Name: ______________________________ (please print)

Signature: ___________________________

ECE 2201 -- Exam #1
October 5, 2019

Keep this exam closed until you are told to begin.

1. This exam is closed book, closed notes. You may use one 8.5" x 11" crib sheet, or its equivalent.
2. Show all work on these pages. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit. A solution that is not given in a reasonable order will lose credit. Clearly indicate your answer (for example by enclosing it in a box).
3. It is assumed that your work will begin on the same page as the problem statement. If you choose to begin your work on another page, you must indicate this on the page with the problem statement, with a clear indication of where the work can be found. **If your work continues on to another page, indicate clearly where your work can be found. Failure to indicate this clearly will result in a loss of credit.**
4. Show all units in solutions, intermediate results, and figures. Units in the exam will be included between square brackets.
5. Do not use red ink. Do not use red pencil.
6. You will have 90 minutes to work on this exam.

1. ______________/25

2. ______________/40

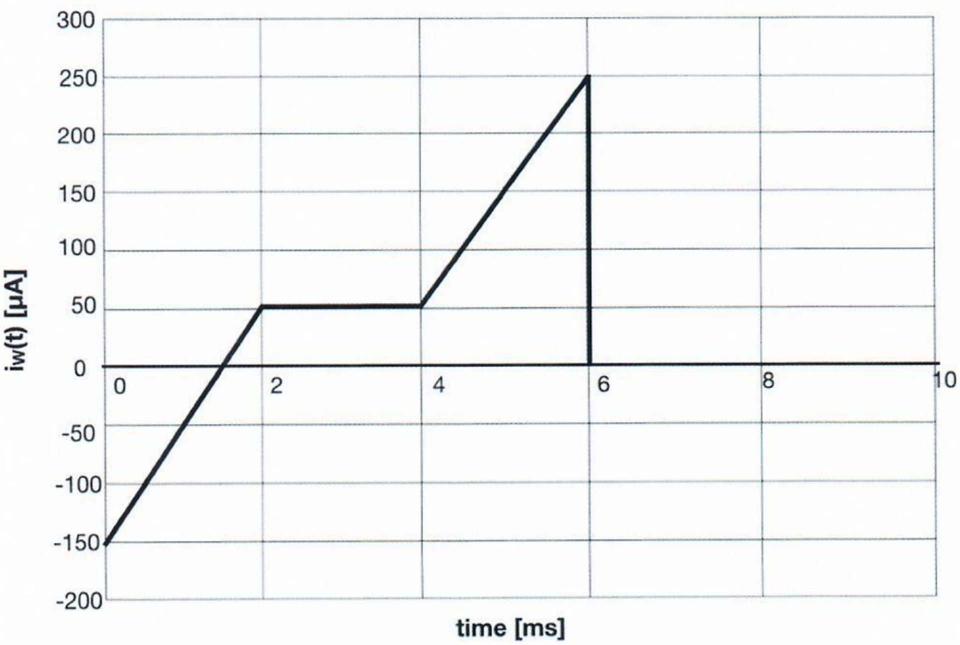
3. ______________/35

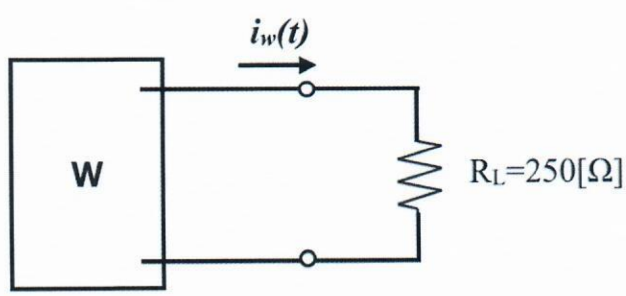
Total = 100

Room for extra work

1. {25 Points} The graph below shows the current in [μA] as a function of time in [ms] in the latest version of the Wanderator device *W*.

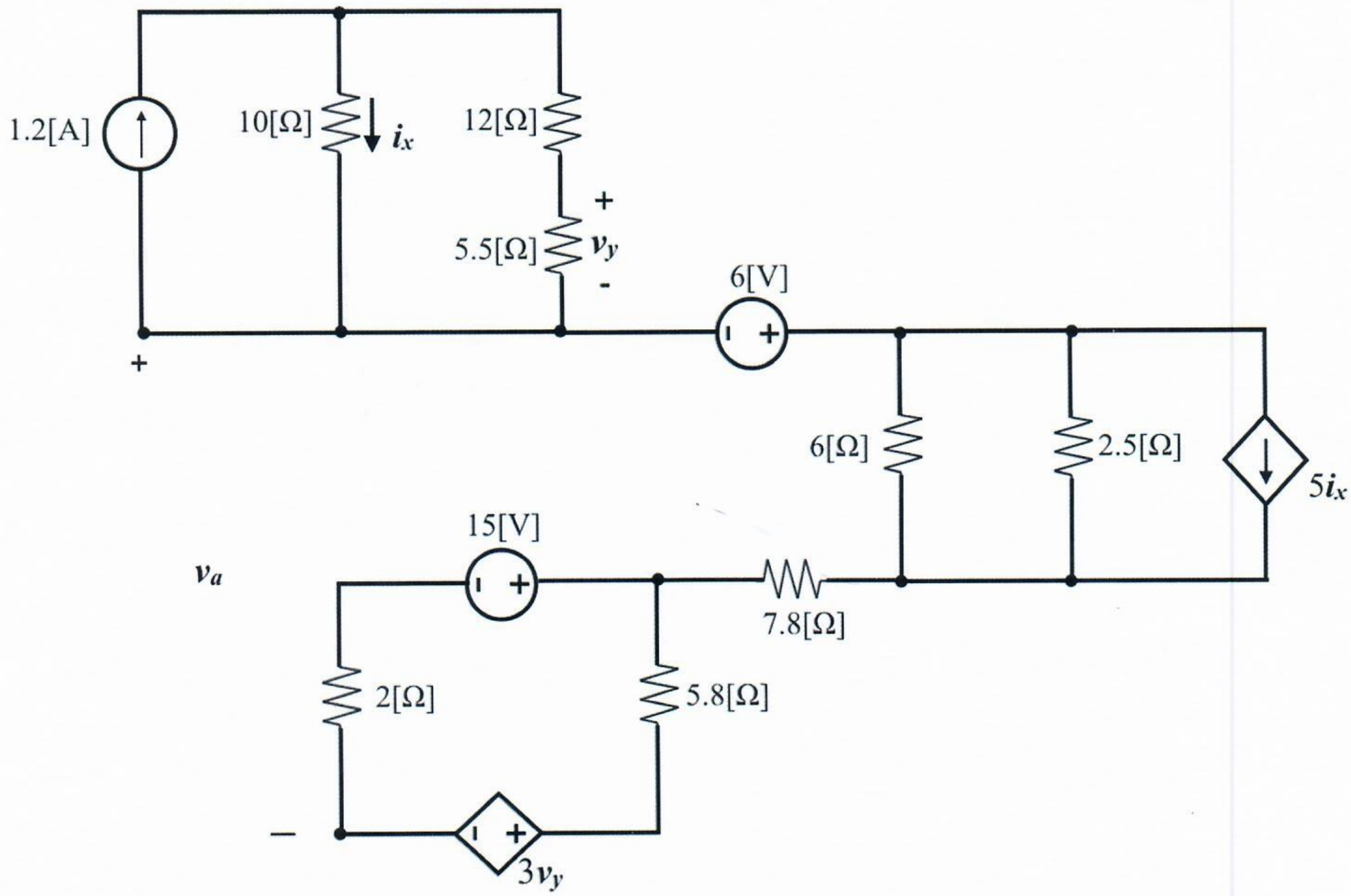
   a) Find the energy delivered by the Wanderator from 2 [ms] to 6 [ms].
   b) If the charge carrier in this circuit is negative, state whether the carriers are gaining or losing energy as they go through the Wanderator at t = 0 [ms]. Explain how you know that.
   c) If the charge carrier is positive, state whether the carriers are gaining or losing energy at t = 0 [ms]. Explain how you know that.





Room for extra work

2. {40 Points} In the circuit shown below
   a) Find the voltage v_a as marked on the circuit.
   b) Find the power delivered by the current dependent current source.
   c) Find the power absorbed by the voltage dependent voltage source.
   Please do not use NVM or MCM.

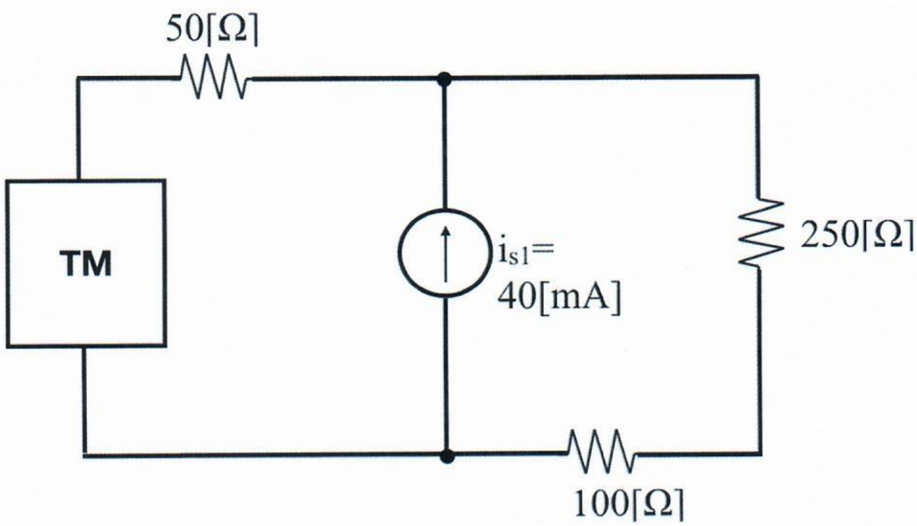


Room for extra work

3. {35 Points} When the latest version of the TrombettaMax® (designated TM) is connected into the circuit shown below, it is found that the source i_{S1} provides power as a function of time as follows:

$$p_{del\ by\ iS1} = 0.1[W]e^{-5\left[\frac{1}{ms}\right]t}.$$

a) Find the power delivered by the TrombettaMax®.
b) Find the energy delivered by the TrombettaMax® between 0 and 1 [s].



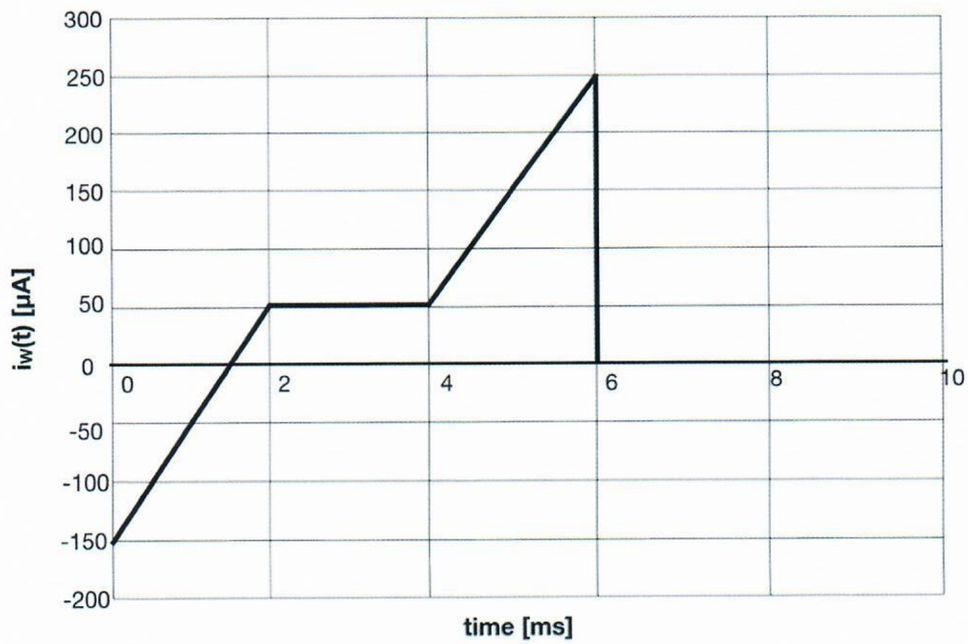
Room for extra work

1. {25 Points} The graph below shows the current in [μA] as a function of time in [ms] in the latest version of the Wanderator device *W*.

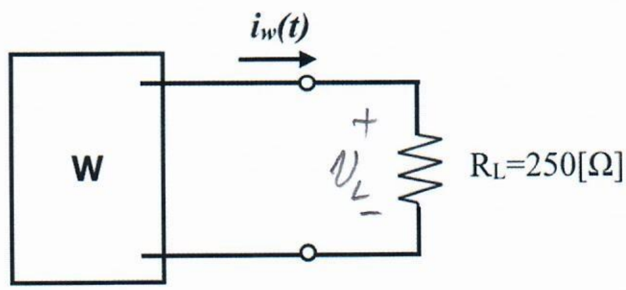
a) Find the energy delivered by the Wanderator from 2 [ms] to 6 [ms].

b) If the charge carrier in this circuit is negative, state whether the carriers are gaining or losing energy as they go through the Wanderator at t = 0 [ms]. Explain how you know that.

c) If the charge carrier is positive, state whether the carriers are gaining or losing energy at t = 0 [ms]. Explain how you know that.



a)



$P_{del\ to\ R_L} = P_{del\ by\ w} = v_L \cdot i_w(t)$
$= i_w^2(t) \cdot R_L$

$$P_{del\ by\ w} = i_w^2 R_L = \begin{cases} 50^2\,[uA]^2 \cdot 250\,[\Omega] & 2 \le t \le 4\ [ms] \\ \left(100\left[\frac{uA}{ms}\right]t - 350\,[uA]\right)^2 \cdot 250 & 4 \le t \le 6\ [ms] \end{cases}$$

$i_w(t) = mt + b$:

$50\,[uA] = m\,4\,[ms] + b$ $\quad m = 100\left[\frac{uA}{ms}\right]$

$250\,[uA] = m\,6\,[ms] + b$ $\quad b = -350\,[uA]$

Room for extra work

So for $2 \le t \le 4$ [ms], we have

$$W_{del\,by\,w} = \int_{2[ms]}^{4[ms]} 2.5\times10^{3}\,[uA]^2 \cdot 250\,[\Omega]\,dt$$

$$= \int_{2\times10^{-3}[s]}^{4\times10^{-3}[s]} (6.25\times10^{5})(10^{-12})\,[W]\,dt$$ convert to [W], [s]

$$= (6.25\times10^{-7}\,[W])\,t\Big|_{2\times10^{-3}[s]}^{4\times10^{-3}[s]} = 1.25\times10^{-9}\,[J]$$

for $4 \le t \le 6$ [ms], we'll convert to A, s :

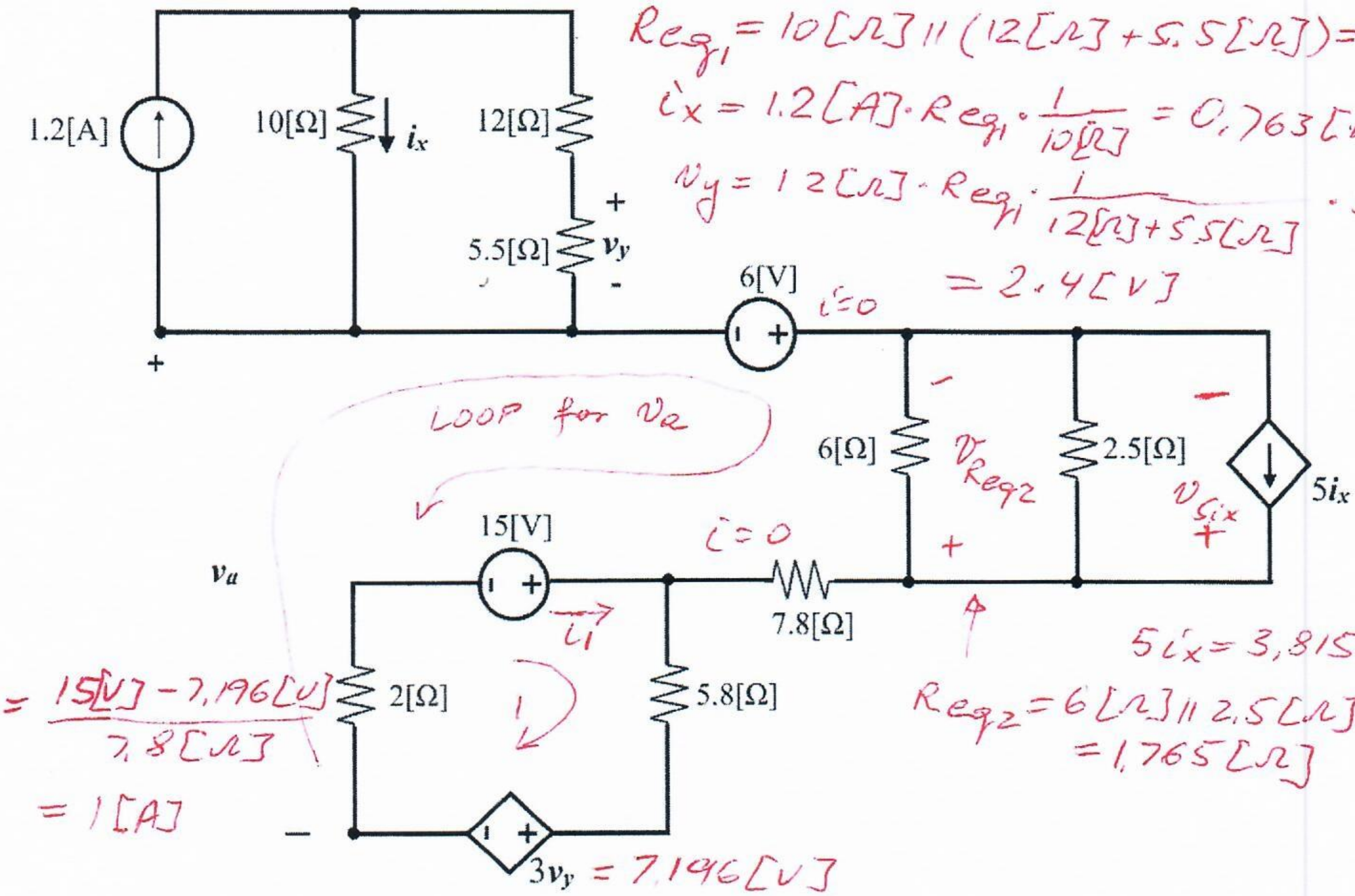
$$i_w(t) = (100\times10^{-3}\,[\tfrac{A}{s}]\,t - 350\times10^{-6}\,[A])$$

So $$W_{del\,by\,w} = \int_{4\times10^{-3}[s]}^{6\times10^{-3}[s]} 250\cdot(100\times10^{-3}\,[\tfrac{A}{s}]\,t - 350\times10^{-6}\,[A])^2\,dt$$

$$= 1.2917\times10^{-8}\,[J] = 12.917\,[nJ]$$

b), c) Regardless of the charge carrier, W is delivering energy, so charge carriers are gaining energy.

2. {40 Points} In the circuit shown below
   a) Find the voltage v_a as marked on the circuit.
   b) Find the power delivered by the current dependent current source.
   c) Find the power absorbed by the voltage dependent voltage source.
   Please do not use NVM or MCM.



$R_{eq1} = 10[\Omega] \parallel (12[\Omega] + 5.5[\Omega]) = 6.36[\Omega]$

$i_x = 1.2[A] \cdot R_{eq1} \cdot \frac{1}{10[\Omega]} = 0.763[A]$

$v_y = 12[\Omega] \cdot R_{eq1} \cdot \frac{1}{12[\Omega] + 5.5[\Omega]} \cdot 5.5[\Omega] = 2.4[V]$

$5i_x = 3.815[A]$

$R_{eq2} = 6[\Omega] \parallel 2.5[\Omega] = 1.765[\Omega]$

$i_1 = \frac{15[V] - 7.196[V]}{7.8[\Omega]} = 1[A]$

$3v_y = 7.196[V]$

a) $-v_a - 6[V] - R_{eq2} \cdot 5i_x + 15[V] - i_1 \cdot 2[\Omega] = 0$

$v_a = 9 - 6.733 - 2 = 0.266[V]$

b) $v_{5ix} = 5i_x \cdot R_{eq2} = 6.733[V]$

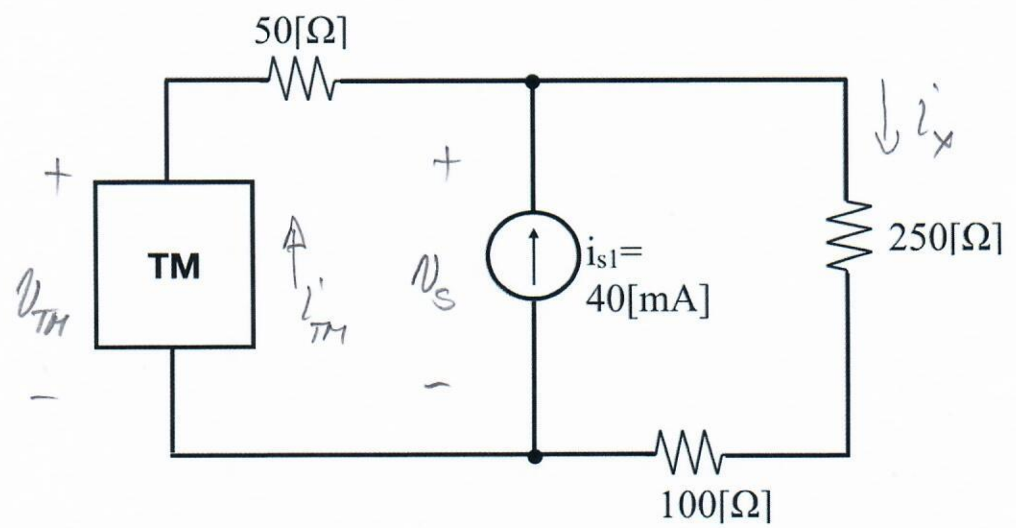
$P_{del,5ix} = v_{5ix} \cdot 5i_x = 25.688[W]$

c) $P_{abs,3vy} = 3v_y \cdot i_1 = 7.196[W]$

3. {35 Points} When the latest version of the TrombettaMax® (designated TM) is connected into the circuit shown below, it is found that the source i_{S1} provides power as a function of time as follows:

$$p_{del\ by\ iS1} = 0.1[W]e^{-5\left[\frac{1}{ms}\right]t}.$$

a) Find the power delivered by the TrombettaMax®.
b) Find the energy delivered by the TrombettaMax® between 0 and 1 [s].



a) $P_{del\ by\ is1} = v_S \cdot i_{S1} = 0.1\,[W]e^{-5\left[\frac{1}{ms}\right]t}$

$\Rightarrow \quad v_S = 2.5\,[V]e^{-5\left[\frac{1}{ms}\right]t}$

So $i_x = \frac{v_S}{350} = 7.143\,[mA]\,e^{-5\left[\frac{1}{ms}\right]t}$

$i_{TM} = i_x - i_{S1} = 7.143\,[mA]e^{-5\left[\frac{1}{ms}\right]t} - 40\,[mA]$

$-v_{TM} + 50 i_{TM} + v_S = 0$

$v_{TM} = 2.857\,[V]e^{-5\left[\frac{1}{ms}\right]t} - 2\,[V]$

↗

Room for extra work

$$P_{del\ by\ TM} = v_{TM}\, i_{TM}$$
$$= \left(2.857[V]e^{-5[\frac{1}{ms}]t} - 2[V]\right)\left(7.143[mA]e^{-5[\frac{1}{ms}]t} - 40[mA]\right)$$

This expression is good for full credit. Expanding...

$$P_{del\ by\ TM} = 20.41[mW]e^{-10[\frac{1}{ms}]t} - 128.6[mW]e^{-5[\frac{1}{ms}]t} + 80[mW]$$

b) $$w_{del\ by\ TM} = \int_0^{1000[ms]} P_{del\ by\ TM}\, dt$$
$$= \frac{20.41[mW]}{-10[\frac{1}{ms}]}e^{-10[\frac{1}{ms}]t}\Big|_0^{1000[ms]} - \frac{128.6[mW]}{-5[\frac{1}{ms}]}e^{-5[\frac{1}{ms}]t}\Big|_0^{1000[ms]}$$
$$+80[mW](1000[ms])$$

$$= -2.04[mJ](0-1) + 25.72[mJ](0-1) + 80000[mJ]$$

$$= 79.976[mJ] \simeq 80000[mJ]$$