Physics 109: Homework #12 Solutions

12.1 The temperature of the photosphere, which is the visible surface of the Sun, averaged over the Sun's disk is 5800 K. The temperature in the interior of the Sun varies by a huge amount: near the center it is roughly 15 million degrees. Energy is produced only in the inner 1.5% of the Sun's interior because that is the only place hot enough for nuclear fusion reactions to occur.

12.2 The p-p chain requires 6 protons (hydrogen nuclei) that are converted into a helium nucleus, 2 protons, some neutrinos, and 26.7 MeV of energy. Energy is released because the mass of a helium nucleus is less than the mass of the 4 protons that made it and that difference in mass appears as energy.

12.3 Solar neutrinos give us a probe of the fusion reactions in the Sun at the present time. They give scientists an almost immediate view of the conditions in the Sun's core. The gallium-based neutrino detection experiments are sensitive to low energy neutrinos that are produced by one of the main reactions of the p-p chain (two protons making a deuteron). It is much more difficult to argue that the low observed rate of these neutrinos is due to some slight error in our standard model of the Sun.

12.4 Although the Sun contains most of the mass of the solar system, it has only about 1% of the angular momentum. Most of the angular momentum that existed in the cloud that formed our solar system, was redistributed so that very little ended up as solar rotation. It is believed that this occured through frictional processes in the flattened disk of dust and gas around the young Sun that ultimately formed the planets.

12.5 At the Earth's location in the solar nebula the estimated temperature when condensation stopped was about 650 K. This was hot enough that only metals, oxides, and silicates condensed, while carbon, carbon-rich silicates, and ices remained in the gaseous state (and were ultimately swept away). This picture is in good agreement with the composition of the Earth. Likewise the compositions of the other planets is generally explained by their location in the solar nebula and the materials that condensed there.