Signature: Solution Key

DO NOT OPEN THIS BOOKLET UNTIL INSTRUCTED TO DO SO.

EXAM 2
ELEE 2335
March 28, 1987

INSTRUCTIONS:

1. Sign your name on the upper left of this page.

2. All work is to be done in the spaces provided in this booklet. Use the backs if necessary. Indicate clearly where your work and answers may be found. Enclose your final answers in a box. No credit will be given unless the necessary work is shown.

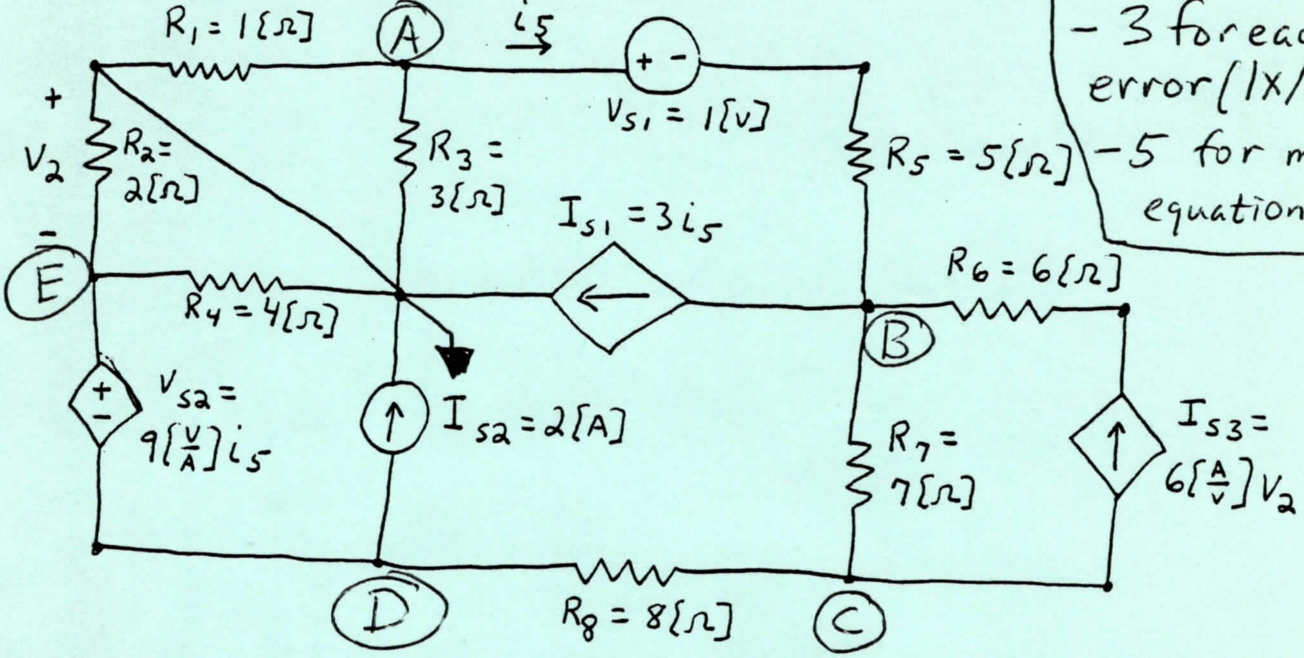
3. Show all of your units explicitly, both in your final answer and in your intermediate steps. Units in exam questions are placed within square brackets.

4. If your answers and work are not in ink, there will be no provision for changing your grade once the exam is returned to you. Do not use red ink.

1. 25
2. 30
3. 25
4. 25
B. 10

110

1. (25 Points) Write the node voltage equations that could be used to solve this network. Show the reference node on the diagram. Do not simplify the circuit. Do not solve the equations.



-3 for each error (1x/equ)
-5 for missing equation (2x/poi

A

$$\frac{V_A}{3[\Omega]} + \frac{V_A}{1[\Omega]} + \frac{V_A - (V_B + 1[V])}{5[\Omega]} = 0$$

B

$$3i_5 + \frac{V_B + 1[V] - V_A}{5[\Omega]} - 6[\tfrac{A}{V}]V_2 + \frac{V_B - V_C}{7[\Omega]} = 0$$

C

$$6[\tfrac{A}{V}]V_2 + \frac{V_C - V_B}{7[\Omega]} + \frac{V_C - V_D}{8[\Omega]} = 0$$

D + E

$$2[A] + \frac{V_D - V_C}{8[\Omega]} + \frac{V_E}{4[\Omega]} + \frac{V_E}{2[\Omega]} = 0$$

Super node

$$V_E - V_D = 9[\tfrac{V}{A}]\, i_5$$

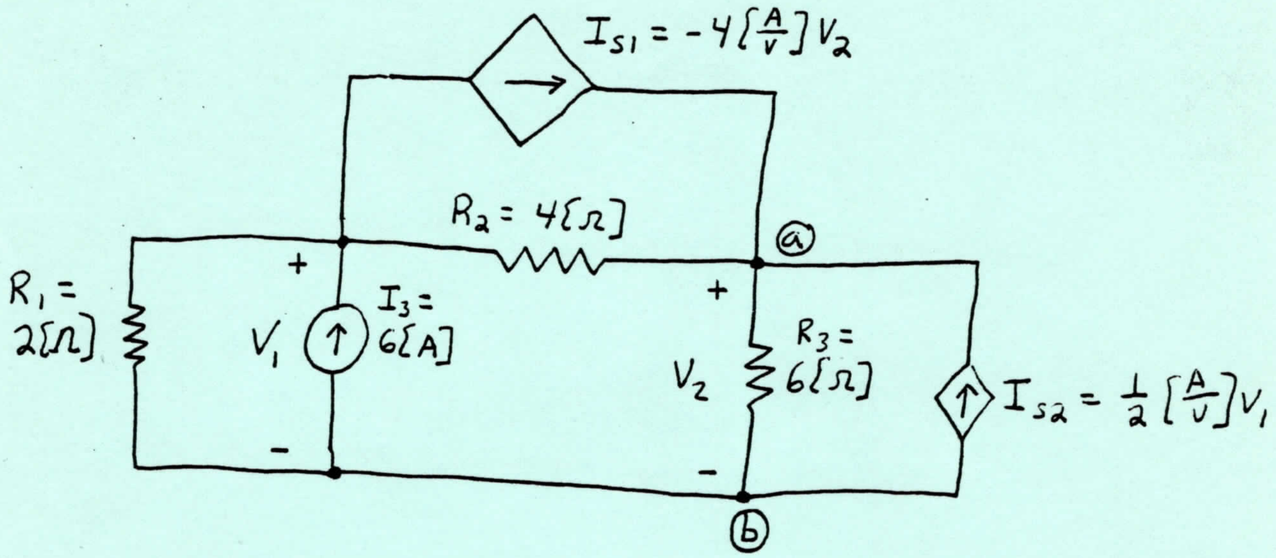
dep. sources

$$i_5 = \frac{V_A - (V_B + 1[V])}{5[\Omega]} \qquad V_2 = -V_E$$

7 equ.

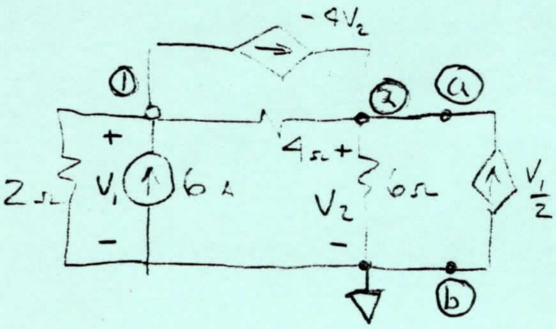
7 unk

2. (30 Points) Determine the Thevenin equivalent for this network with respect to the terminals ⓐ and ⓑ.



SOLUTION

1. Determine $V_{TH} = V_{ab}$ USING : NODE TECHNIQUE



① $\frac{V_1}{2} - 6 - 4V_2 + \frac{V_1 - V_2}{4} = 0$; $\underline{2V_1} - \underline{24} - \underline{16V_2} + \underline{V_1} - \underline{V_2} = 0$

$3V_1 - 17V_2 = 24$

② $\frac{V_2}{6} + \frac{V_2 - V_1}{4} + 4V_2 - \frac{V_1}{2} = 0$; $\underline{2V_2} + 3V_2 - \underline{3V_1} + \underline{48V_2} - \underline{6V_1} = 0$

$-9V_1 + 53V_2 = 0$ OR $V_1 = \frac{53}{9} V_2$

SUB. INTO ①

∴ $\cancel{3} \times \frac{53}{\underset{3}{\cancel{9}}} V_2 - 17V_2 = 24$

ROOM FOR EXTRA WORK

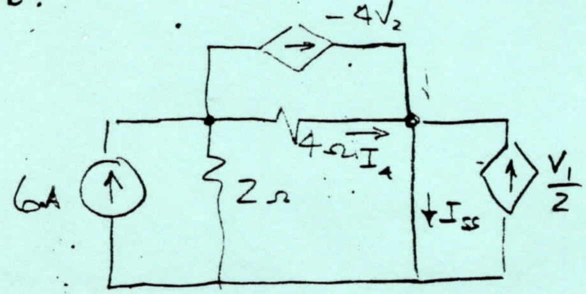
$$53V_2 - 51V_2 = 72$$

$$2V_2 = 72$$

$$V_2 = V_{ab} = V_{TH} = \frac{72}{2} = \underline{\underline{36\ V}}$$

TO DETERMINE R_{TH} CALCULATE I_{ss} between termi

a-b.



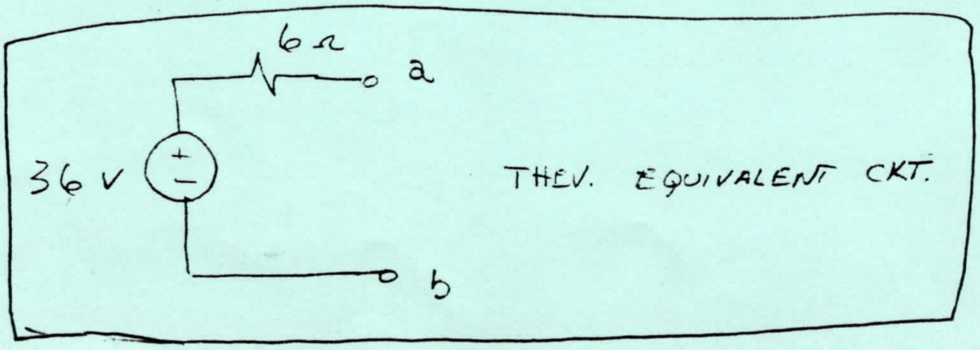
$$I_{ss} = \frac{V_1}{2} - 4V_2 + 6 \times \frac{2}{6}$$ (NOTE $V_2 = 0$)

$$= \frac{V_1}{2} - 0 + 2$$

$$V_1 = 6 \times 2 // 4 = 6 \times \frac{8}{6} = 8\ V$$

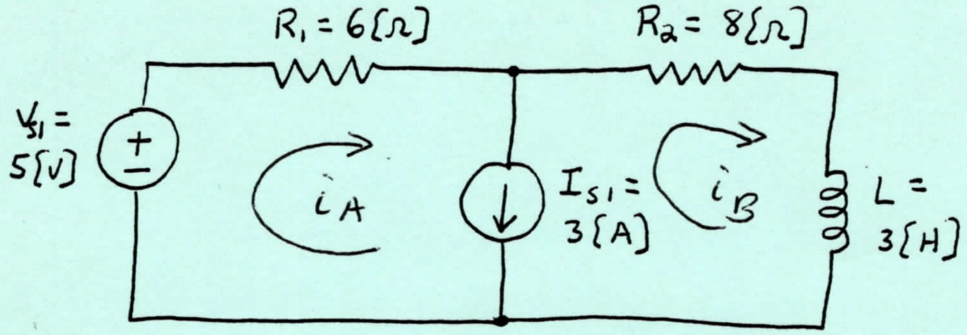
$$\therefore\ I_{ss} = 4 + 2 = 6 (A)$$

$$R_{TH} = \frac{V_{ab}}{I_{ss}} = \frac{36}{6} = \underline{\underline{6\Omega}}$$



THEV. EQUIVALENT CKT.

3. (20 Points) Assume that this circuit has been in this condition for a long time. Use the <u>mesh current method</u> to solve for the energy stored in the inductor.



Solve for i_B, then

$$W = \frac{1}{2} L (i_B)^2$$

Inductor acts as short circuit

Super mesh

$$5[V] - i_A R_1 - i_B R_2 = 0 \quad (+5)$$

$$5[V] - i_A 6[\Omega] - i_B 8[\Omega] = 0$$

$$i_A - i_B = I_{S1} = 3[A] \quad (+5)$$

$$i_A = i_B + 3[A]$$

$$5[V] - (i_B + 3[A]) 6[\Omega] - i_B 8[\Omega] = 0$$

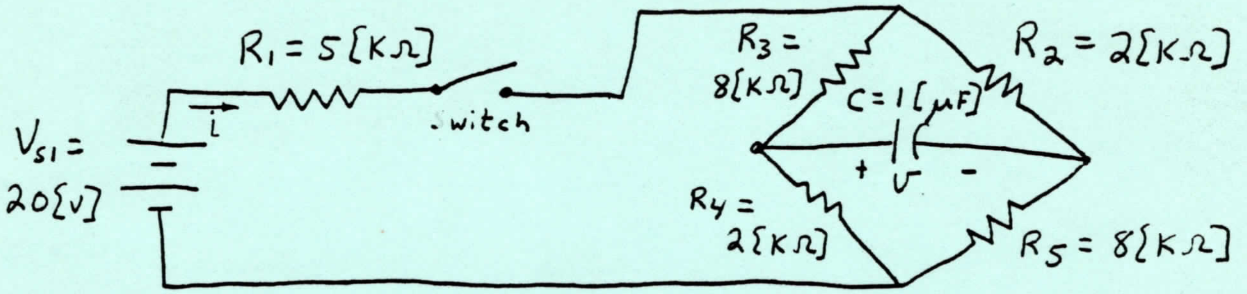
$$-13[V] - i_B (14[\Omega]) = 0$$

$$i_B = \frac{-13}{14}[A] = -.92857[A] \quad (+2)$$

(+5) $$W = \frac{1}{2} L (i_B)^2 = \frac{3}{2}\left(\frac{-13}{14}\right)^2 [J] = 1.293367[J]$$

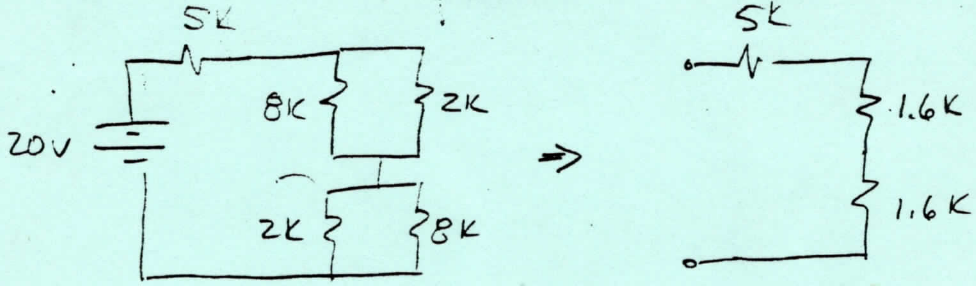
(+3)

4. (25 Points) In this circuit, the switch had been open for a long time, and the capacitor voltage was equal to 0.



a) What is the value of the battery current i immediately after the switch is closed?

a) the cap. acts as short circuit, therefore the circuit becomes

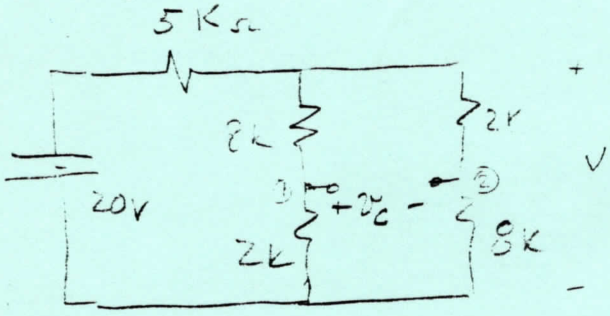


$\therefore \; i = \dfrac{20}{8.2K} = \underline{\underline{2.44 \, ma}}$

4. (continued) b) Then, after the switch had been <u>closed</u> for a long time, the switch is again opened, at t = 0. Write an expression for v(t) for all time t ≥ 0.

b) AFTER the switch is closed for a long time

we have



$$V = \frac{20 \times 5K}{5K + 5K} = 10V$$

$$V_1 = \frac{10 \times 2K}{10K} = 2V$$

$$V_2 = \frac{10 \times 8K}{10K} = 8V$$

$$\therefore\ v_c(0+) = V_1 - V_2 = 2 - 8 = -6V$$

$$v_c(t) = -6e^{-t/RC}$$

$$R = 10K \parallel 10K = 5K\Omega$$

$$\therefore\ v_c(t) = \underline{\underline{-6e^{-200t}}} \text{ VOLTS}$$

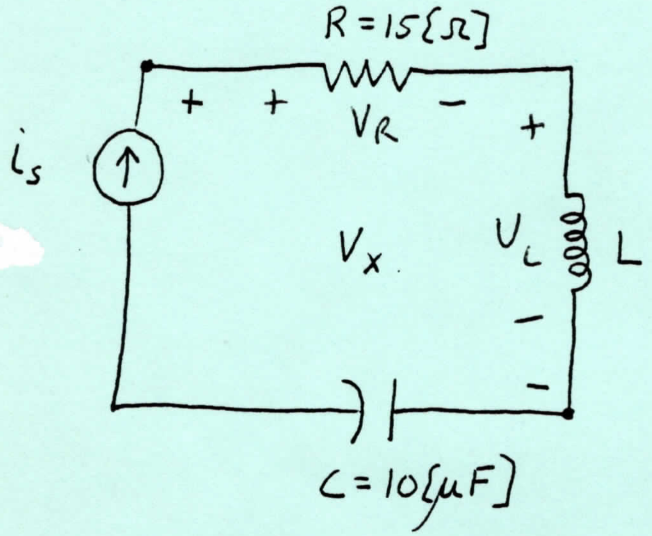
4. (continued) c). What is the value of the energy stored in the capacitor immediately before t = 0?

c) $w = \frac{1}{2} C v(0^-)^2 = \frac{1}{2} \times 1 \times 10^{-6} \times 36 = \underline{\underline{18 \mu J}}$

Bonus Question (10 Points) The values for i_s and v_x in this circuit are given below. Find the value of the inductance L.

$i_s(t) = 5\,e^{-30t}$ [A] ; t in [sec]

$v_x(t) = -100\,e^{-30t}$ [V] ; t in [sec]



$$V_x = V_R + V_L$$

+5

$$-100\,e^{-30t}\,[V] = 5(15)\,e^{-30t}\,[V] + L\,\frac{d}{dt}\left(5e^{-30t}\right)$$

$$-175\,e^{-30t}\,[V] = L\left(-150\,e^{-30t}\right)[A/s]$$

$$L = \frac{-175\,e^{-30t}}{-150\,e^{-30t}}\left[\frac{V-s}{A}\right] = \frac{7}{6}\,[H]$$

+5

$$L = 1.167\,[H]$$