# Physics 222 – Test 3 – Spring 2009

One-page reminder sheet allowed. *Show all work – no credit given if work not shown!*

1. Given that the ground state binding energy of the electron in a hydrogen atom is 13.6 eV, compute the ground state binding energy of the remaining electron in a singly ionized (i. e., one electron missing) helium atom.

2. The positive kaon consists of an up quark and an antistrange quark.

   (a) Does the positive kaon decay by a weak, strong, or electromagnetic process? Explain.

   (b) Sketch a diagram illustrating one possible decay process for a positive kaon, leading to real (rather than virtual) final products.

3. Thinking of a nucleon as three quarks in a box, explain why three up quarks or three down quarks will have higher total energy (and hence less binding energy) than two ups and one down or two downs and one up.

4. Two tritium nuclei (tritium: 1 proton + 2 neutrons; binding energy 8.48 MeV) fuse to form a lithium-6 nucleus (3 protons + 3 neutrons; binding energy 32.00 MeV). The rest energies of the electron, proton, and neutron are respectively 0.511 MeV, 938.280 MeV, and 939.573 MeV.

   (a) What other particles are emitted in this reaction? (Be careful!)

   (b) How much energy is released?

5. There is a hot magma body 19 km under the surface below Socorro. Assuming that this magma has a temperature of 1500 K, how much internal energy is conducted to the surface per unit area per unit time? Assume the surface to be at 300 K and take the thermal conductivity of the ground to be the same as that of brick, or 0.050 W $m^{-1}$ $K^{-1}$.

6. A small object is inside a box with walls at temperature $T$. This object initially has temperature $T_{obj} = T$ as well. However, the emissivity for thermal radiation of this object is $\epsilon_E$ and the reflectivity is $(1 - \epsilon_R)$. For normal materials $\epsilon_E = \epsilon_R$, but in this case $\epsilon_E < \epsilon_R$. Hint: Since the object is small, the radiation energy per unit area per unit time coming off the interior walls of the box (i. e., emitted plus reflected radiation) still equals the black box value of $\sigma T^4$.

   (a) Qualitatively, how does the temperature of the object change initially with time? Explain.

   (b) After a long time, when steady state is reached, what is the temperature of the object, assuming that the temperature of the box does not change?