

**Physics 201, Fall 2008**

**Midterm Exam 2**

October 31, 2008 1-1:50 pm

Write your name on each page of paper submitted. You must show all work to receive credit, but only turn in work you would like graded. This exam is closed book. You may not use any electronic devices or written notes. Good luck!

Possibly Useful Information:

$$c = 3 \times 10^8 \text{ m/s}$$

$$g = 9.8 \text{ m/s}^2$$

$$hc = 1240 \text{ eV nm}$$

$$N_A = 6.02 \times 10^{23}$$

**Problem 1.** (15 points)

a) In the hydrogen spectrum, what is the ratio of wavelengths for Lyman- $\alpha$  radiation to Balmer- $\beta$  radiation?

b) Repeat part (a) for the spectrum of a  $\text{He}^+$  ion.

**Problem 2.** (25 points)

A particle of unknown mass  $M$  decays into two particles of known masses  $m_1 = \sqrt{5} \text{ GeV}/c^2$  and  $m_2 = 2 \text{ GeV}/c^2$ , whose momenta are measured to be  $\mathbf{p}_1 = 2 \text{ GeV}/c$  along the positive  $y$  axis, and  $\mathbf{p}_2 = 1.5 \text{ GeV}/c$  along the positive  $x$  axis, respectively.

a) Find the unknown mass  $M$ .

b) Find its speed.

**Problem 3.** (20 points)

A photon strikes an electron of mass  $m$  that is initially at rest, creating an electron-positron pair. The photon is destroyed and the positron and two electrons move off at equal speeds along the initial direction of the photon. What was the energy of the photon?

**Problem 4.** (10 points)

How many C atoms are there in 1 g of  $\text{CO}_2$ ? (Assume the Carbon atoms are all  $^{12}\text{C}$  and the Oxygen atoms are all  $^{16}\text{O}$ .)

**Problem 5.** (10 points)

Light with frequency  $10^{14}$  Hz is emitted from a light source on the roof of a building. Approximately what is the frequency shift of the light when it reaches the ground 18 m below (due to the gravitational Doppler shift)?

**Problem 6.** (20 points)

Show that the stationary wave function

$$y(x, t) = A \operatorname{Re} \left[ \sin \left( \frac{2\pi x}{\lambda} \right) e^{i\omega t} \right]$$

describes the superposition of two sinusoidal waves with amplitude  $A/2$ , wavelength  $\lambda$  and frequency  $\omega/(2\pi)$ , but moving in opposite directions.