24.1

(a) $$E = \frac{\Delta V}{d}$$

$$\Delta V = E \cdot d = (4.00 \times 10^{6}\ V/m)(2.5 \times 10^{-3}\ m)$$
$$= 10^{4}\ V$$

(b) $$E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A}$$

$$A = \frac{Q}{\varepsilon_0 E} = \frac{8.0 \times 10^{-10}\ C}{(8.85 \times 10^{-12}\ C^2/N \cdot m^2)(4.00 \times 10^{6}\ V/m)}$$

$$= 2.260 \times 10^{-5}\ m^2$$

(c) $$C = \frac{Q}{V} = \frac{8.0 \times 10^{-10}\ C}{10^{4}\ V}$$

$$= 8.0 \times 10^{-14}\ C/V = 80\ pF.$$

24.14

(a) For 2 concentric shells, the capacitance is

$$C = \frac{1}{k}\left(\frac{r_a r_b}{r_b - r_a}\right)$$

$$kCr_b - kCr_a = r_a r_b$$

$$r_b = \frac{kCr_a}{kC - r_a}$$

$$= \frac{k(116 \times 10^{-12}\ F)(0.150\ m)}{k(116 \times 10^{-12}\ F) - 0.150\ m}$$

$$= 0.175\ m$$

(b) $V = 220\ V$, and $Q = CV = (116 \times 10^{-12} F)(220\ V)$
$$= 2.55 \times 10^{-8}\ C$$

24.20

(a) C_1 & C_2 are in parallel, so have same potential.

$$V = \frac{Q_2}{C_2} = \frac{40.0 \times 10^{-6} C}{3.00 \times 10^{-6} F} = 13.33 \text{ V}$$

$$\therefore \quad Q_1 = VC_1 = (13.33 \text{ V})(6.00 \times 10^{-6} F) = 80.0 \times 10^{-6} C$$

C_3 is in series with parallel combination of C_1 & C_2.
So Q_3 must equal their combined charge:

$$Q_3 = 40.0 \times 10^{-6} C + 80.0 \times 10^{-6} C$$
$$= 120.0 \times 10^{-6} C$$

(b) $$\frac{1}{C_{tot}} = \frac{1}{C_{//}} + \frac{1}{C_3} = \frac{1}{9.00 \times 10^{-6} F} + \frac{1}{5.00 \times 10^{-6} F}$$

$C_{tot} = 3.21 \mu F$. Also, $V_{ab} = \frac{Q_{tot}}{C_{tot}} = \frac{120.0 \times 10^{-6} C}{3.21 \times 10^{-6} F} = 37.4 \text{ V}$

24.29

Applied voltage = V.
Each capacitor has capacitance C.

$U = \frac{1}{2} C V^2$.

(a) Series : $U_s = 2\left(\frac{1}{2} C [V/2]^2\right)$

$= \frac{1}{4} C V^2$

Parallel: $U_p = 2\left(\frac{1}{2} C V^2\right)$

$= C V^2$

$\therefore U_p = 4 U_s$

(b) $Q = CV$

$\therefore Q_s = 2\left(C [V/2]\right) = CV$

$Q_p = 2(CV) = 2CV$

$\therefore Q_p = 2 Q_s$

(c) $E = V/d$

$\therefore E_s = V/2d$

$E_p = V/d$

$\therefore E_p = 2 E_s$

24.57

(a) $$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2 + \left(\frac{1}{C_3}+\frac{1}{C_4}\right)^{-1}} + \frac{1}{C_5}$$

$\therefore$ $C_1 = C_5 = 2C_2$ and

$C_2 = C_3 = C_4$ so

$$\frac{1}{C_{eq}} = \frac{2}{C_1} + \frac{2}{3C_2} = \frac{5}{3}C_2^{-1}$$

$$\therefore \quad C_{eq} = \frac{3}{5}C_2 = 2.52\,\mu F$$

(b) $Q = CV = (2.52\,\mu F)(220\,V)$

$= 5.54\times10^{-4}\,C = Q_1 = Q_5$

$\therefore$ $V_1 = V_5 = (5.54\times10^{-4}\,C)/(8.4\times10^{-6}\,F) = 66\,V$

So $V_2 = 220 - 2(66) = 88\,V$

$Q_2 = (88\,V)(4.2\,\mu F) = 3.70\times10^{-4}C$

Also, $V_3 = V_4 = \frac{1}{2}(88V) = 44V$

$\therefore$ $Q_3 = Q_4 = (44V)(4.2\,\mu F) = 1.85\times10^{-4}C.$