Mathematical Physics: PHYS 3705

Final Exam

NAME:_____

1) Identify, briefly and completely! Give examples where cogent.

Neutron -
Beta Particle -
Body Centered Cubic -
Bragg Scattering -
Drude Model -
Compton Effect -
Lepton -
$W^{\pm}$ Boson -
Degenerate Fermi gas -
Energy Gap -
Rutherford Scattering -

2) An astronaut wishes to reach a star 3 light years away with a ship that will take 5 years to get there (as seen by folks on the earth). How much older is she when she arrives at the distant star system?

3) Adam shines a 223 nm light beam on a zinc photocathode in a vacuum chamber. What would one expect the stopping voltage of the photocurrent to be? The work function of zinc is 4.31 eV.

4) A defect on a surface of an insulating saphire substrate acts as a box that is 1nm wide (and very thin...assume it is a 1-d box). The box is charged with one electron. What is the wavelength of light that you must shine on the system to get the electron to be in the first excited state?

5) For the following reactions, state if they are possible OR if not possible tell why.

(a) $^{5}7\mathrm{Co} \rightarrow {}^{5}6\mathrm{Fe} + \mathrm{e}^{-} + \bar{\nu}_e$.

(b) $\bar{\nu}_e + e^- \rightarrow \mu^- + \bar{\nu}_\mu$

(c) $^4\text{He} + ^7\text{Li} \rightarrow ^{10}\text{B} + \text{n}$

(d) $e^- + p \rightarrow n + \gamma + \nu_e$

6) Compute the binding energy of an alpha particle. Use the following mass table (from Fermi book), all in AMU:

Electron	.000548
Proton	1.00759
Hydrogen	1.00813
Neutron	1.00898
Deuterium	2.01471
Helium	4.00390

7) You need to make an RTG (radio-thermal generator) to generate 10 watts of electricity from a block of Strontium-90, which is a beta emitter (about .54 MeV) which has a half life of 28 years. Assume that the conversion efficiency of the RTG is about 10 percent.

(a) What mass of Strontium-90 will you need?

(b) The RTG is for a 10 year space mission. Neglecting degradation of the efficiency of the generator, how much energy can you expect the RTG to give near the end of the mission?

8) An excited ^{40}Ca atom emits two identical photons, each of wavelength 610nm. The lifetime of the excited state is about 1.32 nanoseconds. Express the width (*i.e.* the uncertainty) of the photon energies in GHz.

9) A vacuum tunnel junction consists of two mm-square interfaces of metal separated by a vacuum gap of 2.5nm. One metal is Na (Sodium, work function 2.28eV) and other is Ag (Silver, work function 4.73eV). Initially they are both nuetral.

(a) After a little time a spontaneous tunneling current moves electrons from one to the other. Which is positive and what will be the voltage between the metals when the current ceases?

(b) Estimating the initial tunneling current using the fact that the electrons in both materials have a density of about 2.0 x 10^{28} per m^3 and move at about 3.0 x 10^5 m/s.

(c) Using $Q = CV$ and the fact that the junction has a capacitance of about 1.26 nano Farads, estimate the time it takes for the system to come to equilibrium.

10) Grab Bag extra credit !!

(a) What would be the fermi energy of the metals in part b, problem 9?

(b) A wavefunction $\phi(x) = Ae^{-s|x|}$ for a particle on a line. Find A in terms of s.

(c) A white dwarf has a density of about 100 tons per **cubic centimeter**. It is held up by electron pressure. What is the magnitude of that fermi pressure (1 atm = 10^5 N/m^2)?

(d) Identify one topic that you are dissapointed is **not** on this exam, and tell me why you are dissapointed!