23.23 $|\bar{\mathcal{E}}| = L\frac{\Delta I}{\Delta t} = \left(3.00\times10^{-3}\text{ H}\right)\left(\frac{1.50\text{ A} - 0.200\text{ A}}{0.200\text{ s}}\right) = 1.95\times10^{-2}\text{ V} = \boxed{19.5\text{ mV}}$

***23.26** $\bar{\mathcal{E}} = -L\frac{\Delta I}{\Delta t} = (-2.00\text{ H})\left(\frac{0-0.500\text{ A}}{0.0100\text{ s}}\right)\left(\frac{1\text{ V}\cdot\text{s}}{1\text{ H}\cdot\text{A}}\right) = \boxed{100\text{ V}}$

23.27 From $|\mathcal{E}| = L\left(\frac{\Delta I}{\Delta t}\right)$, we have $L = \frac{\mathcal{E}}{(\Delta I/\Delta t)} = \frac{24.0\times10^{-3}\text{ V}}{10.0\text{ A/s}} = 2.40\times10^{-3}\text{ H}$

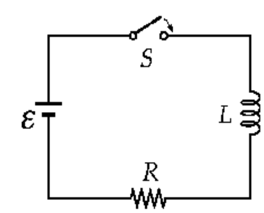
From $L = \frac{N\Phi_B}{I}$, we have $\Phi_B = \frac{LI}{N} = \frac{\left(2.40\times10^{-3}\text{ H}\right)(4.00\text{ A})}{500} = \boxed{19.2\ \mu\text{T}\cdot\text{m}^2}$

23.30 $I = \frac{\mathcal{E}}{R}\left(1-e^{-Rt/L}\right)$: $0.900\frac{\mathcal{E}}{R} = \frac{\mathcal{E}}{R}\left[1-e^{-R(3.00\text{ s})/2.50\text{ H}}\right]$

$$\exp\left(-\frac{R(3.00\text{ s})}{2.50\text{ H}}\right) = 0.100$$

$$R = \frac{2.50\text{ H}}{3.00\text{ s}}\ln 10.0 = \boxed{1.92\ \Omega}$$

23.33 (a) $\tau = L/R = 2.00\times10^{-3}\text{ s} = \boxed{2.00\text{ ms}}$

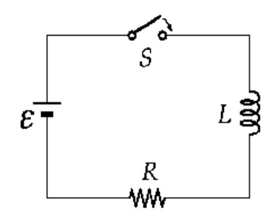


(b) $I = I_{max}\left(1-e^{-t/\tau}\right) = \left(\frac{6.00\text{ V}}{4.00\ \Omega}\right)\left(1-e^{-0.250/2.00}\right) = \boxed{0.176\text{ A}}$

(c) $I_{max} = \frac{\mathcal{E}}{R} = \frac{6.00\text{ V}}{4.00\ \Omega} = \boxed{1.50\text{ A}}$

(d) $0.800 = 1 - e^{-t/2.00\text{ ms}} \rightarrow t = -(2.00\text{ ms})\ln(0.200) = \boxed{3.22\text{ ms}}$

***23.34** $I = I_{max}\left(1-e^{-t/\tau}\right)$: $0.980 = 1 - e^{-3.00\times10^{-3}/\tau}$

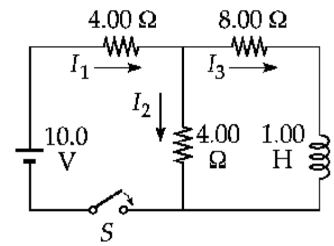


$$0.0200 = e^{-3.00\times10^{-3}/\tau}$$

$$\tau = -\frac{3.00\times10^{-3}}{\ln(0.0200)} = 7.67\times10^{-4}\text{ s}$$

$\tau = L/R$, so $L = \tau R = \left(7.67\times10^{-4}\right)(10.0) = \boxed{7.67\text{ mH}}$

***23.36** Name the currents as shown. By Kirchhoff's laws:



$$I_1 = I_2 + I_3 \quad (1)$$

$$+10.0\text{ V} - 4.00 I_1 - 4.00 I_2 = 0 \quad (2)$$

$$+10.0\text{ V} - 4.00 I_1 - 8.00 I_3 - (1.00)\frac{dI_3}{dt} = 0 \quad (3)$$

From (1) and (2), $+10.0 - 4.00 I_1 - 4.00 I_1 + 4.00 I_3 = 0$

and $I_1 = 0.500 I_3 + 1.25\text{ A}$

Then (3) becomes $10.0\text{ V} - 4.00(0.500 I_3 + 1.25\text{ A}) - 8.00 I_3 - (1.00)\frac{dI_3}{dt} = 0$

$$(1.00\text{ H})(dI_3/dt) + (10.0\ \Omega)I_3 = 5.00\text{ V}$$

We solve the differential equation using Equations 23.13 and 23.14:

$$I_3(t) = \left(\frac{5.00\text{ V}}{10.0\ \Omega}\right)\left[1 - e^{-(10.0\ \Omega)t/1.00\text{ H}}\right] = \boxed{(0.500\text{ A})\left[1 - e^{-10t/s}\right]}$$

$$I_1 = 1.25 + 0.500 I_3 = \boxed{1.50\text{ A} - (0.250\text{ A})e^{-10t/s}}$$

23.40 (a) The magnetic energy density is given by

$$u = \frac{B^2}{2\mu_0} = \frac{(4.50\text{ T})^2}{2(1.26\times10^{-6}\text{ T}\cdot\text{m/A})} = \boxed{8.06\times10^6\text{ J/m}^3}$$

(b) The magnetic energy stored in the field equals u times the volume of the solenoid (the volume in which B is non-zero).

$$U = uV = (8.06\times10^6\text{ J/m}^3)\left[(0.260\text{ m})\pi(0.0310\text{ m})^2\right] = \boxed{6.32\text{ kJ}}$$