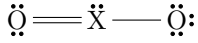
Key for Take-Home Assigment 05

For each of the following molecules or polyatomic ions, identify the group from the perodic table to which X belongs and then report the element within that group with the smallest atomic number that can account for the structure. For example, you might say that X is from Group 17 and that it is chlorine. In addition to identifying X, explain how you arrived at your answer in 1–2 sentences. For all of these problems, the skeletal structure consists only of bonds between X and the other atoms in the molecules or polyatomic ions.

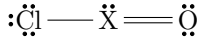
1. XO_2 with an average X–O bond order of 1.5.

   With an X–O bond order of 1.5, the structure must have both a double bond and a single bond between X and O, and these bonds must be equivalent to each other through resonance. The three bonds to X account for six electrons around X, which means there also is a lone-pair of electrons on X so that it has an octet. The structure, shown below, has 18 electrons; subtracting 12 for the two oxygens leaves six electrons for X, which is in group 16 and is oxygen.



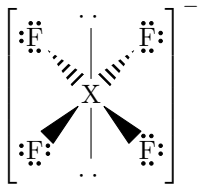
2. XOCl with one lone pair of electrons on X.

   The structure, which is shown below, has 18 total electrons; subtracting six for oxygen and seven for chlorine leaves five electrons for X, which means it is in group 15 and is N.



3. XF_4^- with a square-planar geometry.

   A square planar bonding geometry exists only within an octahedral electron domain geometry. This is an important observation because it tells us that there are two lone-pairs on X, giving a total of 36 electrons for the structure shown below. Subtracting 28 electrons for the four fluorines and subtracting one electron for the negative charge leaves seven electrons for X, which means it is in group 17 and is chlorine as it is the first element in the group that can expand beyond an octet.



4. XF_2^- with geometry that is non-polar.

   Knowing that the ion is non-polar requires that it be linear, which, in turn, requires that it is in either the AX_2 electron domain with no lone-pairs on X, or that it is in the AX_5 electron domain with three lone-pairs on X. As fluorine does not form double bonds, we can eliminate the AX_2 electron domain, giving the structure shown below, which has 22 total electrons. Subtracting the 14 electrons for the two fluorines and subtracting one electron for the negative charge leaves seven electrons for X, which means it is in group 17 and is chlorine as it is the first element in the group that can expand beyond an octet.