Chemistry 11 AP – Coulomb's Law & PES Worksheet

1) The first ionization energies for selected elements from the second period of the periodic table are as follows:

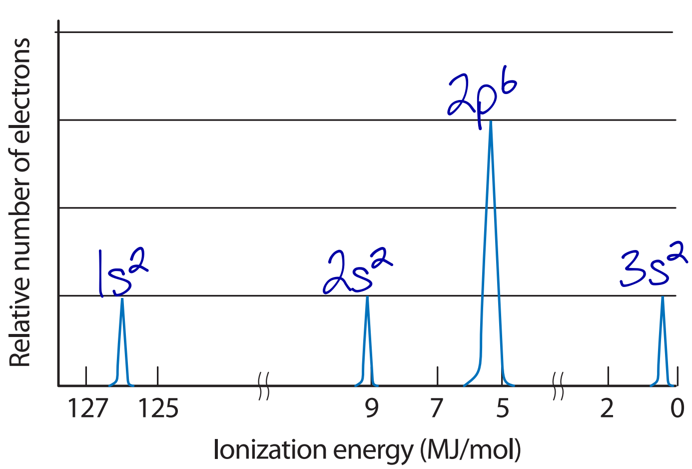
Atom	Li	Be	C	N	F	Ne
IE_1 (kJ/mol)	520	899	1,086	1,302	1,681	2,081

Use Coulomb's Law to explain the trend in ionization energies in terms of the relative location of the electrons and the charge of the nucleus.

As the atomic number/number of protons increases, the effective nuclear charge increases. Since all of the valence electrons currently being compared are in the second energy level, the increasing first ionization energy is due to the increasing positive charge on the nucleus (increasing Q values of Coulomb's Law). Coulomb's Law states that as the force of attraction increases, the distance between an electron and the nucleus decreases, making it harder to remove the valence electron, therefore increasing the first ionization energies when going across the period.

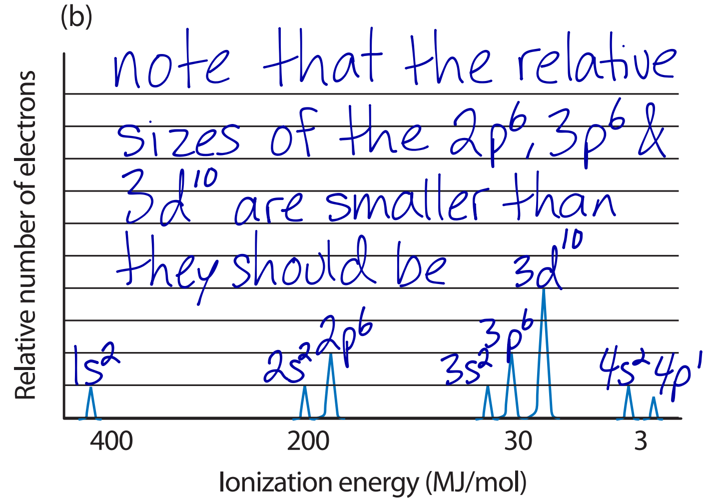
2) What element does each PES spectrum below represent?

(a)



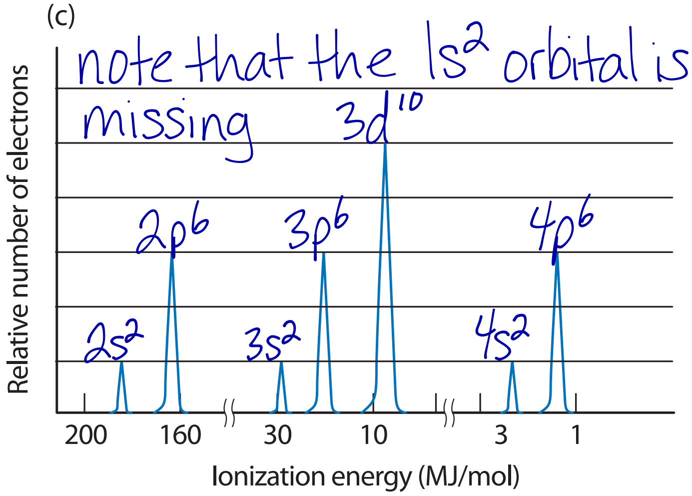
Mg

(b)



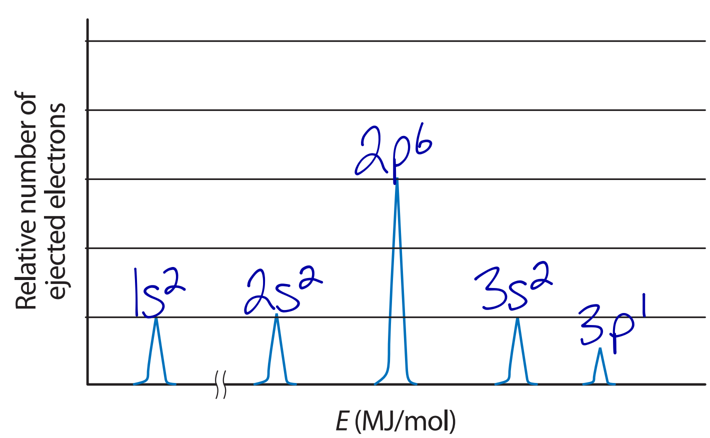
Ga

(c)



Kr

(d)



Al

3) Aluminum has an electron configuration of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$.

(a) How many unique peaks are expected in aluminum's PES spectrum? Explain.

Five, since there are five distinct subshells present in an Al atom.

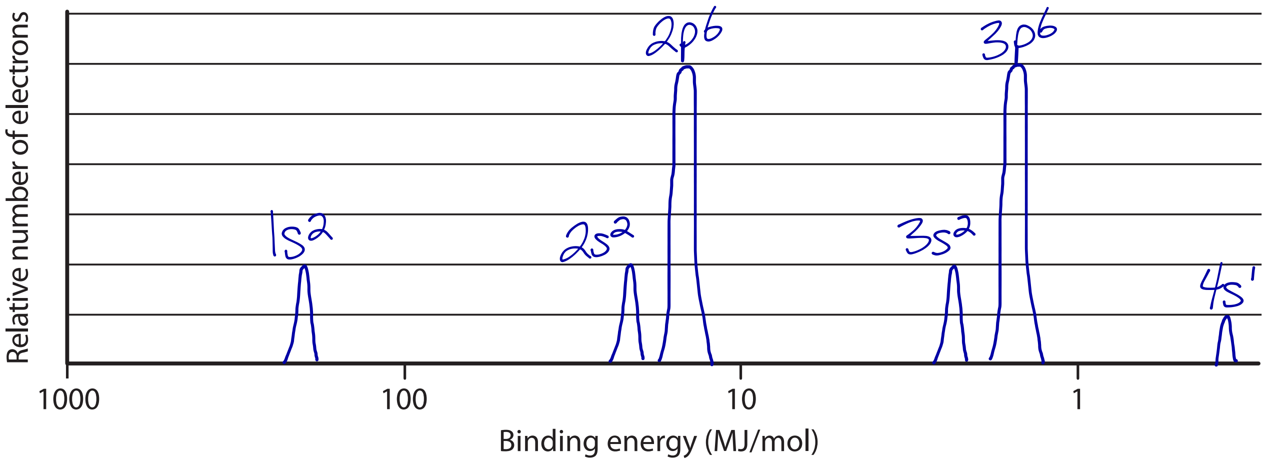
(b) Which electrons correspond to the largest energies? Explain.

The 1s electrons. They are closest to the nucleus and experience the greatest force of attraction according to Coulomb's Law. They will therefore be the most difficult to remove and will require the greatest energy.

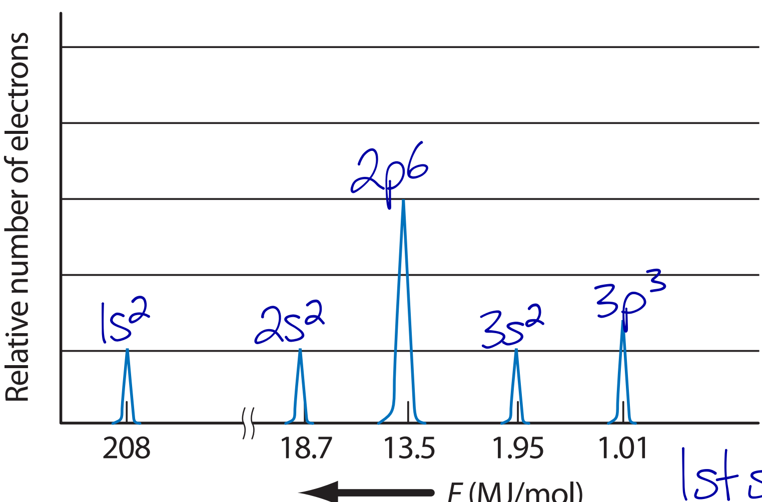
(c) Which peak in the spectrum will have the greatest intensity (i.e., be the largest)? Explain.

The peak corresponding to the 2p electrons. The intensity of the peak is relative to the number of electrons in the orbital. The 6, 2p electrons create a peak with the greatest intensity.

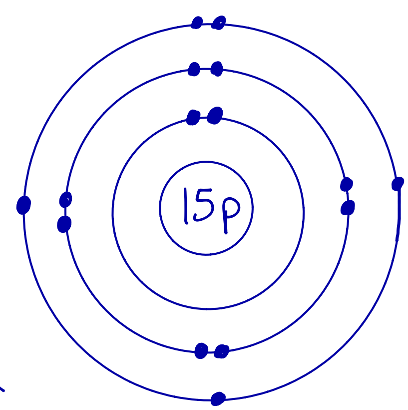
4) Use the following axes to sketch the PES spectrum you would expect for the element potassium. Pay attention to the relative heights of each of the peaks. Exact values for binding energies are not required.



5) (a) Identify the element whose PES spectrum is shown. P



(b) Draw the Bohr diagram for this element.



1st shell - $1s^2$

2nd shell - $2s^2$ & $2p^6$

3rd shell - $3s^2$ & $3p^3$ (3 single e)

(b) Which peak represents the 2s subshell?

The peak at 18.7 MJ/mol.

(c) An electron from which peak would have the greatest velocity after ejection. Explain.

An electron for the peak at 1.01 MJ/mol would have the greatest velocity after ejection. Since these electrons are the farthest away from the positive charge of the nucleus, they would require the least amount of energy to remove them. All of the additional energy that is given to the electron would be converted into kinetic energy causing the electron to move at the greatest velocity when ejected.

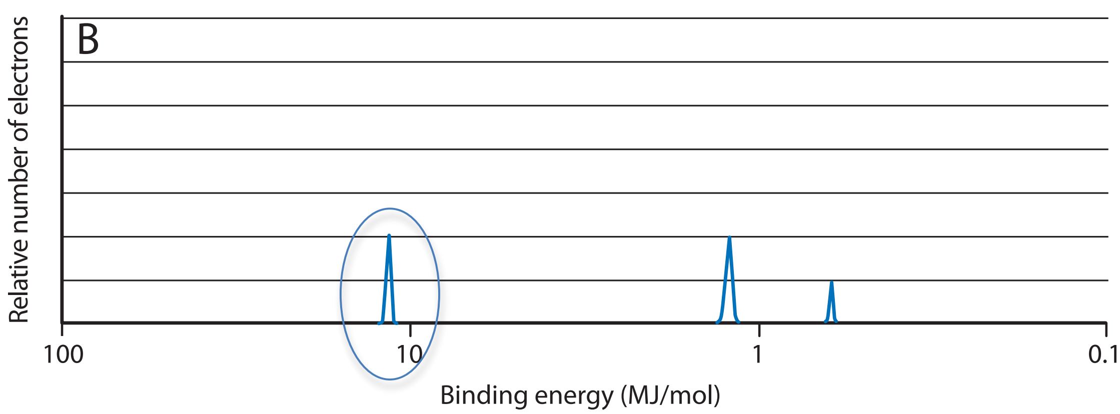
(d) How many valence electrons does this atom have?

5. Valence electrons are those in the outermost energy level. In this case, that is the third level, which has five valence electrons in it (two in the 3s and three in the 3p).

6) The outermost electron of an atom has a binding energy of 2.5 eV. The atom is exposed to light of a high enough frequency to cause exactly one electron to be ejected. The ejected electron is found to have a KE of 2.0 eV. How much energy did the photons of the incoming light contain?

Incoming Radiation Energy = Binding Energy + KE of the ejected electron
= 2.5 eV + 2.0 eV
= 4.5 eV

7) Circle the peak on the following PES spectrum for the electrons that are experiencing the strongest effective nuclear charge. Explain.



The electrons that would experience the greatest effective nuclear charge are the electrons that are closest to the nucleus, therefore the peak representing the 1s electrons at a binding energy of approximately 15 MJ/mol. These electrons are not affected by any shielding effect of other electrons therefore they are experiencing the greatest pull towards the nucleus.