General Chemistry I
24 June 2021

1. **Arrange the following in order of increasing atomic radius:**
   a. **Ca, Rb, S, Si, Ge, and F:** F, S, Si, Ge, Ca, Rb
   b. **Be^{2+}, Ca^{2+}, Mg^{2+}, and 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 terms 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?**
   g. **Ba, Ca, Sr**
   h. **Ga, K, Mn**
   i. **F, N, O**
   j. **Ar, Cs, Ge**
4. **The first ionization energies of As and Se are 0.947 and 0.941 MJ/mol respectively. Rationalize these values.**

Normally, one would expect Se to have a higher ionization energy than As because Se has more protons in the nucleus, and thus its electrons would experience a higher effective nuclear charge. A stronger interaction between the valence electrons and the positive charge in the nucleus is a stabilizing interaction, making it more difficult to remove an electron.
However, this pair does not follow that trend. As has a half filled 4p subshell, while Se has one 4p orbital with paired electrons. Since half---filled subshells are relatively stable and due to electron repulsion, it is easier to remove the paired electron from one of the 4p orbitals in Se to form a half---filled subshell. The 4p subshell of As is already pretty stable, making it harder to remove an electron.

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 = +1/2:

4 (1 in 2s, 3 in 2p)

$2s^2$, $2p^6$. 8 electrons total, so 4 with that spin

b. n = 4, m_l = +1

6 (2 in 4p, 2 in 4d, 2 in 4f)

l must be greater than or equal to 1. 4p, 4d, 4f – m_l of +1 means one orbital from each subshell, so 6 total electrons

c. n = 3, l = 2

10 (10 in 3d)

d. n = 2, l = 0, m_s = - ½

1 (1 in 2s)

This specifies 2s orbital, half of which with this spin. So one electron.

e. n = 4, l = 3, m_l = - 2

2 (2 in 4f)

This is a specific orbital in the 4f subshell.

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

N^{3-}, O^{2-}, Na^+, Mg^{2+}

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

Isoelectronic series

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

$$\frac{520\ kJ}{1\ mol\ Li\ atom} * \frac{1\ mol\ Li\ atom}{6.022 * 10^{23}\ Li\ atom} * \frac{1000\ J}{1\ kJ} = 8.635 * 10^{-19}\ \frac{J}{atom}$$

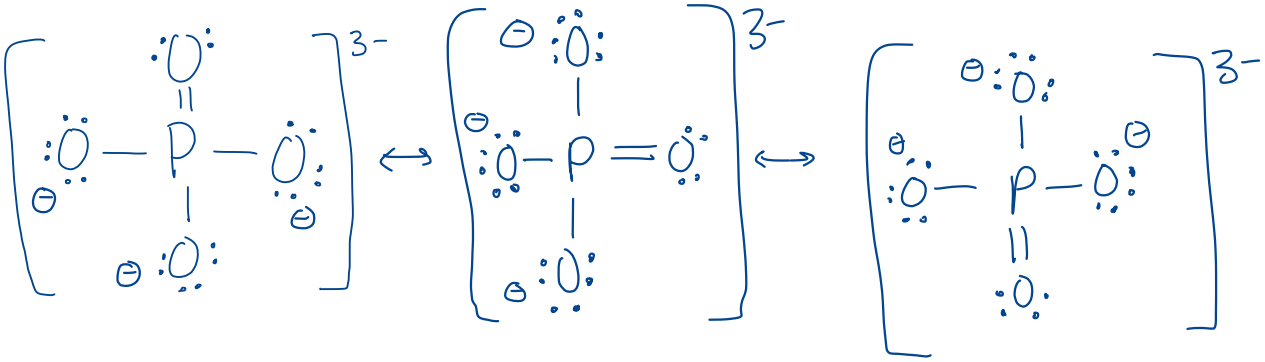
This means it takes 8.635×10^{-19} J to remove an electron from one atom of Li.

$$E = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E} = \frac{(6.626 * 10^{-34} J * s)\left(3.00 * 10^{8} \frac{m}{s}\right)}{8.635 * 10^{-19} J} = 2.3 * 10^{-7}\, m = 230\, nm$$

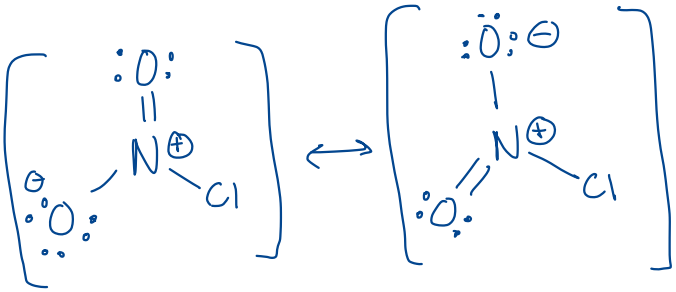
This is the longest wavelength because anything shorter would have more energy and thus enough energy to ionize Li.

8. Draw three resonance structures for phosphate = PO_4^{3-}



9. The formula for nitryl chloride is ClNO2.

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



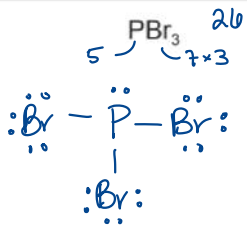
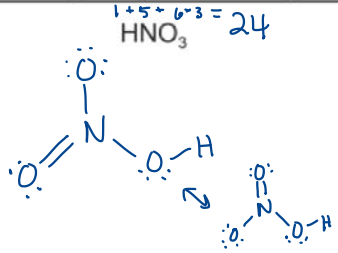
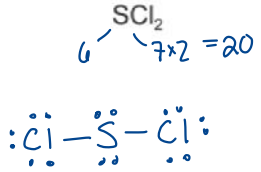
b. Describe the electron pair geometry and molecular geometries, and give values for all bond angles

Both electron pair and molecular geometries are trigonal planar. 120° bond angles.

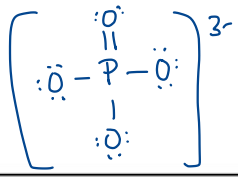
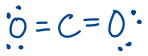
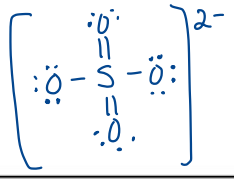
c. What is the most polar bond in the molecule? Is the molecule polar? Why or why not?

The N-O bond is the most polar one (and the only polar one). N-Cl is not a polar bond because there is no difference in their electronegativity values. The molecule is polar because there is a downward pointing net polarity.

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

PBr_3 26 	HNO_3 24 	SCl_2 20 

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/polyatomic ion.

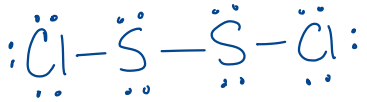
$Mg_3(PO_4)_2$ Both: Mg^{2+} & PO_4^{3-} 	CO_2 covalent 	$CaSO_4$ Both - Ca^{2+} / SO_4^{2-} 

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 formal charge of 0. Please draw its Lewis structure.

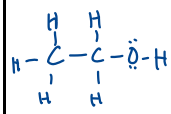
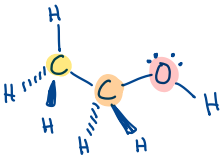
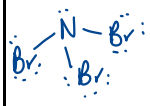
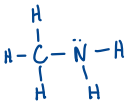
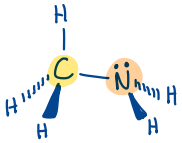
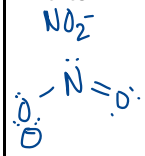
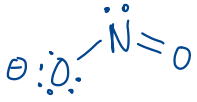
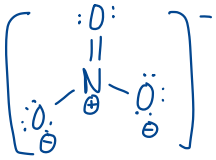
Cl likes to have 1 bond
S likes to have 2 bonds



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	3-D Structure	Polar or nonpolar	Electron Pair Geometry	Molecular Geometry
CH_3CH_2OH 		Polar	tetrahedral tetrahedral tetrahedral	tetrahedral tetrahedral bent
NBr_3 		Nonpolar	tetrahedral	trigonal pyramidal
H_2CO 		Polar	trigonal planar	trigonal planar
CH_3NH_2 		Polar	tetrahedral tetrahedral	tetrahedral trigonal pyramidal
Nitrite NO_2^- 		Polar	trigonal planar	bent
Nitrate NO_3^-		Nonpolar	trigonal planar	trigonal planar