Photoelectron Spectroscopy (PES)

Watch the video “Photoelectron Spectroscopy – Part 1.”
https://www.youtube.com/watch?v=fnLLERYDHsY
1. Describe the photoelectric effect. Make a sketch to support your description.


Watch the video “Photoelectron Spectroscopy – Part 2.”
https://www.youtube.com/watch?v=2h6GeXrFGzY

The graphic below shows models for an atom of magnesium.

3. Label each of the following representations in the above graphic:
   - Electron configuration, Energy diagram, Bohr model, PES spectrum

4. Each peak on the PES spectrum represents a sublevel. Note that the x-axis goes from high to low binding energy.
   - Discuss with a partner how the PES spectrum relates to each representation.
   - Identify and label each peak.
   - What does the intensity (height of the peak) indicate?
   - For Mg, which peak is the highest? Explain why.
   - What does the magnitude of the binding energy indicate?
   - For Mg, which peak has the highest binding energy? Explain why.
5. The PES spectrum for Mg is given below. Using a pencil, sketch what the PES spectrum for Al would look like. Think about: How many peaks would Al have? How does the energy of the 1s peak for Al compare to the energy of the 1s peak for Mg?

Multiple Choice Practice Questions

Practice Question #1

Which of the following elements might this spectrum represent? Explain your choice.
A) He  
B) N  
C) Ne  
D) Ar

Practice Question #2

Which element could be represented by the complete spectrum above? Label the peaks. Explain your choice.
A) Li  
B) B  
C) N  
D) Ne
Practice Question #3
Which of the following best explains the relative positioning and intensity of the 2s peaks in the following spectra?

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

Practice Question #4
Given the photoelectron spectra above for phosphorus, P, and sulfur, S, which of the following best explains why the 2p peak for S is further to the left than the 2p peak for P, but the 3p peak for S is further to the right than the 3p peak for P?

A) S has a greater effective nuclear charge than P, and the 3p sublevel in S has a greater electron repulsions than in P.
B) S has a greater effective nuclear charge than P, and the 3p sublevel is more heavily shielded in S than in P.
C) S has a greater number of electrons than P, so the third energy level is further from the nucleus in S than in P.
D) S 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.
Practice Question #5

Given the photoelectron spectrum of scandium below, which of the following best explains why Scandium commonly makes a 3+ ion as opposed to a 2+ 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.

Write the electron configuration for Sc.
Label each peak in the spectrum.
Choose the best explanation for why Sc commonly makes a 3+ ion as opposed to a 2+ ion.