Physics 122
Winter 2012
First Hour Exam

Name:________KEY______________________

Part I. Short answer questions: Circle your single choice of the correct answer. (2 points each for a total of 20%)

1. If an observer records 1 hour has passed on a stationary clock, she will measure that on a moving clock
(a) more than an hour has passed
(b) less than an hour has passed
(c) exactly an hour has passed
(d) can measure any of these- depending on the relative velocity between the observer and the clock

2. A spear is thrown past you at very high velocity. As it passes you measure its length to be one-quarter of its rest length. From this you conclude that the moving spear's mass must be
(a) one-quarter of its rest mass
(b) twice its rest mass
(c) four times its rest mass
(d) none of the above

3. Consider a spaceship traveling at a speed of 0.7 c in a straight line towards one star (A) and away from a second star (B). Scientists on the ship measure the velocity of light coming from each star. What do they find?
(a) The light speed from "A" is less than c and from "B" is greater than c
(b) The light speed from "B" is less than c and from "A" is greater than c
(c) The light speed from both stars is measured to be less than c
(d) The light speed from both is measured to be exactly c
(e) The light speed from both is measured to be greater than c

4. A beam of red light and a beam of violet light each deliver the same power on a surface. For which beam is the number of photons hitting the surface per second the greatest?
(a) the red beam
(b) the violet beam
(c) it is the same for both beams
(d) cannot answer this without knowing the light intensity

5. A metal surface is illuminated with green light and electrons are ejected at a certain rate, each with a certain amount of energy. Assuming a constant efficiency for the photoelectric effect at different frequencies, if the frequency of light is increased, maintaining the same intensity of light, the electrons are ejected
(a) at the same rate, but with more energy per electron
(b) at the same rate, but with less energy per electron
(c) at a reduced rate, but with no change in energy per electron
(d) at a reduced rate with more in energy per electron
(e) at an increased rate, but with more energy per electron

6. When an electron in an atom jumps from an orbit where n = 3 to one where n = 5
(a) a photon is emitted
(b) a photon is absorbed
(c) two photons are emitted
(d) two photons are absorbed
(e) none of the above

7. In the Compton Effect, for a given incident photon energy, the recoil electron has its greatest energy when the scattered photon
(a) travels in the forward direction
(b) is scattered at a 90^o angle
(c) is backscattered
(d) none of the above

8. In pair annihilation, why are *two* photons created?
(a) in order to conserve energy
(b) in order to conserve angular momentum
(c) in order to conserve linear momentum
(d) in order to be friendly

9. Which of the following is not an assumption of Bohr theory?
(a) stationary states have definite energy
(b) classical physics describes the equilibrium of stationary states
(c) Angular momentum is quantized in multiples of $(h/2\pi)$
(d) Emission of a photon occurs when atoms make transitions from the ground state to other atomic states
(e) all of the above are assumptions that Bohr made

10. Which of the following is not true of x-rays?
(a) they can be produced by decelerating high-speed electrons
(b) they are produced when high speed electrons hit metal targets
(c) they have continuous spectra plus discrete characteristic wavelengths
(d) they are produced in vacuum tubes with internal metal electrodes
(e) all of the above are true statements

Part II. Problems – **answer all parts and show all of your work (& logic) for full credit**.

1. A friend of yours travels by you in her personal rocket of the future at a speed of 0.8 c. She measures its length to be 4.5 m along the direction of motion, 2.5 m high and to have a rest mass of 1800 kg.

(a) What will you measure its length, height, and relativistic mass to be?

$L = 4.5\sqrt{1-\beta^2} = 2.7$ m

H = 2.5 m unchanged

$m = \gamma m_o = 3000$ kg

(b) How many seconds will have elapsed on your friend's watch when 30 s passed on yours?

$T_{friend} = T_{yours} / \gamma = 18$ s

(c) How many seconds would she say elapsed on your watch when she saw 30 s pass on hers?

Same 18 s because the situation is symmetric

(d) What speed do you measure for the light from the rocket's headlights?

c without using any equations, or you'll find the same thing using rel velocity eqns

(e) Find the kinetic energy of the rocket as measured both by you *and* by your friend.

$K_{friend} = 0$ since she sees the rocket to be stationary

$K_{you} = E - m_o c^2 = 1200\ c^2 = 1.08 \times 10^{20}$ J

2. A photon can have many different possible interactions with matter.

(a) In a photoelectric experiment it is found that a stopping potential of 1.00 V is needed to stop all the electrons when incident light of 260 nm wavelength is used and 2.30 V is needed for light of 207 nm wavelength light. From these data find a value for Planck's constant and the work function of the metal.

$$\frac{hc}{\lambda_1} = \phi + eV_1 \quad and \quad \frac{hc}{\lambda_2} = \phi + eV_2$$

Subtracting gives:

$$hc\left[\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right] = e\left[V_1 - V_2\right]$$

So that we can solve for h:

$$h = \frac{e\left[V_1 - V_2\right]}{c\left[\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right]} = 7.04x10^{-34}\,Js$$

Then subbing back into one of the earlier equations, we find $\phi = 4.1eV = 6.6x10^{-19}\,J$

(b) If a 6.0 KeV photon scatters from a free proton at rest, what is the percent change in the photon's wavelength if the photon recoils at 60°?

$$\Delta\lambda = \frac{h}{mc}\left(1 - \cos\theta\right) = 6.62x10^{-16}\,m$$

Then $E = hc/\lambda \quad gives \quad \lambda = \frac{hc}{E} = 2.07x10^{-10}\,m$

So, finally, $\frac{\Delta\lambda}{\lambda}100 = 0.00032\%$

(c) A uv photon is absorbed by a hydrogen atom in its ground state and excited to its fourth excited state (n = 5). Find the wavelength of the photon.

$$\frac{1}{\lambda} = R_H\left[\frac{1}{1} - \frac{1}{5^2}\right] \quad or \quad \lambda = 95nm$$

3. Bohr energy levels in Hydrogen

(a) From classical physics show how to write the total energy of a hydrogen atom in terms of r, the electron-nucleus separation distance (hint: write down F = ma and use it to get an expression for the velocity of the electron in terms of its radius of orbit)

See text

(b) Using quantization of angular momentum (L = mvr), find an expression for the allowed radii of the electron in hydrogen

See text

(c) Finally get an expression for the allowed energy levels in hydrogen

See text