CH301H: Principles of Chemistry I: Honors
Fall 2015, Unique 49310

Quiz 3, 13 October 2015

Let's imagine an electron in a chemical bond 1 Å long as being a standing wave with fixed ends.

a) Calculate the wavelength of the electron in its ground state.

b) Calculate the momentum of the electron in its ground state.

c) Is the total energy of the electron composed only of kinetic energy, or does it have a potential energy contribution as well? Justify your answer.

The following information may be useful.

$q = 1.602 \times 10^{-19}$ C
$h = 6.626 \times 10^{-34}$ J s
$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 J^{-1} m^{-1}
$c = 3.0 \times 10^{8}$ m s^{-1}
$m_e = 9.11 \times 10^{-31}$ kg

a) $\lambda = 2\text{Å}$

b) $p = \frac{h}{\lambda} = \frac{(6.626\times10^{-34}\,\text{Js})}{2\times10^{-10}\,\text{m}} = 3.3\times10^{-24}\,\frac{\text{Js}}{\text{m}} = \frac{\text{kgm}}{\text{s}}$

c) $E_{TOT} = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\,\text{Js})(3.0\times10^{8}\,\text{m/s})}{2\times10^{-10}\,\text{m}} = 9.9\times10^{-16}\,\text{J} = KE + PE$

KE? $p = mv \Rightarrow v = \frac{p}{m} = \frac{3.3\times10^{-24}\,\frac{\text{kgm}}{\text{s}}}{9.11\times10^{-31}\,\text{kg}} = 3.6\times10^{6}\,\text{m/s}$

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(9.11\times10^{-31}\,\text{kg})(3.6\times10^{6}\,\text{m/s})^2$

$KE = 6.0\times10^{-18}\,\text{J}$

This is only a small part of the total energy, so there use PE contributions as well.