34.21. Visualize: The solenoid has inductance and when a current flows there is energy stored in the magnetic field.

Solve: The inductance and energy of the solenoid are

$$L_{\text{sol}} = \frac{\mu_0 N^2 A}{l} = \frac{(4\pi \times 10^{-7}\ \text{H/m})(200)^2 \pi (0.015\ \text{m})^2}{0.12\ \text{m}} = 2.96 \times 10^{-4}\ \text{H}$$

$$U_{\text{L}} = \tfrac{1}{2} L I^2 = \tfrac{1}{2}(2.96 \times 10^{-4}\ \text{H})(0.80\ \text{A})^2 = 9.5 \times 10^{-5}\,\text{J}$$

34.24. Visualize: The rate at which the charges leave the capacitor will determine the current through the inductor.

Solve: The charge on the capacitor is $Q = Q_0 \cos\omega t$ where $Q_0 = C\Delta V$ is the maximum charge at t = 0 s. The current is given by $I = -dQ/dt = \omega Q_0 \sin\omega t$. Since the sine function oscillates between +1 and −1, the maximum current is

$$I_{\text{max}} = \omega Q_0 = \left(\frac{1}{\sqrt{LC}}\right)C\Delta V = \Delta V\sqrt{\frac{C}{L}} = (5.0\text{ V})\sqrt{\frac{0.10\times10^{-6}\text{ F}}{1.0\times10^{-3}\text{ H}}} = 5.0\times10^{-2}\text{ A} = 50\text{ mA}$$

34.25. Visualize: Please refer to Figure Ex34.25. This is a simple *LR* circuit if the resistors in parallel are treated as an equivalent resistor in series with the inductor.
Solve: We can find the equivalent resistance from the time constant since we know the inductance. We have

$$\tau = \frac{L}{R_{\text{eq}}} \Rightarrow R_{\text{eq}} = \frac{L}{\tau} = \frac{3.6\times10^{-3}\ \text{H}}{10\times10^{-6}\ \text{s}} = 360\ \Omega$$

The equivalent resistance is the parallel addition of the unknown resistor *R* and 600 Ω. We have

$$\frac{1}{R_{\text{eq}}} = \frac{1}{600\ \Omega} + \frac{1}{R} \Rightarrow R = \frac{(600\ \Omega)(360\ \Omega)}{600\ \Omega - 360\ \Omega} = 900\,\Omega$$

34.77. Model: Assume negligible resistance in the circuit.

Visualize: Energy is conserved. The maximum voltage on the right capacitor will occur when all of the energy from the left capacitor is transferred to the right one.

Solve: **(a)** The voltage is calculated as follows:

$$\tfrac{1}{2}C_1\Delta V_{C1}^2 = \tfrac{1}{2}C_2\Delta V_{C2}^2 \Rightarrow \Delta V_{C2} = \sqrt{\frac{C_1}{C_2}}\Delta V_{C1} = \sqrt{\frac{300}{1200}}(100\text{ V}) = 50\text{ V}$$

(b) Closing S_1 causes the charge and current of the left LC circuit to oscillate with period T_L. After one-quarter of a period, the 300 μF capacitor is completely discharged and the current through the inductor is maximum. At that instant we'll open S_1 and close S_2. Then the right LC circuit will start to oscillate with period T_R and the inductor current will charge the 1200 μF capacitor. The capacitor will be fully charged after one-quarter of a period, so we will open S_2 at that time to keep the charge on the 1200 μF capacitor. The periods are

$$T_L = \frac{2\pi}{\omega_L} = 2\pi\sqrt{LC_1} = 2\pi\sqrt{(5.3\text{ H})(300\times10^{-6}\text{ F})} = 0.25\text{ s} \Rightarrow \tfrac{1}{4}T_L = 0.063\text{ s}$$

$$T_R = \frac{2\pi}{\omega_R} = 2\pi\sqrt{LC_2} = 2\pi\sqrt{(5.3\text{ H})(1200\times10^{-6}\text{ F})} = 0.50\text{ s} \Rightarrow \tfrac{1}{4}T_R = 0.125\text{ s}$$

So the procedure is to close S_1 at t = 0 s, open S_1 and close S_2 at t = 0.0625 s, then open S_2 at t = 0.0625 s + 0.1250 s = 0.1875 s.

34.80. Visualize: Please refer to Figure P34.80.

Solve: **(a)** After a long time has passed the current will no longer be changing. With steady currents, the potential difference across the inductor is $\Delta V_L = -L(dI/dt) = 0$ V. An ideal inductor has no resistance ($R = 0\ \Omega$), so the inductor simply acts like a wire. The circuit is simply that of a battery and resistor R, so the current is $I_0 = \Delta V_{bat}/R$.

(b) In general, we need to apply Kirchhoff's loop law to the circuit. Starting with the battery and going clockwise, the loop law is

$$\Delta V_{bat} + \Delta V_R + \Delta V_L = \Delta V_{bat} - IR - L\frac{dI}{dt} = 0$$

$$\frac{dI}{dt} = \frac{\Delta V_{bat}}{L} - \frac{IR}{L} = \frac{R}{L}\left(\frac{\Delta V}{R} - I\right) = \frac{R}{L}(I_0 - I)$$

This is a differential equation that we can solve by direct integration. The current is $I = 0$ A at $t = 0$ s, so separate the current and time variables and then integrate from 0 A at 0 s to current I at time t:

$$\int_0^t \frac{dI}{I_0 - I} = \frac{R}{L}\int_0^t dt \Rightarrow -\ln(I_0 - I)\Big|_0^I = \frac{R}{L}t\Big|_0^t \Rightarrow -\ln\left(\frac{I_0 - I}{I_0}\right) = \frac{t}{L/R}$$

Taking the exponential of both sides gives

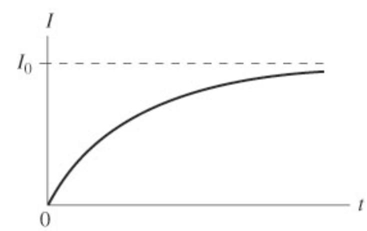
$$\frac{I_0 - I}{I_0} = e^{-t/(L/R)} \Rightarrow I_0 - I = I_0 e^{-t/(L/R)}$$

Finally, solving for I gives

$$I = I_0\left(1 - e^{-t/(L/R)}\right)$$

The current is 0 A at $t = 0$ s, as expected, and exponentially approaches I_0 as $t \to \infty$.

(c)



Assess: The current is zero at the start and approaches the steady final value. The behavior is similar to the charging of a capacitor.