AUB Physics Dept. | Physics 212 Final Exam | February 4, 1998 Time: 2 hours

Don't forget to write your name and I.D. number on the top of your booklet.

1) **10 marks**

Observer S assigns to an event the coordinates x = 100 km, t = 200 μs . Find the coordinates of this event in frame S' , which moves in the direction of increasing x with speed 0.950 c. Assume x = x' at t = t' = 0.

2) **10 marks**

One cosmic-ray proton approaches the Earth along its axis with a velocity 0.787 c toward the north pole and another, with velocity 0.612 c toward the south pole. Find the relative speed of approach of one particle with respect to the other.

3) **10 marks**

Calculate the speed parameter (β) of a particle with a momentum of 12.5 MeV/c if the particle is a) an electron (E_{oe} = 0.511 MeV) b) a proton (E_{op} = 939 MeV)

4) **15 marks**

An α particle with kinetic energy 7.70 MeV strikes a ^{14}N nucleus at rest. An ^{17}O nucleus and a proton are produced, the proton emitted at 90° to the direction of the incident α particle and carrying kinetic energy 4.44 MeV. The rest energies of the various particles are : $\alpha \rightarrow$ 3730.4 MeV; $^{14}N \rightarrow$ 13,051 MeV; $p \rightarrow$ 939.29 MeV; $^{17}O \rightarrow$ 15.843 MeV.

a) Find the kinetic energy of the ^{17}O nucleus.

b) At what angle with respect to the direction of the incident α particle does ^{17}O nucleus moves?

5) **15 marks**

A cavity radiator has its maximum spectral radiancy at a wavelength of 25.0 μm, in the infrared region of the spectrum. The temperature of the body is now increased so that the radiant intensity I (T) of the body is doubled.

a) What is this new temperature?

b) At what wavelength the spectral radiancy now have its maximum value?

6) **10 marks**

a) State the Planck's radiation law R (λ, T) in terms of wavelength λ and temperature T.

b) An ideal radiator has a spectral radiancy R at 400 nm that is 3.50 times its spectral radiancy at 200 nm. What is its temperature?

k = 1.381 $\times 10^{-23}$ J/k. h = 6.626 $\times 10^{-34}$ J s.

7) **10 marks**

a) If the work function for a metal is 1.85 eV what would be the stopping potential for light having a wavelength of 410 nm?

b) What would be the maximum speed of the emitted photoelectrons at the metal's surface?

hc = 1240 eV.nm and m_e = 9.11 $\times 10^{-31}$ kg.

8) **15 marks**

a) Consider an electron confined by electrical forces to an infinitely deep 1-dim. potential well whose length L is 100 pm. What are the energies of its four lowest allowed states in eV.

b) The potential well has now a finite depth of 500 eV. What is the energy of its allowed ground bound states.

9) **15 marks**

A cobalt target is bombarded with electrons, and the wavelengths of its characteristic X-rays spectrum are measured. There is also a second fainter characteristic spectrum, which is due to an impurity in the cobalt. The wavelengths of the k_α lines are 178.9 pm (Co) and 143.5 pm (impurity). Use the Moseley's formula : $\sqrt{f} = C(Z - 1)$ in which C is a constant to identify the impurity. ($_{27}$Co, $_{28}$Ni, $_{29}$Cu, $_{30}$Zn, $_{31}$Ga, $_{32}$Ge).

10) **10 marks**

An electron in a hydrogen atom is in a state with $\ell = 5$. What is the minimum possible angle between $\vec{L}$ and L_z ?

11) **10 marks**

What is the wavelength of a photon that will induce transition of an electron spin from parallel to anti-parallel orientation in a magnetic field of magnitude 0.200 T ? Assume that $\ell = 0$; $\mu_B = 5.788 \times 10^{-5}$ eV/T.

12) **20 marks**

A hypothetical atom has two energy levels, with a transition wavelength between them of 580 nm. In a particular sample at 300 K, 4.0×10^{20} such atoms are in the state of lower energy.

a) How many atoms are in the upper state assuming conditions of thermal equilibrium?

b) Suppose, instead, that 3.0×10^{20} of these atoms are pumped into the upper state by an external process, with 1.0×10^{20} atoms remaining in the lower state. What is the maximum energy in Joule that could be released by the atoms in a single laser pulse if each is affected once?

$k_B = 8.62 \times 10^{-5}$ eV/K hc = 1240 eV.nm.

13) **20 marks**

Consider the decays:

$^{223}\text{Ra} \rightarrow {}^{209}_{82}Pb + {}^{14}C$

$^{223}\text{Ra} \rightarrow {}^{219}_{86}Rn + {}^{4}_{2}\alpha$

a) Calculate the Q-values for these decays and determine that both are energetically possible.

b) The Coulomb barrier height for α particles in this decay is 30.0 MeV. What is the barrier height for ^{14}C decay?

The needed atomic masses are:

^{223}Ra → 223.01850 u	^{14}C → 14.00424 u.
^{209}Pb → 208.98107 u	^{4}He → 4.00260 u.
^{219}Rn → 219.00948 u	1u = 931.5 MeV/c^2

14) **10 marks**

An airline pilot spends an average of 20 h per week flying at 35 000 ft, at which altitude the dose equivalent due to cosmic radiation is 7.0 μSv/h. What is the annual (52 week) dose equivalent from this source alone?

Note that the maximum permitted yearly dose equivalent (from all sources) for the general population is 5 mSv, and for radiation workers it is 50 mSv.

15) **20 marks**

The Ξ particle decays as follows

$$\Xi^- \rightarrow \Lambda^0 + \pi^- \quad (1)$$

the product are both unstable. The following decay processes occur in cascade until only stable products remain:

$\Lambda^0 \rightarrow p + \pi^-$

$\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$

$\mu^- \rightarrow e^- + \ldots + \ldots$

a) Complete the last reaction

b) Conclude from the overall decay scheme what is the nature of Ξ particle: a meson or a baryon?

c) Are Lepton numbers conserved in the overall decay scheme?

d) the quark compositions of the reaction (1) are respectively ssd, uds and d u. Plot a quark - diagram for the reaction (1).