

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

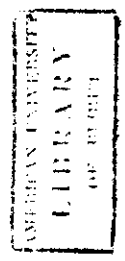
Observer S assigns to an event the coordinates $x = 100 \text{ km}$, $t = 200 \mu\text{s}$. Find the coordinates of this event in frame S' , which moves in the direction of increasing x with speed $0.950 c$. Assume $x = x'$ at $t = t' = 0$.

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 $12.5 \text{ MeV}/c$ if the particle is a) an electron ($E_{0e} = 0.511 \text{ MeV}$) b) a proton ($E_{0p} = 939 \text{ MeV}$)



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 : $\alpha \rightarrow 3730.4 \text{ MeV}$; $^{14}\text{N} \rightarrow 13,051 \text{ MeV}$; $p \rightarrow 939.29 \text{ MeV}$; $^{17}\text{O} \rightarrow 15.843 \text{ MeV}$.

- 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 radiance at a wavelength of $25.0 \mu\text{m}$, 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 radiance now have its maximum value?

6) 10 marks

- a) State the Planck's radiation law $R(\lambda, T)$ in terms of wavelength λ and temperature T .
- b) An ideal radiator has a spectral radiance R at 400 nm that is 3.50 times its spectral radiance at 200 nm . What is its temperature?
 $k = 1.381 \cdot 10^{-23} \text{ J.k}$, $h = 6.626 \cdot 10^{-34} \text{ J.s}$.

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

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. ($_{27}\text{Co}$, $_{28}\text{Ni}$, $_{29}\text{Cu}$, $_{30}\text{Zn}$, $_{31}\text{Ga}$, $_{32}\text{Ge}$).

10) 10 marks

An electron in a hydrogen atom is in a state with $l = 5$. 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 $l = 0$; $\mu_B = 5.788 \cdot 10^{-5}$ eV/T.

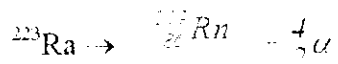
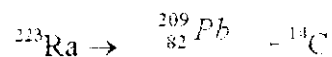
12) 20 marks

A hypothetical atom has two energy levels, with a transition wavelength between them of 580 nm. In a particular sample at 300 K, $4.0 \cdot 10^{20}$ 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 $3.0 \cdot 10^{20}$ of these atoms are pumped into the upper state by an external process, with $1.0 \cdot 10^{20}$ 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?
- $k_B = 8.62 \cdot 10^{-5}$ eV/K $hc = 1240$ eV.nm.

13) 20 marks

Consider the decays:



- 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 ${}^4\text{He}$ decay?

The needed atomic masses are:

$${}^{223}\text{Ra} \rightarrow 223.01850 \text{ u}$$

$${}^4\text{He} \rightarrow 4.00260 \text{ u}$$

$${}^{209}\text{Pb} \rightarrow 208.98107 \text{ u}$$

$${}^{219}\text{Rn} \rightarrow 219.00948 \text{ u}$$

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$$1 \text{ u} = 931.5 \text{ MeV}/c^2$$

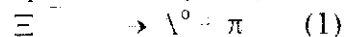
14) 10 marks

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 $\mu\text{Sv h}$. What is the annual (52 week) dose equivalent from this source alone?

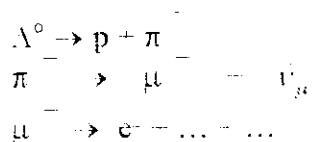
Note that the maximum permitted yearly dose equivalent (from all sources) for the general population is 5 mSv, and for radiation workers it is 50 mSv.

15) 20 marks

The Ξ^- particle decays as follows



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



- 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 $\bar{s}sd$, uds and $d\bar{u}$. Plot a quark - diagram for the reaction (1).