# TOPIC: 1.6 PHOTOELECTRON SPECTROSCOPY

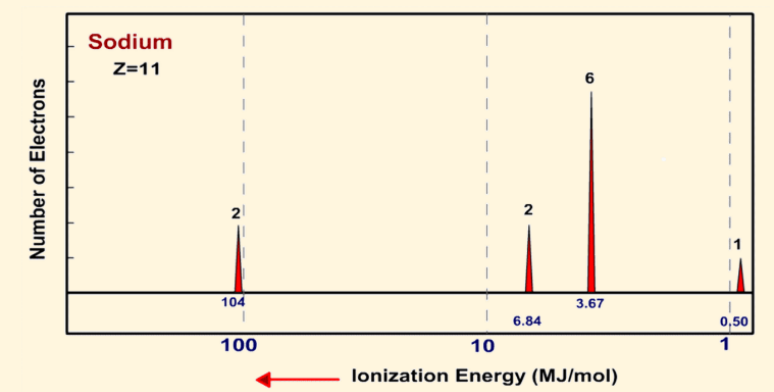
| ENDURING UNDERSTANDING: | |
|---|---|
| SAP-1 | Atoms and molecules can be identified by their electron distribution and energy. |
| **LEARNING OBJECTIVE:** | |
| SAP-1.B | Explain the relationship between the photoelectron spectrum of an atom or ion and:<br>a. The electron configuration of the species<br>b. The interactions between the electrons and the nucleus. |
| **ESSENTIAL KNOWLEDGE:** | |
| SAP-1.B.1 | The energies of the electrons in a given shell can be measured experimentally with photoelectron spectroscopy (PES). The position of each peak in the PES spectrum is related to the energy required to remove an electron from the corresponding subshell, and the height of each peak is (ideally) proportional to the number of electrons in that subshell. |
| **EQUATION(S):** | |
| | N/A |

## NOTES:

Photoelectron spectroscopy (PES) is an experimental technique that measures the relative energies of electrons in atoms or molecules. It works by ejecting electrons from the materials using high energy electromagnetic radiation (like UV or x-rays) and then measuring the kinetic energy of those electrons. This process can be described as photoionization.

PES graphs show the relative number of electrons and their corresponding binding energy. The binding energy can be described as the amount of energy needed to remove an electron from an atom. The electrons with the highest binding energy are the ones that have the greatest coulombic attraction to the nucleus because they are the closest to the nucleus.

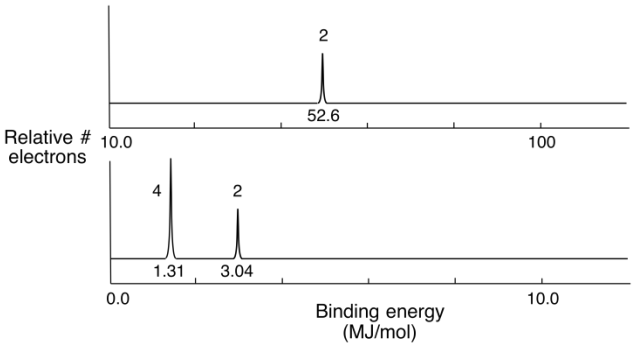
The PES graphs directly correspond to the electron configuration.
The PES for sodium is below. The graphs are often set up so that the x axis gives the largest values first. The graphs are scaled so that they can show many orders of magnitude. ALWAYS read the axis! The highest value for the ionization energy (binding energy) will be the innermost electrons. On this graph they are the peak on the left. We know that there are 2 electrons in the 1s orbital so we can use the height of that peak to estimate the others. Often the graph is not labeled with the number of electrons in each peak.
The electron configuration for sodium is $1s^2\ 2s^2\ 2p^6\ 3s^1$, notice that this corresponds to the peaks given. This provides additional evidence for the quantum mechanical model of the atom as the $2s^2\ 2p^6$ peaks have different energy values.




https://chemicalthinking.xyz/pem/pem.html

## I DO:

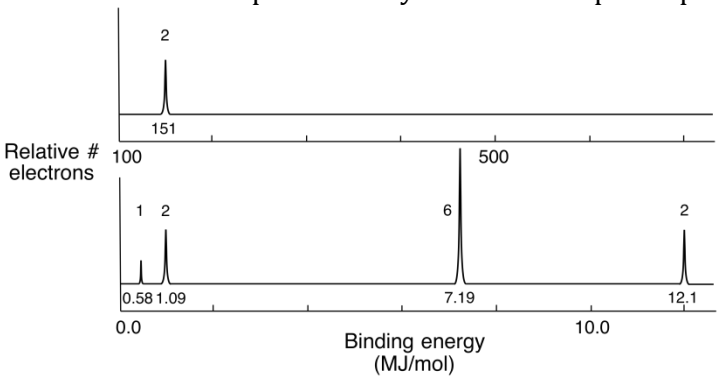
Which element is represented by the PES absorption spectra shown? Oxygen




https://khanacademy.org/science/chemistry/electronic-structure-of-atoms/electron-configurations-jay-sal/a/photoelectron-spectroscopy

## WE DO:

Which element is represented by the PES absorption spectra shown?

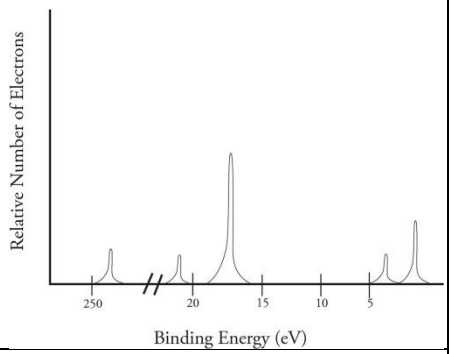



SCAN ME

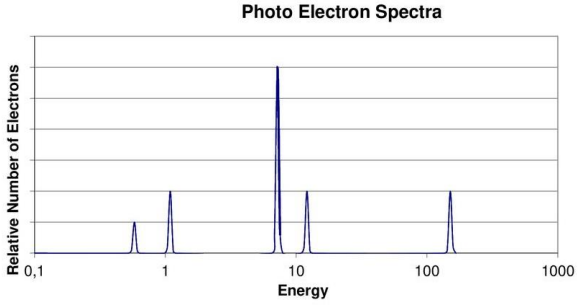
https://khanacademy.org/science/chemistry/electronic-structure-of-atoms/electron-configurations-jay-sal/a/photoelectron-spectroscopy

## YOU DO:

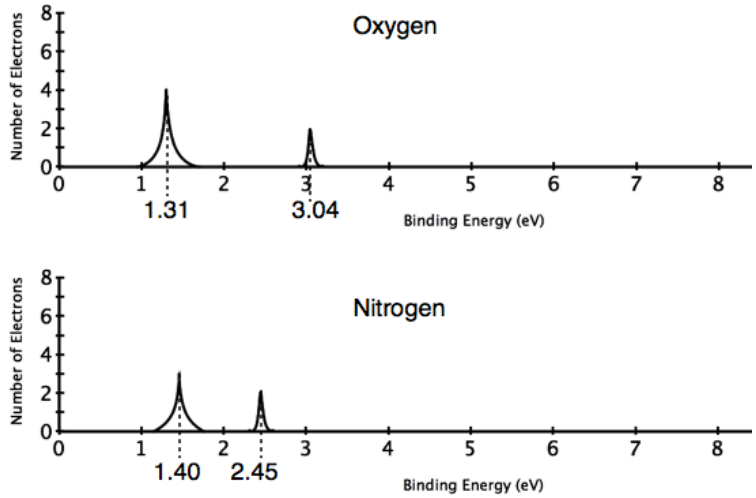
1) Which element is represented by the PES absorption spectra shown?
https://schoolbag.info/chemistry/ap_chemistry/8.html




2) Inspect the PES spectra provided.
https://slideplayer.com/slide/15177715/
   a) Identify the element shown
   b) Write the electron configuration
   c) Predict the charge this element will form as an ion



3) Below are the PES spectra for the valence electrons for oxygen and nitrogen.

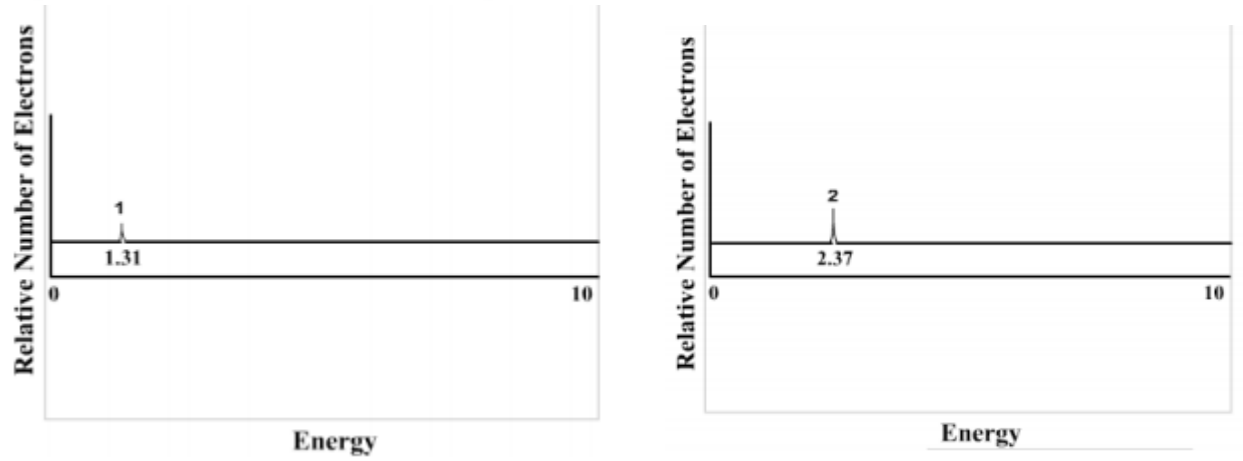



http://www.learnapchemistry.com/potd/problem.php?pc=5881a1ba31d56308ba187d6c6496a8af

a) Write a complete electron configuration for both elements.
b) Identify and label the 2s peaks on each spectrum.
c) Explain the difference in energy for the 2s peaks.
d) Write/Draw a valence electron orbital diagram for each element.
e) Based on the orbital diagram, propose an explanation for the difference in energy for the 2p peaks.

4) The PES spectra for hydrogen and helium are provided.

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




a) Label each graph as Hydrogen or Helium
b) Explain the difference in the intensity (height) of the peaks.
c) Explain the difference in the energy of the peaks.