Homework #1

CHMY 564
16Jan17
Due Wednesday, 18jan17

The statement was made during the previous lecture that all energy level expressions from quantum mechanics can be expressed in the form:

$$E \propto \frac{h^2}{2\mathrm{m}\Delta x^2}$$

While this is obviously true for the particle in an infinite square well (particle in a box) and for the rigid rotor, textbook expressions for the energy of the H atom and one-electron ions are most always expressed as

$$E = -\frac{Z^2}{2n^2}\frac{e^2}{4\pi\varepsilon_0 a}, \text{ in SI units, where } a \text{ stands for the collection of constants } \frac{4\pi\varepsilon_0\hbar^2}{\mu e^2}$$

μ is the reduced mass of the nucleus-electron pair, and e is the proton charge.

In class we found a characteristic length for the harmonic oscillator to be the classical turning point in the zero point state, $x_0 = \left(\frac{\hbar}{\mu\omega}\right)^{1/2}$, which is most often seen in the harmonic oscillator wave function as: $\alpha = \left(\frac{\mu\omega}{\hbar}\right) = \frac{1}{x_0^2}$

Write the expression for the zero point energy of the following systems in the form:

$$E \propto \frac{h^2}{2\mathrm{m}\Delta x^2}$$

(a) particle in a box
(b) rigid rotor
(c) hydrogen atom
(d) harmonic oscillator