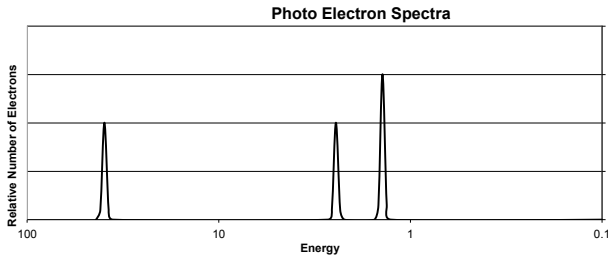
P H.1 Photoelectron Spectroscopy PES

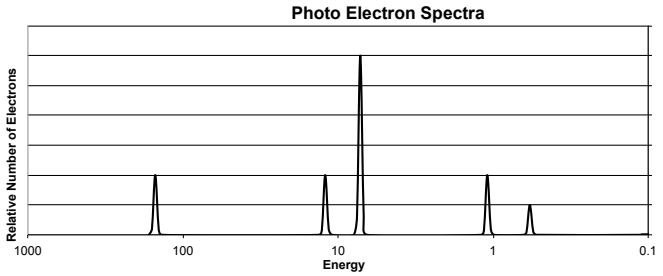
Name_____Per___

1. Which element could be represented by the complete PES spectrum to the right?
   a. Li
   b. B
   c. N
   d. Ne



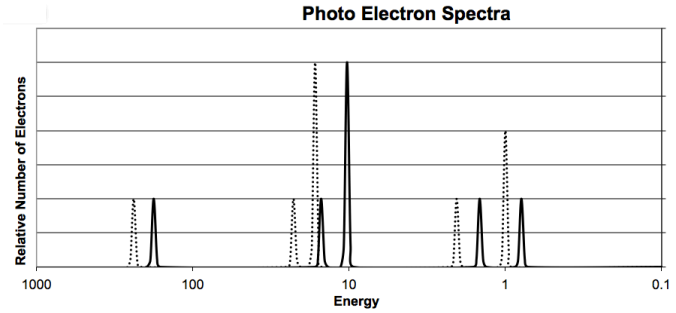
2. Which element could be represented by the complete PES spectrum to the right?

   Explain what electrons each peak represents, and what the height of the peaks represent.



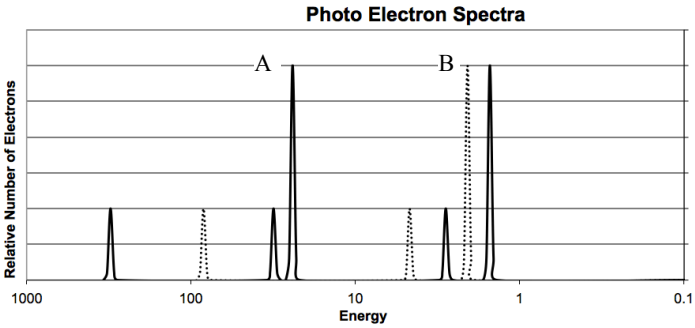
3. Which elements could be represented by the complete PES spectra to the right?

   Explain why all of the dashed peaks are to the left of the solid peaks?

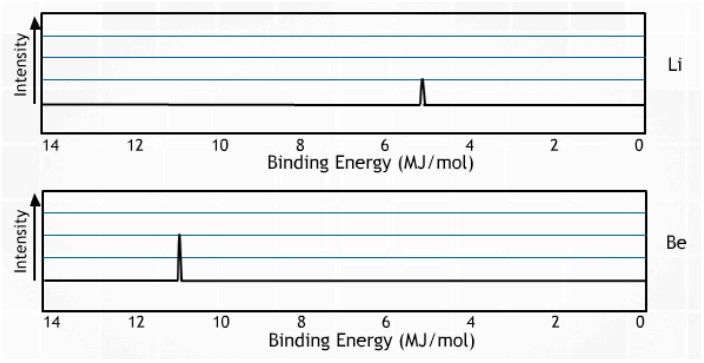


4. Which elements could be represented by the complete PES spectra to the right?

   Why might someone be inclined to think that peak A and peak B should be in the same location, yet they are not? Why might someone think this, and explain why they are so far apart.



5. Which of the following best explains the relative positioning and intensity of the 2s peaks in the two spectra to the right?
   a. Be has a greater nuclear charge than Li and more electrons in the 2s orbital.
   b. Be electrons experience greater electron-electron repulsions than Li electrons.
   c. Li has a greater pull from the nucleus on the 2s electrons, so they are harder to remove.
   d. Li has greater electron shielding by the 1s orbital, so the 2s electrons are easier to remove.



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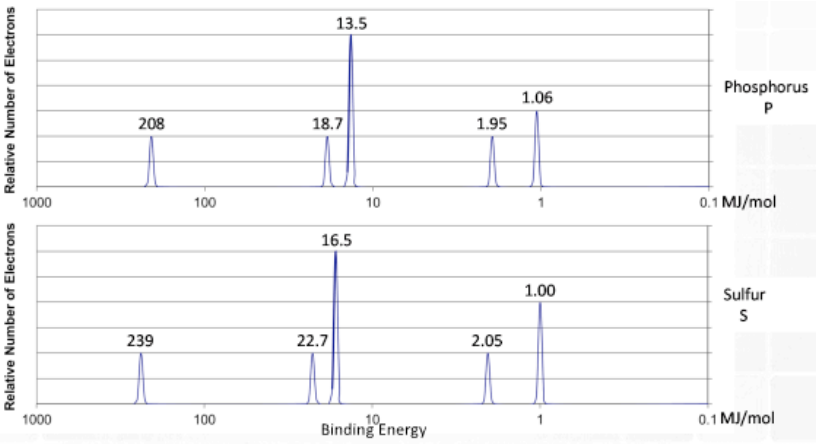
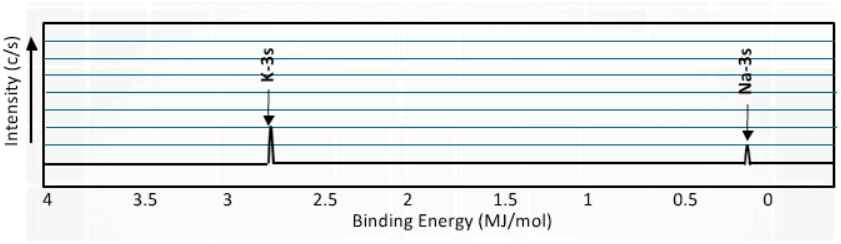
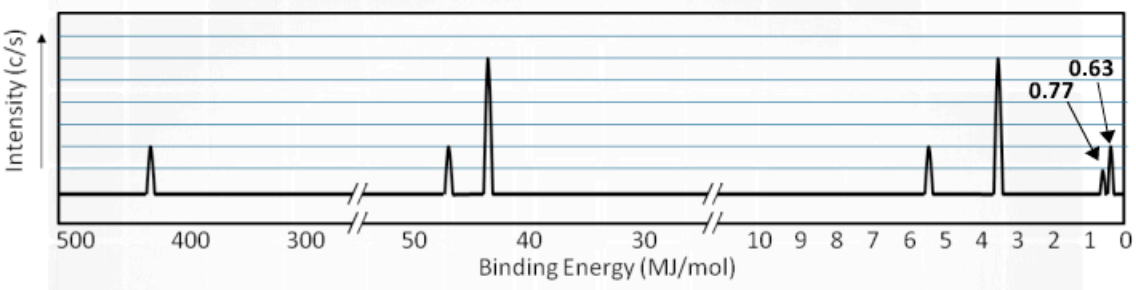
6. Given the photoelectron spectra above for phosphorus, P, and sulfur, S, which of the following best explains why the 2p peak for sulfur is further to the left than the 2p peak for phosphorous, but the 3p peak for sulfur is further to the right than the 3 p peak for phosphorous?
   a. Sulfur has a greater effective nuclear charge than phosphorus, and the 3p sublevel is more heavily shielded in S than in P.
   b. Sulfur has a greater effective nuclear charge than P, and the 3p sublevel in S has greater electron repulsions than in phosphorus.
   c. Sulfur has a greater number of electrons than P, so the third energy level is further from the nucleus in S than in P.
   d. Sulfur has a greater number of electrons than P, so the coulombic attraction between the electron cloud and the nucleus is greater in S than in P.



7. Looking at the spectra for Na and K below, which of the following would best explain the difference in binding energy for the 3s electrons?
   a. K has a greater nuclear charge than Na.
   b. K has more electron-electron repulsions than Na.
   c. Na has one valence electron in the 3s sublevel.
   d. Na has less electron shielding than K.



8. Looking at the spectra above for Na and K above, which of the following would best explain the difference in signal intensity for the 3s electrons?
   a. K has a greater nuclear charge than Na.
   b. K has more electron-electron repulsions than Na.
   c. Na has one valence electron in the 3s sublevel.
   d. Na has less electron shielding than K.



9. Given the photoelecton spectrum of scandium above, which of the following best explains why scandium commonly makes a 3+ ion as opposed to a 4+ ion?
   a. Removing 3 electrons releases more energy than removing 2 electrons.
   b. Scandium is in Group 3, and atoms only lose the number of electrons that will result in a noble gas electron configuration.
   c. The amount of energy required to remove an electron from the 3d sublevel is close to that for the 4s sublevel, but significantly more energy is needed to remove electrons from the 3p sublevel.
   d. Removing 2 electrons alleviates the spin-pairing repulsions in the 4s sublevel, so it is not as energetically favorable as emptying the 4s sublevel completely.

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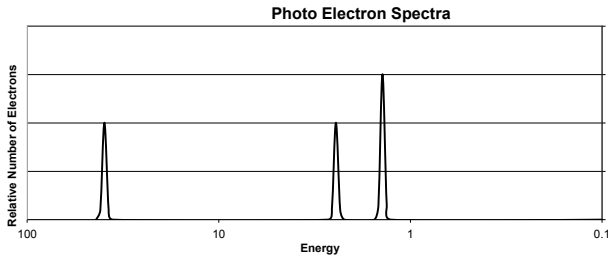
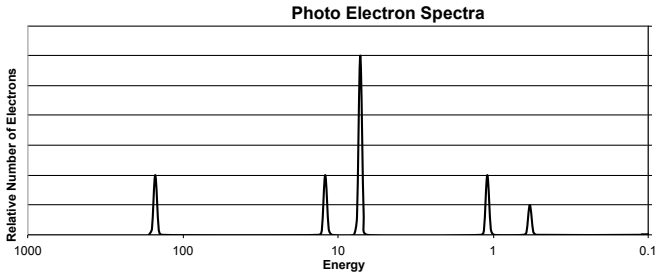


2. Which element could be represented by the complete PES spectrum to the right?

   Explain what electrons each peak represents, and what the height of the peaks represent.

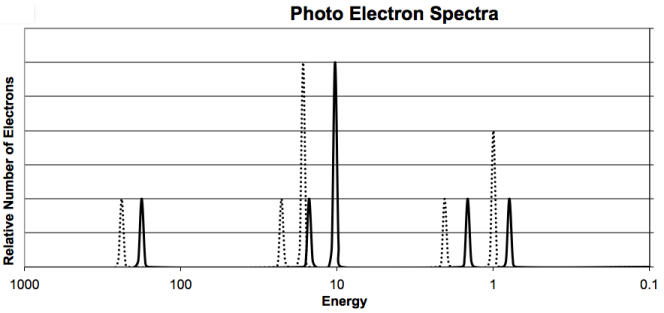
It is aluminum.
The peaks in order from left to right represent $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$
The height of the peaks tell us the number of electrons.



3. Which elements could be represented by the complete PES spectra to the right?

   Explain why all of the dashed peaks are to the left of the solid peaks?

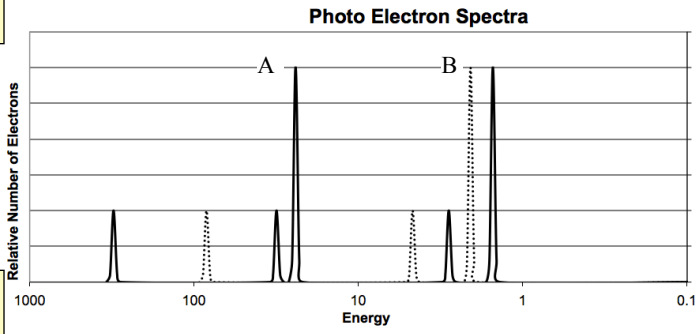
The dashed peaks represent sulfur, and the solid peak represent silicon. Note that the closer the peak is to the left, the higher the energy to remove those electrons, thus the tighter those electrons are held. Sulfur has two extra protons and thus has a stronger nuclear force, thus holding all of its electrons more tightly, which is why the peaks representing each orbital of electrons are higher energy than the corresponding silicon electrons.



4. Which elements could be represented by the complete PES spectra to the right?

   Why might someone be inclined to think that peak A and peak B should be in the same location, yet they are not? Why might someone think this, and explain why they are so far apart.

The solid peaks, A, represent argon, and the dashed peaks, B, represent neon. Since the peaks labeled A and B both represent $2p^6$ electrons, one might think that they would require the very same energy to remove, however, Argon has eight extra protons and thus has a stronger nuclear force. This holds its electrons more tightly, which is why the peaks representing same orbital of electrons, $2p^6$, are higher energy in argon than the corresponding neon electrons.



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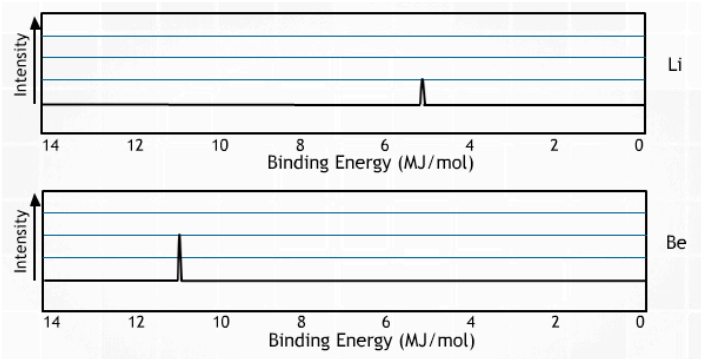

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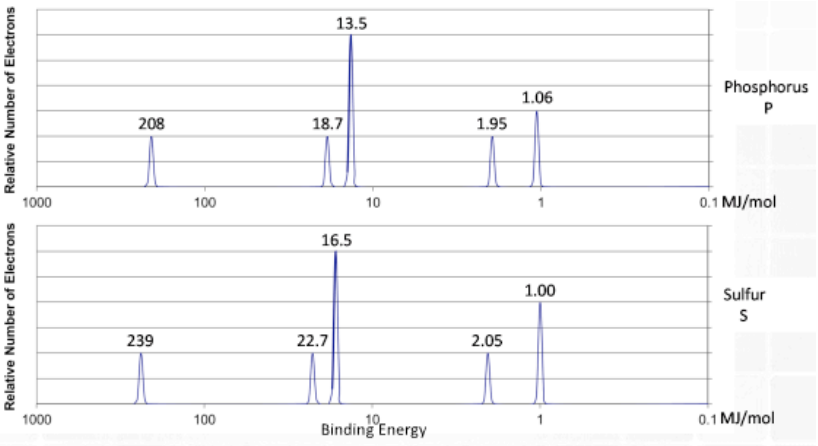
   d. Sulfur has a greater number of electrons than P, so the coulombic attraction between the electron cloud and the nucleus is greater in S than in P.



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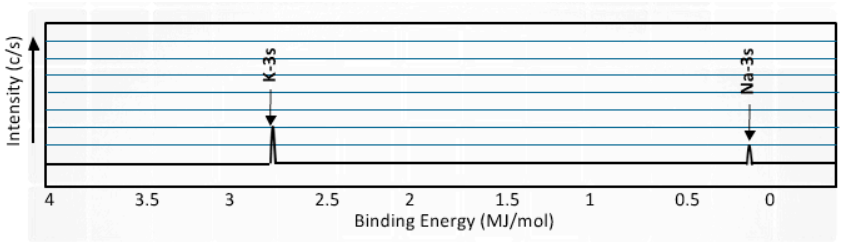

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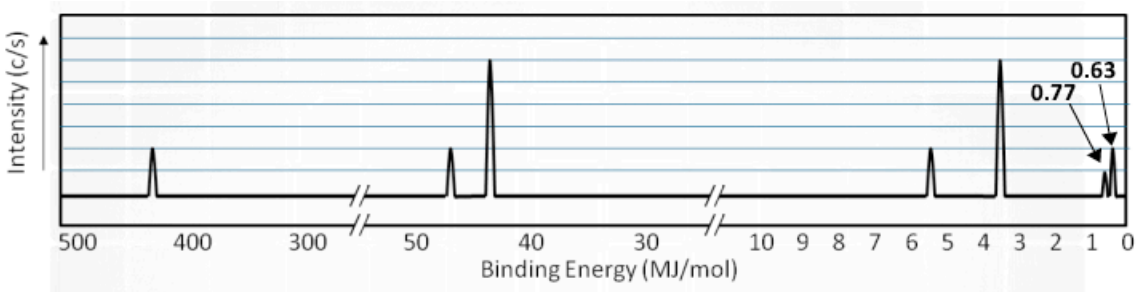

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