Physics 137A Ivo ~~Ize~~ Souza Fall 2009
Midterm #1 Wed. Oct. 7th

$\hbar = 1.055 \times 10^{-34}$ Js $\quad c = 2.998 \times 10^{8}$ m/s $\quad e = 1.602 \times 10^{-19}$ C
$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/Jm $\quad m_e = 9.11 \times 10^{-31}$ Kg $\quad m_p = 1.67 \times 10^{-27}$ Kg$\simeq m_n$

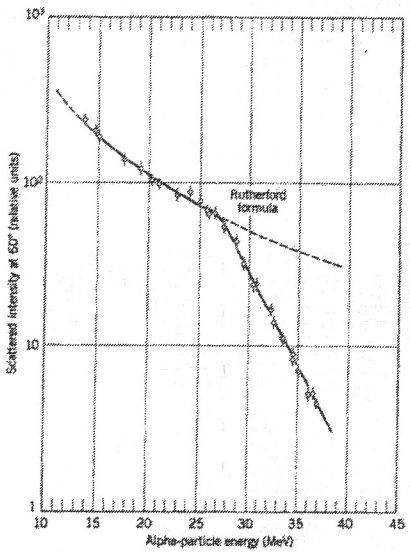
1. **(25 points)** Answer the following questions succintly:

   (a) Describe Stefan's law and Wien's displacement law of blackbody radiation.

   (b) Sketch the curve of the photoelectric current versus the potential difference between the electrodes in Lenard's photoelectric effect experiment, when the cathode is illuminated with monochromatic UV light, for two values of the light intensity. Which feature of the data defies a classical explanation?

   (c) Compton scattering is a phenomenom which brings out (select one) (i) the wave-like nature of electrons; (ii) the particle-light nature of light; (iii) the quantization of energy.

2. **(25 points)** The figure shows deviations from Rutherford's formula in the scattering of high-energy alpha-particles from ^{208}Pb. On the basis of these results, estimate the size of the ^{208}Pb nucleus. How does it compare with typical *atomic* radii?



3. **(25 points)** Calculate the difference in wavelengths $\Delta\lambda$ between the Balmer lines (final state is the $n = 2$ state) in atomic hydrogen (nucleus = 1 proton) and deuterium (nucleus = 1 proton + 1 neutron).

4. **(25 points)**

   (a) Starting from the expression for the *total* energy of a relativistic particle of rest mass $m_0 > 0$, use de Broglie's relations to show that the phase velocity v_ϕ of a "matter wave" is larger than the speed of light c.

   (b) Show that the phase and group velocities obey the relation $v_\phi v_g = c^2$, which implies that $v_g < c$.