Problem Set 7
Due: Nov. 19, 2003

1. (a) Estimate the average velocity of atomic hydrogen atoms (1 proton), oxygen atoms (6 protons and 6 neutrons) and neon atoms (10 protons and 10 neutrons) in a gas at room temperature.
   Use $v^2 = 3kT/m$ where $k = 1.38 \times 10^{-16}$ erg/K, T is temperature (in degrees Kelvin) and m is the mass of the nucleus. The mass of the proton and neutron are almost the same: 1.7×10^{-24} g

   (b) compare these velocities to the escape velocity from the Earth's surface, $v_{esc}^2 = 2GM/R$, where M and R are the mass and radius of the Earth

2. Compute the equilbrium temperature for an ice covered Earth (albedo = 0.8) and for an ocean covered Earth (albedo = 0.2). Assume the Sun has its current luminsoty, $L_\odot = 4 \times 10^{33}$ ergs/s. Ignore the effects of the Earth's atmosphere, i.e. assume no greenhouse effect.

3. **Angular Momentum and Neutron Stars**

   (a) First, what is the radius, $R_\star$, of a main sequence star with mass $M = 1.4$ $M_\odot$? Assume that $R_\star \propto M^{3/5}$ on the main sequence. Hint: the Sun is a main sequence star with $R_\star = R_\odot = 7 \times 10^{10}$ cm.

   (b) Assume that the star mentioned in (a) has a rotational period, $P_\star = 1$ month, similar to the Sun. Furthermore assume that this star collapses to a neutron star with the same mass and a radius $R_{\rm ns} = 15$ km and that spin angular momentum, J, is conserved. Use $J = (2/5)MR^2\omega$ (strictly true for uniform spheres) and the relation between angular frequency and period, $\omega = 2\pi/P$. Derive an algebraic expression (in terms of $R_{\rm ns}$, $R_\star$, and $P_\star$) for the spin period of the neutron star, $P_{\rm ns}$.

   (c) Give a numerical value for $P_{\rm ns}$ in seconds.

   (d) Interpret your answer, answering the following questions. Is this a reasonable value for the spin period of a neutron star? Do 1.4 $M_\odot$ main sequence stars collapse to form neutron stars, and if not what is their eventual fate? What objects are the progenitors of neutron stars?