Physics 448 **HOMEWORK SET 3** **Fall 2008**

Due Wednesday September 24

Remember that for relativistic particles the momentum and energy are related by $E^2 = (pc)^2 + (mc^2)^2$ where E is the rest energy plus the kinetic energy.

12) Find the splitting, $\Delta\lambda$, between the Balmer-α lines ($n = 3 \rightarrow n = 2$) of ordinary hydrogen, deuterium and tritium. The nuclear masses are $m_{\rm h} = 938.3$ MeV, $m_{\rm d} = 1875.6$ MeV and $m_{\rm t} = 2808.9$ MeV.

13) Use the Wilson-Sommerfeld quantization rule, $\oint pdq = nh$, to find the energy levels of a particle subject to a potential $V(z) = mgz$ for $z > 0$ and $V(z) = \infty$ for $z < 0$.

14) Use the Wilson-Sommerfeld quantization rule to find the energies of a rigid body (moment of intertia I) rotating about its center of mass.

15) (a) Find the energy difference between the circular n=2 orbit (k=2) and the elliptical n=2 orbit (k=1) of the hydrogen atom. The energies are given by the formula

$$\mathrm{E} = -\frac{1}{2}\alpha^2 \mathrm{mc}^2 \, [1 + \frac{\alpha^2}{\mathrm{n}}(\frac{1}{\mathrm{k}} - \frac{3}{4\mathrm{n}})] \, \frac{1}{\mathrm{n}^2}.$$

(b) If we neglect the splitting of the n=3 states we would expect the $\mathrm{n} = 3 \rightarrow \mathrm{n} = 2$ emission line to have two components. Find the wavelength difference $\Delta\lambda$ between the two components.

16) A photon of energy E = 300 keV Compton scatters through an angle of 45°.

(a) Use the Compton formula to find the energy of the scattered photon.

(b) Find the magnitude and direction of the momentum of the recoil electron.

17) Find the deBroglie wavelength of (a) electrons with kinetic energy 10 eV; (b) electrons with kinetic energy 50 MeV; (c) protons with kinetic energy 50 MeV.