LUMS School of Science and Engineering

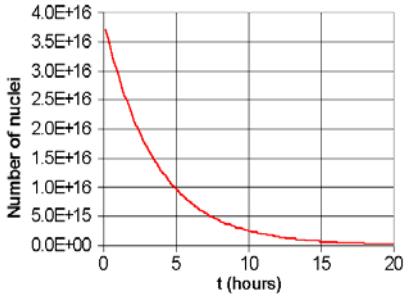
PHY201 Modern Physics – Assignment # 9

Due at 4:00pm, Monday, 26 Nov 2012

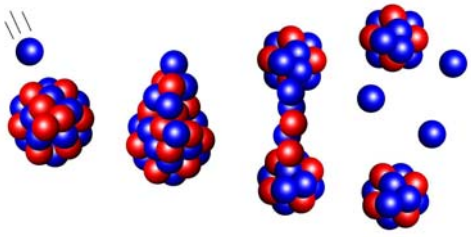
Q.1 In a lab there is 2 micrograms of pure $^{31}_{14}$Si which has a half life of roughly 2.5 hours. How many nuclei are present initially, and how many are left after 4 hours?

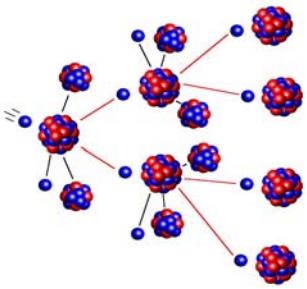
Q.2 The method of carbon dating discussed in the notes can only be used for time scales of a few thousand years. For longer time scales we must use the decay of $^{238}_{92}U$, which has a half-life of 4.5×10^{9} years. Discuss how this could be possible, and how we could use this to find the age of rocks that formed when the earth was formed. You should consult a book or use Google.

Q.3 From the graph shown here, estimate the lifetime of the element. After how much time will the number of nuclei decrease to 4×10^{10} ? If you want to use this element for estimating the age of something, in what range of values would it be useful?



Q.4 In the early days of nuclear physics it was discovered that slow neutrons can be very effective in producing the fission of uranium. Typically a reaction could be like this one: $^{1}_{0}n + {}^{235}_{92}U \rightarrow \left({}^{236}_{92}U\right) \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$. The 3 neutrons produced can then produced more fissions, and this leads to a chain reaction of the kind shown in second diagram:





a)Suppose that a slow neutron enters a block of $^{235}_{92}U$. Assuming that all 3 neutrons go on to fission another nucleus. This is called a chain reaction. After 2,3,4,5..fissions, what will be the number of neutrons? Write down a general formula for N fissions.

b)It is possible that some neutrons are too fast and can escape the uranium block without causing fission. Suppose the probability that a neutron does cause fission is p. How is your answer above modified. Evaluate for $p = 0.7$

5. In a collapsed star called a white dwarf, nuclei are almost touching each other. Calculate the density of this matter in kg/m^3 and compare with that of water.

6. In class we calculated the properties of a collection of non-interacting fermions that are confined in a 3-dimensional volume. Repeat these calculations for a 2-D gas of electrons, such as may exist at the surface of a material.

a) Find the number of states in a small interval d^2k.

b) Find the Fermi momentum and energy.

b) Calculate the pressure exerted by electrons on the boundaries.