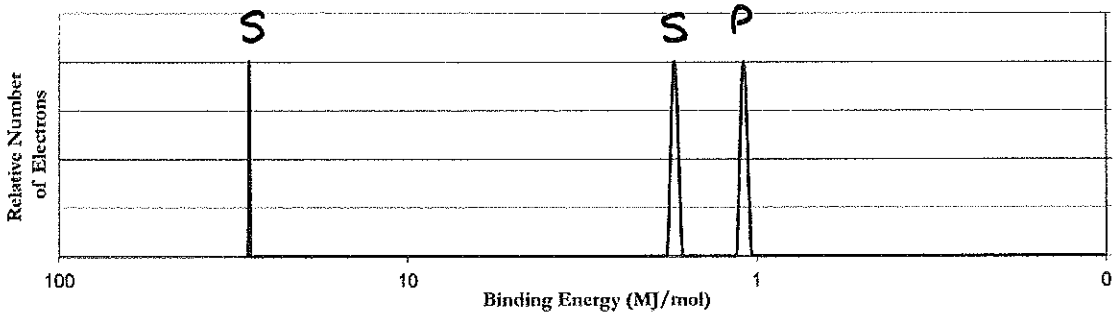
AP Chem - Unit 5 - PES

Name: Key Date: _____ AP CHEMISTRY BIG IDEA 1

Worksheet: Photoelectron Spectroscopy & Electron Configuration

1. Refer to the PES spectrum below. Make note of the relative energies of each peak.



   a. How do the peak heights compare? What does this tell us about the relative number of electrons represented by each?

   All of the Peak heights are the Same.
   Each Peak represents same # of electrons.

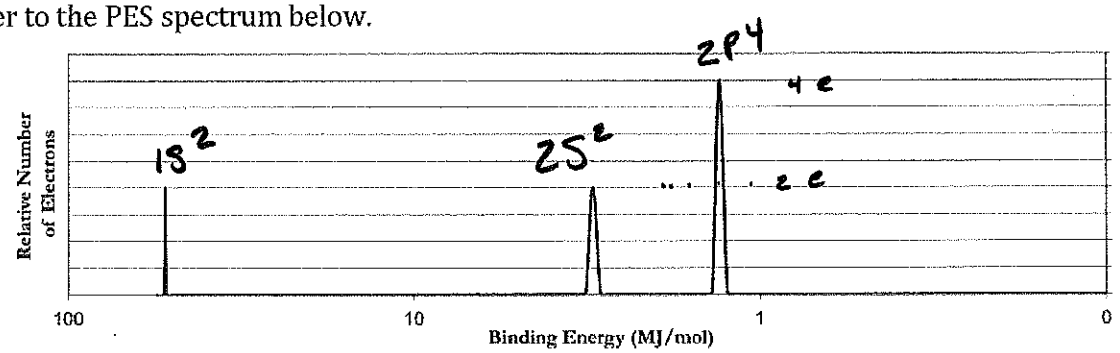
   b. If the peaks shown represent all of the electrons in this atom, identify the element.

   S has max 2e, P same height, so all S have 2e ⇒ 6e', Atomic 6 = Carbon

   c. Which peak represents the core (innermost) electrons? Explain.

   The 1st peak is closest to nucleus Because it has the highest Binding Energy.

2. Refer to the PES spectrum below.



   a. How many electrons are represented in each peak?

   2 2 4

   b. How many electrons does the atom contain? How many electrons are in its valence shell?

   8e's total
   6 electrons are valence ($2s^2, 2p^4$)

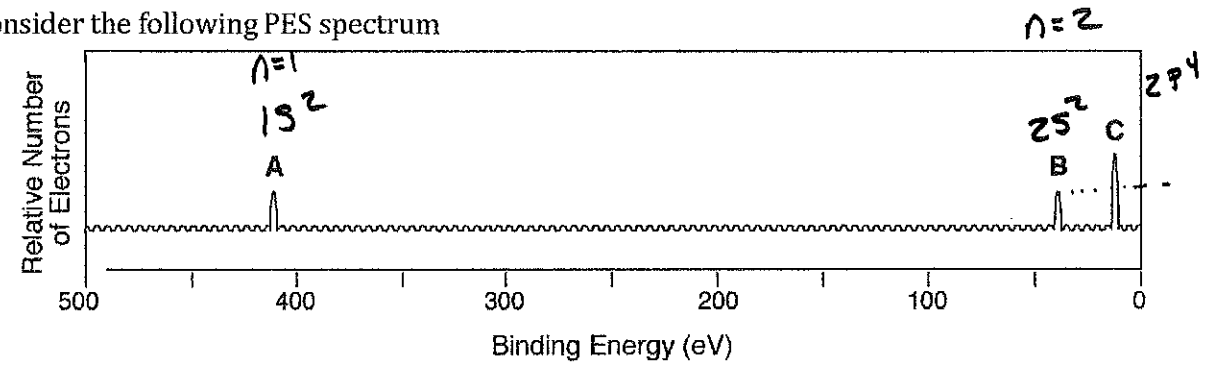
   c. Write the electron configuration for this element.

   $1s^2 2s^2 2p^4$ ⇒ oxygen

Key

1.5 Photoelectron Spectroscopy & Electron Configuration

3. Consider the following PES spectrum



a. Using the plot, write the electron configuration of the element, and identify it.

$1s^2 2s^2 2p^4$

b. Label each peak with the appropriate shell and subshell.

See graph

c. Suggest a reason for the huge jump in energy between peak A and peak B.

The huge jump is the difference Between electron shell levels (n=1 vs n=2)

d. This element has a very high first ionization energy *and* a very high electron affinity. Would you expect it to form a cation or anion? What would be the charge of the ion? Justify your answers.

It would form an −2 Anion. Adding 2e⁻ would fill the 2p⁴ shell to 2p⁶, giving this atom a pseudo noble gas Configuration.

e. Write the electron configuration for the ion. $1s^2 2s^2 2p^6$ ⇒ isoelectronic with Neon

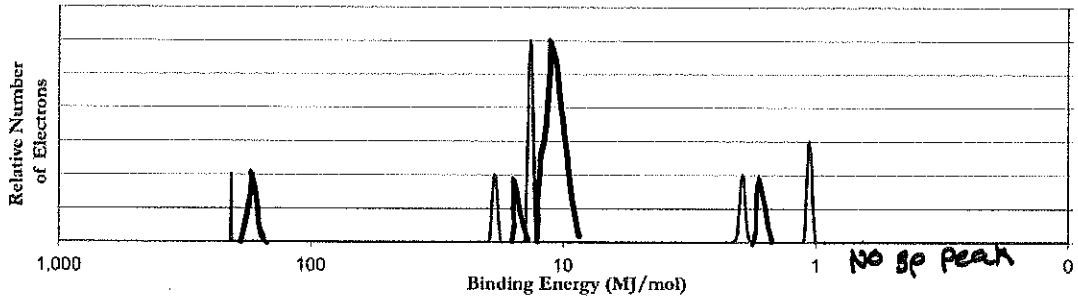
f. How would the radius of the ion compare to the radius of the neutral atom. Use Coulomb's law to justify your response. Coulomb's Law $F = k_c \frac{q_1 q_2}{r^2}$

Adding e⁻ to the same energy level without additional protons would not increase or decrease the force of Attraction described by Coulomb's law Because the distance Between the nucleus & all Valence e⁻ would be the same.

The radius would <u>Increase</u> because of e⁻/e⁻ Repulsion within the shell & subshell

Key

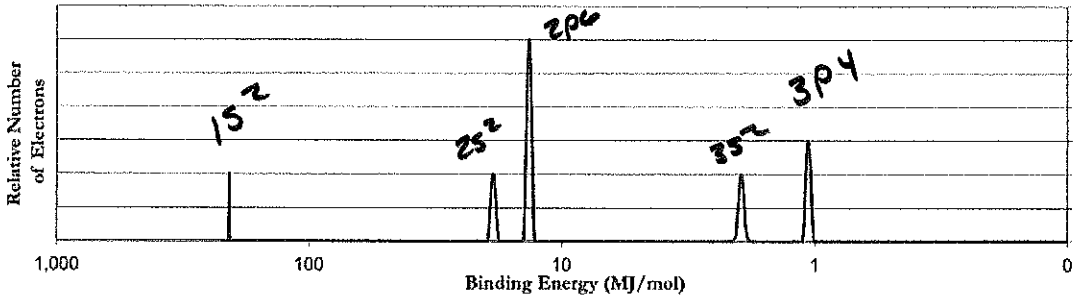
4. Below is a photoelectron spectrum for the element phosphorus. $1s^2 2s^2 2p^6 3s^2 3p^3$ or $1s^2 2s^2 2p^6 3s^2$



a. On the graph above, sketch in a PES spectrum for the element magnesium. How will the peak heights and relative energies of the peaks compare? Explain your reasoning.

Mg has less protons P, ∴ there is less Binding energy in Mg & its electron's will shift to the Right of the Phosphorus peaks.

b. Consider the photoelectron spectrum for sulfur



c. Write the electron configuration of sulfur.

$1s^2 2s^2 2p^6 3s^2 3p^4$

d. Which subshell contains the electrons with the lowest ionization energy? Justify your answer.

3P has the lowest ionization energy Because those electrons are in the furthest energy level, farthest from the nucleus & have the lest Attraction to the protons ∴ lowest Binding energy

e. How might you explain the fact that the 2p peak for sulfur is further to the left than the 2p peak for phosphorus, yet the 3p peak for sulfur is further to the right than the 3p peak for phosphorus?

Sulfur has 1 more proton, but it's valence e's are in the same shell a P valence e's. More proton's increase the force of Attraction Between the nucleus & the electron's according to Coulomb's LAW

f. Since potassium forms a cation, would you expect the electron affinity to be relatively low or relatively high? Explain. (+)

Cation's are the Result of a loss of an electron. So Potassium would have a low e^- Affinity & low ionization energy

1.5 Photoelectron Spectroscopy & Electron Configuration

- same # of e's or same electronic structure

5. A student makes the following statement: "Since Ca^{2+} and Ar, and S^{2-} are isoelectronic, their PES spectra are identical." Is this statement true or false? Justify your answer

False, ~~They~~ would the same number of peaks. with same heights But Because Ca^{+2} has more protons its peaks would be shifted to left.

6. Write the electron configuration for the following elements or ions. Then, indicate how many peaks you would expect to see in a PES spectrum.

a. P $1s^2 2s^2 2p^6 3s^2 3p^3$ 5 Peaks

b. Br^- ion!! $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$ 8 Peaks

c. Zn^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 \cancel{4s^2} 3d^{10}$ 6 Peaks

d. Ba $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2$ 12peaks

e. Co^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 \cancel{4s^2} 3d^7$ 6peaks

7. Identify the element given the electron configurations

a. $1s^2 2s^2 2p^3$ N

b. $1s^2 2s^2 2p^6 3s^2 3p^5$ Cl

c. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$ Cr

d. $[Ne]\ 3s^2 3p^2$ Si

e. $[Xe]\ 6s^2$ Ba

cation ← 0 0 0 0 → Anion

8. Identify four ions that are isoelectric with xenon. Rank them in order of increasing atomic radius.

Xe : $[Kr]\ 5s^2 4d^{10} 5p^6$ Cs^+ Ba^{+2} I^- Te^{-2} ~~Sb^{-3}~~ All isoelectric

$$Ba^{+2} < Cs^+ < Xe < Te^{-2} < I^-$$

9. Which elements fit the following descriptions:

a. Has a valence shell configuration of $4f^{14}\ 5d^{10}\ 6s^1$ Cs

b. Halogen with the lowest ionization energy F to At ↓ IE At has most shielding

c. Has 13 more electrons than argon 18 + 13 = 31 Ga

d. The smallest nonmetal H

e. Group 4A element with the largest ionization energy C - smallest Radius + protons closest to Valence electrons

f. Its ~~X~~ 2+ ion has the electron configuration $[Kr]\ 4d^{10}$ Cd