A.U.B.	Physics 212	Jan. 29 ,1997
Physics Department	Final Exam	Time 2 Hours

Don't forget to write your name and I.D. # on the top of your booklet.
All supplementary information is given at the end of your exam sheet

Part I- Relativity

1)-15 Marks

A particle at rest with mass M decays into two particles of equal mass m. calculate the speed of the two decay particles. Give numerical answer for the decay of a rho particle ($M_\rho = 770\ MeV/c^2$) into two charged pions ($m_\pi = 140\ MeV/c^2$).

2)- 15 Marks

Two protons are directed toward each other. As measured in the laboratory frame, the protons have speed $|\vec{v_1}| = |\vec{v_2}| = 0.85\ c$. What is the speed of one proton in the rest frame of the other?

3)- 15 Marks

Calculate the speed of a galaxy relative to the Earth if the red shift causes the photon wavelength to bee doubled.

4)- 25 Marks

Two protons each with energy of 500 GeV , travel in the opposite direction and collide. Calculate the energy of one of the protons in the frame where the other proton is at rest.

Part II- Quantum physics

5)- 15 Marks

a)- What should the energy of the photons be so that the maximum change in wavelength due to Compton scattering by electrons is one percent?

b)- Using these photons, what is $\Delta\lambda$ in Å for Compton scattered photons at 60° from the incident beam?

c)- What is the energy of the recoil electron in this case?

6)- 15 Marks

It is possible for a muon μ^- to be captured by a proton to form a muonic atom. The muon mass is $105.5\ MeV/c^2$.

a)- Calculate the radius of the first Bohr orbit of a muonic atom (taking into account the reduced mass effect).

b)- Calculate the magnitude of the lowest energy.

c)- What is the shortest wavelength in the Lyman series for this atom?

7)- 15 Marks

Consider a system of two electrons, each with $\ell = 1$, and $s = ½$.

a)- Neglecting spin, what are the possible values of the quantum number for the total orbital angular momentum $\vec{L} = \vec{L_1} + \vec{L_2}$?

b)- What are the possible values of the quantum number S for the total spin $\vec{S}=\vec{S}_1+\vec{S}_2$

c)- Using the results of parts a) and b), find the possible quantum numbers j for the combination $\vec{J}=\vec{L}+\vec{S}$.

d)- What are the possible numbers j_1 and j_2 for the total angular momentum of each particle?

e)- Use the result of part d) to calculate the possible values of j from the combination of j_1 and j_2. Are these the same as in part c) ?

8)- 15 Marks

Which of the following transitions in Sodium do not occur as electric dipole transition? Give the selection rule that is violated. The levels are written in the spectroscopic notation : n[symbol of ℓ]$_j$

a)- $4S_{1/2} \rightarrow 3S_{1/2}$

b)- $4S_{1/2} \rightarrow 3P_{3/2}$

c)- $4P_{3/2} \rightarrow 3S_{1/2}$

d)- $4D_{5/2} \rightarrow 3P_{1/2}$

e)- $4D_{3/2} \rightarrow 3P_{1/2}$

f)- $4D_{3/2} \rightarrow 3S_{1/2}$

9)- 20 Marks

The wavefunction of the Hydrogen ground state is $\Psi_{1,0,0} = \frac{1}{\sqrt{\pi}} \frac{1}{a_B^{3/2}} e^{-\frac{r}{a_B}}$

a)- What is the radial probability density to find the electron anywhere in the spherical shell of radius r and thickness dr ?

b)-Calculate the probability that the electron in the ground state of Hydrogen will be found outside the first Bohr radius a_B. You may use the integration by parts :

$$\int_a^b u\,dv = uv\Big|_a^b - \int_a^b v\,du$$

Part III- Nuclear and Elementary Physics

10)- 15 Marks

Calculate the decay rate per gram per min. of a living organism, assuming the ratio $^{14}C/^{12}C = 1.3 \times 10^{-12}$, and $t_{1/2}(^{14}C) = 5730$ years.

11)- 25 Marks

A person works for 4 hours in a room that contains an unshielded 10 mCi ^{60}Co source. Knowing that $^{60}Co \rightarrow {}^{60}Ni$ (stable) + e^- (~ 1MeV) + X. The angular distribution of the emitted electrons is isotropic.

a)-Identify the particle X.

b)- What is the activity of the source . ($1Ci = 3.7 \times 10^{10}$ Bq)

c)-What is the total energy that appears in electrons in 4 hours.

d)- If all of this energy were absorbed by a person of mass 60 kg, what is the radiation absorbed dose in Gray (Gy) and in Sievert (Sv)? ($1\ Gy = 6.24 \times 10^{12}$ MeV/kg).

e)- The maximal recommended occupational dose is 50 mSv per year. To get one-hundredth of this dose what is the fraction of the electrons absorbed?

f)- If the area of the person is 0.5 m^2 , at what distance the person must keep from the source, to limit the dose to 0.5 mSv ?

12)- 10 Marks

In the quark model, the nucleon {p,n} and the two Δ- particles $\{\Delta^+, \Delta^o\}$ are represented by the same combinations : { uud, udd }. Even that, these two sets of particles are different. What is the main difference between them?

Given:

$\lambda_c = h/mc = 0.0243$ Å, 1nm = 10 Å , $m_e = 0.511$ MeV/c^2 , $m_p = 938.28$ MeV/c^2

$r_n = n^2 \hbar^2 / m_e k e^2 = 0.53\, n^2$ Å, $v_n/c = \alpha/n$, $E_n = - m_e c^2 \alpha^2/2n^2$, hc= 1240 eV.nm ,

$ke^2 = 1.44$ eV.nm , $\alpha = \frac{1}{137}$, $Q(e^- \sim 1\,MeV) = 1$.