Ionization Energies Key

Questions to Consider

1. Do you expect ionization energies (IEs) to have positive values or negative values? Why?
   The ionization energy is positive because E_∞ is zero (the energy of a free electron) and E_n is negative (the energy of attraction between electron and nucleus).

2. Suppose an electron has a potential energy of -2.31×10^{-18} J. What is the electron's IE?

   The ionization energy is +2.31×10-18 J because E_∞ is zero.

3. Is the IE for an electron 500 picometers (pm) away from its nucleus larger, smaller or identical in magnitude to the IE for an electron that is 1000 pm away from the same nucleus? If the ionization energies are not identical, which electron has the greater ionization energy and how many times greater is the IE?

   Because an electron's potential energy is inversely proportional to distance, the closer an electron is to the nucleus, the more negative its potential energy; thus, an electron 500 pm from the nucleus has an IE that is two times greater than that for an electron that is 1000 pm from the nucleus.

4. Assuming the distance between the electron and the nucleus is the same for a hydrogen atom, H, and a helium ion, He^+, which has the larger IE? Or, are their IEs equal?

   The helium ion has the larger IE because its nuclear charge of +2 is twice that for the hydrogen atom.

5. Given this model, suppose you have an atom with two electrons, each at a different distance from the nucleus. Do these electrons have the same ionization energies? If no, which electron has the lower IE?

   They will have different IE's because an electron's potential energy is inversely proportional to its distance from the nucleus. The electron with the smaller IE, therefore, is the one that is further from the nucleus.

6. Given this model, suppose several electrons in an atom are equidistant from the nucleus. Do you expect these electrons to have identical or different ionization energies? Suppose two electrons have identical ionization energies. Based on our current model, will removing one of the electrons affect the other electron's ionization energy?

   Given this model, all electrons at the same distance from a common nucleus have the same potential energy and the same IE. As there is no reason to expect that removing one electron changes either the charge on the nucleus or the distance between the second electron and the nucleus, our current model does not suggest that removing one electron will affect the ionization energy of the remaining electron. We will see, later, that removing an electron does change the ionization energies of other electrons, which means that our model needs additional work.