UNIVERSITY OF ALABAMA Department of Physics and Astronomy

PH 102 / LeClair

Summer II 2012

Problem Set 3: Electric potential, etc.

Instructions:

- 1. Answer all questions below. Show your work for full credit.
- 2. All problems are due Monday 16 July 2012 by the end of the lab period.
- 3. You may collaborate, but everyone must turn in their own work.

1. In Rutherford's famous scattering experiments that led to the planetary model of the atom, alpha particles (having charge +2e and masses of 6.64×10^{-27} kg) were fired toward a gold nucleus with charge +79e. An alpha particle, initially very far from the gold nucleus, is fired at a speed of $v_i = 2.00 \times 10^7$ m/s directly toward the nucleus, as shown below.

- a) How close does the alpha particle get to the gold nucleus before turning around? Assume the gold nucleus remains stationary, and that energy is conserved.
- b) What will the acceleration of the alpha particle be at the moment it reverses direction?



2. An interstellar dust grain, roughly spherical with a radius of 3×10^{-7} m, has acquired a negative charge such that its electric potential is -0.15 Volts.

- (a) How many extra electrons has it picked up?
- (b) What is the strength of the electric field at its surface?
- **3.** Calculate the total electric potential energy in the following two cases:
 - a) Four particles of equal charge q are located at the corner of a square of side a while a fifth charge of value -4q is placed at the center (Figure (a) below).
 - b) Four equal and opposite charges (of magnitude 2q each) are located at the corner of a square of side a (Figure (b) below)



4. In the circuit below, $C_1 = 2.0 \,\mu\text{F}$, $C_2 = 6.0 \,\mu\text{F}$, $C_3 = 3.0 \,\mu\text{F}$, and $\Delta V = 10.0 \,\text{V}$. Initially all capacitors are uncharged and the switches are open. (a) What is the charge on C_2 when switch S_1 is open and switch S_2 is closed? (b) What is the charge on C_1 when S_1 is closed and switch S_2 is open?



5. In the circuit diagram below, the resistors represent light bulbs. In these three circuits, all the batteries are identical and have negligible internal resistance, and all the light bulbs are identical. Rank all 5 light bulbs (A, B, C, D, E) in order of brightness from brightest to dimmest. Justify your rankings briefly.

