[electrostatics ii] .quiz

1) Coulomb's law

John Townsend in his free time does an experiment similar to the one we did in Electrostatics II. The humidity is low. After charging both spheres, by touching them with a charged rod, he reads $m = 0.34$ gr on the scale for the electrostatic force. He measures the distance between the spheres to be $r = 12.5$ cm. We call the charges on the spheres Q_1 and Q_2.

a) Write an equation and find $Q_1 Q_2$.
b) He contacts the spheres together for a moment. We call the charges on the spheres q_1 and q_2. Explain why $q_1 = q_2$.
c) Now he measures $m = 0.51$ gr on the scale for the electrostatic force. Find q_1.
d) Now if he discharges one of the spheres to a capacitor, $C = 4.7\ \mu$F, which is connected in parallel to a voltmeter, what would be the reading on the voltmeter?
e) Can you use previous parts to find Q_1 and Q_2? How?

a) $F_E = k\frac{Q_1 Q_2}{r^2} = .34 \times 10^{-3} \times 9.8\ N \rightarrow Q_1 Q_2 = 5.8 \times 10^{-15}\ C^2$.

b) Same spheres → Same capacitance (i)
touching conductors → same potential (ii)
(i), (ii) ⇒ $q_1 = q_2$.

c) $F_E' = k\frac{q_1 q_2}{r^2} = .51 \times 10^{-3} \times 9.8\ N \rightarrow q_1 q_2 = 8.7 \times 10^{-15}\ C^2 \xrightarrow{q_1 = q_2} q_1 = 9.3 \times 10^{-8}\ C$.

d) $V = \frac{q_1}{C} = \frac{9.3 \times 10^{-8}\ C}{4.7 \times 10^{-6}\ F} = 20$ mV.

e) yes, but we do not know which sphere had Q_1 & which sphere had Q_2 charges.

$$\begin{cases} Q_1 + Q_2 = q_1 + q_2 = 2q_1 = 1.86 \times 10^{-7}\ C, & (1) \\ Q_1 Q_2 = 5.8 \times 10^{-15}\ C^2 \end{cases}$$

$$\rightarrow (Q_1 - Q_2)^2 = 4q_1^2 - 4Q_1 Q_2 = 11.6 \times 10^{-15}\ C^2 \rightarrow |Q_1 - Q_2| = 1.1 \times 10^{-7}\ C. \quad (2)$$

(1), (2) → either $\begin{cases} Q_1 = 1.5 \times 10^{-7}\ C \\ Q_2 = 0.4 \times 10^{-7}\ C \end{cases}$ or $\begin{cases} Q_1 = 0.4 \times 10^{-7}\ C \\ Q_2 = 1.5 \times 10^{-7}\ C \end{cases}$.