Chemistry 2720 Fall 2003 Quiz 8 Solutions

An electron in a 2p state has $\ell = 1$. According to modern quantum mechanical theory,

$$\begin{aligned} L^2 &= \ell(\ell+1)\hbar^2 = 1(1+1)\hbar^2 = 2\hbar^2. \\ \therefore |L| &= \hbar\sqrt{2}. \end{aligned}$$

In the Bohr-de Broglie theory, the quantization condition is

$$2\pi r = n\lambda.$$

(The circumference of the orbit must be an integer number of wavelengths.) The wavelength λ is related to the momentum by $\lambda = h/p$, so we have

$$\begin{aligned} 2\pi r &= nh/p. \\ \therefore rp = |L| &= \frac{nh}{2\pi} = n\hbar. \end{aligned}$$

For an electron in a 2p orbital, the principal quantum number n is 2, so Bohr theory predicts $|L| = 2\hbar$.

The two calculations disagree, which tells us that electrons do not in fact move in circular orbits.