KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
PHYSICS DEPARTMENT
PHYS 201- Term 112
QUIZ #1 – CHAPTER 31

Name: Key ID#:

A coil with inductance L = 1.0 H and a resistance R = 10 Ω is suddenly connected to an ideal battery with $\mathcal{E}$ = 200 V. At t = 0.5 s after the connection is made, what is the **rate** at which

(a) Energy is being stored in the magnetic field
(b) Thermal energy is appearing in the resistance
(c) Energy is being delivered by the battery

a) $i = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau_L}\right)$ $\quad \tau_L = \frac{L}{R} = \frac{1}{10} = 0.1\,s$

$$P_L = \frac{dU_B}{dt} = \frac{d}{dt}\left(\frac{1}{2}Li^2\right) = Li\frac{di}{dt}$$

$$\frac{di}{dt} = \frac{\mathcal{E}}{R\tau_L}e^{-t/\tau_L} = \frac{\mathcal{E}}{L}e^{-t/\tau_L}$$

$$P_L = \frac{\mathcal{E}^2}{R}\left(1 - e^{-t/\tau_L}\right)\left(e^{-t/\tau_L}\right) = \frac{(200)^2}{10}\left(1 - e^{-\frac{0.5}{0.1}}\right)\left(e^{-\frac{0.5}{0.1}}\right)$$

$$= \underline{\underline{26.8\,W}}$$

b) $P_R = i^2R = \frac{\mathcal{E}^2}{R}\left(1 - e^{-t/\tau_L}\right)^2 = \frac{(200)^2}{10}\left(1 - e^{-\frac{0.5}{0.1}}\right)$

$$= \underline{\underline{3946.3\,W}}$$

c) $P_\mathcal{E} = i\mathcal{E} = \frac{\mathcal{E}^2}{R}\left(1 - e^{-t/\tau_L}\right) = \frac{(200)^2}{10}\left(1 - e^{-\frac{0.5}{0.1}}\right)$

$$= \underline{\underline{3973\,W}}$$

Note $P_\mathcal{E} \simeq P_R + P_L$