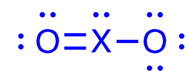
Review of Unit II

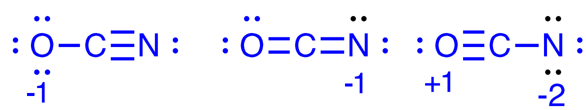
In which we consider the types of bonding in and geometry of inorganic compounds and consider the structure of solid-state materials.

1. The compound XO_2 has a bent geometry with a double bond to one oxygen and a single bond to the other oxygen, and a single lone-pair of electrons on X. Limiting yourself to the first 18 elements, identify the possible choices for X. The Lewis structure is shown to the right and includes 18 total valence electrons. Each oxygen provides six valence electrons, leaving six valence electrons for X. Of the first 18 elements, both oxygen and sulfur are possibilities.



2. Suggest a possible element for X in the compound XF_4^- if there are two lone-pairs of electrons on X. For X to be bound to four fluorines and to have two lone pairs of electrons, it must have a square planar bonding geometry and an octahedral electron domain geometry. Each fluorine has three lone-pairs of electrons and a single bond to X, accounting for eight electrons each and a total of 32 electrons. Including the two lone-pairs of electrons on X increases the total number of valence electrons to 36. Each fluorine provides seven valence electrons, accounting for 28 of the 36 electrons. This leaves eight electrons unaccounted for, one of which is the anionic charge. Element X, therefore, has seven valence electrons. Possible elements are chlorine, bromine, iodine, and astatine; fluorine is not a possibility as it cannot expand beyond an octet.

3. Consider the polyatomic anion OCN^-. Draw all possible Lewis structures for this anion and give the formal charge on each atom in each structure. Rank the structures from best to worst and explain your reasoning? There are 16 valence electrons in this polyatomic anion. The three possible Lewis structures are shown here (with formal charges below the elements).



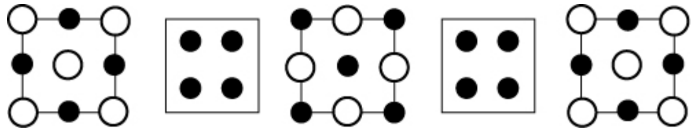
   The best of these structures is the one on the left as it places the formal charge on the most electronegative element. For several reasons, the worst of these structures is the one on the right: it has more elements with formal charges; it separates positive and negative formal charges; and, it has a positive formal charge on the most electronegative element.

4. Draw the best Lewis structure for CS_2 and for SO_2, and identify the compound that has the larger dipole moment. The Lewis structures for the two compounds are shown here

   Because CS_2 is a symmetrical linear compound, it is non-polar and has no dipole moment. On the other hand, SO_2 has a bent geometry, which makes it polar and with a dipole moment.

5. Consider the compounds HgO, ZrO, SrO, and SeO_2. Which compound is likely to have the highest melting point? Explain your reasoning. Ionic compounds generally have higher melting points than do covalent compounds; we can, therefore, eliminate SeO_2 from consideration as bonding between two non-metals is more covalent-like. The other three compounds are more ionic-like and the simplest way to evaluate their relative melting points is to use Coulomb's law, which states that the force of attraction between a cation and an anion is directly proportional to the cation's charge, the anion's charge, and the distance separating them. As all three compoiunds have a +2 cation and a –2 anion, and since the anion, O^{2-}, is the same in all three compounds, we need consider only the relative size of the cations and choose the smallest. Of the three, Zr^{2+} is the smallest; thus, ZrO has the highest melting point.

6. The cross sections below show the arrangements of lithium ions (black circles) and bismuth ions (white circles) in lithium bismuthide. What is the simplest, empirical formula of this compound? What type of packing is adopted by bismuth ions? In what type of holes do you find lithium ions?



Working from left-to-right, the first layer has four lithium ions on edges, each contributing to four unit cells (a net of one Li^{+} ion), four bismuth ions on corners, each contributing to eight unit cells, and one bisumth on a face, contributing to two unit cells (a net of one Bi^{3-} ion). The second layer has four lithium ions wholly within the unit cell (a net of four Li^{+} ions). The third layer has four lithium ions on edges, each contributing to four unit cells and one lithium ion wholly within the unit cell (a net of two Li^{+} ions), and four bismuth ions on faces, each contributing to two unit cells (a net of two Bi^{3-} ions). The fourth layer has four lithium ions wholly within the unit cell (a net of four Li^{+} ions). Finally, the last layer has four lithium ions on edges, each contributing to four unit cells (a net of one Li^{+} ion) four bismuth ions on corners, each contributing to eight unit cells, and one bisumth on a face, contributing to two unit cells (a net of one Bi^{3-} ion). Across all five layers we have 12 Li^{+} ions and 4 Bi^{3-} ions, giving an empirical formula of Li_3Bi. The lithium ions in layers two and four occupy tetrahedral holes; the lithium ions in the other three layers occupy octahedral holes.