1. a) $P = VI$

$= 250 \times 10^{-3} \times 24$

$= 6W$

$P = W/t$

$W = 6 \times 2 \times 60 \times 60$

$W = 43200J$

$$\boxed{W = 43.2\,KJ}$$

b) $i(t) = (5-2t)^2$

$q(t) = \int_0^t i(\tau)\, d\tau$

$= \int_0^t (5-2\tau)^2 d\tau$

$= \left. \dfrac{(5-2\tau)^3}{3(-2)} \right|_0^t$

$= -\dfrac{(5-2t)^3}{6} + \dfrac{5^3}{6}$

$= \dfrac{125-(5-2t)^3}{6}$

$$\boxed{q(t) = \frac{125-(5-2t)^3}{6} \; ; \; t \geq 0}$$

c) $q(t) = 4\sin(2\pi t + \pi/3) - \cos\left(\frac{5\pi t}{2}\right)$ mC

$i(t) = \dfrac{dq(t)}{dt}$

$i(t) = 4\cos(2\pi t + \pi/3)(2\pi) - \left(-\sin\left(\frac{5\pi t}{2}\right)\right)\left(\frac{5\pi}{2}\right)$

$i(t) = 8\pi\cos(2\pi t + \pi/3) + \frac{5\pi}{2}\sin\left(\frac{5\pi t}{2}\right)$ mA

at $t = 1s$

$i(1) = 8\pi\cos(2\pi + \pi/3) + \frac{5\pi}{2}\sin\left(\frac{5\pi}{2}\right)$ mA

$$\boxed{i(1) = \frac{13\pi}{2}\text{ mA}}$$

Q2-

a)

(i) $E = qV$

$q = it$

$= (1.3)(2 \times 60)$

$= 156\ C$

$\Rightarrow E = (156)(12) = 1872\ J$

$\approx 1.87\ kJ$ Ans.

(ii) $q = E/V$

$= 3700/12 = 308.3\ C$

$i = q/t = 308.3/8 = 38.5\ A$ Ans.

b) $E = qV$

$= (-45 \times 10^{-3})(5)$

$= 0.225\ J$ Ans.

c) $q(t) = \int i(t)\, dt$

$0 < t \leq 3$

$q = \int_0^3 4t\, dt = 2t^2 \Big|_0^3 = 18\ C$

$3 < t \leq 7$

$q = \int_3^7 3t^2 + 2\, dt = t^3 + 2t \Big|_3^7 = 324\ C$

$7 < t \leq 9$

$q = \int_7^9 -7t + 1\, dt = -\frac{7}{2}t^2 + t \Big|_7^9 = -110\ C$

$9 < t \leq 13$

$q = \int_9^{13} 5\, dt = 5t \Big|_9^{13} = 20\ C$

Total $= 18 + 324 - 110 + 20 = 252\ C$ Ans.

3. a) $i(t) = \frac{dq(t)}{dt} = -12e^{-2t}(-2)$

$= \boxed{24e^{-2t}\,mA}$

$\boxed{i(t) = 24e^{-2t} \times 10^{-3}\,A}$

b) $v(t) = \frac{p(t)}{i(t)} = \frac{3e^{-8t}}{24e^{-2t} \times 10^{-3}}$

$\boxed{v(t) = 125e^{-6t}\,V}$

c) Energy delivered $= W = \int_0^{0.5} 3e^{-8t}\,dt$

$= \frac{3e^{-8t}}{-8}\Big|_0^{0.5}$

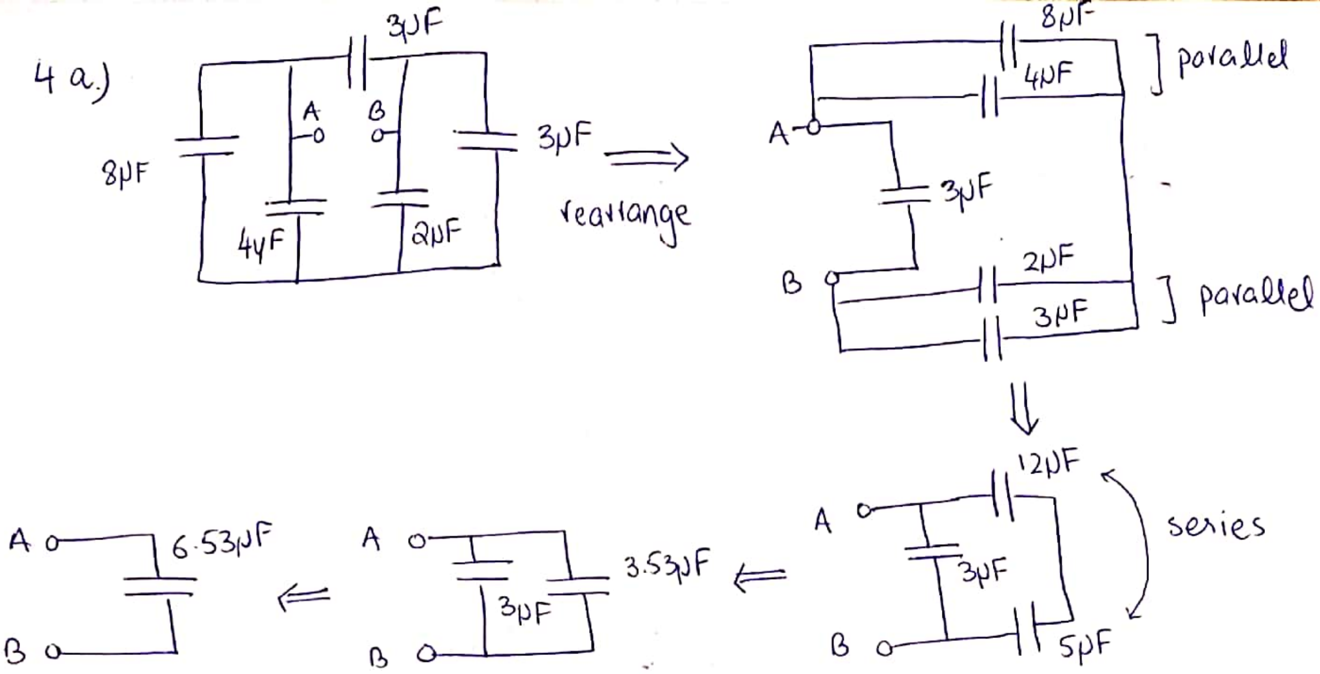
$= \frac{3}{8}\left| -e^{-8t} \right|_0^{0.5}$

$= \frac{3}{8}(e^{-4} + 1)$

$\boxed{= 0.368\,J}$

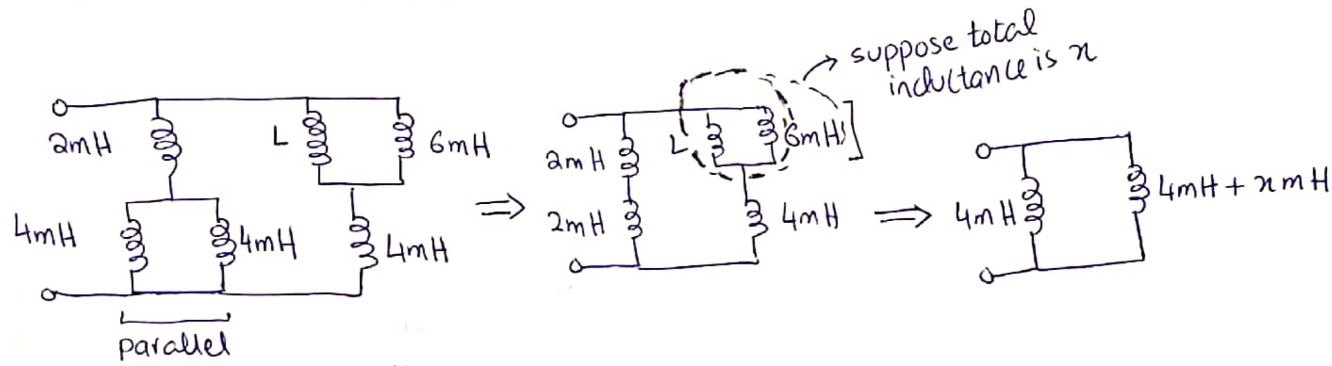
$\boxed{W = 368\,mJ}$

4 a.)



$$\boxed{C_{AB} = 6.53\mu F}$$

b)



in parallel with

$L_{eq} = 4 \| 4+x$

$2.4 = \dfrac{4(4+x)}{4+4+x}$

$2.4(8+x) = 16 + 4x$

$19.2 + 2.4x = 16 + 4x$

$3.2 = 1.6x$

$x = 2mH$

$L \| 6 = 2$

$\dfrac{6L}{6+L} = 2$

$6L = 2(6+L)$

$6L = 12 + 2L$

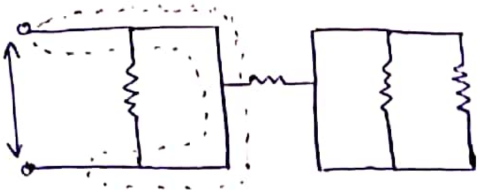
$4L = 12$

$$\boxed{L = 3mH}$$

Q5-

a)

(i)

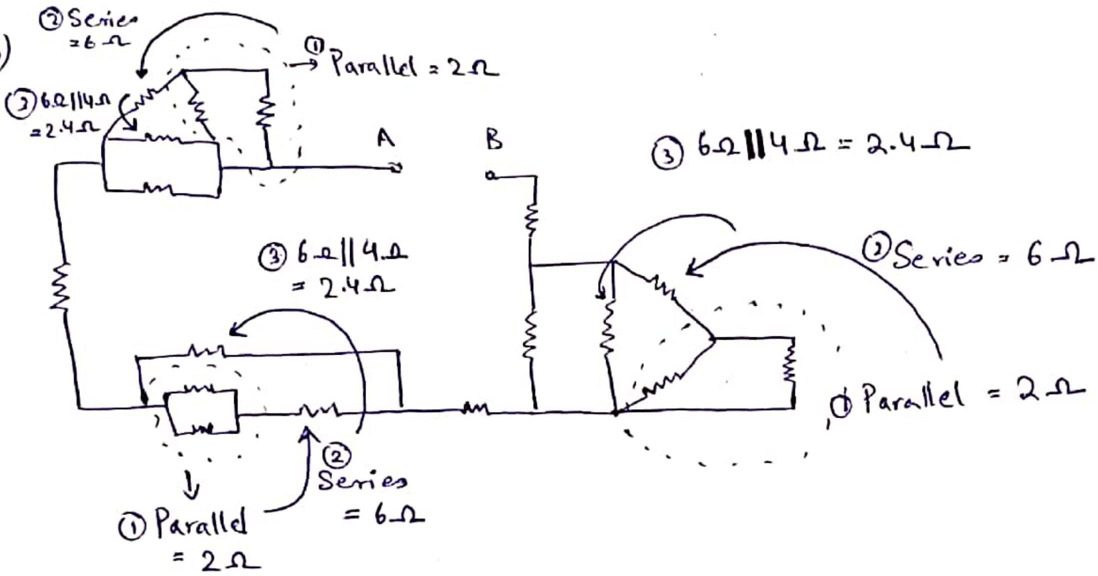


This is a trick question. Req is short circuited. Hence:

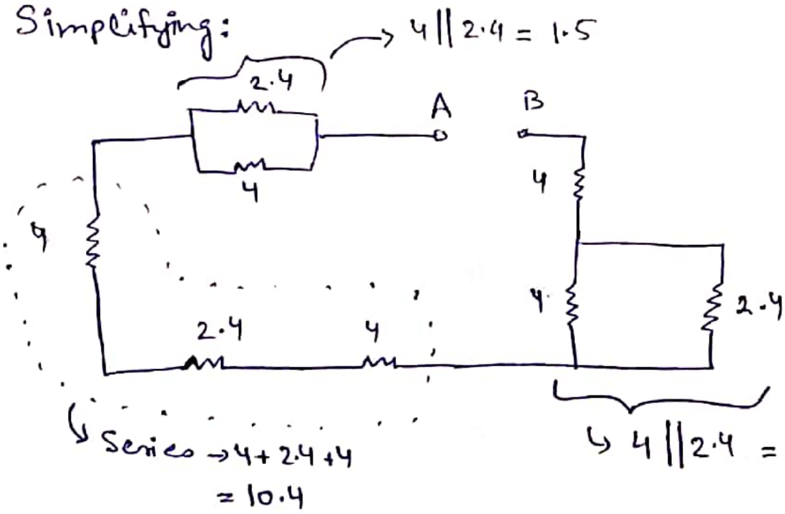
$R_{eq} = 0\ \Omega$.

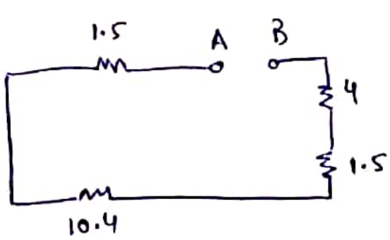
(ii) One resistor in series and 3 in parallel. Any valid combination will be accepted.

b)



Simplifying:





All in series

$\Rightarrow 1.5 + 10.4 + 1.5 + 4$

$= 17.4\ \Omega$ Ans.

6. a) $q = CV$

$= 10 \times 10^{-6} \times 24$

$= 2.4 \times 10^{-4} C$

$$\boxed{q = 0.24 mC}$$

b) $\frac{q}{V} = \frac{A\varepsilon_0}{d} = C$

$q = \frac{A\varepsilon_0 V}{d}$

$q = A \left(\frac{\varepsilon_0 V}{d}\right)$ → constant

double the area, double the charge

$$\boxed{q_{new} = 0.48 mC}$$

c) $q = \frac{A}{d} (\varepsilon_0 V)$ → constant

$q_{new} = \frac{A}{2} \frac{1}{4d} \varepsilon_0 V$

$q_{new} = \frac{q_{old}}{8}$

$$\boxed{q_{new} = 0.03 mC}$$

Q7 -

a) $L = \dfrac{N^2 \mu_0 \pi r^2}{l}$

$N = 200$

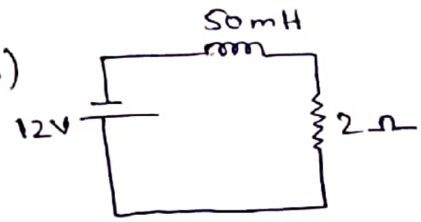
$\mu_0 = 1.257 \times 10^{-6}$

$r = 10 \times 10^{-3}$

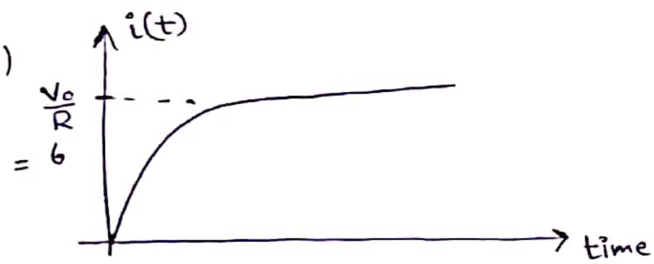
$l = 0.5$

$$L = \frac{(200)^2 (1.257 \times 10^{-6}) \pi (10 \times 10^{-3})^2}{(0.5)} = 3.16 \times 10^{-5} \text{ H} \quad \underline{\underline{\text{Ans.}}}$$

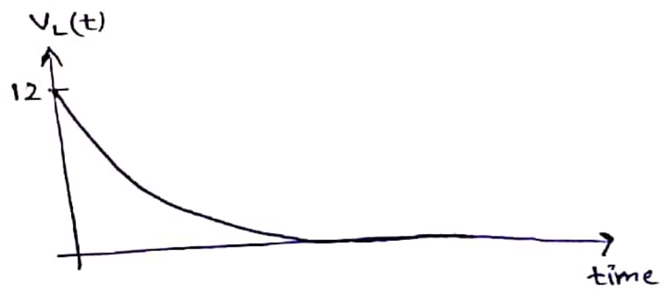
b)



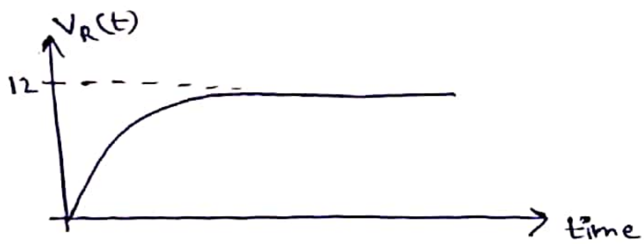
(i)



(ii)



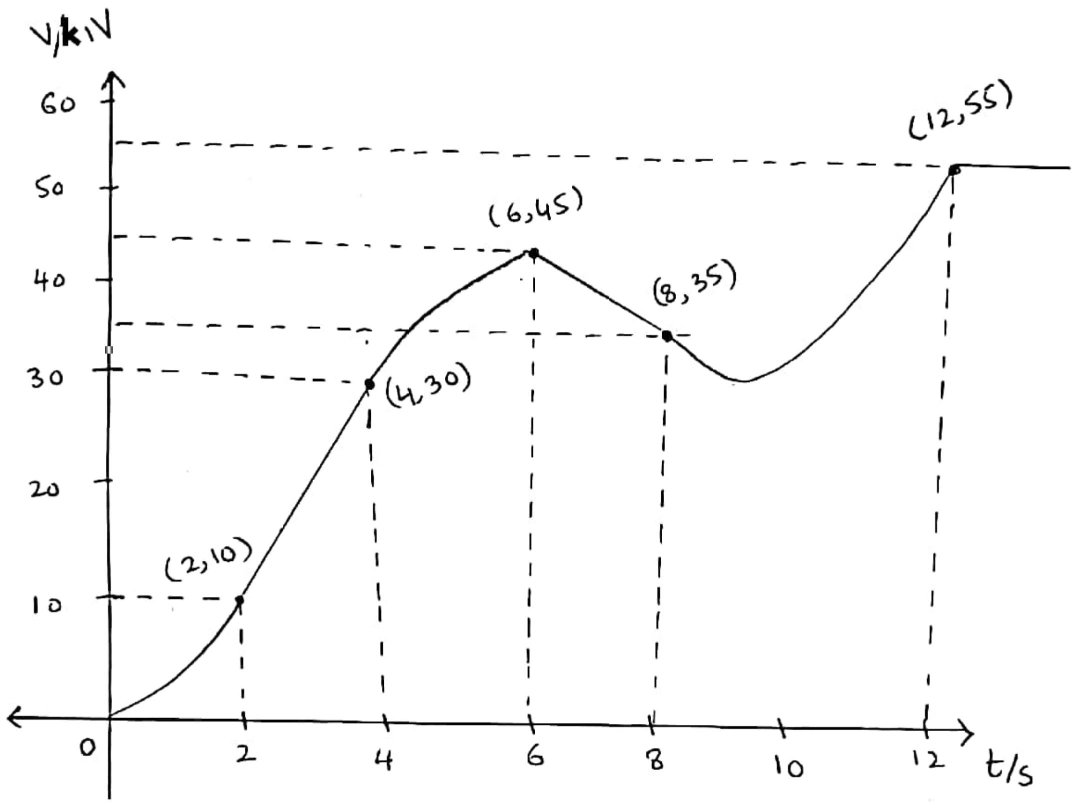
(iii)



8\. a)

$$i(t) = \begin{cases} 5t & 0 \le t < 2 \\ 10 & 2 \le t < 4 \\ -2.5t+20 & 4 \le t < 6 \\ -5 & 6 \le t < 8 \\ 5t-45 & 8 \le t < 12 \\ 0 & t \geq 12 \end{cases} \text{ mA}$$

$$v(t) = \begin{cases} 5t^2/2 & 0 \le t < 2 \\ 10t-10 & 2 \le t < 4 \\ \frac{-2.5t^2}{2}+20t\cancel{8}-30 & 4 \le t < 6 \\ -5t+75 & 6 \le t < 8 \\ \frac{5t^2}{2}-45t+235 & 8 \le t < 12 \\ 55 & t \geq 12 \end{cases} \text{ kV}$$



b) $t = 4s$

$P = VI$

$= 30 \times 10^3 \times 10 \times 10^{-3}$

$\boxed{P = 300 \text{ W}}$

c) $P = \begin{cases} \frac{25t^3}{2} & 0 < t \le 2 \\ 100t - 100 & 2 < t \le 4 \end{cases}$

$$W = \int_0^2 \frac{25t^3}{2}\,dt + \int_2^3 100t-100\,dt$$

$= \cancel{2}\ 50 + 150$

$\boxed{W = 200 \text{ J}}$

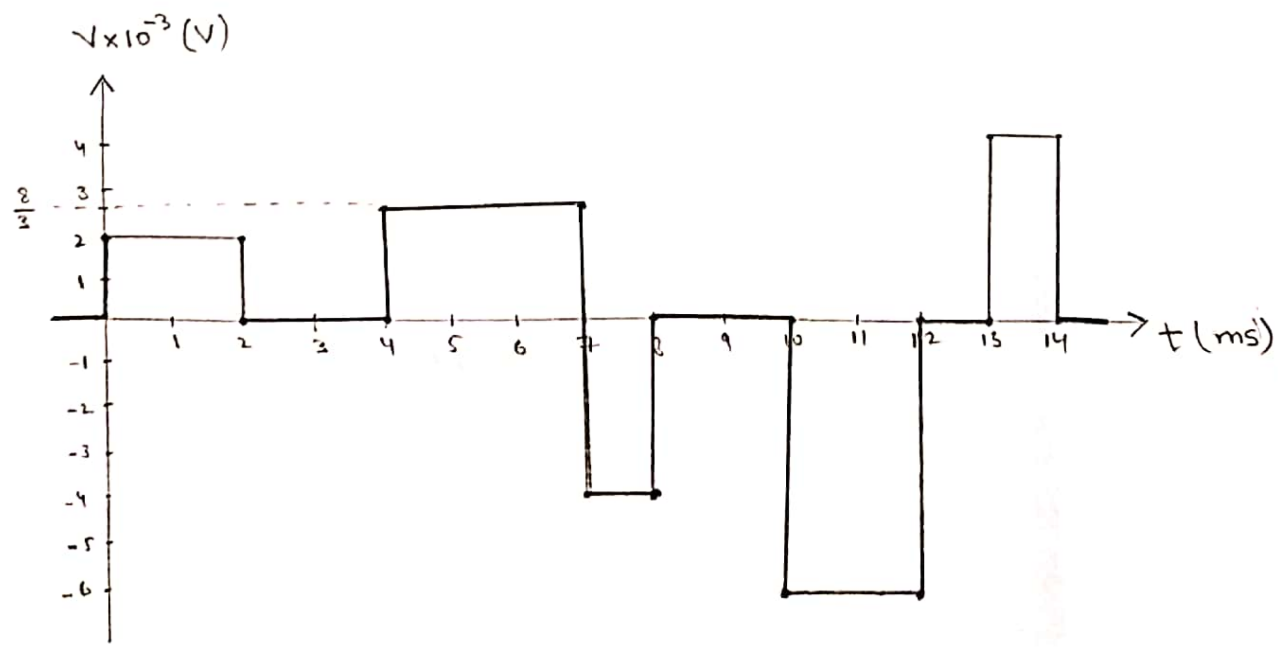
Q9.

a) i(t) from the graph:

$$i(t) = \begin{cases} t & 0 < t \leq 2 \\ 2\times10^{-3} & 2 < t \leq 4 \\ \frac{4}{3}t - \frac{10}{3}\times10^{-3} & 4 < t \leq 7 \\ -2t + 20\times10^{-3} & 7 < t \leq 8 \\ 4\times10^{-3} & 8 < t < 10 \\ -3t + 34\times10^{-3} & 10 < t \leq 12 \\ -2\times10^{-3} & 12 < t \leq 13 \\ 2t - 28\times10^{-3} & 13 < t \leq 14 \\ 0 & \text{otherwise} \end{cases}$$

$$v(t) = L\frac{di(t)}{dt} \quad \text{and} \quad L = 2\times10^{-3}$$

$$v(t) = \begin{cases} 2\times10^{-3} & 0 < t \leq 2 \\ 0 & 2 < t \leq 4 \\ \frac{8}{3}\times10^{-3} & 4 < t \leq 7 \\ -4\times10^{-3} & 7 < t \leq 8 \\ 0 & 8 < t \leq 10 \\ -6\times10^{-3} & 10 < t \leq 12 \\ 0 & 12 < t \leq 13 \\ 4\times10^{-3} & 13 < t \leq 14 \\ 0 & \text{otherwise} \end{cases}$$



Q9

b) $$W = \int_0^{2\times10^{-3}} (t)(2\times10^{-3})\,dt + \int_{2\times10^{-3}}^{4\times10^{-3}} (2\times10^{-3})(0)\,dt + \int_{4\times10^{-3}}^{5\times10^{-3}} \left(\frac{4}{3}t - \frac{10}{3}\times10^{-3}\right)\left(\frac{8}{3}\times10^{-3}\right)dt$$

$$= (2\times10^{-3})\,\frac{t^2}{2}\Big|_0^{2\times10^{-3}} + 3.55\times10^{-3}\left[\frac{t^2}{2}\Big|_{4\times10^{-3}}^{5\times10^{-3}}\right] - 8.88\times10^{-6}\,t\Big|_{4\times10^{-3}}^{5\times10^{-3}}$$

$$= 4\times10^{-9} + 1.5975\times10^{-8} - 8.88\times10^{-9}$$

$$= 1.11\times10^{-8}\ \text{J}$$ Ans.

10. a) $p(t) = v(t)\, i(t)$

$$= 30(1-e^{-15t}) \times 75e^{-15t} \times 10^{-3}$$

$$= 2.25\,(1-e^{-15t})\,e^{-15t}$$

$$\boxed{p(t) = 2.25\,(e^{-15t} - e^{-30t})\ \mathrm{W}}$$

b) $\dfrac{dp(t)}{dt} = 0$

$$2.25\,\left(e^{-15t}(-15) - e^{-30t}(-30)\right) = 0$$

$$-15e^{-15t} + 30e^{-30t} = 0$$

$$2\,\cancel{30}e^{-30t} = \cancel{15}e^{-15t}$$

$$\frac{e^{-30t}}{\cancel{e^{-15t}}} = \frac{1}{2}$$

$$e^{-15t} = 1/2$$

* taking ln on both sides

$$\ln e^{-15t} = \ln(1/2)$$

$$-15t = \ln(1/2)$$

$$t = \frac{\ln(1/2)}{-15} = 0.0462\ \mathrm{s}$$

$$\boxed{t = 46.2\ \mathrm{ms}}$$

c) $W_{tot} = \displaystyle\int_0^\infty p(t)\, dt$

$$= 2.25 \int_0^\infty e^{-15t} - e^{-30t}\, dt$$

$$= 2.25 \left| \frac{e^{-15t}}{-15} + \frac{e^{-30t}}{30} \right|_0^\infty$$

$$= 2.25\left[0 - \left(-\frac{1}{15} + \frac{1}{30}\right)\right]$$

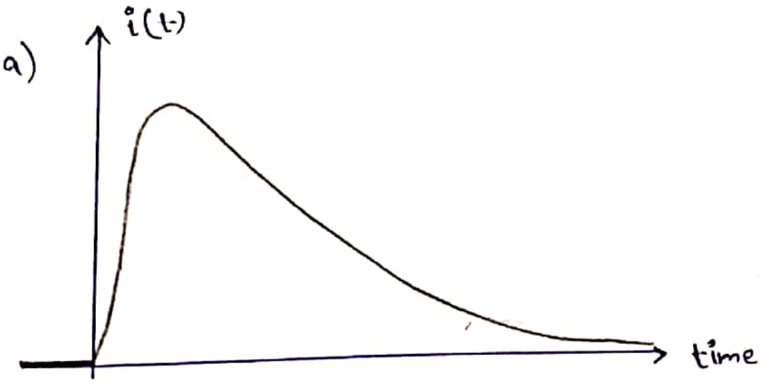
$$= 2.25\left(\frac{1}{15} - \frac{1}{30}\right)$$

$$= \frac{3}{40} = 0.075\ \mathrm{J}$$

$$\boxed{W_{tot} = 75\ \mathrm{mJ}}$$

Q11-

a)



b) Current maximum when $\frac{di}{dt} = 0$

$$i(t) = 14te^{-2t}$$

$$\frac{di}{dt} = 14\left(t(-2e^{-2t}) + e^{-2t}\right) = 0$$

$$= 14e^{-2t}(-2t + 1) = 0$$

$\frac{di}{dt} = 0$ when $t = \frac{1}{2}$ Ans.

c) $v(t) = L\frac{di(t)}{dt}$

$$= (50\times10^{-3})\,14e^{-2t}(1-2t)$$

$$= 0.7e^{-2t}(1-2t)$$

$$v(t) = \begin{cases} 0.7e^{-2t}(1-2t) & t \geq 0 \\ 0 & t \leq 0 \end{cases}$$ Ans.

d)