PHYSICS 101B – HOMEWORK SET 5

Reading: Tipler and Llewellyn, Sections 10.6–10.8, 11.1–11.4, Chapter 13. Please read casually (not responsible for exam) 11.5–11.6. For those with an interest in nuclear reactions (stellar burning, reactors, etc) please read Chapter 12.

Due Wednesday 3/14/07.

1.) Problem 10.28 (Answer: 0.37 eV; 4300 K)

2.) Problem 10.48 (Answer: 9.17×10^5; 0.10% – rather good! In fact, it's not quite this good - some energy is lost to exciting vibrations (phonons) in the lattice, so in fact it's more like 3-5 eV per conduction electron.)

3.) Problem 10.50 (Answer: 25.0 MΩ; 500 MΩ; 1.03Ω; 0.052 Ω)

4.) A radioactive sample which begins with N_0 particles at t=0 will decay exponentially according to

$$N(t) = N_0 e^{-t/\tau}$$

where 'τ' is the radioactive decay constant (in seconds) for the particular radioactive material under study. Show that the 'half-life' $\tau_{1/2}$ is related to the decay constant τ via

$$\tau_{1/2} \simeq 0.693\tau.$$

5.) Problem 11.50 (Answer: 6.52 d; 23.0 d; 13 d)

6.) Problem 11.18 (Answer: $3.61 \times 10^{-10} s^{-1}$; 4.87 MeV)

7.) Problem 11.9

For the next few problems, we will make use of the Bethe-Weizsacker Mass Formula from the notes (which is in a slightly different, but equivalent form, of that of Chapter 11's 'More' section on the Semiempirical Mass Formula on the Tipler Website)

$$\Gamma(A,Z) = a_1 - \frac{a_2}{A^{1/3}} - a_3\frac{Z^2}{A^{4/3}} - a_4\frac{(Z^{5/3} + N^{5/3})}{A^{5/3}}$$

where $\Gamma(A,Z)$ is the binding energy per neucleon for a nucleus of A total nucleons, composed of Z protons and N=A-Z neutrons. The values for the constants, determined by fits to the masses of many different nuclei, are 57.5, 16.8, 0.72, and 66.6 MeV for a_1 through a_4, respectively.

8.) The mass of a nucleus is given by the sum of its free proton and neutron masses minus the *total* binding energy. Use the Betha-Weizsacker formula to find an expression which approximates the mass of a nucleus of arbitrary mass number A and atomic number Z. Express your answer in terms of A, Z, m_n (the neutron mass), and m_p (the proton mass).

9.) Differentiate this appropriately to find an expression (which can't be solved algebraically) for the atomic number Z (at the bottom of the 'valley of stability) which yields the nucleus of minimum mass for any given atomic mass number A.

10.) Show that the value of Z implied by this expression is close to the observed value (for which you can consult the periodic table at the end of the book) for A = 8 and A = 125.

11.) Problem 11.31 (just use the masses provided in the example).

12.) ^{6}He is radioactive. What type of decay would you expect it to undergo? What would the decay energy be? (The 'decay energy' is the total kinetic energy available to the decay products after the decay.) (Answer: 3.51 MeV)