CHEM 103
R&R 14
19 June 2024
Adapted from a 24 June 2021 document

1. Arrange the following in order of increasing atomic radius:

a. Ca, Rb, S, Si, Ge, F $F < S < Si < Ge < Ca < Rb$

b. Be^{2+}, Ca^{2+}, Mg^{2+}, Sr^{2+} $Be^{2+} < Mg^{2+} < Ca^{2+} < Sr^{2+}$

c. Na^{+}, Al^{3+}, Mg^{2+} $Al^{3+} < Mg^{2+} < Na^{+}$

d. Cl^{-}, K^{+}, Se^{2-} $K^{+} < Cl^{-} < Se^{2-}$

e. Cl^{-}, Br^{-}, I^{-} $Cl^{-} < Br^{-} < I^{-}$

f. F^{-}, Na^{+}, O^{2-} $Na^{+} < F^{-} < O^{2-}$

2. Rank the following elements in order of increasing electron affinity: Si, F, O, C

$Si < C < O < F$

3. In each of the following sets, which atom or ion has the smallest first ionization energy?

a. Ba, Ca, Sr

b. Ga, K, Mn

c. F, N, O N is $\uparrow\uparrow\uparrow$, O is $\uparrow\downarrow\uparrow\uparrow$

d. Ar, Cs, Ge

4. The first ionization energies of As and Se are 0.947 and 0.941 MJ mol^{-1}, respectively. Rationalize these values.

As: $[Ar]3d^{10}4s^{2}4p^{3}$ Se: $[Ar]3d^{10}4s^{2}4p^{4}$

Even though Se has a greater Z_{eff}, and so we would typically expect a greater first ionization energy, As has a particularly stable electron configuration, with an exactly half-filled set of p orbitals.

5. What is the maximum number of electrons in an atom that can have the following quantum numbers? Specify the orbitals in which the electrons would be found.

a. n = 2, m_s = +½ 4 e^-. one in 2s, three in 2p

b. n = 4, m_l = 1 6 e^-. two in each of 4p, 4d, 4f.

c. n = 3, l = 2 10 e^-. All in 3d

d. n = 2, l = 0, m_s = -½ 1 e^-. This electron is spin down in 2s.

e. n = 4, l = 3, m_l = -2 2 e^-. They are in 4f.

6. Rank the following ions in order of decreasing ionic radii: Na^+, O^{2-}, N^{3-}, Mg^{2+}

$N^{3-} > O^{2-} > Na^+ > Mg^{2+}$

What name is given for a set of ions like this?

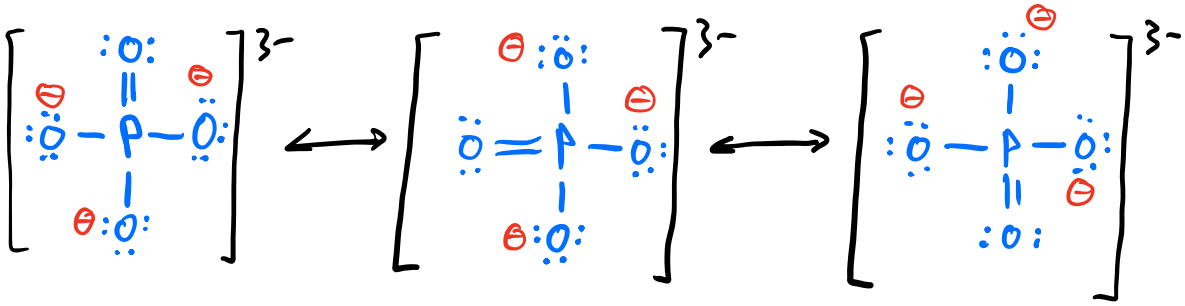
isoelectronic series

7. Lithium has a first ionization energy of 520 kJ mol^{-1}. What is the longest wavelength of light that can remove the valence electron from Li?

$E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E}$ ✡ Minimizing E maximizes λ.

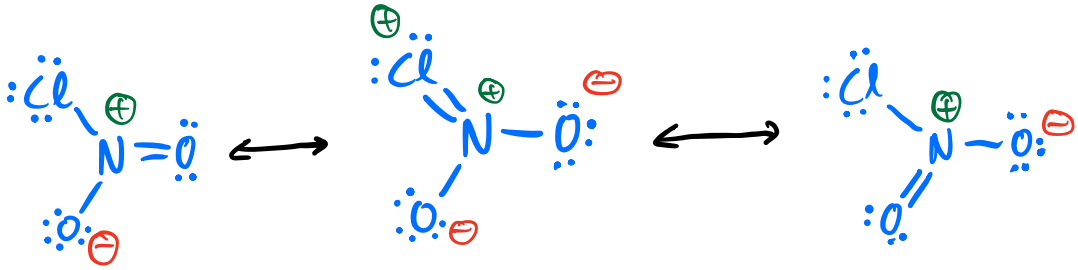
$$\lambda = \frac{(6.626\times10^{-34}\ J\cdot s)\left(3.00\times10^{8}\ \frac{m}{s}\right)}{(520\times10^{3}\ J)(6.022\times10^{23})^{-1}} = 2.3\times10^{-7}\ m = 230\ nm$$

8. Draw three resonance structures for phosphate.



9. The formula for nitryl chloride is NO_2Cl.

a. Draw the Lewis dot structure for the molecule, including all resonance structures.



b. Describe the electron pair geometry and molecular geometries, and give values for all bond angles.

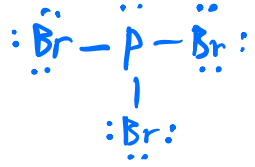
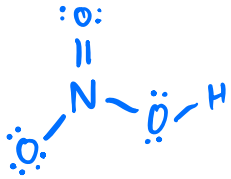
electron pair geometry: trig. planar
molecular geometry: trig. planar
bond angles: 120°

c. What is the most polar bond in the molecule? Is the molecule polar? Why or why not?

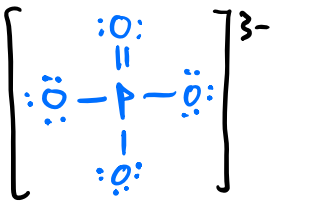
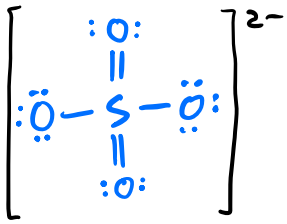
The N-O bond is the most polar because it has the largest electronegativity difference without sharing as many electrons.

The molecule is polar because the dipole moments of each bond do not cancel out.

10. Draw the Lewis dot structure for the following compounds and give the total number of electrons.

PBr_3 26 e⁻	HNO_3 24 e⁻	SCl_2 20 e⁻
		

11. Indicate whether the following compounds contain ionic or covalent bonds. If both bonds are present, write "both." If the compounds contain covalent bonds, draw the Lewis structure of the covalent molecule or polyatomic ion.

$Mg_3(PO_4)_2$ both	CO_2 covalent	$CaSO_4$ both
		

12. Predict, using an electronegativity table, which bond in each of the following groups will be the most polar.

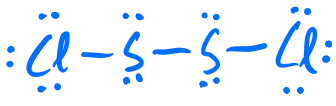
a. C—F Ge—F

b. S—F S—Cl S—Br

c. P—Cl S—Cl

d. Ti—Cl Si—Cl Ge—Cl

13. When molten sulfur reacts with chlorine gas, a vile-smelling orange liquid forms that has an empirical formula of SCl. All elements in this compound have a complete octet and a formal charge of 0. Draw the Lewis structure of this compound.

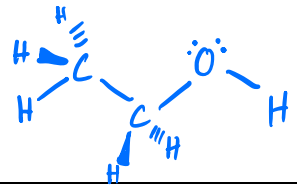
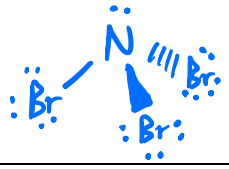
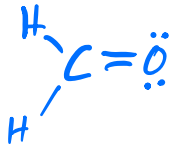
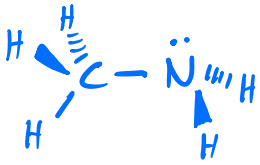
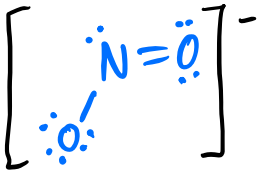
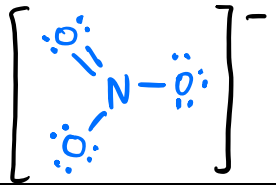
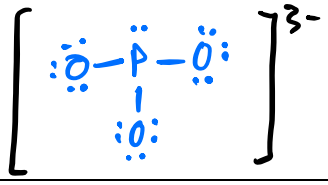
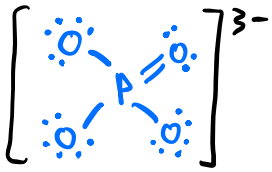


14. Rank the following molecules in the order of increasing polarity:

CH_4, CH_2Cl_2, CH_2F_2, CCl_2F_2, CCl_4, CF_4

$CH_4 = CCl_4 = CF_4 < CCl_2F_2 < CH_2Cl_2 < CH_2F_2$

15. Fill out the following table:

Molecule	3D Structure	Polar or nonpolar?	Electron pair geometry	Molecular geometry
CH_3CH_2OH		polar	C: tetrahedral O: tetrahedral	C: tetrahedral O: bent
NBr_3		polar	tetrahedral	trigonal pyramidal
CH_2O		polar	trigonal planar	trigonal planar
CH_3NH_2		polar	C: tetrahedral N: tetrahedral	C: tetrahedral N: trig pyramidal
Nitrite		polar	trig planar	bent
Nitrate		nonpolar	trig planar	trig planar
Phosphite		polar	tetrahedral	trig pyramidal
Phosphate		nonpolar	tetrahedral	tetrahedral