry. Has a C_4 axis. Has 4 perpendicular C_2 axes. Has σ_h.
Therefore, *trans*-$[CrCl_2(H_2O)_4]^+$ is of the D_{4h} point group. □

f) 1,3,5-trichlorobenzene.

Answer. Not low or high symmetry. Has a C_3 axis. Has 3 perpendicular C_2 axes. Has σ_h.
Therefore, 1,3,5-trichlorobenzene is of the D_{3h} point group. □

g) *trans*-$Pt(NH_3)_2Cl_2$

Answer. Not low or high symmetry. Has a C_2 axis. Has 2 perpendicular C_2 axes. Has σ_h.
Therefore, *trans*-$Pt(NH_3)_2Cl_2$ is of the D_{2h} point group. □

h) SF_5Cl

Answer. Not low or high symmetry. Has a C_4 axis. No perpendicular C_2 axes. No σ_h. Has two perpendicular σ_v planes and two perpendicular σ_d planes.
Therefore, SF_5Cl is of the C_{4v} point group. □

i) BFClBr

Answer. BFClBr is of the C_s point group. □

j) $PF_2{}^+$

Answer. Not low or high symmetry. Has a C_2 axis. No perpendicular C_2 axes. No σ_h. Has two perpendicular σ_v planes.
Therefore, $PF_2{}^+$ is of the C_{2v} point group. □

IV) In the octahedral ion FeF_6^{3-}, what symmetry elements are destroyed if two *trans* F ions are moved away from the Fe^{3+} center in an equidistant fashion?

Answer. If the described change is made, the point group changes from O_h to D_{4h}. In this change, every C_3 and S_6 axis, two of the three C_4 axes, four C_2 axes, and every σ_d that does not contain the axis along which the F ions are stretched are destroyed. □