Rutherford's atom II

A.C. Norman
anorman@bishopheber.cheshire.sch.uk

1. (a) What do you understand by the term *the nuclear atom*?
   (b) Alpha particles in a narrow parallel beam are scattered by a thin metallic foil. What are the results of such an experiment, and how do they provide evidence for the nuclear atom?
   (c) Explain:
      i. why the experiment is carried out in a vacuum
      ii. why the incident alpha particles are confined to a narrow beam,
      iii. why the foil is thin.
2. (a) Sketch, on the same diagram, the paths of three alpha particles, of the same energy, which are directed towards a nucleus so that they are deflected though
      i. about 20°,
      ii. about 90°,
      iii. 180°.
   (b) For the deflection of 180°, describe how
      i. the kinetic energy,
      ii. the potential energy,
      iii. the speed,

      of the alpha particle varies along its path.
3. It is known that the potential energy of two charged particles is given by

$$E_p = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r},$$

   where $\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$, Q_1 and Q_2 are the charges in coulombs, and r is the separation of the charges in metres.

   Using the information below, calculate

   (a) the kinetic energy of an alpha particle travelling at $6.9 \times 10^6\,\mathrm{m\,s^{-1}}$. ($\mathrm{KE} = \frac{1}{2}mv^2$)
   (b) the charge in coulombs of a nucleus of $^{118}_{50}\mathrm{Sn}$.
   Assume a head-on approach of an alpha particle and a $^{118}_{50}\mathrm{Sn}$ nucleus. At the distance of closest approach, all the kinetic energy is converted to potential.
   (c) By equating the KE from (a) to the potential energy from the above equation, calculate the distance of closest approach, r.

   Mass of proton = mass of neutron = $1.67 \times 10^{-27}\,\mathrm{kg}$, Charge on the proton = $1.6 \times 10^{-19}\,\mathrm{C}$. An alpha particle is two protons and neutrons.