57. If the plates initially have a charge Q on each plate, the energy to move a charge ΔQ will increase the stored energy:

$$\Delta U = U_2 - U_1 = (\tfrac{1}{2}Q_2{}^2/C) - (\tfrac{1}{2}Q_1{}^2/C)$$
$$= [(Q + \Delta Q)^2 - Q^2]/2C = [(2Q\,\Delta Q + (\Delta Q)^2]/2C = (2Q + \Delta Q)\,\Delta Q/2C;$$

$8.5\text{ J} = (2Q + 3.0\times10^{-3}\text{ C})(3.0\times10^{-3}\text{ C})/2(9.0\times10^{-6}\text{ F})$, which gives $Q = 0.024\text{ C} =$ **24 mC.**

58. (*a*) The kinetic energy of the electron ($q = -e$) is

$$\text{KE}_e = -qV_{BA} = -(-e)V_{BA} = eV_{BA}.$$

The kinetic energy of the proton ($q = +e$) is

$$\text{KE}_p = -qV_{AB} = -(+e)(-V_{BA}) = eV_{BA} =$$ **5.2 keV.**

(*b*) We find the ratio of their speeds, starting from rest, from

$$\tfrac{1}{2}m_e v_e{}^2 = \tfrac{1}{2}m_p v_p{}^2, \quad \text{or} \quad v_e/v_p = (m_p/m_e)^{1/2} = [(1.67\times10^{-27}\text{ kg})/(9.11\times10^{-31}\text{ kg})]^{1/2} =$$ **42.8.**

59. The mica will change the capacitance. The potential difference is constant, so we have

$$\Delta Q = Q_2 - Q_1 = (C_2 - C_1)V = (K - 1)C_1V$$
$$= (7 - 1)(2600\times10^{-12}\text{ F})(9.0\text{ V}) = 1.4\times10^{-7}\text{ C} =$$ **0.14 μC.**

60. If we equate the heat flow to the stored energy, we have

$$U = \tfrac{1}{2}CV^2 = mc\,\Delta T;$$

$\tfrac{1}{2}(4.0\text{ F})V^2 = (2.5\text{ kg})(4186\text{ J/kg}\cdot\text{C°})(95°\text{C} - 20°\text{C})$, which gives $V =$ **6.3×10^2 V.**

61. Because the charged capacitor is disconnected from the plates, the charge must be constant. The paraffin will change the capacitance, so we have

$$Q = C_1V_1 = C_2V_2 = KC_1V_2;$$

$24.0\text{ V} = (2.2)V_2$, which gives $V_2 =$ **10.9 V.**

62. The uniform electric field between the plates is related to the potential difference across the plates:

$$E = V/d.$$

For a parallel-plate capacitor, we have

$$Q = CV = (\epsilon_0 A/d)(Ed) = \epsilon_0 AE$$
$$= (8.85\times10^{-12}\text{ C}^2/\text{N}\cdot\text{m}^2)(56\times10^{-4}\text{ m}^2)(3.0\times10^6\text{ V/mm}) = 1.5\times10^{-7}\text{ C} =$$ **0.15 μC.**