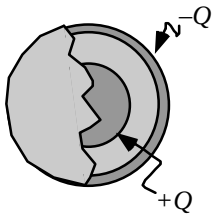
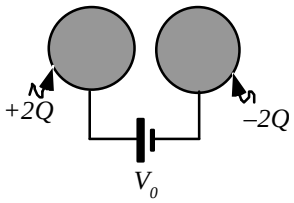
Name (please print): _____ total points: _____
(last) (first)

2. [25 points] Two systems (shown at right) are set up in such a way that they have the **same** capacitance.
   - System A consists of two insulated concentric spherical conducting shells. Net charge of magnitude *Q* is placed on each surface as shown.
   - System B consists of two identical spherical conducting shells. The spheres are connected to a battery so that a net charge of magnitude 2Q is on each sphere.

System *A*



System *B*



A. [7 pts] Let W_A be the magnitude of the work done by the electric field when a positive test charge (q_0) is moved from one sphere to another in system A. Let W_B be the magnitude of the work done by the electric field when the same positive test charge is moved from one sphere to another in system B. Is W_A *greater than, less than,* or *equal to* W_B? Explain your reasoning.

$W_A < W_B$

Since both systems have the same capacitance, the ratio of Q/ C, must be the same. System B has a greater charge so it must also have a greater ΔV between the spheres. Work is directly related to potential difference so whichever system has the greater potential difference must also have the greater work.

The two spheres in system B are moved closer together (but not touching).

B. [10 pts] State whether each of the following quantities would *increase*, *decrease*, or *remain the same* when the two spheres are moved closer together. Be sure to explain your reasoning in each case.

- the magnitude of the net charge on each sphere

Charge increases. Since the spheres are connected to a battery, the work to move a charge between them stays fixed. If the work is the same, but the distance has decreased, it must be true that the force on the charge by the electric field must have increased. In order to increase the electric force, the charge on each sphere must have increased.

- the magnitude of the work done by the electric field in moving the positive test charge (q_0) (from part A) from one sphere to the other

Work remains the same. The potential difference between the spheres has not changed, since they are connected to a battery (which supplies a constant potential difference). Since the potential difference is the work required to move one unit of charge, the work must also remain constant for a given test charge.

Name (please print): _____ total points: _____
(last) (first)

C. [8 pts] While the spheres in system A are close together, is the capacitance of system A *greater than*, *less than*, or *equal to* the capacitance of system B? Explain. If the capacitances are not equal, would the radius of the inner sphere in system B need to be *increased* or *decreased* in order to make the capacitances equal again? Explain.

$C_A < C_B$; the inner sphere of must be increased. From the changes in Q and ΔV found in part B, it can be seen that $C_B = Q/\Delta V$ must have increased. In order to increase the capacitance in system A (with **fixed** charge), the potential difference between the plates must be decreased. By decreasing the distance between the spheres in system B, the work to move a test charge also decreases, and therefore the potential difference.