PHYSICS 4E QUIZ 1 SPRING QUARTER 2010
PROF. HIRSCH APRIL 9

Formulas and constants:

$hc = 12{,}400\ eV\,A$; $k_B = 1/11{,}600\ eV/K$; $ke^2 = 14.4 eVA$; $m_e c^2 = 0.511\times10^6 eV$; $m_p/m_e = 1836$

Relativistic energy - momentum relation $E = \sqrt{m^2c^4 + p^2c^2}$; $c = 3\times10^8 m/s$

Photons: $E = hf$; $p = E/c$; $f = c/\lambda$ Lorentz force: $\vec{F} = q\vec{E} + q\vec{v}\times\vec{B}$

Photoelectric effect : $eV_0 = (\frac{1}{2}mv^2)_{\max} = hf - \phi$, $\phi \equiv$ work function

Integrals : $I_n \equiv \int_0^\infty x^n e^{-\lambda x^2}dx$; $\frac{dI_n}{d\lambda} = -I_{n+2}$; $I_0 = \frac{1}{2}\sqrt{\frac{\pi}{\lambda}}$; $I_1 = \frac{1}{2\lambda}$; $\int_0^\infty \frac{x^3}{e^x - 1}dx = \frac{\pi^4}{15}$

Planck's law : $u(\lambda) = n(\lambda)\bar{E}(\lambda)$; $n(\lambda) = \frac{8\pi}{\lambda^4}$; $\bar{E}(\lambda) = \frac{hc}{\lambda}\frac{1}{e^{hc/\lambda k_B T} - 1}$

Energy in a mode/oscillator : $E_f = nhf$; probability $P(E) \propto e^{-E/k_B T}$

Stefan's law : $R = \sigma T^4$; $\sigma = 5.67\times10^{-8} W/m^2K^4$; $R = cU/4$, $U = \int_0^\infty u(\lambda)d\lambda$

Wien's displacement law : $\lambda_m T = hc/4.96k_B$

Compton scattering : $\lambda' - \lambda = \frac{\mathrm{h}}{\mathrm{m_e}c}(1-\cos\theta)$; $\lambda_c \equiv \frac{\mathrm{h}}{\mathrm{m_e}c} = 0.0243A$

Hydrogen spectrum : $\frac{1}{\lambda} = R(\frac{1}{m^2} - \frac{1}{n^2})$; $R = 1.097\times10^7\ m^{-1} = \frac{1}{911.3A}$

Rutherford scattering: $b = \frac{kq_\alpha Q}{m_\alpha v^2}\cot(\theta/2)$; $\Delta N \propto \frac{1}{\sin^4(\theta/2)}$

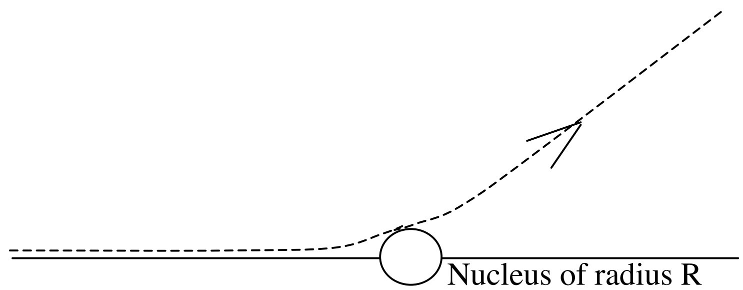
Electrostatics : $F = \frac{kq_1q_2}{r^2}$ (force) ; $U = q_0 V$ (potential energy) ; $V = \frac{kq}{r}$ (potential)

Justify all your answers to all problems
If you copy any part of your work from anybody you are in violation of UCSD's policies and subject to severe sanctions.
Show your work, write clearly.
There are 3 problems in this quiz

Problem 1 (10 pts)
A filament at temperature T emits maximum power at wavelength 2900A. The power it emits in a wavelength range of 1A around 2900A is 2W. Assume it is a black body.
(a) What is the temperature of the filament?
(b) How much power does it emit in a wavelength range of 1A around 5800A?
(c) Does it emit more power in the wavelength range 10A to 50A or in the wavelength range 10,000A to 10,001A? Justify your answer.

Problem 2 (10 pts)
X rays of wavelength 1A are incident on a material.
(a) The ejected electrons at a certain angle ϕ (relative to the incident direction) have kinetic energy 200 eV. Find the angle θ at which the photons where scattered that caused ejection of these electrons. You are allowed to approximate a little bit.
(b) What is the maximum kinetic energy that ejected electrons can have for these X rays, and at which angle ϕ are they ejected?
(c) What is the value of the y component (direction perpendicular to the incident direction) of the electron momentum when the photon is scattered at a 1^o angle? Give your answer in units eV/c.

Problem 3 (10 pts)



An α particle (charge q_α=2e) with kinetic energy E_k = 10MeV is incident on a nucleus of gold (Z=79, charge Q=79e) and radius R=3x10^{-4}A. Assume its impact parameter b is such that it almost touches the surface of the nucleus, as shown in the figure above.
(a) Find the kinetic energy of the α particle when it is closest to the nucleus, in MeV. Hint: it is not 0.
(b) Find its impact parameter b in terms of R. Hint: use angular momentum conservation. If you didn't find the answer for (a), you can still find an answer for (b) expressed in terms of (E'_k/E_k) where E'_k is the answer to (a) (and you will get full credit for (b)).

Justify all your answers to all problems