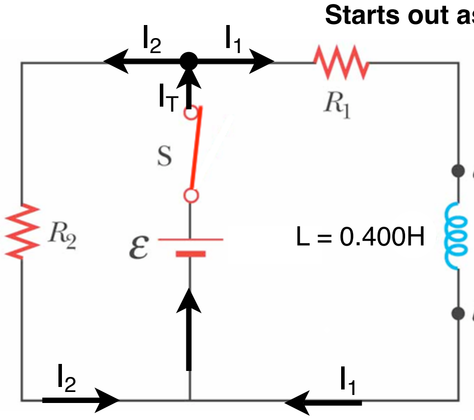
Physics 196 Chapter 32 Problem 71

The emf = 14.0 V, R_1 = 2.80 kohms, and R_2 = 5.00 kohms. The switch is closed for t < 0, and steady-state conditions are established. The switch is now thrown open at t = 0. (a) Find the initial voltage emf_0 across L just after t = 0. Which end of the coil is at the higher potential: a or b? (b) Make freehand graphs of the currents in R_1 and in R_2 as a function of time. Show values before and after t = 0. (c) How long after t = 0 does the current in R_2 have the value 2.00 mA? (30 points)

Starts out as a

. . .Parallel Circuit

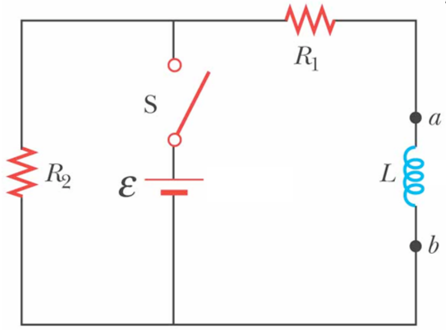


Current is constant

. . .then ends as a ____________________

Show which end of the inductor is at a higher potential. *4 pts*

Show the initial direction of the current.



After the switch is opened use Kirchhoff's Voltage Sum Rule

What is the induced emf over the inductor?

$$I(R_1 + R_2) + \square = 0$$

Is the initial current is increasing or decreasing? *3 pts*

a. The switch is closed for a long time so the current in both branches has reached a constant value.

b. The voltage over the inductor is zero because the current has stopped changing. No change in current no 'back emf'.

c. A constant Magnetic Field has been established in the coil.

Find the ***steady state current*** *for the left and right loops when the switch is closed using Kirchhoff's Current Sum Rule.*

$$I_T = I_1 + I_2$$

$$I_T = \frac{\mathcal{E}}{R_1}(1 - e^{\frac{-R_2 t}{L}}) + \frac{\mathcal{E}}{R_2}$$

Derive the current wrt time when the switch is closed.

symbolically *6 pts*

a. The power source is disconnected. Initially the current is CW / CCW thru the inductor.

b. Because the current is ____________ the coil reacts by inducing a ____________emf.

c. The current through the inductor will begin to ____________ in magnitude but continue in the ____________ direction. The current in the left loop ____________ direction.

d. ____________ is at a higher potential because the coil is trying to keep the current from falling to zero.

Find the Steady-state current in the ***left*** *and* ***right*** *loop*

plug in values *4 pts*

$$I = \frac{\mathcal{E}}{R_2 + R_1}(e^{\frac{-(R_2+R_1)}{L}t})$$

$$I_f = I_0 e^{\frac{-(R_2+R_1)}{L}t}$$

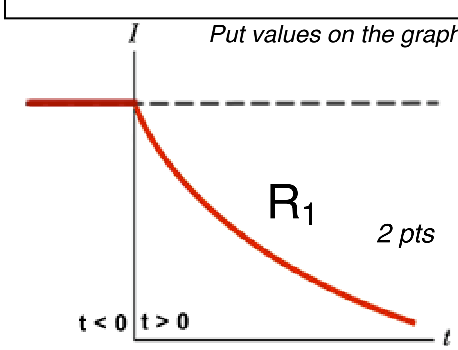
Find the initial emf over the Inductor when the switch is opened? Use Kirchhoff's Voltage Sum Rule. *2 pts*

symbolically

plug in values

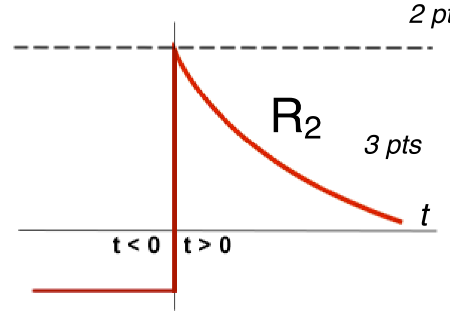
2 pts

Put values on the graphs below.



What is the time required for current to fall to 2.00mA?

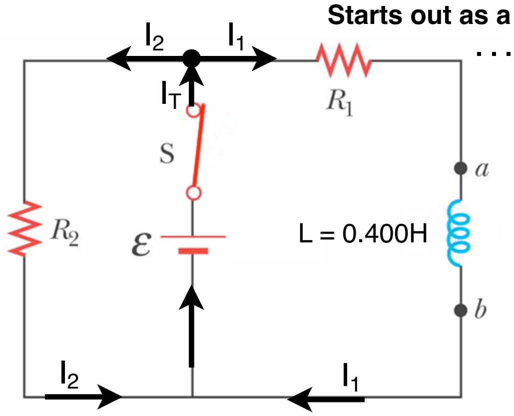
plug in values *2 pts*
Put values on the graphs below.



Physics 196   Chapter 32   Problem 71

The emf = 14.0 V, R_1 = 2.80 kohms, and R_2 = 5.00 kohms. The switch is closed for t < 0, and steady-state conditions are established. The switch is now thrown open at t = 0. (a) Find the initial voltage emf_0 across L just after t = 0. Which end of the coil is at the higher potential: a or b? (b) Make freehand graphs of the currents in R_1 and in R_2 as a function of time. Show values before and after t = 0. (c) How long after t = 0 does the current in R_2 have the value 2.00 mA?

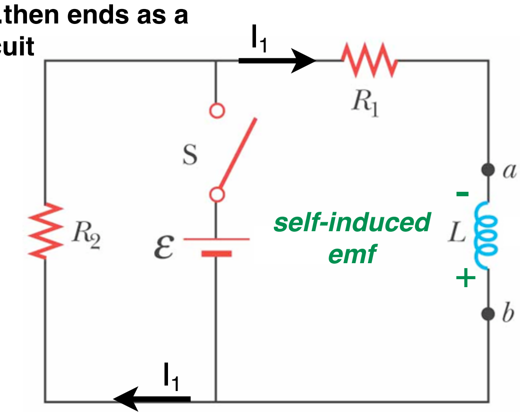
Starts out as a . . .Parallel Circuit



Current is constant

Closed switch. . . . . Open Switch

. . .then ends as a Series Circuit



Current is decreasing

a. The switch is closed for a long time so the current in both branches has reached a constant value.

b. The voltage over the inductor is zero because the current has stopped changing. No change in current no 'back emf'.

c. A constant Magnetic Field has been established in the coil.

Find the steady state current when the switch is closed using Kirchhoff's Current Sum Rule

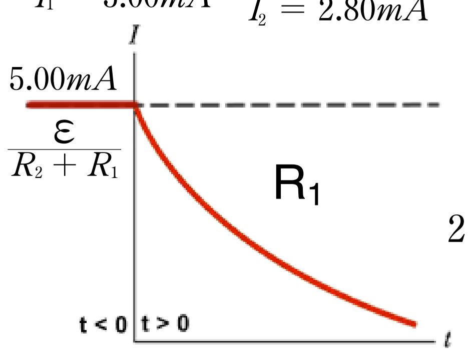
$$I_T = I_1 + I_2$$

$$I_T = \frac{\varepsilon}{R_1}(1 - e^{\frac{-R_2 t}{L}}) + \frac{\varepsilon}{R_2}$$

Steady-state current ($t \longrightarrow \infty$)
in the ***left*** *and* ***right*** *loop*

$$I_T = \frac{14.0\,V}{2800} + \frac{14.0\,V}{5000} = 7.80mA$$

$$I_1 = 5.00mA \qquad I_2 = 2.80mA$$



After the switch is opened use Kirchhoff's Voltage Sum Rule

$$I(R_1 + R_2) + L\frac{dI}{dt} = 0$$

$$\frac{dI}{dt} = \frac{-I(R_2 + R_1)}{L}$$

$$\frac{dI}{I} = -\frac{(R_2 + R_1)\,dt}{L}$$

$$\int_0^I \frac{dI}{I} = \int_0^t \frac{-(R_2 + R_1)\,dt}{L}$$

$$I = \frac{\varepsilon}{R_2 + R_1}(e^{\frac{-(R_2+R_1)}{L}t})$$

$$I_f = I_0 e^{\frac{-(R_2+R_1)}{L}t}$$

Time required for current to fall to 2.00mA.

$$2.00mA = 5.00mA\,(e^{\frac{-(5000+2800)}{0.400H}t})$$

$$t = 4.70\,x10^{-5}s = 47.0\mu s$$

a. The power source is disconnected. Initially the current is CW through the inductor.

b. Because the current is changing (decreasing) the coil reacts by inducing a forward emf (CW).

c. The current through the inductor will begin to decrease in magnitude but continue in the same direction. The current in the left loop changes direction.

d. Point **b** *is at a higher potential because the coil is trying to keep the current from falling to zero.*

Find the initial forward emf over the Inductor when the switch is opened using Kirchhoff's Voltage Sum Rule in the outer loop

$$\varepsilon_{ind} - (R_2 + R_1)I_o = 0$$

Initial Forward emf

$$\varepsilon = (5000 + 2800)\,5.00mA = 39.0\,V$$