Homework: Ch. 30 & 33

1. If someone wanted to build a scale model of the atom with a nucleus 1.00 m in diameter, how far away would the nearest electron need to be?

2. Rutherford found the size of the nucleus to be about 10^{-15} m. This implied a huge density. What would this density be for gold, which has a mass of 197 amu and 1 amu = 1.66×10^{-27} kg?

3. By calculating its wavelength, show that the first line in the Lyman series is UV radiation.

4. If a hydrogen atom has its electron in the n = 4 state, how much energy in eV is needed to ionize it?

5. Find the radius, in nm, of a hydrogen atom in the n = 2 state according to Bohr's theory.

6. Atoms can be ionized by thermal collisions, such as at the high temperatures found in the solar corona. One such ion is C^{+5}, a carbon atom with only a single electron. (a) By what factor are the energies of its hydrogen-like levels greater than those of hydrogen? (b) What is the wavelength of the first line in this ion's Paschen series?

7. Estimate the density of a nucleus by calculating the density of a proton, taking it to be a sphere 1.2 fm in diameter. Compare your result with the value estimated of 10^{18} kg/m^3.

8. A carbon dioxide laser used in surgery emits infrared radiation with a wavelength of 10.6 μm. In 1.00 ms, this laser raised the temperature of 1.00 cm^3 of flesh to 100 °C and evaporated it. How many photons were required? You may assume flesh has the same heat of vaporization as water, which is 2.256×10^6 J/kg.

9. Calculate the mass in GeV/c^2 of a virtual carrier particle that has a range limited to 10^{-30} m by the Heisenberg uncertainty principle. Such a particle might be involved in the unification of the strong and electroweak forces.

10. The primary decay mode for the negative pion is $\pi^- \rightarrow \mu^- + \overline{\nu}_\mu$. What is the energy release in MeV in this decay?

11. The decay mode of the positive tau is $\tau^+ \rightarrow \mu^+ + \nu_\mu + \overline{\nu}_\tau$. What energy is released?

12. One of the decay modes of the omega minus is $\Omega^- \rightarrow \Xi^0 + \pi^-$. What is the change in strangeness?

13. One decay mode for the eta-zero meson is $\eta^0 \rightarrow \pi^0 + \pi^0$.
    a. Write the decay in terms of the quark constituents.
    b. How much energy is released?

14. Assuming conservation of momentum, what is the energy of each γ ray produced in the decay of a neutral at rest pion, in the reaction $\pi^0 \rightarrow \gamma + \gamma$?