

Ionization Energies

When an electron moves between energy levels the resulting change in energy, ΔE , is always given by the following equation

$$\Delta E = E_2 - E_1$$

where E_2 is the electron's final energy and E_1 is its initial energy. Of particular interest to us is the change in energy when an electron moves to a distance that is infinitely far away from the nucleus; this is called the ionization energy (IE).

Questions to Consider

Do you expect an ionization energy to have a positive value or a negative value? Explain your reasoning.

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

Is the IE for an electron that is 500 pm away from a nucleus larger, smaller or identical to the IE for an electron that is 1000 pm away from the same nucleus? Explain your reasoning.

If the two ionization energies are not identical, how many times greater is the larger of the two ionization energies? Explain your reasoning.

Which do you expect to have the larger IE, a hydrogen atom, H, or a helium ion, He^+ ? Explain your reasoning? Have you made any assumption(s) in reaching your answer? If so, what are they.

Ionization energies are obtained experimentally by bombarding atoms in the gas-phase with a beam of fast-moving particles. If the particle's KE is less than the electron's IE, nothing happens when it collides with the atom; however, when the particle's KE matches or exceeds the electron's IE, the collision ejects the electron from the atom. Thus, ionization energies can be measured by slowly increasing the particle beam's KE and looking for the precise energy where an electron is ejected from the atom. For a H atom, the reaction is



and the IE is 2.178×10^{-18} J. Usually, ionization energies are reported with units of kJ/mol. What is the IE for H in these units? ($N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$)

Suppose you have an atom with many electrons, each at a different distance from the nucleus. Does every electron in the atom have the same ionization energy? Explain your reasoning. If the IEs are not the same, which electron – the one closest to the nucleus or the one furthest from the nucleus – has the lowest IE? Explain your reasoning.

Suppose that several electrons in an atom are equidistant from the nucleus. Do you expect these electrons to have identical or different ionization energies? Explain your reasoning.

Suppose that two electrons have identical ionization energies. Based on our current model, will removing one of the electrons affect the other electron's ionization energy?