EE 271 - FALL 2017 MIDTERM SOLUTIONS Instructor: Cenk Efeler

1- a) $i(t) = \frac{d}{dt}\left[\frac{1}{5} - (2t+4)\cdot e^{-0.5t}\right] = -\frac{d}{dt}\left[(2t+4)e^{-0.5t}\right]$ ⟨1⟩

$i(t) = -\left[2\cdot e^{-0.5t} - 0.5e^{-0.5t}(2t+4)\right] = \left[0.5e^{-0.5t}(2t+4) - 2e^{-0.5t}\right]$

$i(t) = e^{-0.5t}\left[0.5(2t+4)-2\right] = e^{-0.5t}\left[t+2-2\right] = te^{-0.5t}$ $t \geq 0$ ⟨2⟩

$\frac{di(t)}{dt} = \frac{d}{dt}\left[te^{-0.5t}\right] = 1\cdot e^{-0.5t} - 0.5e^{-0.5t}\cdot t = 0$

$\Rightarrow e^{-0.5t}\left[1-0.5t\right]=0$ $t=2$ ⟨2⟩

t	2
$\frac{di(t)}{dt}$	+ + + + + + 0 - - - -

at $t=2$ we have a local maximum.

$i(2) = 2e^{-1} = 0.735\,A$ ⟨1⟩

b) $p = vi = e^{-0.5t}\cos\left[\left(\frac{\pi}{3}\right)t\right]\cdot te^{-0.5t} = e^{-t}\cdot t\cdot\cos\left[\left(\frac{\pi}{3}\right)t\right]$ ⟨3⟩

$p = e^{-2}\cdot 2\cdot\cos\left(\frac{2\pi}{3}\right) = 2e^{-2}\left(-\frac{1}{2}\right) = -e^{-2} = -0.135W$ ⟨3⟩

c) The circuit element is delivering power. ⟨6⟩

2-a) $\text{Error} = \frac{I_{MEASURED} - I_{TRUE}}{I_{TRUE}}$, $I_{TRUE} = \frac{12V}{5k\Omega} = 2.4mA$

$-0.005 = \frac{I_M - 2.4}{2.4}$ $\quad I_M = 2.4 - (5\times10^{-3})(2.4)$

$I_M = 2.388\,mA$

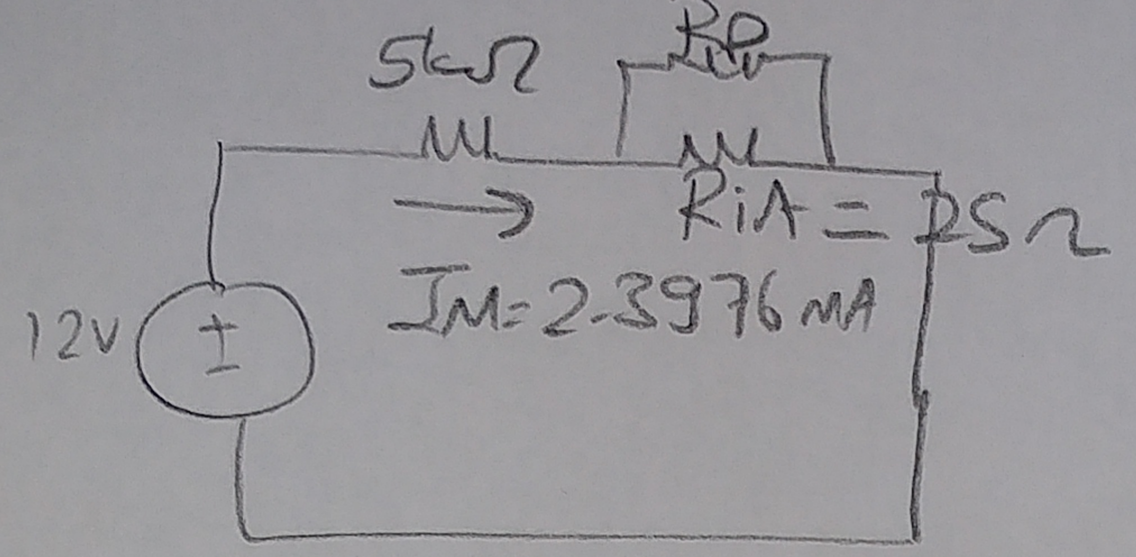
$I_M = \frac{12V}{5k\Omega + R_{iA}} = 2.388mA$

$12 = (5k\Omega)(2.388mA) + (2.388mA)R_A$

$R_A = \frac{12V - 11.94V}{2.388mA} = 0.025k\Omega \Rightarrow \underline{\underline{25\Omega}}$

b)

$$-0.001 = \frac{I_M - 2.4}{2.4} \qquad I_m = 2.4 - (10^{-3})(2.4) = 2.3976\ mA$$



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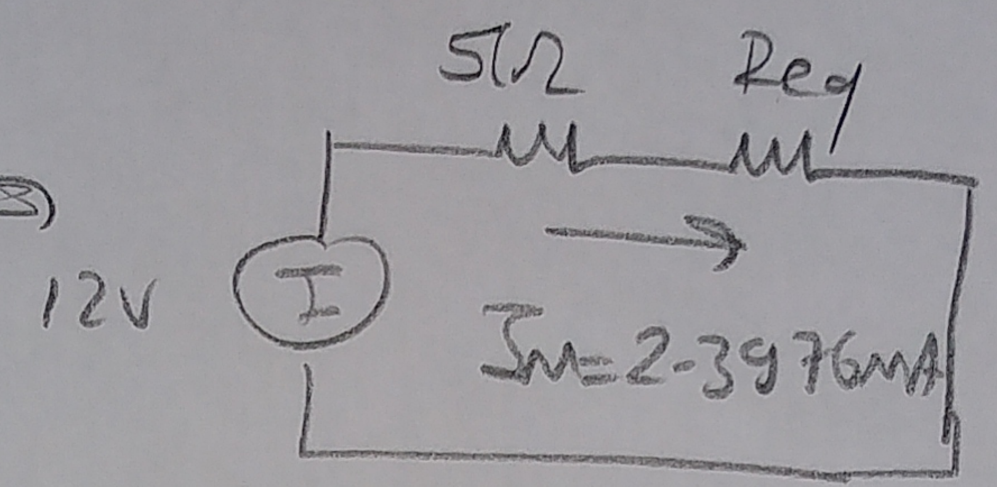


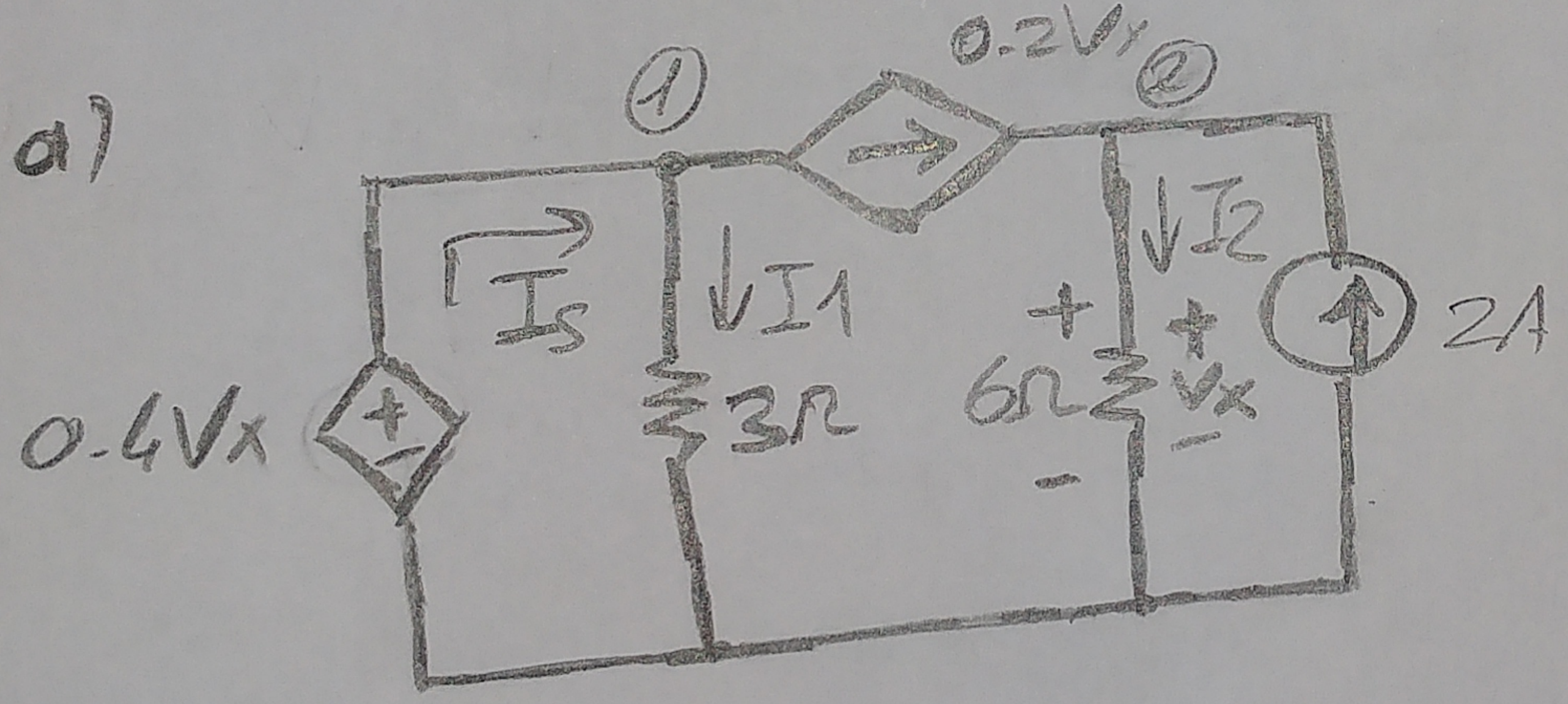
$$I_M = \frac{12V}{5\Omega + Req} = 2.3976\ mA \Rightarrow 12V = (5k\Omega)(2.3976mA) + Req \cdot (2.3976mA)$$

$$Req = \frac{12V - 11.988V}{2.3976mA} = 5 \times 10^{-3}\ k\Omega = 5\Omega$$

$$Rp \,||\, R_{iA} = 5\Omega \qquad \frac{Rp \times 25\Omega}{Rp + 25\Omega} = \underline{\underline{5\Omega}}$$

$$25Rp = 5Rp + 125 \qquad 20Rp = 125 \qquad \underline{\underline{Rp = 6.25\Omega}}$$

3- a)



K.C.L at Node ①:

$$-I_s + I_1 + 0.2Vx = 0$$

K.C.L at Node ②:

$$-0.2Vx + I_2 - 2 = 0$$

$Vx = 6I_2$ Substituting into ② Node equation

$$-1.2I_2 + I_2 - 2 = 0 \Rightarrow -0.2I_2 = 2 \qquad I_2 = \underline{\underline{-10A}}$$

$$Vx = 6(-10A) = \underline{\underline{-60V}}$$

K.V.L for leftmost loop: $0.4Vx = 3I_1 \qquad I_1 = \frac{0.4Vx}{3} = \frac{0.4(-60V)}{3}$

$\underline{I_1 = -8A} \Rightarrow$ From Node equation ① $I_s = I_1 + 0.2Vx$

$$I_s = -8A + (0.2)(-60V) = -8A - 12A = \underline{\underline{-20A}}$$

$P_{(0.4V_x)} = -(0.4V_x)(I_s) = -(0.4\times(-60V))\times(-20A) = \underline{-480W}$

To find the power associated with the 0.2Vx source, we have to first find the voltage on it

K.V.L (Mesh 1 & Mesh 2 together) $-0.4V_x + V' + V_x = 0$

$V' = -0.6V_x = (-0.6)(-60V) = \underline{36V}$

$P_{(0.2V_x)} = (36V)(0.2[\frac{A}{V}]\times(-60V)) = \underline{-432W}$

$P_{(2A)} = -(-60V)(2A) = 120W$

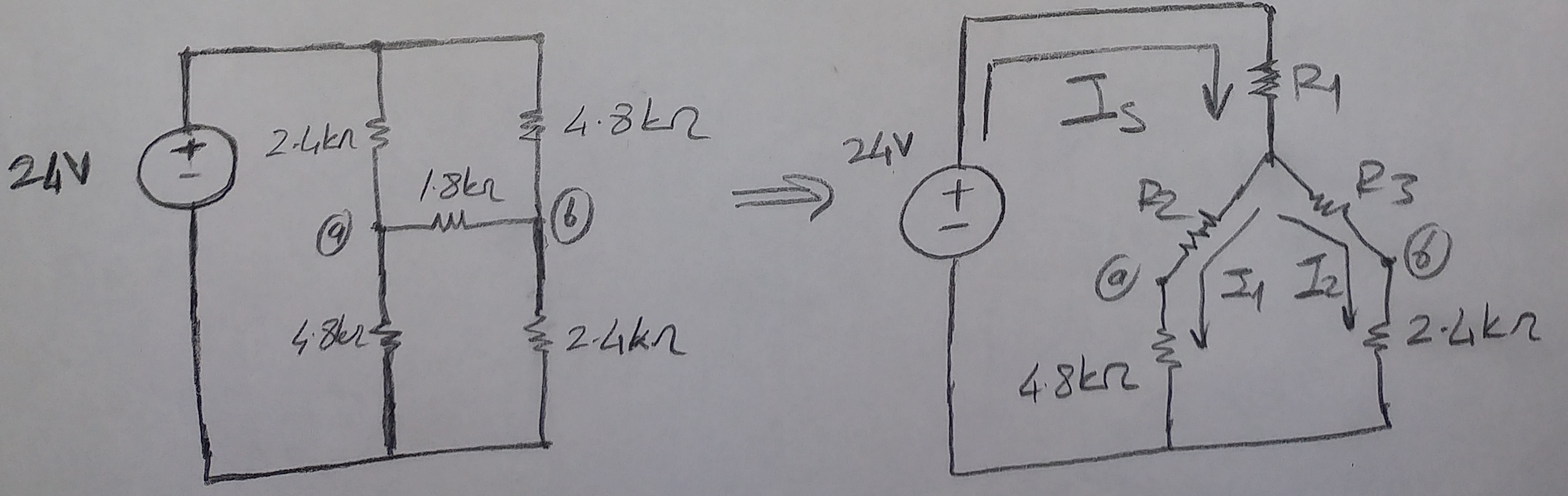
$P_{TOTAL\ SOURCES} = -480W - 432W + 120W = \underline{-792W}$

b) $P_{3\Omega} = (I_1)^2(3\Omega) = (-8A)^2\times(3) = \underline{192W}$

$P_{6\Omega} = (I_2)^2(6\Omega) = (-10A)^2 6 = \underline{600W}$

$P_{TOTAL} = 600W + 192W = \underline{792W}$

4- We apply Δ to Y transformation; to upper delta.

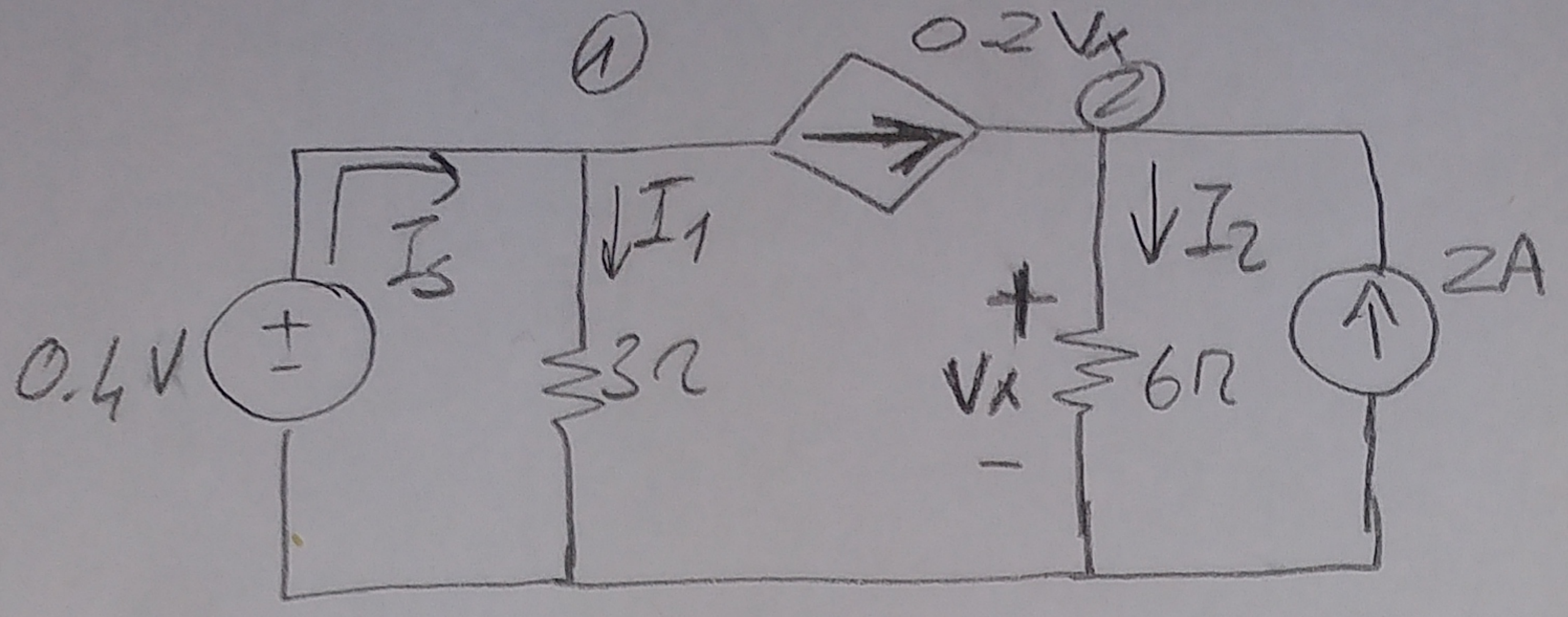


$R_1 = \dfrac{(2.4k\Omega)(4.8k\Omega)}{(2.4k\Omega + 4.8k\Omega + 1.8k\Omega)} = \dfrac{11.52k\Omega}{9k\Omega} = \underline{1.28k\Omega}$

$R_2 = \dfrac{(2.4k\Omega)(1.8k\Omega)}{9k\Omega} = \underline{0.48k\Omega}$

$R_3 = \dfrac{(4.8k\Omega)(1.8k\Omega)}{9k\Omega} = \underline{0.96k\Omega}$

3 - a) Alternative solution with independent source = 0.4 V.



Node ① $I_s = \frac{V_1}{3} + 0.2V_x$ $\quad V_x = 6I_2$

Node ② $-0.2V_x + \frac{V_x}{6} - 2 = 0$ $\quad$ / × 6

$-1.2V_x + V_x - 12 = 0$

$-0.2V_x = 12$ $\quad$ $\underline{V_x = -60V}$ <3>

$I_2 = \frac{V_x}{6} = \frac{-60V}{6} = \underline{-10A}$ <3>

K.V.L $\quad 0.4 = 3I_1 = V_1$ $\quad I_1 = \frac{0.4}{3} = \underline{0.133\ A}$ <3> /

<3>

$I_s = \frac{0.4}{3} + 0.2(-60) = 0.133 - 12 = \underline{-11.867A}$

b) $P(0.4V) = -(0.4V)(I_s) = -(0.4V)(-11.867A) = \underline{4.746W}$ <3>

V': voltage on the 0.2Vx current source:

K.V.L: (Mesh 1 & Mesh 2 combined) $-0.4V + V' + V_x = 0$

$V' = 0.4 - V_x = 0.4 + 60 = \underline{60.4V}$ <3>

$P(0.2V_x) = (60.4V)(0.2[\frac{A}{V}] \times (-60V)) = \underline{-724.8\ W}$ <3>

$P(2A) = -(-60V)(2A) = \underline{120W}$ <3> $\quad P_{TOTAL\ DEL} = \underline{-600.53W}$

b) $P_{3\Omega} = (0.133A)^2(3\Omega) = \underline{0.053W}$

$P_{6\Omega} = (-10A)^2(6) = \underline{600W}$ $\quad P_{TOTAL\ ABS} = \underline{600.053W}$

$$R_{eq} = 1.28k\Omega + (4.8k\Omega + 0.48k\Omega) \parallel (2.4k\Omega + 0.96k\Omega)$$

$$R_{eq} = 1.28k\Omega + 5.28k\Omega \parallel 3.36k\Omega = 1.28k\Omega + 2.053k\Omega = \underline{\underline{3.333k\Omega}}$$

$$I_S = \frac{24V}{3.33k\Omega} = \underline{\underline{7.2mA}}$$

$$I_1 = \frac{3.36k\Omega}{3.36k\Omega + 5.28k\Omega} \times 7.2mA = \underline{\underline{2.8mA}}$$

$$I_2 = \frac{5.28k\Omega}{3.36k\Omega + 5.28k\Omega} \times 7.2mA = \underline{\underline{4.4mA}}$$

$$V_{ab} = V_a - V_b = (4.8k\Omega) \cdot I_1 - (2.4k\Omega) I_2$$

$$V_{ab} = (4.8k\Omega)(2.8mA) - (2.4k\Omega)(4.4mA)$$

$$V_{ab} = \underline{\underline{2.88V}}$$

$$I_{(1.8k\Omega)} = \frac{2.88V}{1.8k\Omega} = \underline{\underline{1.6mA}}$$

$$P = I_{(1.8k\Omega)}^2 \cdot (1.8k\Omega) = (1.6mA)^2 (1.8k\Omega) = \underline{\underline{4.608mW}}$$

$$E = P \cdot \Delta t = (4.608mW) \left[\frac{10^{-3}W}{mW} \right] \times 3600s = \underline{\underline{16.589J}}$$