

24. (a) The capacitance is

$$C = \frac{\varepsilon_0 A}{d} = \frac{\left(8.85 \times 10^{-12} \frac{\text{C}^2}{\text{N} \cdot \text{m}^2}\right) (40 \times 10^{-4} \text{ m}^2)}{1.0 \times 10^{-3} \text{ m}} = 3.5 \times 10^{-11} \text{ F} = 35 \text{ pF} .$$

(b) $q = CV = (35 \text{ pF})(600 \text{ V}) = 2.1 \times 10^{-8} \text{ C} = 21 \text{ nC}$.

(c) $U = \frac{1}{2} CV^2 = \frac{1}{2} (35 \text{ pF})(21 \text{ nC})^2 = 6.3 \times 10^{-6} \text{ J} = 6.3 \mu\text{J}$.

(d) $E = V/d = 600 \text{ V}/1.0 \times 10^{-3} \text{ m} = 6.0 \times 10^5 \text{ V/m}$.

(e) The energy density (energy per unit volume) is

$$u = \frac{U}{Ad} = \frac{6.3 \times 10^{-6} \text{ J}}{(40 \times 10^{-4} \text{ m}^2)(1.0 \times 10^{-3} \text{ m})} = 1.6 \text{ J/m}^3 .$$