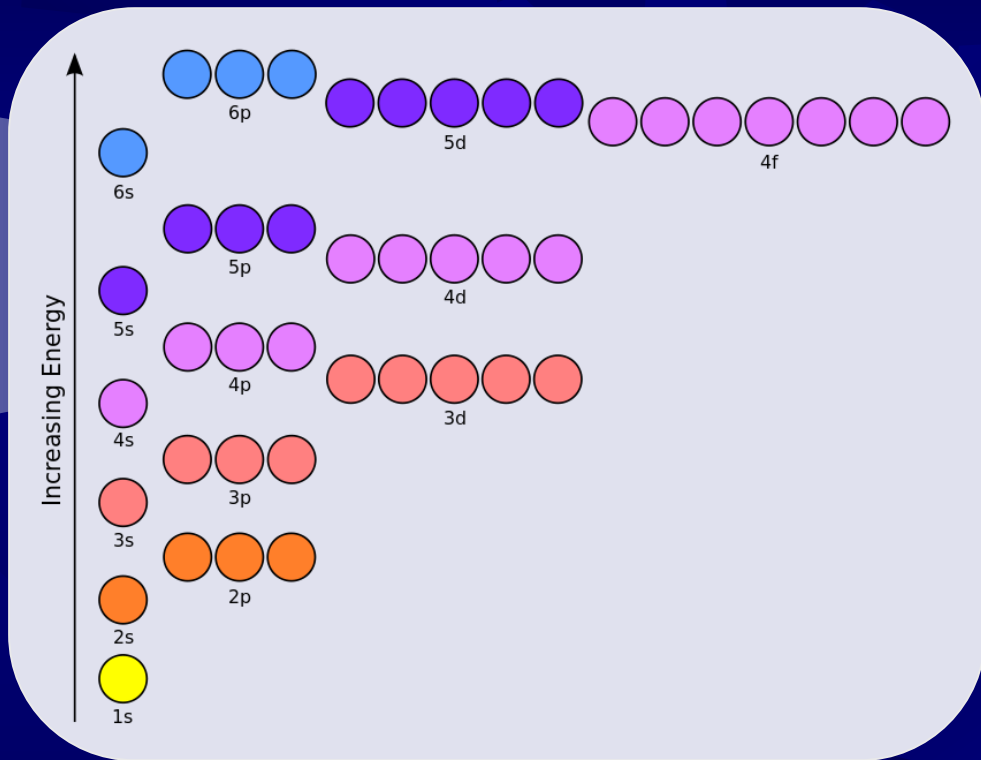


Spectroscopy for AP Chemistry

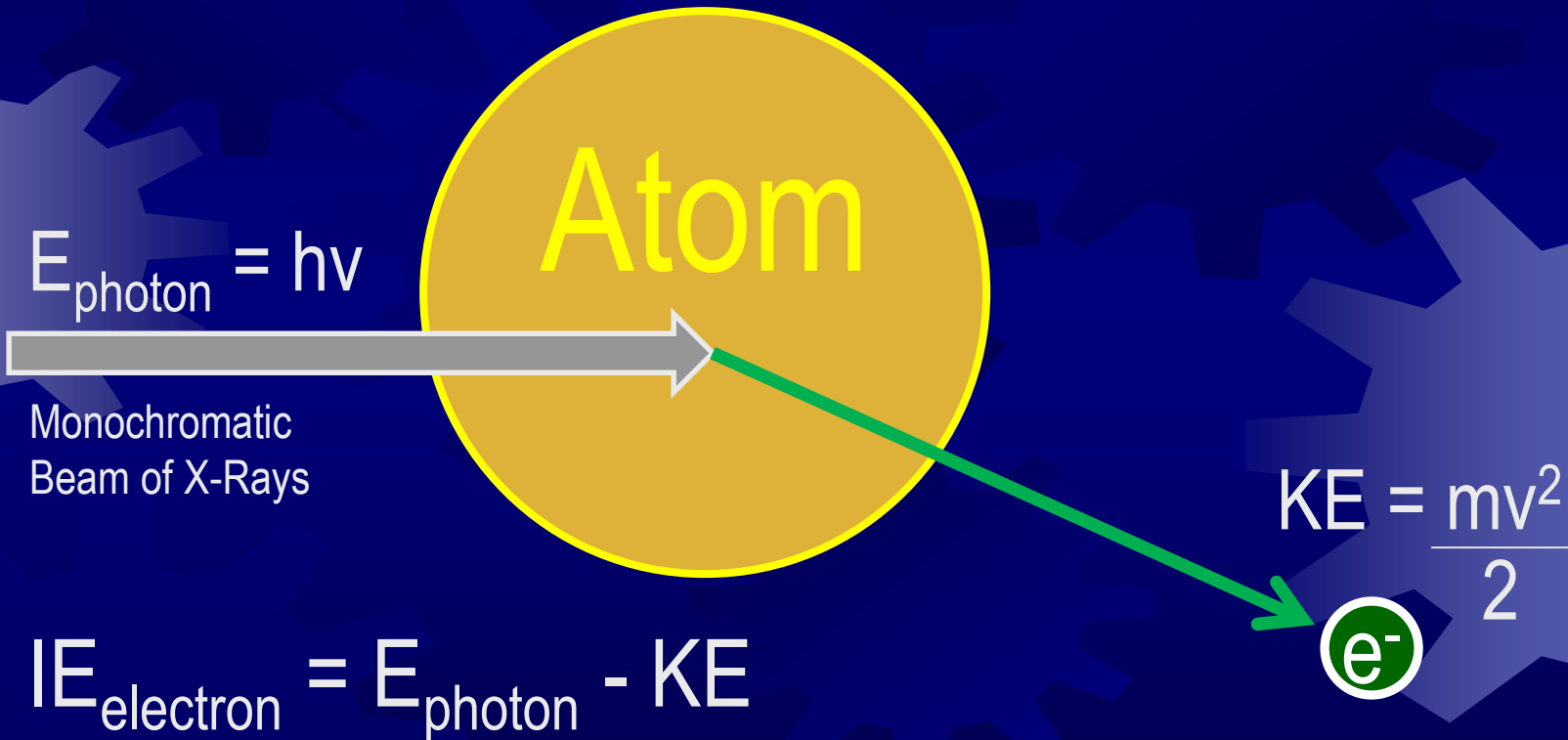
- Photoelectron Spectroscopy (PES)
 - Provides data for ionization energy trends and applications
- Mass Spectrometry
 - Provides atomic/molar mass data as it ionizes

Electron Configuration



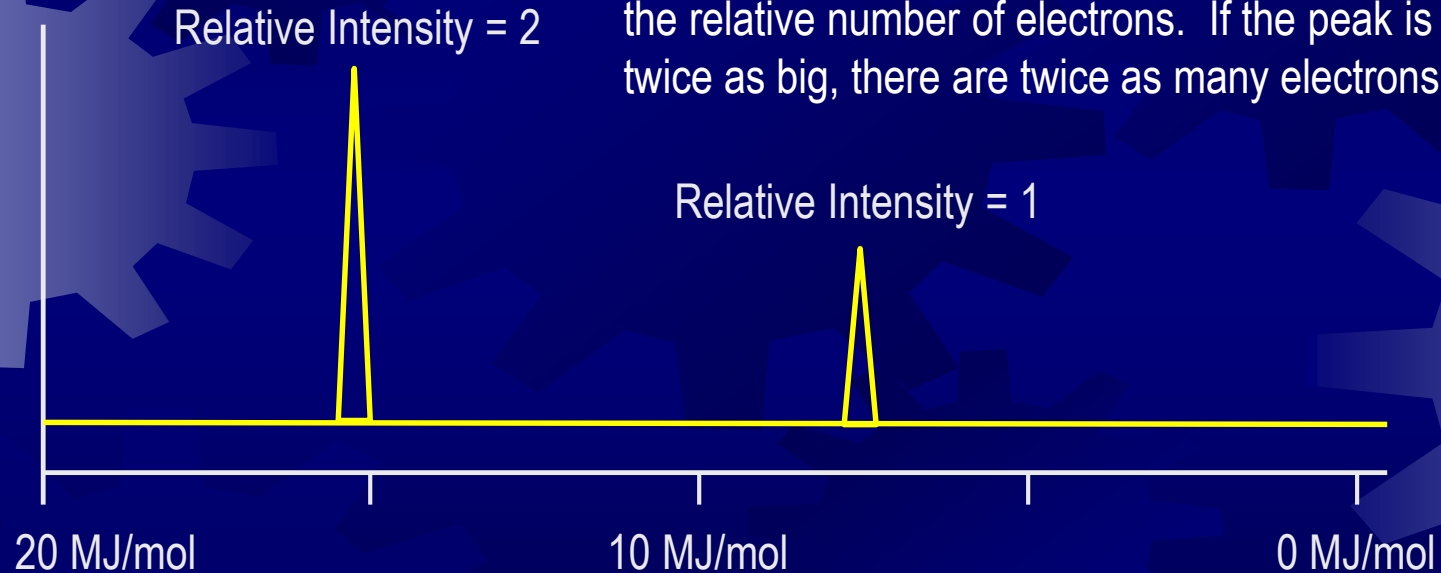
Is there any direct evidence that this diagram is accurately showing potential energy of electrons on the atom?

Photoelectron Spectroscopy

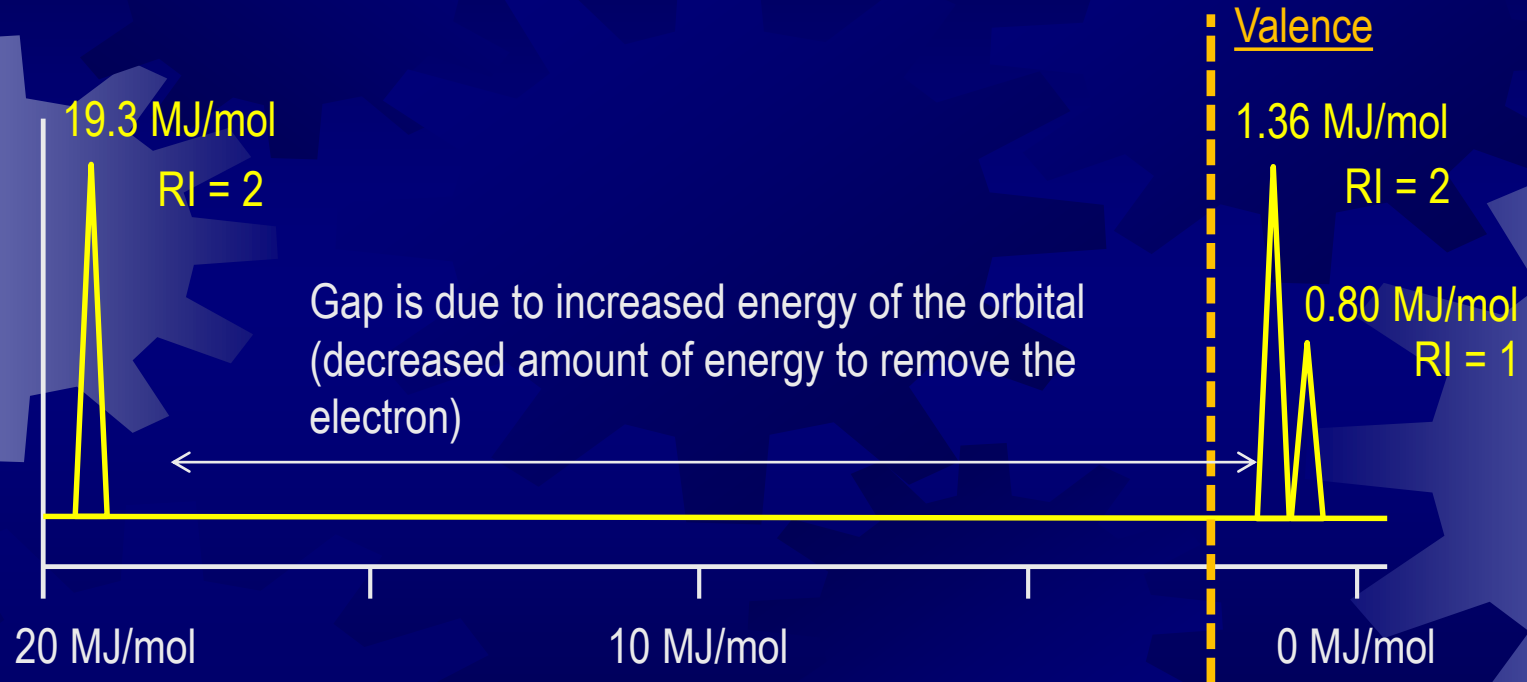


Photoelectron Spectrum

Each peak is relative to the others. This indicates the relative number of electrons. If the peak is twice as big, there are twice as many electrons.

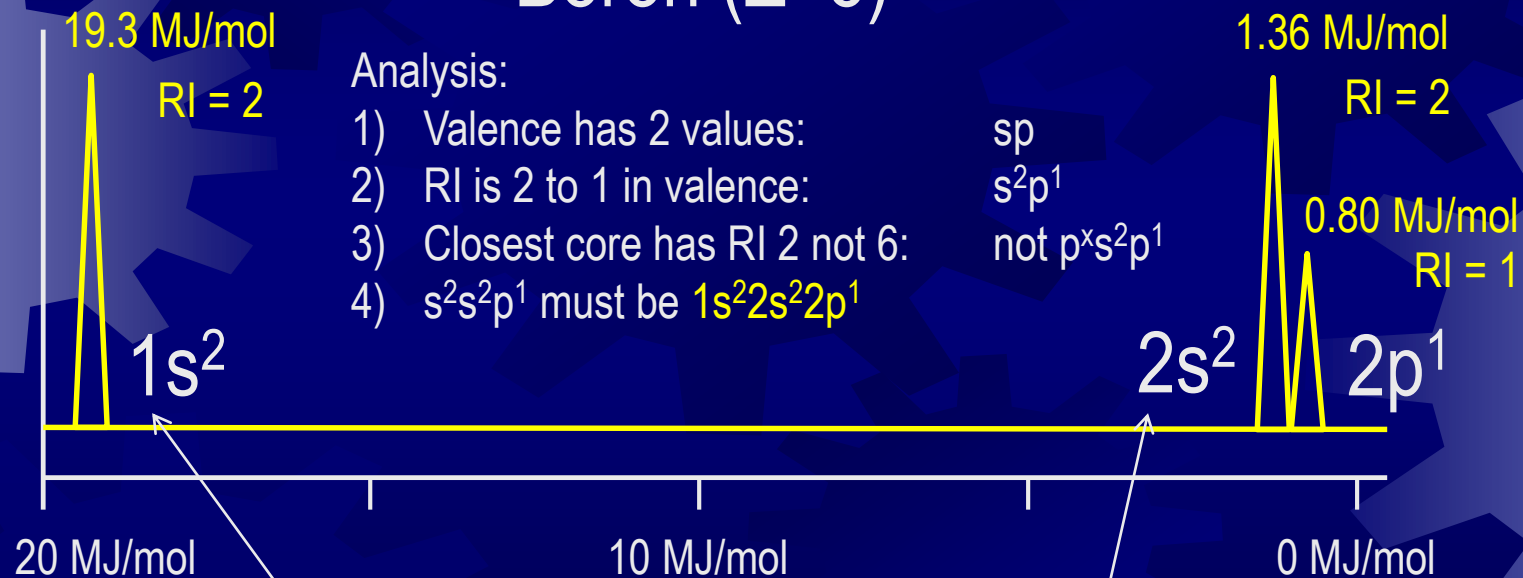


Photoelectron Spectrum



Photoelectron Spectrum

Boron ($Z=5$)



Analysis:

- 1) Valence has 2 values:
- 2) RI is 2 to 1 in valence:
- 3) Closest core has RI 2 not 6:
- 4) $s^2s^2p^1$ must be $1s^22s^22p^1$

sp
 s^2p^1
 not $p^x s^2 p^1$

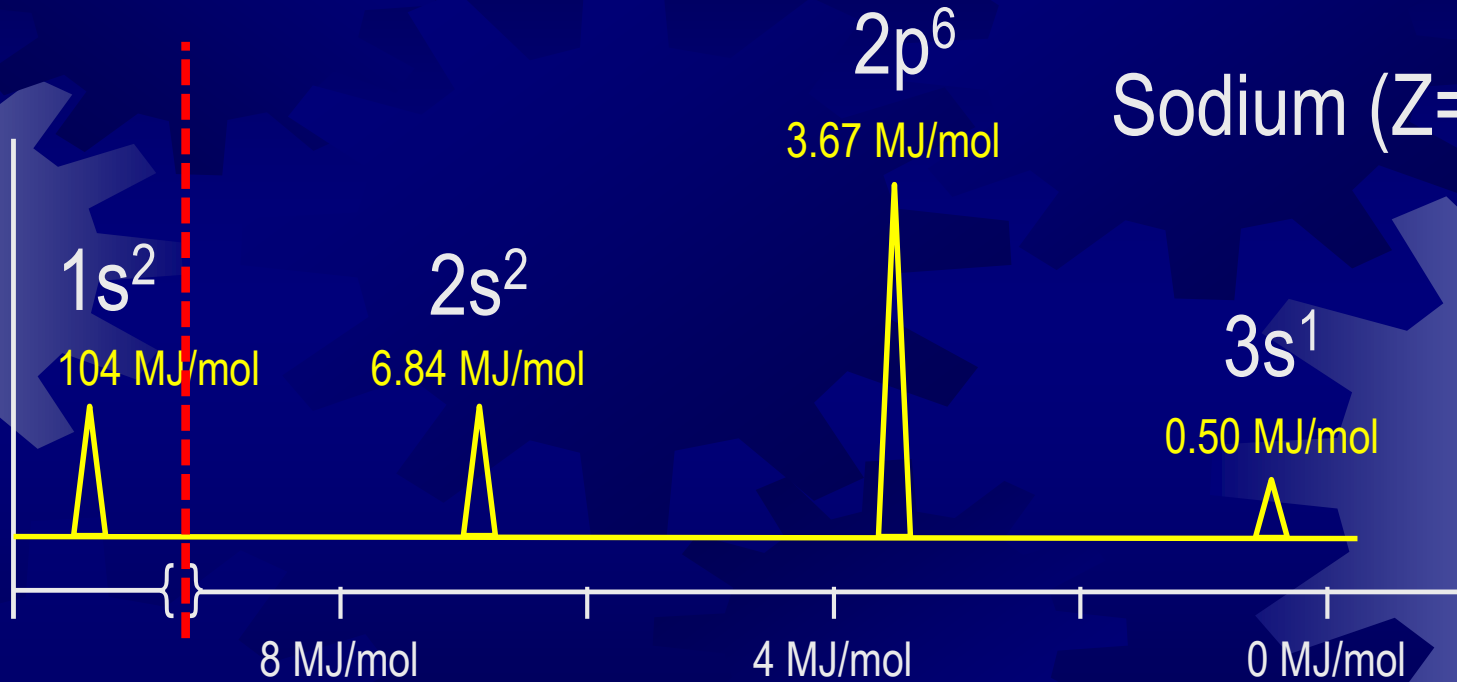
Inner orbitals require the most energy

Valence orbitals require the least energy

Photoelectron Spectrum

- Depending on the size of the table, 1s may be intentionally cut out of view because it's too far away and makes the graph too long
- Remember IE is about REMOVING electrons, which means they are removed from the OUTSIDE to the INSIDE, and NOT in reverse order of energy! For example, 4s is removed BEFORE 3d.

Photoelectron Spectrum



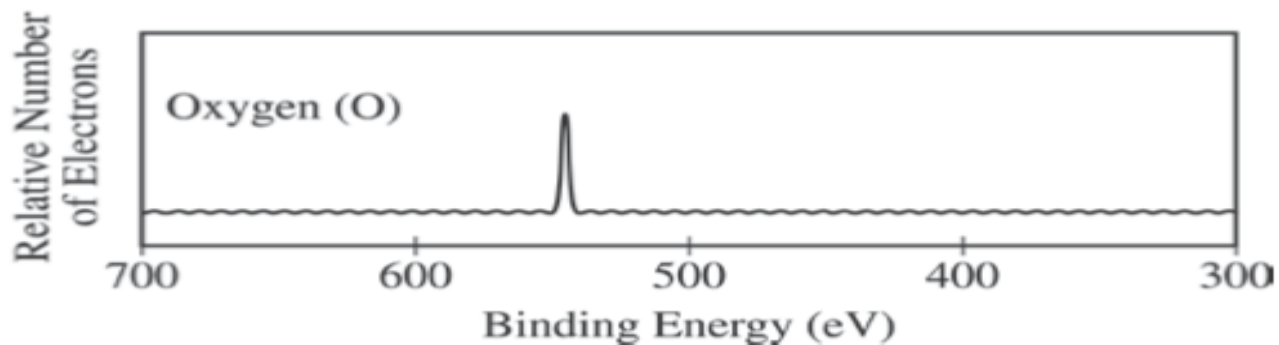
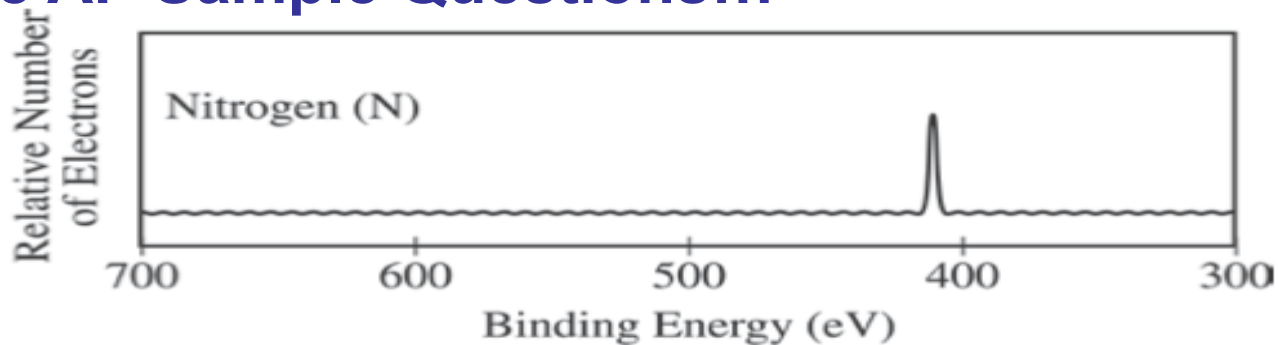
Online PES Resources

<http://www.chem.arizona.edu/chemt/Flash/photoelectron.html>

https://www.youtube.com/watch?v=NRlqXeY1R_I

<https://www.youtube.com/watch?v=vANbxozsRSA>

From the AP Sample Questions...



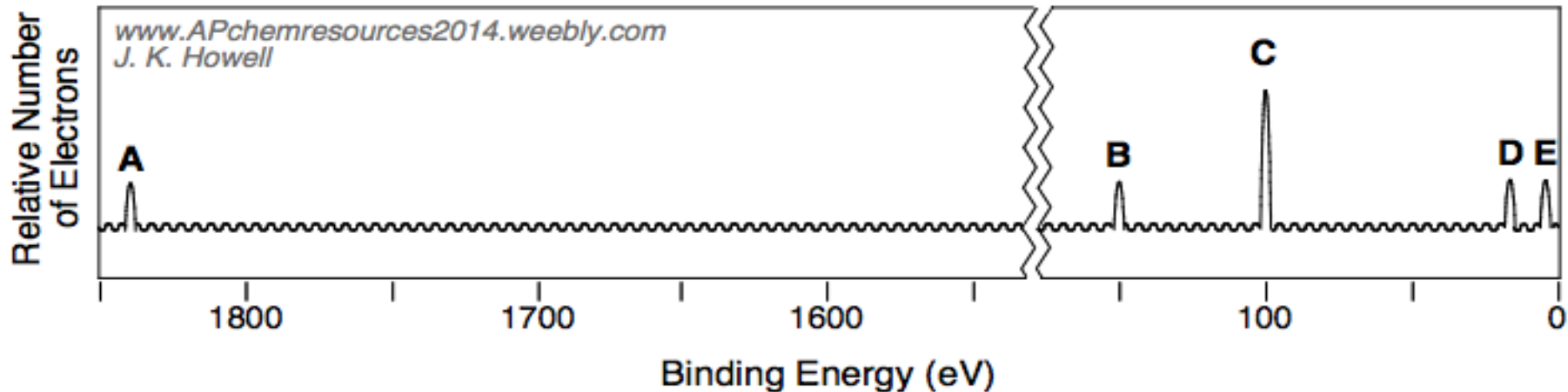
The photoelectron spectra above show the energy required to remove a 1s electron from a nitrogen atom and from an oxygen atom. Which of the following statements best accounts for the peak in the upper spectrum being to the right of the peak in the lower spectrum?

From the AP Sample Questions...

The photoelectron spectra above show the energy required to remove a $1s$ electron from a nitrogen atom and from an oxygen atom. Which of the following statements best accounts for the peak in the upper spectrum being to the right of the peak in the lower spectrum?

- (A) Nitrogen atoms have a half-filled p subshell.
- (B) There are more electron-electron repulsions in oxygen atoms than in nitrogen atoms.
- (C) Electrons in the p subshell of oxygen atoms provide more shielding than electrons in the p subshell of nitrogen atoms.
- (D) Nitrogen atoms have a smaller nuclear charge than oxygen atoms.

Photoelectron Spectrum of Element Q



Which peaks in the photoelectron spectrum are representative of the binding energy of p orbital electrons?

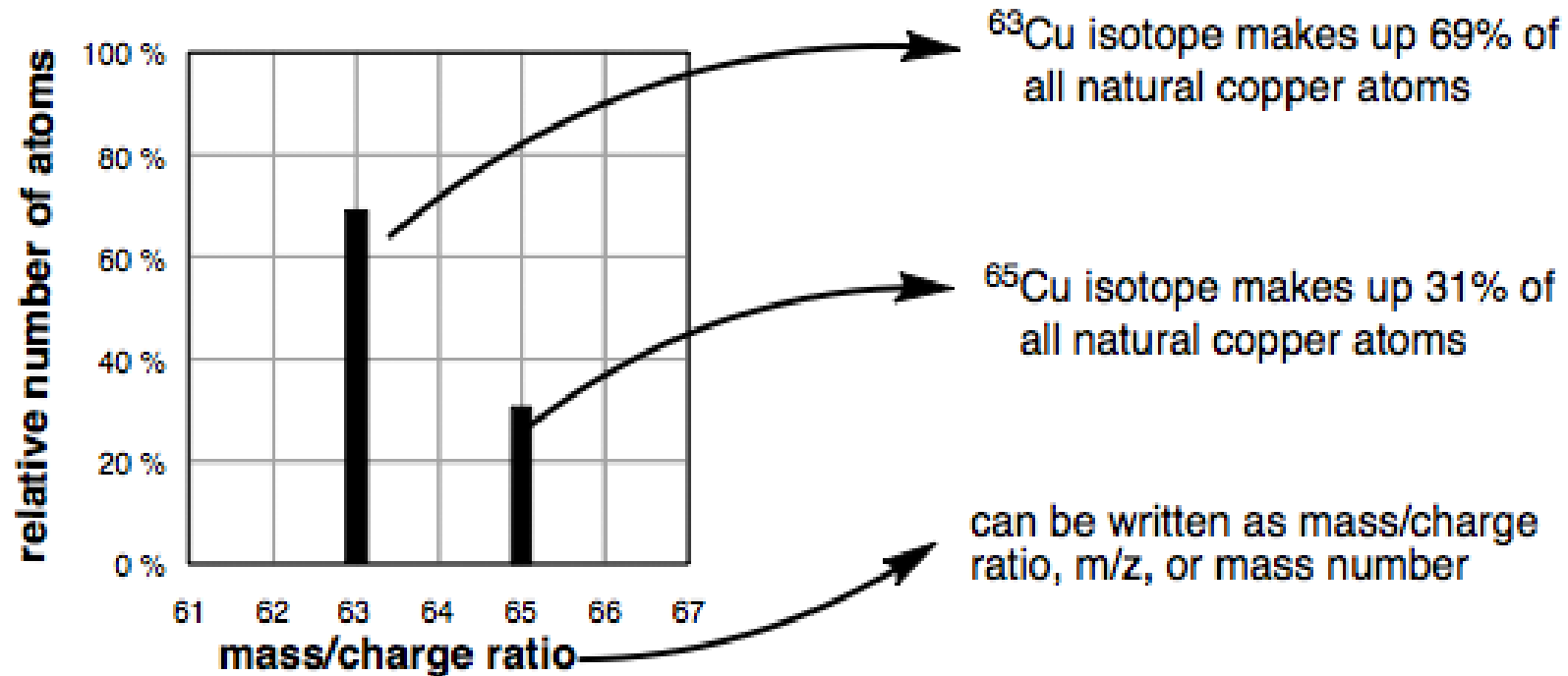
- a. C only
- b. D only
- c. C and E
- d. B, C and D

Mass Spectrometry

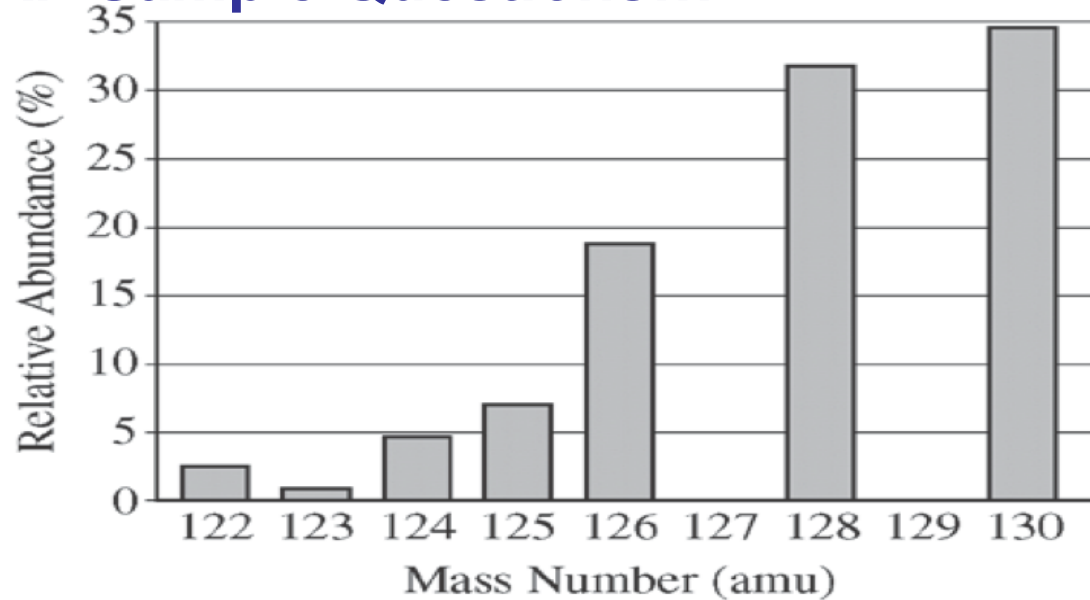
- Mass spectrometry gives the mass to charge ratio
- Like PES, the relative size of the peaks indicates the relative number of particles
- Separates isotopes according to mass
- Used to find relative abundance and atomic/molar mass of unknown samples

Mass Spectrometry

Mass Spectrum of Natural Copper

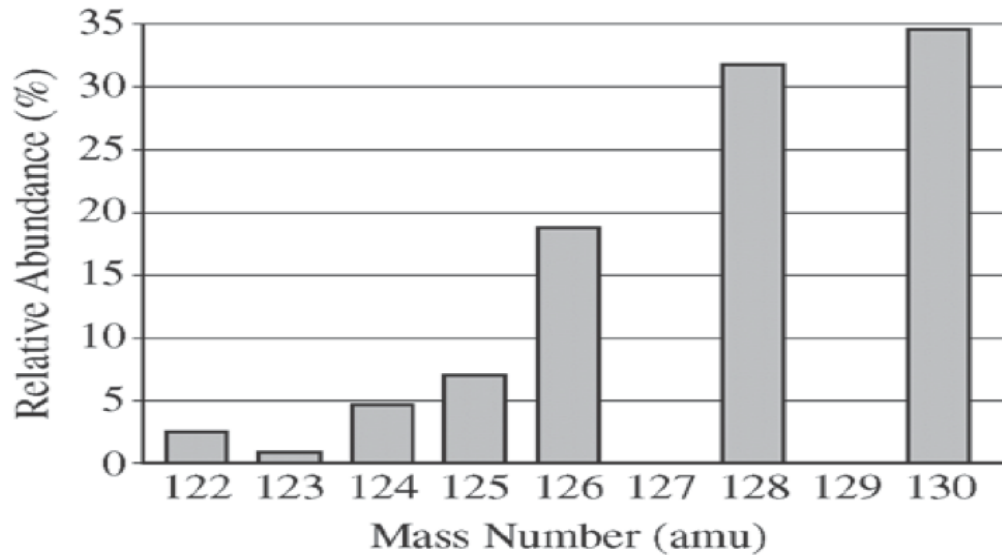


From the AP Sample Questions...



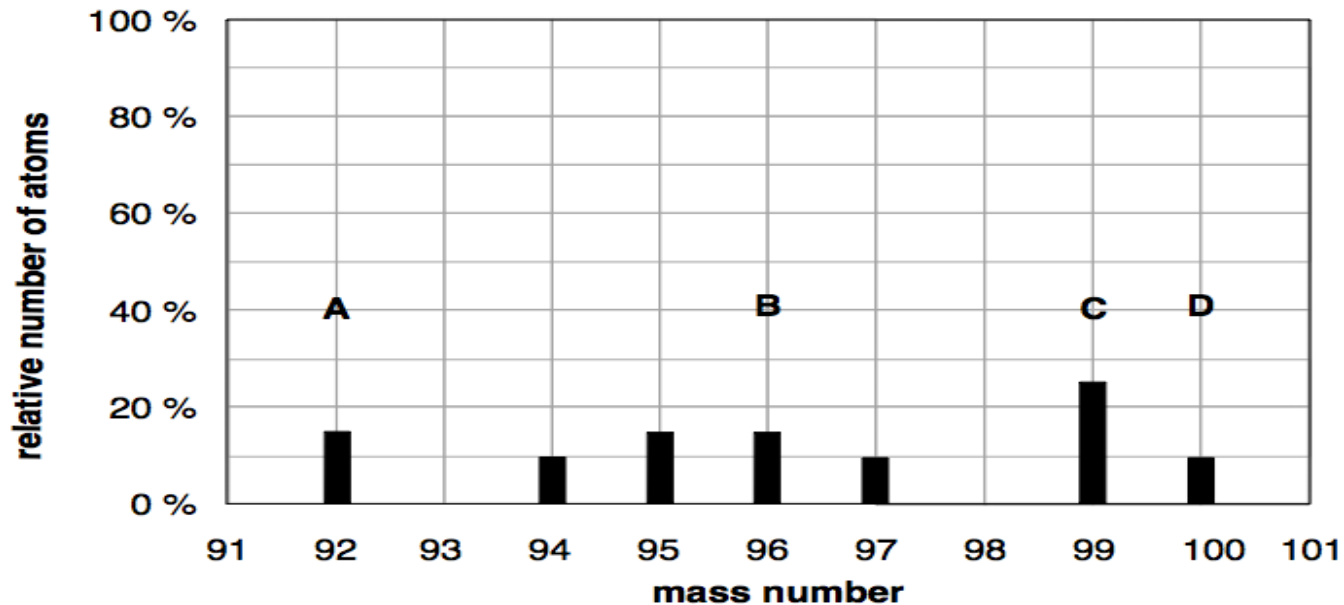
The elements I and Te have similar average atomic masses. A sample that was believed to be a mixture of I and Te was run through a mass spectrometer, resulting in the data above. All of the following statements are true. Which one would be the best basis for concluding that the sample was pure Te?

From the AP Sample Questions...



- Te forms ions with a -2 charge.
- Te is more abundant than I in the universe.
- I consists of only one naturally occurring isotope with 74 neutrons, whereas Te has more than one isotope.
- I has a higher first ionization energy than Te does.

Mass Spectrum of Atom Y



Based on the mass spectrum of atom Y, which of the following statements is false?

- peak A and peak D come from atoms that have the same number of electrons
- there are seven isotopes of atom Y
- peak C comes from the most abundant isotope of atom Y
- peak D comes from an atom with 4 more protons than the atom that gave peak B