PHYSICS 232 – TEST # 3

NAME:

STUDENT ID #:

USEFUL CONSTANTS

$$\epsilon_0 = 8.85 \times 10^{-12} C^2/(N \cdot m^2)$$
$$c = 3 \times 10^8 m/s$$
$$h = 6.6 \times 10^{-34} J \cdot s$$
$$k = 1.38 \times 10^{-23} J/K$$
$$e = 1.6 \times 10^{-19} C$$
$$m_e = 9.1 \times 10^{-31} kg$$

USEFUL FORMULAS

Time dilation:

$$\Delta t == \gamma \Delta t_o \ , \qquad \gamma = \frac{1}{\sqrt{1 - u^2/c^2}}$$

Length contraction: $l = \frac{l_o}{\gamma}$

Lorentz transformation

$$x' = \gamma(x - ut) \ , \qquad t' = \gamma(t - ux/c^2) \ .$$

Addition of velocities:

$$v' = \frac{v - u}{1 - uv/c^2}$$

Doppler effect:

$$f = \sqrt{\frac{c + u}{c - u}} f_o$$

Momentum and energy:

$$\vec{p} = \gamma m \vec{v} \ , \qquad E = \sqrt{m^2c^4 + p^2c^2} = \gamma mc^2$$

Energy of a photon:

$$E = hf = \frac{hc}{\lambda}$$

Photoelectric effect: $eV_0 = hf - \phi$

Bohr model of the H atom:

$$L = m_e vr = n\frac{h}{2\pi} \qquad r = n^2 a_0$$

where $a_0 = \frac{\epsilon_0 h^2}{\pi m_e e^2} = 5.29 \times 10^{-11} m$,

$$E_n = -\frac{m_e e^4}{8h^2\epsilon_0^2 n^2} = -\frac{13.6 \ eV}{n^2}$$

X-rays from electron impact on a target:

$$eV_{AC} = hf_{max} = \frac{hc}{\lambda_{min}}$$

Compton scattering:

$$\lambda' - \lambda = \frac{h}{mc}(1 - \cos\phi)$$

Stefan-Boltzmann law:

$$I = \sigma T^4 \qquad \sigma = 5.67 \times 10^{-8} W/m^2 \cdot K^4$$

Wien displacement law:

$$\lambda T = 2.9 \times 10^{-3} m \cdot K$$

Planck radiation law:

$$I(\lambda) = \frac{2\pi hc^2}{\lambda^5(e^{hc/\lambda kT} - 1)}$$

de Broglie wavelength

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

Heisenberg uncertainty principle:

$$\Delta p_x \Delta x \geq \hbar \ , \qquad \Delta E \Delta t \geq \hbar \ , \qquad \hbar = \frac{h}{2\pi}$$

Schrödinger equation:

$$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + U(x)\psi(x) = E\psi(x)$$

Infinitely deep square potential well:

$$E_n = \frac{n^2h^2}{8mL^2} \ , \qquad \psi_n = \sqrt{\frac{2}{L}} \sin\frac{n\pi x}{L}$$

Harmonic oscillator:

$$E_n = \left(n + \frac{1}{2}\right)\hbar\omega \qquad (n = 0, 1, 2, \dots)$$

There are five (5) problems in this test. Make sure you answer all questions in each problem for full credit. Show as much of your work as possible to receive partial credit, in case you don't come up with the right answer. Good luck!

George Siopsis - 11/10/05

Problem 1

(a) The average life span in the US is about 70 years. Does this mean that it is impossible for an average person to travel a distance greater than 70 light years away from the Earth? *Explain.*

(b) As a body is heated to a very high temperature and becomes self-luminous, the apparent color of the emitted radiation shifts from red to yellow and finally to blue as the temperature increases. Why does the color shift? How does the radiation intensity change?

(c) A stone is dropped from the top of a building. You can ignore air resistance. As the stone falls, does its de Broglie wavelength increase, decrease or stay the same? *Explain.*

Problem 2

A spaceship moves with velocity 0.6c with respect to the Earth. At midnight it passes the Earth and observers on both the spaceship and on Earth agree that their clocks read midnight. At 12:50 a.m. spaceship time the spaceship passes an interplanetary navigation station and sends a signal back to Earth.

(a) How far from Earth (as measured by an Earth based observer) is the navigational station?

(b) At what time (Earth based clock) did the spaceship pass the navigational station?

(c) At what time (Earth based clock) does the receiver on Earth detect the signal from the spaceship?

Problem 3

When a photoelectric surface is illuminated with light of wavelength 437 nm, the stopping potential is 1.67 V.

(a) Calculate the work function of the metal.

(b) What is the maximum speed of the ejected electrons?

Problem 4

An electric current through a tungsten filament maintains its temperature at 2800 K. Assume that the filament behaves as a blackbody.

(a) Calculate the wavelength at which the spectrum has a peak.

(b) If the radiating area of the filament is 2 mm^2, what is the total power radiated by the filament?

Problem 5

An electron is bound in an infinite well of width 0.7 nm. If the electron is initially in $n = 4$ and falls to $n = 2$, find the wavelength of the emitted photon.