78. (a) Initially, the capacitance is

$$C_0 = \frac{\varepsilon_0 A}{d} = \frac{\left(8.85 \times 10^{-12}\ \frac{\mathrm{C}^2}{\mathrm{N \cdot m}^2}\right)(0.12\,\mathrm{m}^2)}{1.2 \times 10^{-2}\,\mathrm{m}} = 89\ \mathrm{pF}\ .$$

(b) Working through Sample Problem 26-6 algebraically, we find:

$$C = \frac{\varepsilon_0 A \kappa}{\kappa(d-b)+b} = \frac{\left(8.85 \times 10^{-12}\ \frac{\mathrm{C}^2}{\mathrm{N \cdot m}^2}\right)(0.12\,\mathrm{m}^2)(4.8)}{(4.8)(1.2-0.40)(10^{-2}\,\mathrm{m}) + (4.0 \times 10^{-3}\,\mathrm{m})} = 120\ \mathrm{pF}\ .$$

(c) Before the insertion, $q = C_0 V (89\,\mathrm{pF})(120\,\mathrm{V}) = 11\,\mathrm{nC}$. Since the battery is disconnected, q will remain the same after the insertion of the slab.

(d) $E = q/\varepsilon_0 A = 11 \times 10^{-9}\,\mathrm{C}/\left(8.85 \times 10^{-12}\ \frac{\mathrm{C}^2}{\mathrm{N \cdot m}^2}\right)(0.12\,\mathrm{m}^2) = 10\,\mathrm{kV/m}$.

(e) $E' = E/\kappa = (10\,\mathrm{kV/m})/4.8 = 2.1\,\mathrm{kV/m}$.

(f) $V = E(d-b) + E'b = (10\,\mathrm{kV/m})(0.012\,\mathrm{m} - 0.0040\,\mathrm{m}) + (2.1\,\mathrm{kV/m})(0.40 \times 10^{-3}\,\mathrm{m}) = 88\,\mathrm{V}$.

(g) The work done is

$$\begin{aligned} W_{\mathrm{ext}} &= \Delta U = \frac{q^2}{2}\left(\frac{1}{C} - \frac{1}{C_0}\right) \\ &= \frac{(11 \times 10^{-9}\,\mathrm{C})^2}{2}\left(\frac{1}{89 \times 10^{-12}\,\mathrm{F}} - \frac{1}{120 \times 10^{-12}\,\mathrm{F}}\right) \\ &= -1.7 \times 10^{-7}\ \mathrm{J}\ . \end{aligned}$$