41. We find the initial charge on the 7.7-μF capacitor when it is connected to the battery:
$Q = C_1V = (7.7\ \mu\text{F})(125\ \text{V}) = 962.5\ \mu\text{C}.$
When C_1 is disconnected from the battery and then connected to C_2, some charge will flow from C_1 to C_2. The flow will stop when the voltage across the two capacitors is the same:
$V_1 = V_2 = 15\ \text{V}.$
Because charge is conserved, we have
$Q = Q_1 + Q_2.$
We find the charge remaining on C_1 from
$Q_1 = C_1V_1 = (7.7\ \mu\text{F})(15\ \text{V}) = 115.5\ \mu\text{C}.$
The charge on C_2 is
$Q_2 = Q - Q_1 = 962.5\ \mu\text{C} - 115.5\ \mu\text{C} = 847\ \mu\text{C}.$
We find the value of C_2 from
$Q_2 = C_2V_2;$
$847\ \mu\text{C} = C_2(15\ \text{V})$, which gives $C_2 = \boxed{56\ \mu\text{F}.}$

42. We find the initial charges on the capacitors:
$Q_1 = C_1V_1 = (2.50\ \mu\text{F})(1000\ \text{V}) = 2500\ \mu\text{C};$
$Q_2 = C_2V_2 = (6.80\ \mu\text{F})(650\ \text{V}) = 4420\ \mu\text{C}.$
When the capacitors are connected, some charge will flow from C_2 to C_1 until the potential difference across the two capacitors is the same:
$V_1' = V_2' = V.$
Because charge is conserved, we have
$Q = Q_1' + Q_2' = Q_1 + Q_2 = 2500\ \mu\text{C} + 4420\ \mu\text{C} = 6920\ \mu\text{C}.$
For the two capacitors we have
$Q_1' = C_1V$, and $Q_2' = C_2V.$
When we add these, we get
$Q_1' + Q_2' = Q = (C_1 + C_2)V;$
$6920\ \mu\text{C} = (2.50\ \mu\text{F} + 6.80\ \mu\text{F})V$, which gives $V = \boxed{744\ \text{V}.}$
The charge on C_1 is
$Q_1' = C_1V = (2.50\ \mu\text{F})(744\ \text{V}) = 1.86 \times 10^3\ \mu\text{C} = \boxed{1.86 \times 10^{-3}\ \text{C}.}$
The charge on C_2 is
$Q_2' = C_2V = (6.80\ \mu\text{F})(744\ \text{V}) = 5.06 \times 10^3\ \mu\text{C} = \boxed{5.06 \times 10^{-3}\ \text{C}.}$

43. The energy stored in the capacitor is
$U = \frac{1}{2}CV^2 = \frac{1}{2}(7200 \times 10^{-12}\ \text{F})(550\ \text{V})^2 = \boxed{1.09 \times 10^{-3}\ \text{J}.}$

44. We find the capacitance from
$U = \frac{1}{2}CV^2;$
$200\ \text{J} = \frac{1}{2}C(6000\ \text{V})^2$, which gives $C = 1.1 \times 10^{-5}\ \text{F} = \boxed{11\ \mu\text{F}.}$