753.

Problem 51.32 (RHK)

We have to show (a) *that the magnetic moments of the electrons in the various Bohr orbit are given by*

$$\mu = n\mu_{\mathrm{B}}$$

in which μ_{B} *is the Bohr magneton and* $n = 1, 2, 3...$(b) *We have to compare this expression with the actual values*.

Solution:

(a)

The Bohr quantization condition is

$l = mvr = n\mathrm{h},\ n = 1, 2, 3...$

Let the speed of the electron in the shell with quantum number n and orbit radius r be v. This motion will result in current

$$i = \frac{e}{T},$$

where T is the period of the orbital motion of the electron and is given by

$T=\dfrac{2\pi r}{v}$, and so $i=ev/2\pi r$. We know that magnetic moment in a current carrying planar loop of area A is given by

$$\mu = iA.$$

Thus the magnetic moment of the orbit of radius r will be

$$\mu = i\left(\pi r^2\right) = \frac{ev}{2\pi r}\times \pi r^2 = \frac{e}{2}rv = \frac{e}{2m}mrv = \frac{e}{2m}n\mathrm{h},$$

or

$$\mu = \frac{eh}{4\pi m}\times n = n\mu_{\mathrm{B}}.$$

(b)

We expect from this result that the magnetic moment of the $n=1$ shell be μ_{B}, but experimentally it is found to be zero. Also, the state with principal quantum number n contains subshells of angular momentum quantum number $l=n-1, n-2, ..., 1, 0$, and the angular momentum of the state with quantum number l is $\sqrt{l\left(l+1\right)}$.