PHYS 315 EXAM I **9/20/05**

Place your answers in the spaces provided. You must show your work for full credit.
10 pts each.

#1- How fast must a meter stick be moving if it's length is observed to shrink to 0.5 m? Express your answer relative to the speed of light

v = ________________ c

L = Lo / γ
γ = 0.5 = sqrt(1/1−β^2)

$\beta^2 = 1 - 1/\gamma^2 = 0.75$
β = 0.87 c

#2- Calculate how fast you are going in when you pass through a red light (λ=650nm) and it appeared green((λ=570nm) to you.

v = ________________ m/s

$650/570 = (1+ \beta / 1-\beta)^{1/2}$

$(1.14)^2 = 1.3 = 1+ \beta / 1-\beta$
1.3 −1.3β = 1+ β
2.3β = 0.3
β = 0.13 c v = 3.9e7 m/s

#3- Protons at Fermi National Laboratory are accelerated to 400 times their rest energy. What is the speed of these protons relative to the speed of light?

$\gamma = 400$
$\beta = 1 - 1/\gamma^2 = 0.99999375...$
$v \sim c$

v = ______________ c

What is their kinetic energy in MeV?

T = ______________ MeV

$E = 400\ Mc^2$
$T = E - Mc^2 = 399\ Mc^2$

$T = \sim 399\ (939\ \text{MeV}) = 374660\ \text{MeV}$

#4- How much energy is released in ***one kilogram*** of $^{236}U_{92}$ through the the decay $^{236}U_{92} \rightarrow {}^{90}Rb_{37} + {}^{143}Cs_{55} + 3\ {}^{1}n_{0}$.

M(U) = 236.045563 u
M(Rb) = 89.914811 u
M(Cs) = 142.927220 u

ΔE = ____________ MeV

$\Delta mc^2 = \{236.045563u - 89.914811u - 142.927220u - 3(1.009)u\}\ c^2$
$= \{0.177532\ u\}\ c^2 = 165.4\ \text{MeV}$ per atom

N = (1000g/236) moles x 6.02e23 = 2.55e24 atoms

ΔE = (2.55e24 atoms)(165.4 MeV/atom)
ΔE = 4.22e26 MeV

See Example 2.7

#5- A sodium vapor lamp has a power of 10 W. Using λ = 589.3 nm as the average wavelength of the source, calculate the number of photons emitted per second.

N/s = ________________

N/s = P/hf = 10 W / 3.37e-19 J = (10W/3.37e-19 J)
N/s = 2.97e19 1/s

hf = hc/λ = 1240/589.3 = 2.1 eV = 3.37e-19 J per photon

#6- When Cesium metal is illuminated with light of wavelength 300nm the photoelectrons emitted have a maximum kinetic energy of 2.23 eV.
Find the work function of cesium.

ϕ = _____________eV

hf = 1240/300 eV = 4.13 eV

KEmax = hf - ϕ
ϕ = hf – KEmax = (4.13-2.23) eV
ϕ = 1.9 eV

What is the stopping voltage *Vs* when λ=400nm light is incident?

Vs = _____________ V

hf = (1240/400) eV = 3.1 eV

eVs = hf - ϕ = (3.1 – 1.9) eV
eVs = 1.2 eV
Vs = 1.2 V

#7- A 10 KeV X-ray Compton scatters in a Pb shield giving the electron a maximum of kinetic energy. Determine the kinetic energy of the Compton electron. *(What photon scattering angle gives the maximum energy transfer?)*

KEe = ____________ eV

λo = 1240 /10000eV = 0.124 nm

λ = λo - (0.00243 nm)(1-cosθ) = 0.124 + 0.00486 nm = 0.129 nm

θ = 180^o for maximum energy transfer to the electron (Compton backscatter)

hfo = hc/λo = 1240 / 0.124 = 10000 eV

hf = hc/λ = 1240 / 0.129 = 9612 eV

Ke = hfo – hf

Ke = 388 eV

#8 – An electron in hydrogen makes a transition from an n=3 state to an n=1 state without emitting a photon. Instead an n=2 electron is ejected by the Auger process. Find the kinetic energy of the emitted Auger electron. Draw the energy level diagram.

KEe = ____________eV

En = -13.6 eV
E1 = -13.6 eV
E2 = -3.4 eV
E3 = -1.51 eV

E13 = E3 – E1 = 12.1 eV

Ee = E13 - *I* = 12.1eV - 3.4 eV

Ee = 8.7 eV (*Auger Electron*)