P29-5 (a) The time it takes to complete one turn is $t = (250\,\text{m})/c$. The total charge is

$$q = it = (30.0\,\text{A})(950\,\text{m})/(3.00\times10^8\text{m/s}) = 9.50\times10^{-5}\text{C}.$$

(b) The number of charges is $N = q/e$, the total energy absorbed by the block is then

$$\Delta U = (28.0\times10^9\ \text{eV})(9.50\times10^{-5}\text{C})/e = 2.66\times10^6\,\text{J}.$$

This will raise the temperature of the block by

$$\Delta T = \Delta U/mC = (2.66\times10^6\,\text{J})/(43.5\,\text{kg})(385\text{J/kgC}^\circ) = 159\,\text{C}^\circ.$$

P29-6 (a) $i = \int j\,dA = 2\pi\int jr\,dr$;

$$i = 2\pi\int -0^R j_0(1-r/R)r\,dr = 2\pi j_0(R^2/2 - R^3/3R) = \pi j_0 R^2/6.$$

(b) Integrate, again:

$$i = 2\pi\int -0^R j_0(r/R)r\,dr = 2\pi j_0(R^3/3R) = \pi j_0 R^2/3.$$

P29-15 The current is found from Eq. 29-5,

$$i = \int \vec{\mathbf{j}} \cdot d\vec{\mathbf{A}},$$

where the region of integration is over a spherical shell concentric with the two conducting shells but between them. The current density is given by Eq. 29-10,

$$\vec{\mathbf{j}} = \vec{\mathbf{E}}/\rho,$$

and we will have an electric field which is perpendicular to the spherical shell. Consequently,

$$i = \frac{1}{\rho}\int \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = \frac{1}{\rho}\int E\,dA$$

By symmetry we expect the electric field to have the same magnitude anywhere on a spherical shell which is concentric with the two conducting shells, so we can bring it out of the integral sign, and then

$$i = \frac{1}{\rho}E\int dA = \frac{4\pi r^2 E}{\rho},$$

where E is the magnitude of the electric field on the shell, which has radius r such that $b > r > a$.

The above expression can be inverted to give the electric field as a function of radial distance, since the current is a constant in the above expression. Then $E = i\rho/4\pi r^2$ The potential is given by

$$\Delta V = -\int_b^a \vec{\mathbf{E}} \cdot d\vec{\mathbf{s}},$$

we will integrate along a radial line, which is parallel to the electric field, so

$$\begin{aligned} \Delta V &= -\int_b^a E\,dr, \\ &= -\int_b^a \frac{i\rho}{4\pi r^2}\,dr, \\ &= -\frac{i\rho}{4\pi}\int_b^a \frac{dr}{r}, \\ &= \frac{i\rho}{4\pi}\left(\frac{1}{a} - \frac{1}{b}\right). \end{aligned}$$

We divide this expression by the current to get the resistance. Then

$$R = \frac{\rho}{4\pi}\left(\frac{1}{a} - \frac{1}{b}\right)$$

P30-10 Let $\Delta V = \Delta V_{xy}$. By symmetry $\Delta V_2 = 0$ and $\Delta V_1 = \Delta V_4 = \Delta V_5 = \Delta V_3 = \Delta V/2$. Suddenly the problem is *very* easy. The charges on each capacitor is q_1, except for $q_2 = 0$. Then the equivalent capacitance of the circuit is

$$C_{\text{eq}} = \frac{q}{\Delta V} = \frac{q_1 + q_4}{2\Delta V_1} = C_1 = 4.0\times 10^{-6}\text{F}.$$

P30-21 (a) q doesn't change, but $C' = C/2$. Then $\Delta V' = q/C = 2\Delta V$.
(b) $U = C(\Delta V)^2/2 = \epsilon_0 A(\Delta V)^2/2d$. $U' = C'(\Delta V')^2/2 = \epsilon_0 A(2\Delta V)^2/4d = 2U$.
(c) $W = U' - U = 2U - U = U = \epsilon_0 A(\Delta V)^2/2d$.

P30-24 The result is effectively three capacitors in series. Two are air filled with thicknesses of x and $d - b - x$, the third is dielectric filled with thickness b. All have an area A. The effective capacitance is given by

$$
\begin{aligned}
\frac{1}{C} &= \frac{x}{\epsilon_0 A} + \frac{d-b-x}{\epsilon_0 A} + \frac{b}{\kappa_e \epsilon_0 A}, \\
&= \frac{1}{\epsilon_0 A}\left((d-b) + \frac{b}{\kappa_e}\right), \\
C &= \frac{\epsilon_0 A}{d - b + b/\kappa_e}, \\
&= \frac{\kappa_e \epsilon_0 A}{\kappa_e - b(\kappa_e - 1)}.
\end{aligned}
$$