24-3. (a)

$$V = Q/C = \frac{.148 \times 10^{-6}}{245 \times 10^{-12}} = 604 \text{ V}$$

(b) $C = \epsilon_0 A/d$, so:

$$A = \frac{Cd}{\epsilon_0} = \frac{245 \times 10^{-12} \cdot .328 \times 10^{-3}}{8.8542 \times 10^{-12}} = 90.8 \times 10^{-4} \text{ m}^2$$

This would correspond, for example, to a square with side: $s = \sqrt{90.8 \times 10^{-4}} = 9.53 \times 10^{-2}$ m $= 9.53$ cm.

(c)

$$E = \frac{V}{d} = \frac{604}{.328 \times 10^{-3}} = 1.84 \times 10^6 \text{ V/m}$$

(d)

$$\sigma = \epsilon_0 E = 8.8542 \times 10^{-12} \cdot 1.84 \times 10^6 = 1.63 \times 10^{-5} \text{ C/m}^2$$

(b) Another method of finding the area is to use the charge/(charge density):

$$A = \frac{Q}{\sigma} = \frac{.148 \times 10^{-6}}{1.63 \times 10^{-5}} = 90.8 \times 10^{-4} \text{ m}^2$$

24-7. Diameter of penny: dia=19 mm (measure or use the web); area $A = \frac{1}{4}\pi \text{ dia}^2$

$$d = \frac{\epsilon_0 A}{C} = \frac{\frac{1}{4}\pi(19 \times 10^{-3})^2 \cdot 8.8542 \times 10^{-12}}{10^{-12}} = 2.51 \times 10^{-3} \text{ m}$$

This separation is about the thickness of two dimes together: thin but not super-thin. Deviations from the infinite plane approximation typically extend $\pm d$ around the edge of the capacitor. Kirchhoff showed in 1877 that C is increased by fringing: approximately as if the radius of the capacitor were increased by an amount proportional to d. Here d is about 25% of the radius, so the resulting C would be noticeably larger than that calculated using the parallel plate approximation. Do note that 1 pF is quite small for a capacitor (with a result that d is unusually large): the smallest cap value we commonly stock is 10 pF, and I'd have no problem showing you a capacitor a million times bigger than that! So for reasonably sized capacitors, d would be microscopic, and the correction to the parallel plate approximation way less than 1%.

24-15. Symbolically the diagram corresponds to: $((C_1 + C_2)\|C_3) + C_4$, where $+$ denotes series and $\|$ denotes parallel. Note the simple formula valid for series combination of exactly two capacitors (product over sum):

$$C_{\text{eq}} = \frac{C_1 \cdot C_2}{C_1 + C_2}$$

For the block: $((C_1 + C_2)\|C_3)$, we have:

$$C_{\text{eq}} = \frac{C_1 \cdot C_2}{C_1 + C_2} + C_3 = \frac{C}{2} + C = \frac{3}{2}\, C$$

Adding in the series combination with C_4 gives:

$$C_{\text{eq}} = \frac{\frac{3}{2}C^2}{\frac{5}{2}C} = \frac{3}{5}C = 2.4\ \mu\text{F}$$

The charge on this equivalent capacitor (which is also the charge on C_4):

$$Q = CV = 2.4 \times 10^{-6} \cdot 28 = 67.2\ \mu\text{C}$$

The voltage drop across C_4 can now be calculated:

$$V_4 = Q_4/C_4 = 67.2 \times 10^{-6}/4 \times 10^{-6} = 16.8\ \text{V}$$

Knowing V_4 allows us to find the voltage drop across the $((C_1 + C_2)\|C_3)$ block: $28 - 16.8 = 11.2$ V. This is of course the voltage drop across each of C_3 and $C_1 + C_2$. The charge on C_3 is then:

$$Q = CV = 4 \times 10^{-6} \cdot 11.2 = 44.8\ \mu\text{C}$$

The charge on $C_1 + C_2$ is:

$$Q = CV = 2 \times 10^{-6} \cdot 11.2 = 22.4\ \mu\text{C}$$

This same charge is stored on each of C_1 and C_2. The voltage drop across either of C_1 and C_2 can be found from this charge:

$$V = Q/C = 22.4 \times 10^{-6}/4 \times 10^{-6} = 5.6\ \text{V}$$

24-22. Symbolically the diagram corresponds to: $10\ \mu\text{F} + (5\ \mu\text{F}\|8\ \mu\text{F}) + 9\ \mu\text{F}$, where $+$ denotes series and $\|$ denotes parallel.

(a)

$$\frac{1}{C_{\text{eq}}} = \frac{1}{10\ \mu\text{F}} + \frac{1}{5\ \mu\text{F} + 8\ \mu\text{F}} + \frac{1}{9\ \mu\text{F}} = \frac{1}{10} + \frac{1}{13} + \frac{1}{9} = .288 \Rightarrow C_{\text{eq}} = \frac{1}{.288} = 3.47\ \mu\text{F}$$

(b)

$$Q = CV = 3.47 \times 10^{-6} \cdot 50 = 174 \times 10^{-6}\ \text{C}$$

(c) Same. FYI: the voltage drop across the 10 μF is $V = Q/C = 17.4$ V, the 9 μF is $V = Q/C = 19.3$ V, and the (equivalent) 13 μF is $V = Q/C = 13.4$ V; note that these add up to the initial 50 V. If it had been requested, we could find the charge stored on the 8 μF capacitor from: $Q = VC = 13.4 \cdot 8 \times 10^{-6}$ (and similarly for the 5 μF cap).