上 海 交 通 大 学 试 卷

（ 2025~ 2026~1 Academic Year/Fall Semester ）

Class No.______________________ Name in English or Pinyin: ______________________

Student ID No.________________ Name in Hanzi(if applicable): ______________________

ECE2150J Intro to Circuits

Mid-term Exam

12th November 14:00 – 15:40

The exam paper has 13 pages in total.

You are to abide by the Global College, Shanghai Jiao Tong University honor code. Please sign below to signify that you have kept the honor code pledge.

THE GLOBAL COLLEGE HONOR CODE

I accept the letter and spirit of the honor code:

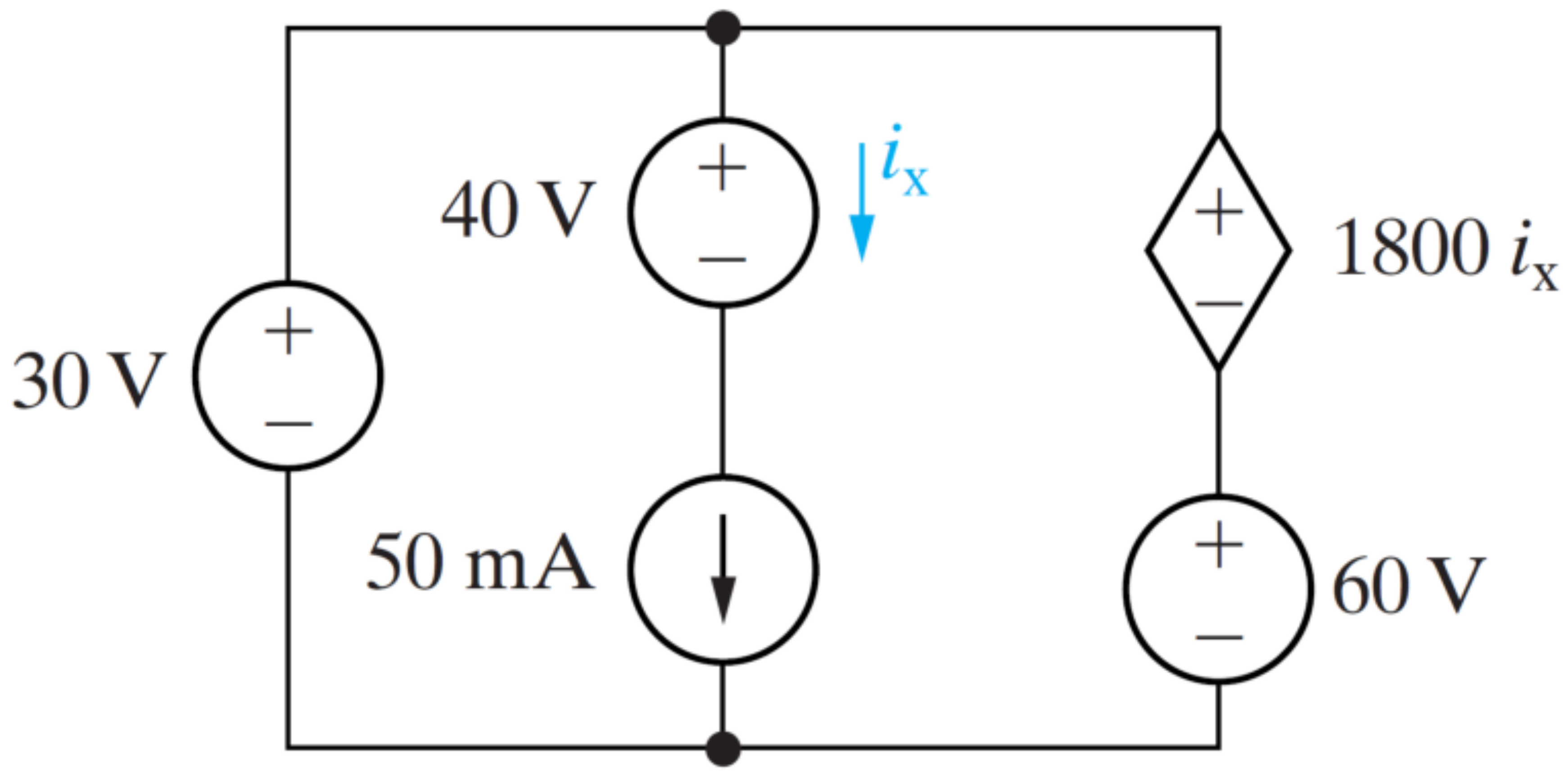
I have neither given nor received unauthorized aid on this examination, nor have I concealed any violations of the Honor Code by myself or others.

Signature:____________

Please enter grades here:

Exercises No. 题号	Points 得分	Grader's Signature 流水批阅人签名
1		
2		
3		
4		
5		
6		
7		
8		
Total 总分		

1. If the interconnection in the circuit below is valid, find the total power developed in the circuit. If the interconnection is not valid, explain why. [8 points]



(a) Is it valid or invalid? Invalid +2

(b) What is the value of I_x? 50 mA +2

(c) What is the voltage generated by the current dependent voltage source? 90 V +2

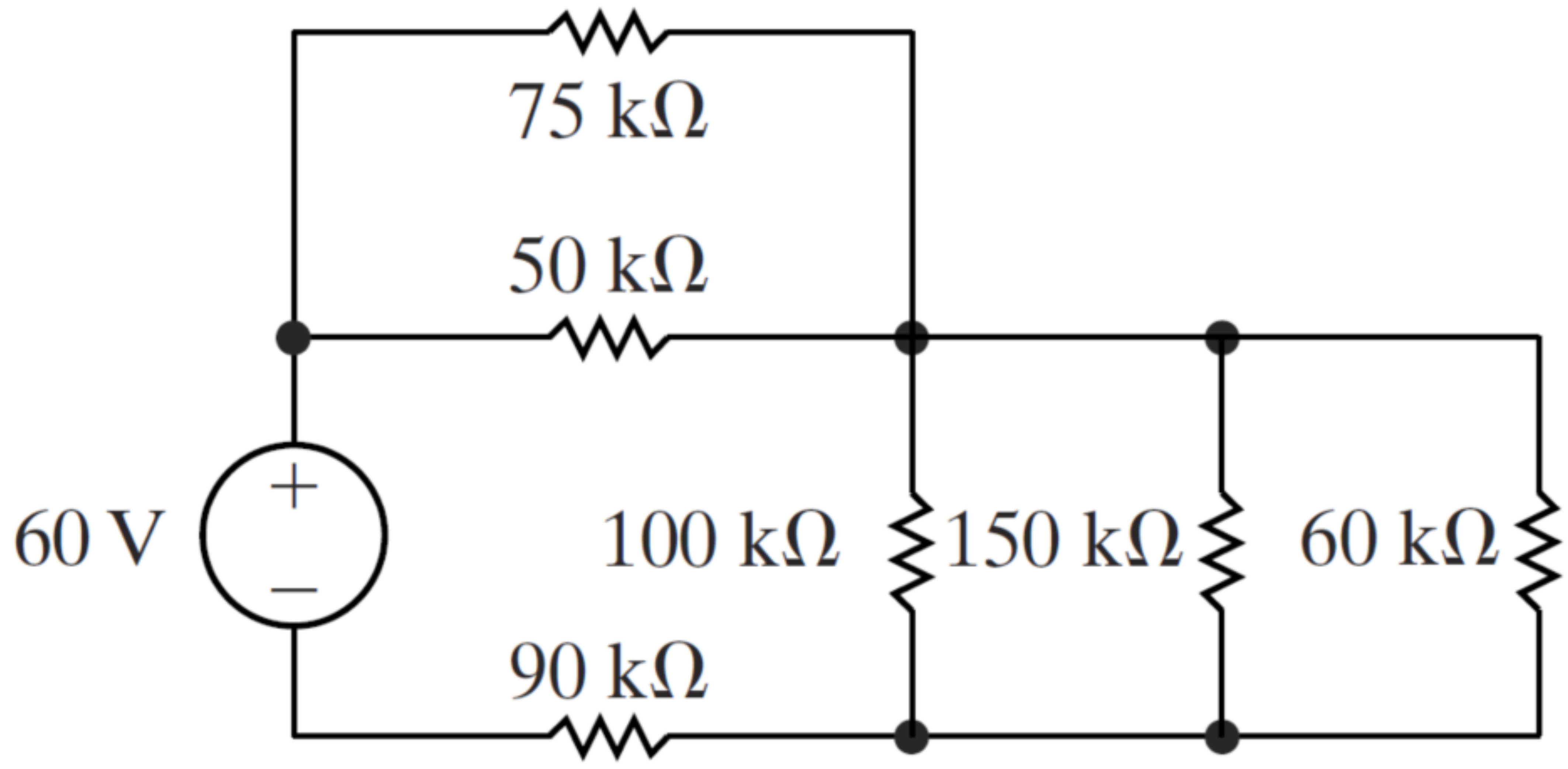
(d) Provide reason for your answer in (a). In the middle branch, the value of the current i_x must be 50 mA, since the 50 mA current source supplies current in this branch in the same direction as the current i_x. Therefore, the voltage supplied by the dependent voltage source in the right-hand branch is 1800(0.05) = 90 V. This gives **a voltage drop** from the top terminal to the bottom terminal in the right-hand branch of **90 + 60 = 150 V**. But **the voltage drop** between these same terminals in the left-hand branch is **30 V**, due to the voltage source in that branch. Therefore, the interconnection is invalid. +2

(b) I_x = 50 mA / $-\frac{1}{60}$ A +2

(c) V = 90 V / −30 V +2

(a). (d) each 2 points

2. Find the equivalent resistance R_{eq} seen by the source and power delivered by the source. [7 points]



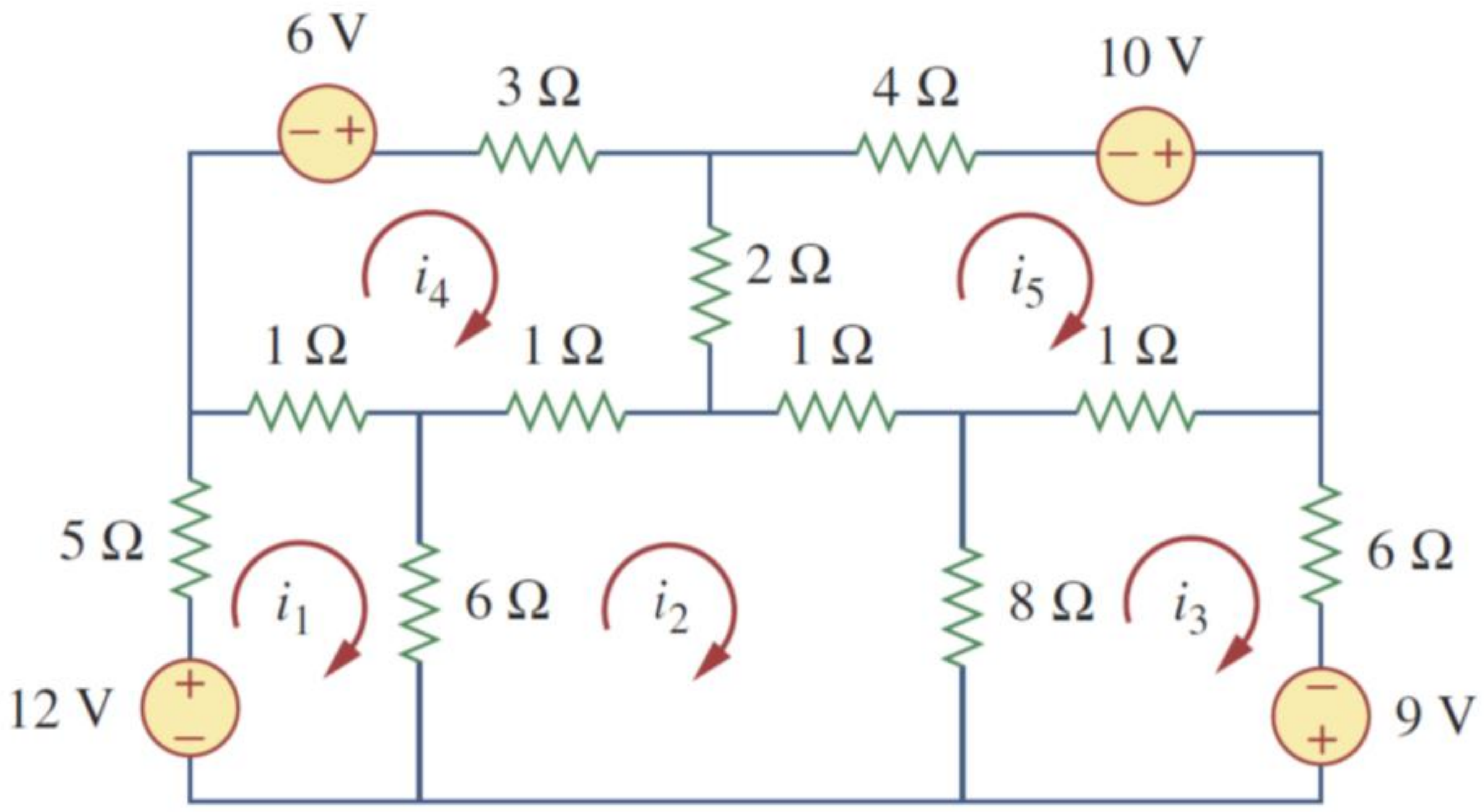
R_{eq} = 75k‖50k + 100k‖150k‖60k + 90k = **150 kΩ, or 150,000Ω** +3 (required to show that it is kilo scale).

P = VI = V^2/R_{eq} = 24 mW, or 0.024 W +4 (required to show that it is milli scale).

correct answer 2 + 2 (units 1')

process / equations 1 + 2

3. Please use the mesh analysis by inspection to build the matrix below. [9 points]



For example,

$$\begin{bmatrix} R_{11} & R_{12} & \dots & R_{1N} \\ R_{21} & R_{22} & \dots & R_{2N} \\ \vdots & \vdots & \vdots & \vdots \\ R_{N1} & R_{N2} & \dots & R_{NN} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ \vdots \\ i_N \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_N \end{bmatrix}$$

$\mathbf{R_{kk}}$ = Sum of the resistances in mesh k

$\mathbf{R_{kj}}$ = $\mathbf{R_{jk}}$ = Negative of the sum of the resistances in common with meshes k and j, k≠j

$\mathbf{i_k}$ = Unknown current for mesh k in the clockwise direction

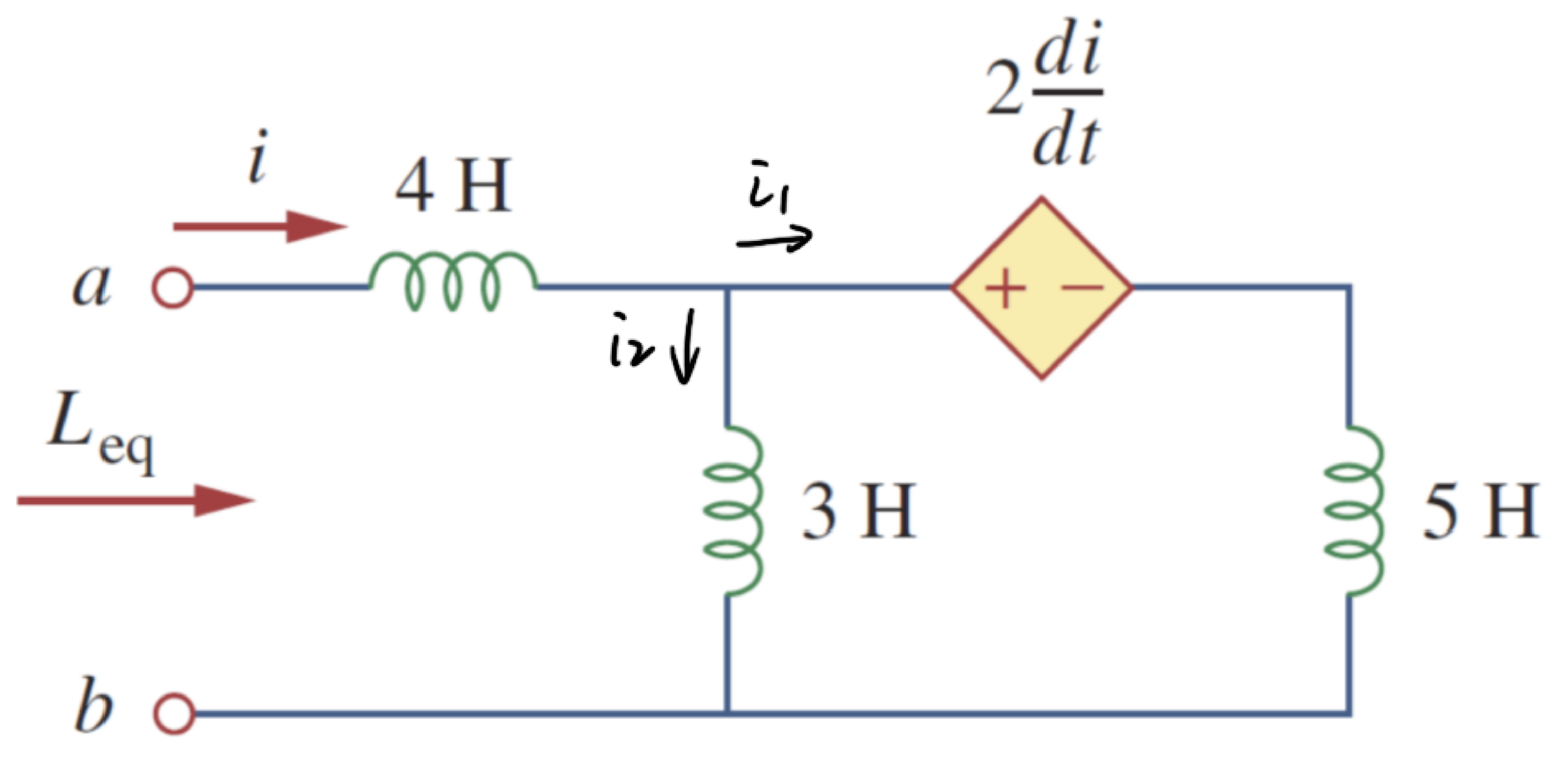
$\mathbf{v_k}$ = Sum taken clockwise of all independent voltage sources in mesh k, with voltage rise treated as positive

$$R = \begin{bmatrix} 12 & -6 & 0 & -1 & 0 \\ -6 & 16 & -8 & -1 & -1 \\ 0 & -8 & 15 & 0 & -1 \\ -1 & -1 & 0 & 7 & -2 \\ 0 & -1 & -1 & -2 & 8 \end{bmatrix} \begin{matrix} i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \end{matrix} = \begin{bmatrix} 12 \\ 0 \\ 9 \\ 6 \\ 10 \end{bmatrix}$$

each element 0.3 point

$0.3 \times 30 = 9$

4. Determine L_{eq} to represent the inductive network at the ***a-b*** terminals in the circuit below. The goal is to find a numerical value of L_{eq}. [14 points]



$\boxed{KCL.\quad i = i_1 + i_2}$ 2

$\boxed{V = 2\frac{di}{dt} + 5\frac{di_1}{dt} = 3\frac{di_2}{dt}}$ 2

$\boxed{7\frac{di_1}{dt} = \frac{di_2}{dt} \qquad \frac{di}{dt} = 8\frac{di_1}{dt}}$ 2 (relation between i)

$\boxed{V = 21\frac{di_1}{dt} \qquad V = \frac{21}{8}\frac{di}{dt}}$ 2 (relation between i and v)

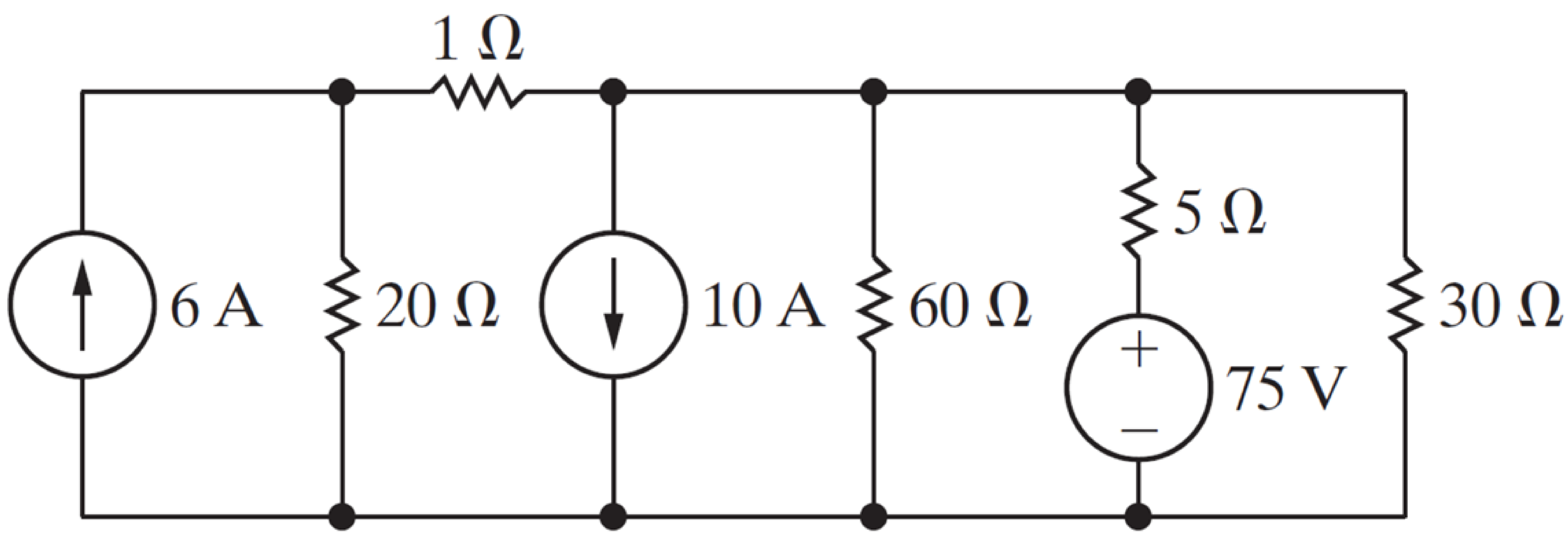
$\boxed{V_{ab} = V + 4\frac{di}{dt} = \frac{53}{8}\frac{di}{dt}}$ 2

$\boxed{L_{eq} = \frac{53}{8}\,H}$ 4 $\boxed{V_{ab} = L_{eq}\frac{di}{dt}}$ 1'

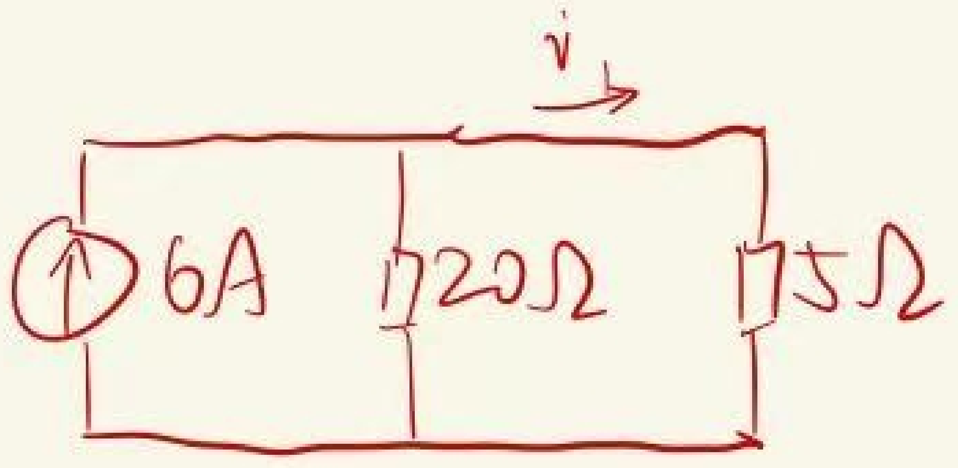
2'

5. Use the principle of superposition to find power consumed at 1 Ω resistor, $\boldsymbol{P_{1\Omega}}$. [12 points]

$$P_{1\Omega} = i^2 R$$

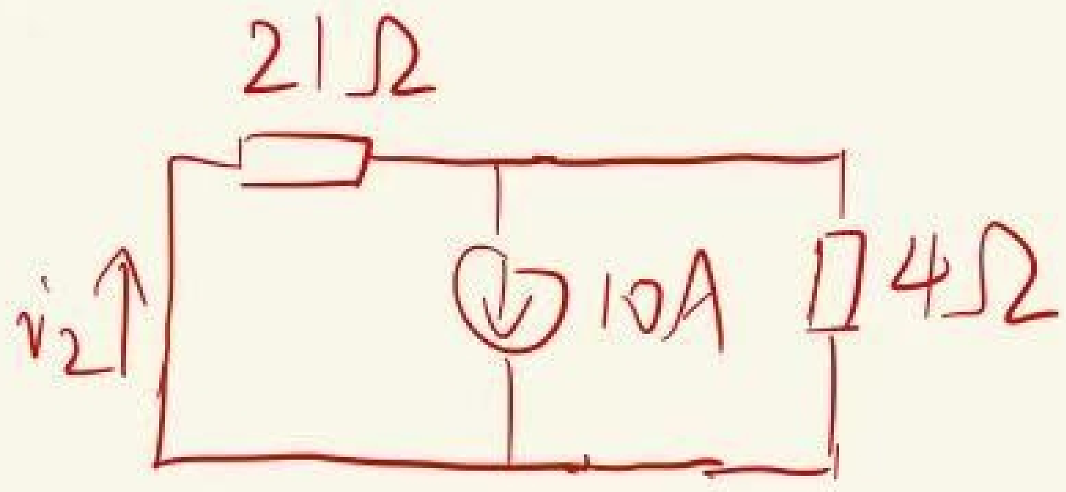


5.

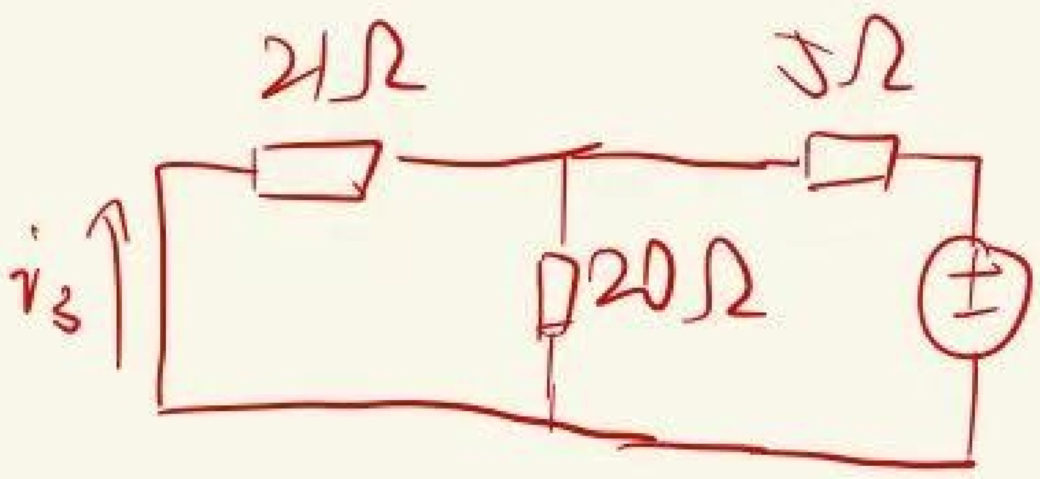
① 

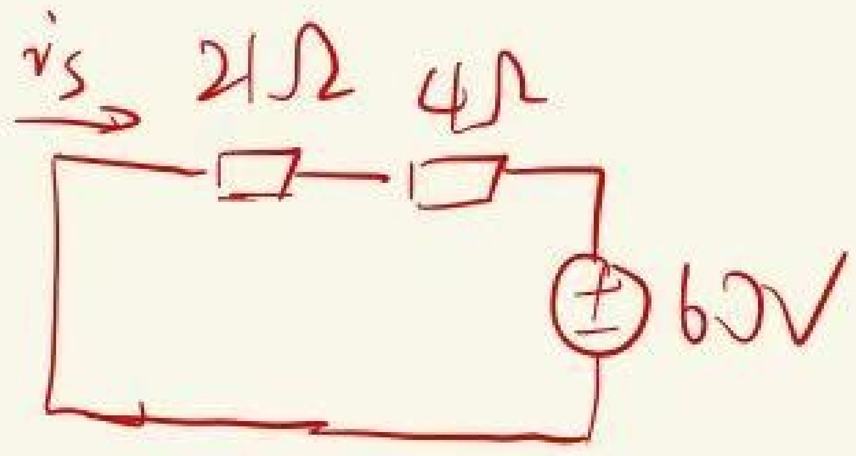
$\Rightarrow i_1 = \frac{24}{5} A \left(v_1 = \frac{24}{5} V \right)$ (4.8A)

3pts

② 

$\Rightarrow i_2 = \frac{8}{5} A, \left(v_2 = \frac{8}{5} V \right)$ (1.6A) 3pts

③ 

$\Rightarrow$ 

$\Rightarrow i_3 = -\frac{12}{5} A$ $\left(v_3 = -\frac{12}{5} V \right)$. (-2.4A)

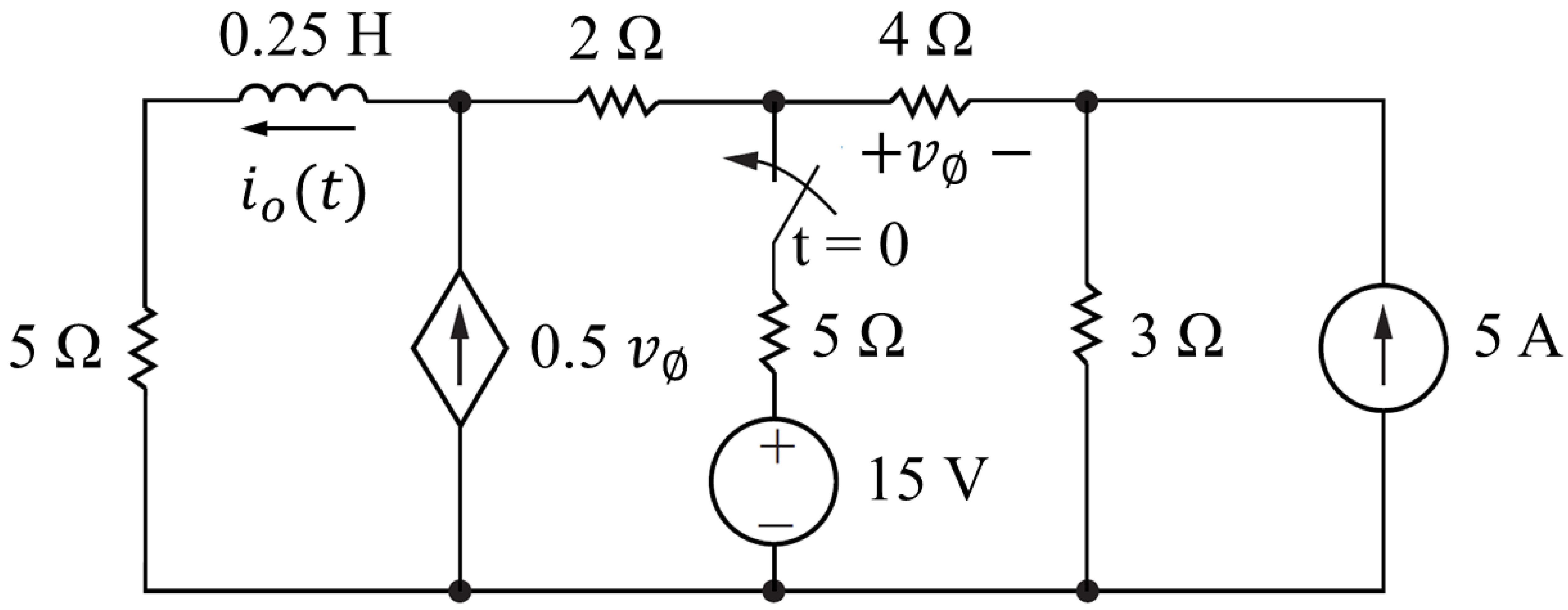
3pts

$\Rightarrow i = i_1 + i_2 + i_3 = 4A$. $P = i^2 R = 16W$

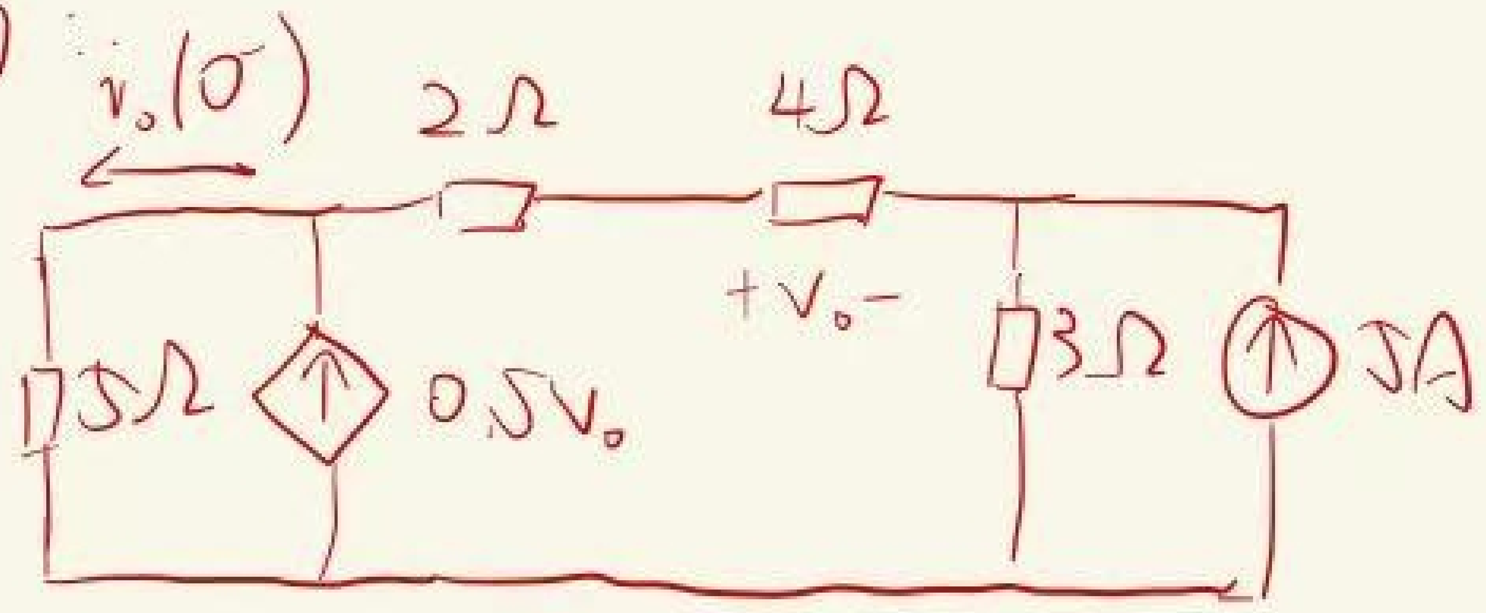
$(v = v_1 + v_2 + v_3 = 4V)$ $P = \frac{v^2}{R} = 16W$.

1pt 2pts

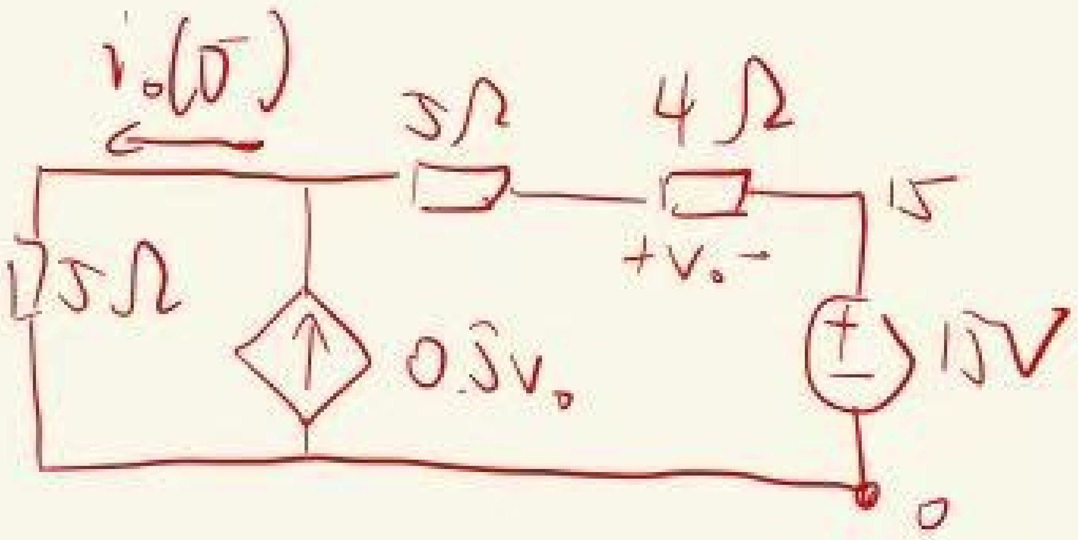
6. Before $t = 0$ the circuit was under DC bias condition for a long time, i.e. DC steady state. Find $i_o(t)$ for $t > 0$ when the switch is closed at $t = 0$. [20 points]



$t<0$:



$\Rightarrow$



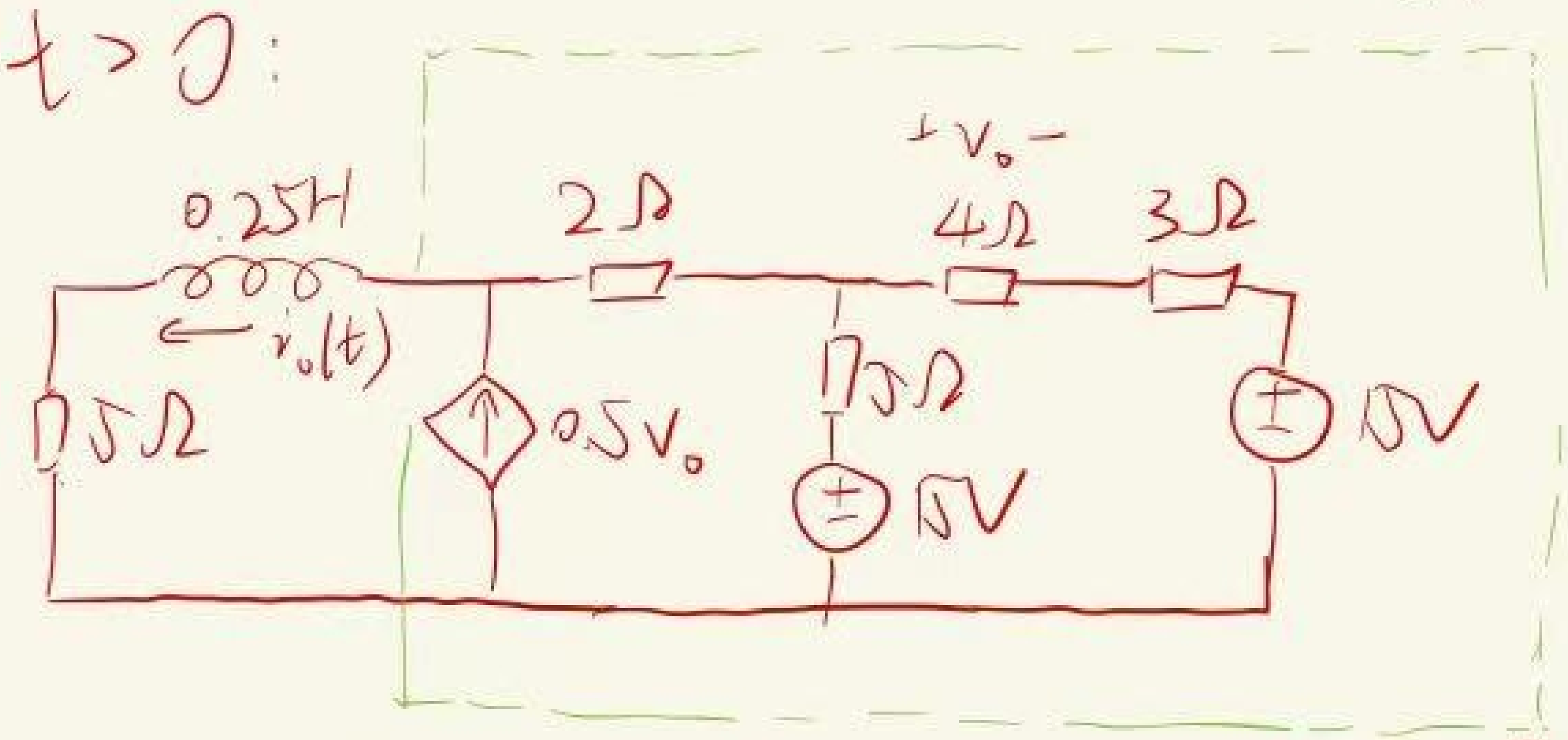
$$\begin{cases} i_o = \dfrac{15+\frac{9}{4}v_o}{5} \\ i_o + \dfrac{v_o}{4} = \dfrac{v_o}{2} \end{cases} \Rightarrow \begin{cases} v_o = -15V \\ i_o = -\dfrac{15}{4}A \end{cases}$$

$(-3.75A)$

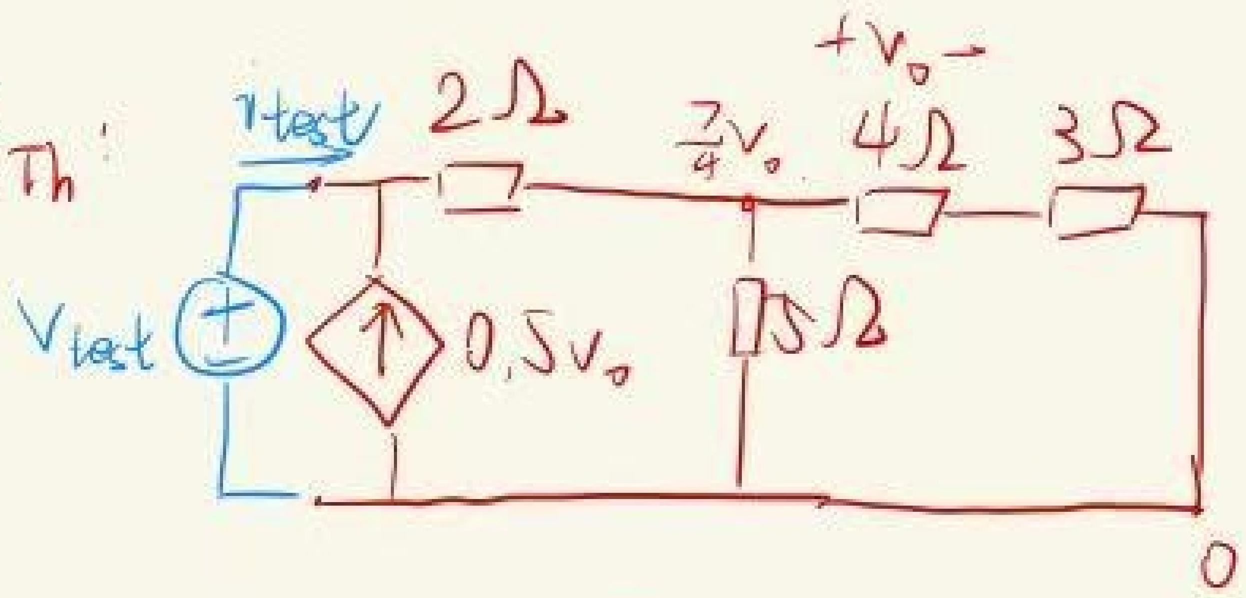
formula - 2pts

result - 2pts

$t>0$:



R_{Th}:



$$\begin{cases} \dfrac{v_{test}-\frac{7}{4}v_o}{2} = i_{test} + \dfrac{v_o}{2} \\ i_{test} + \dfrac{v_o}{2} = \dfrac{\frac{7}{4}v_o}{5} + \dfrac{\frac{7}{4}v_o}{7} \end{cases}$$

2pts

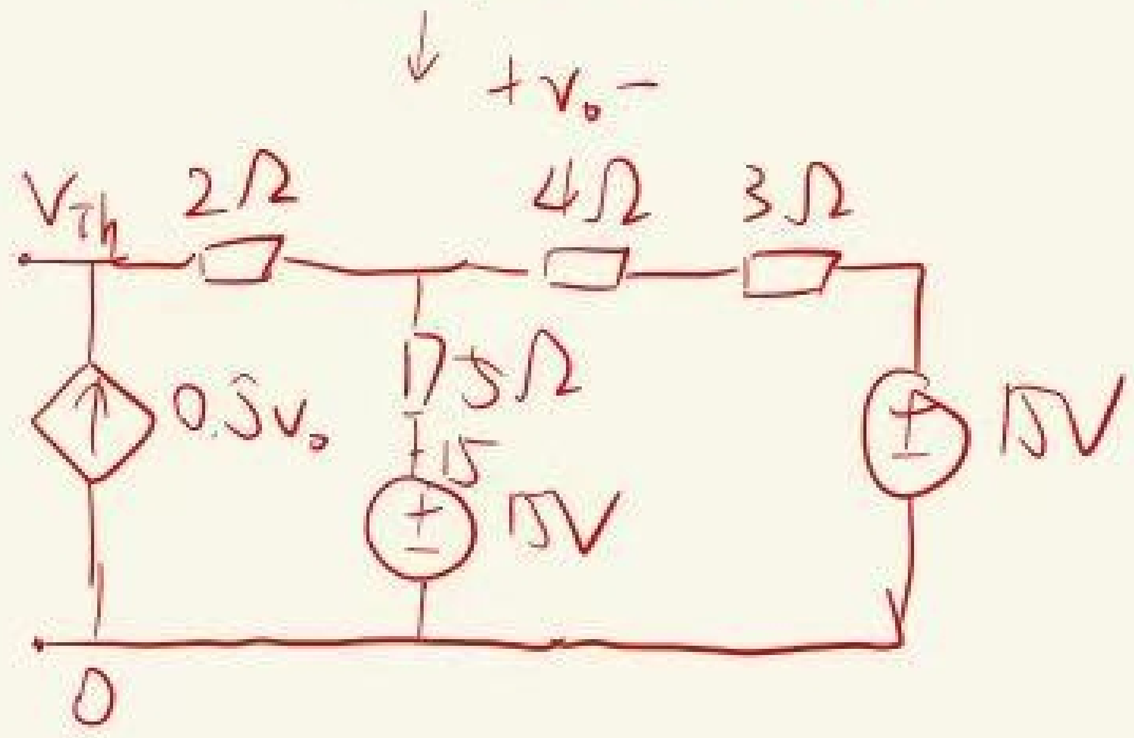
$$\Rightarrow R_{Th} = \frac{v_{test}}{i_{test}} = \cdots = \frac{59}{2}\Omega$$

(29.5Ω)

2pts

$15+\frac{7}{4}v_o = V_{Th} - v_o$

V_{Th}:



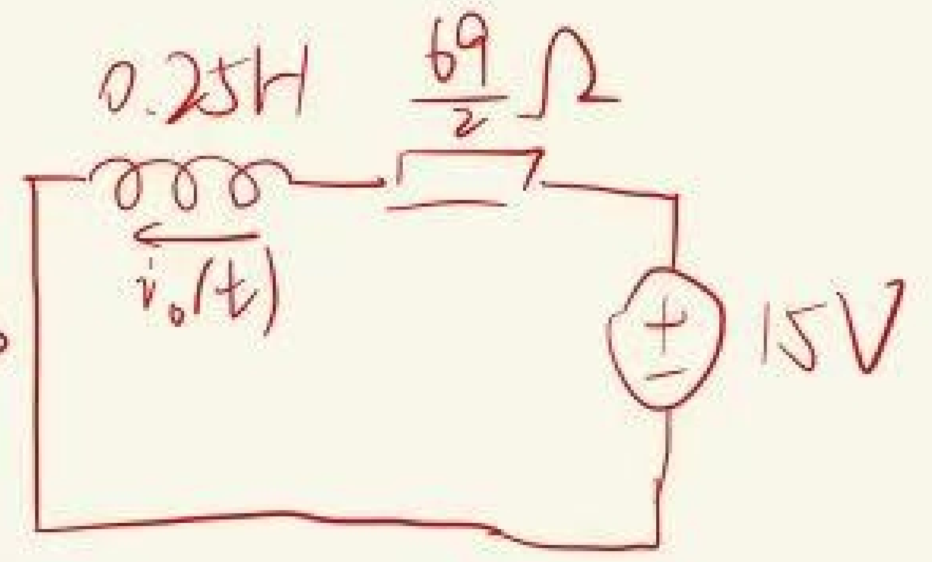
$$\begin{cases} \dfrac{V_{Th}-(15+\frac{7}{4}v_o)}{2} = 0.5v_o \\ 0.5v_o = \dfrac{v_o}{4} + \dfrac{\frac{7}{4}v_o}{5} \end{cases}$$

2pts

$$\Rightarrow V_{Th} = 15V$$

2pts

$\Rightarrow$



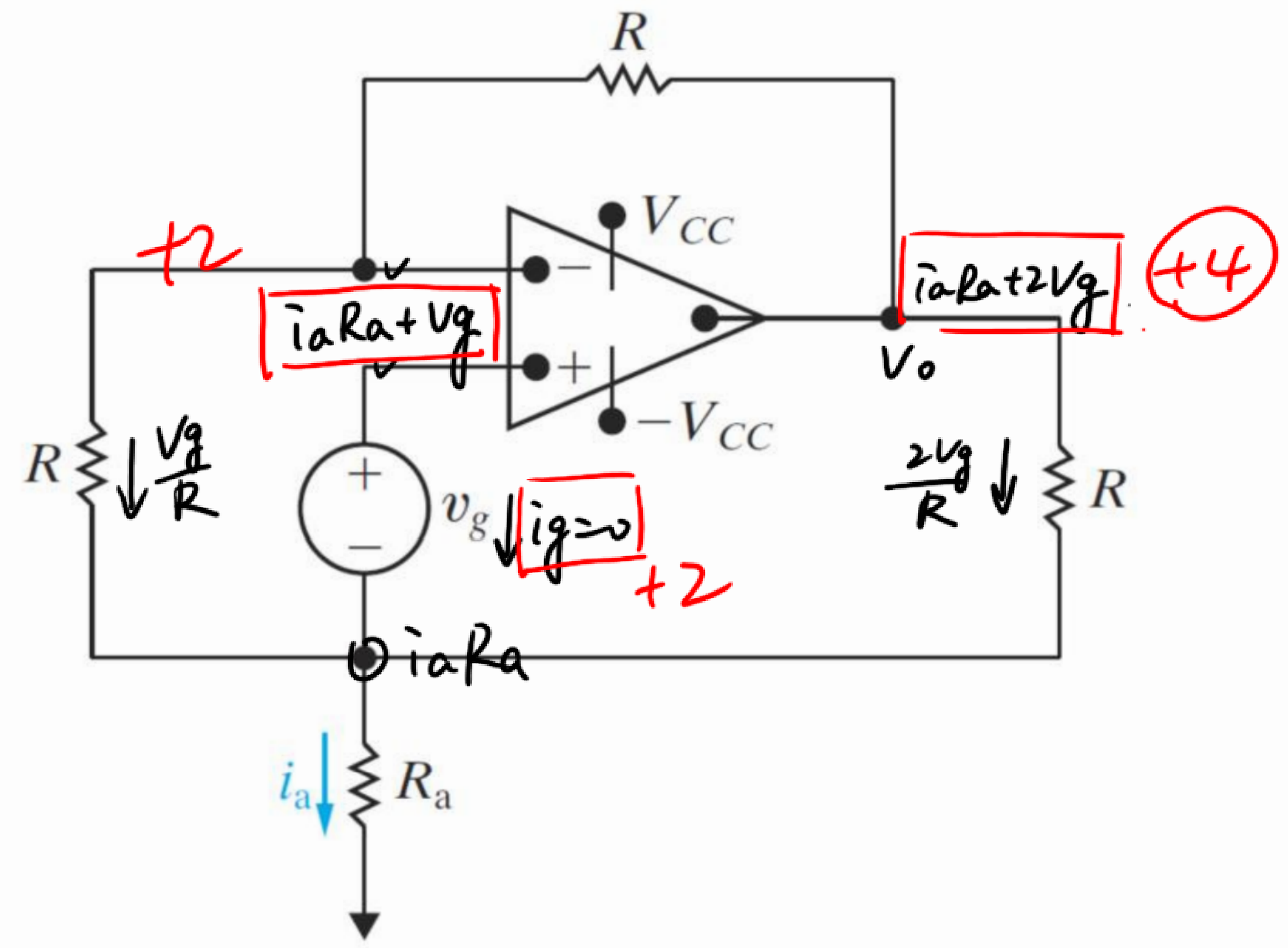
$i_o(\infty) = \frac{10}{23}A$, $\tau = \frac{L}{R} = \frac{1}{138}$ 4pts

$$\Rightarrow i_o(t) = i_o(\infty) + (I_o - i_o(\infty))e^{-\frac{t}{\tau}}$$
$$= \left(\frac{10}{23} - \frac{385}{92}e^{-138t}\right)A$$

4pts

$((0.43 - 4.18e^{-138t})A)$

7. Please prove $i_a = \frac{3v_g}{R}$ when the ideal op amp below is operating in its linear region. [12 points]



KCL: $\boxed{\frac{V_o-(i_aR_a+V_g)}{R} = \frac{V_g}{R}}$ +2

$V_o = i_aR_a + 2V_g$.

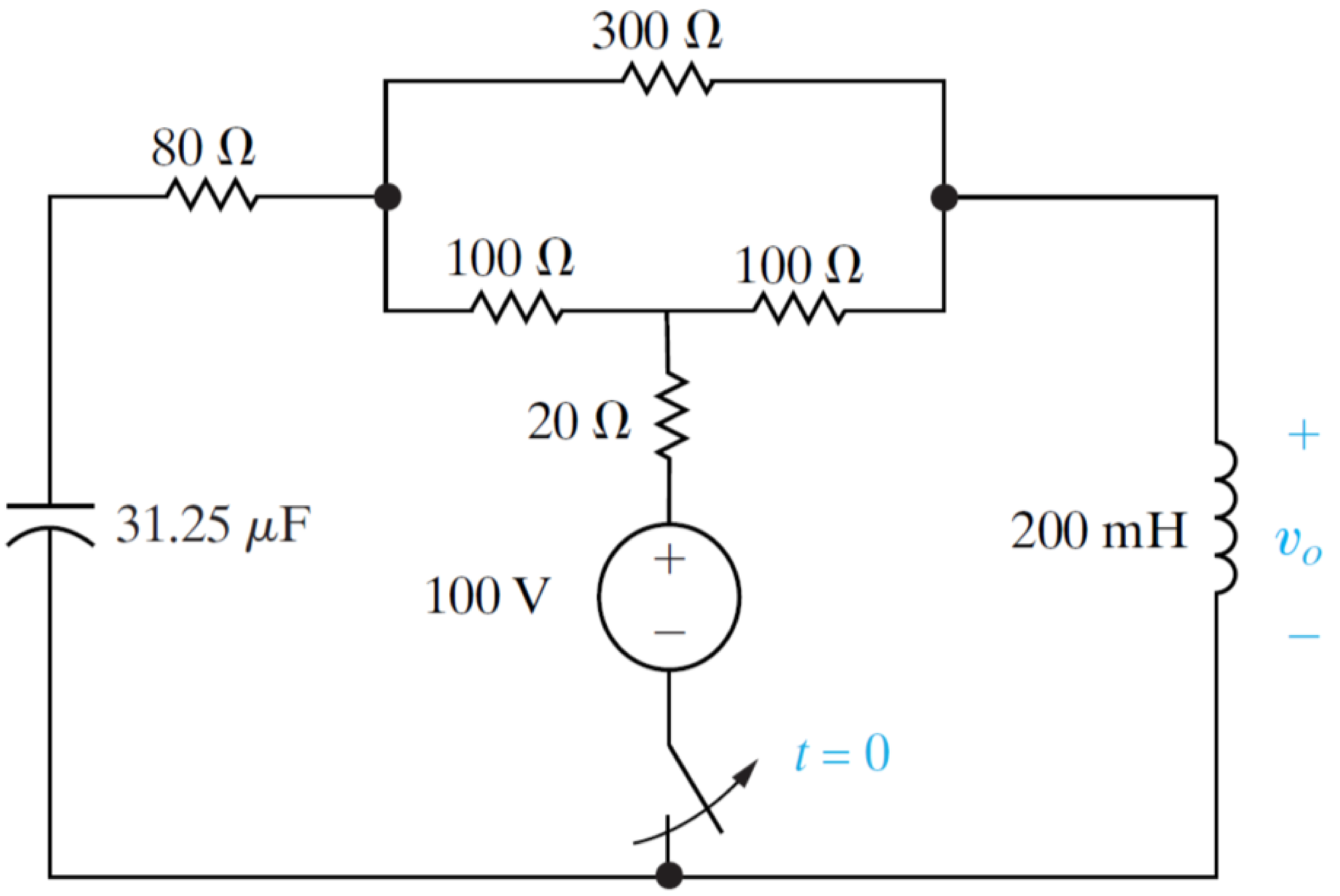
$\boxed{i_a = \frac{V_g}{R} + \frac{2V_g}{R} = \frac{3V_g}{R}}$ +2

Set reference node ✓

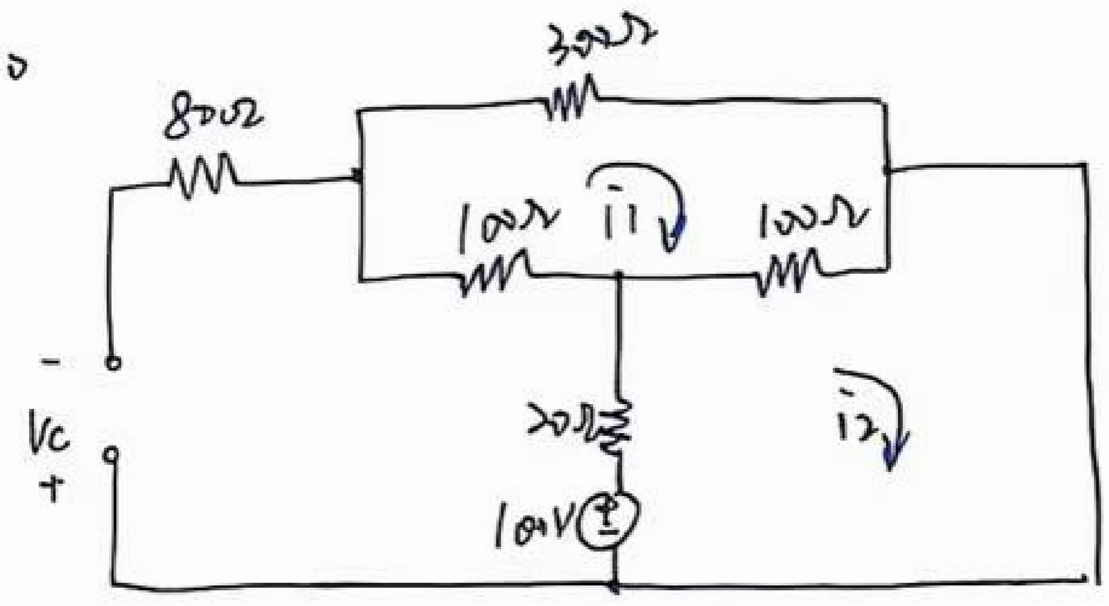
Suppose / let -2

Say nothing -4

8. The switch in the circuit shown below has been closed for a long time, i.e. DC steady state. The switch opens at $t = 0$. Find $v_o(t)$ for $t > 0$. [18 points]



$t<0$



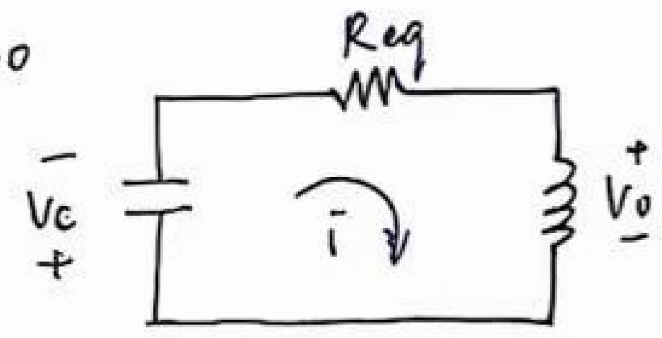
$500 i_1 - 100 i_2 = 0$

$120 i_2 - 100 i_1 = 100$ $\Rightarrow$ $\boxed{i_1 = 0.2 A}$ -- 1

$100 i_1 - 20 i_2 = 0$ $\qquad \boxed{i_L = 1 A}$ -- 2

$V_c(0^-) + 100 - 20 - 20 = 0 \qquad \boxed{V_c(0^-) = -60 V}$ -- 3

$t>0$



$V_c + R_{eq} i + V_o = 0 \qquad \boxed{R_{eq} = 200 \Omega}$ -- 1

$i = C \frac{dV_c}{dt}$

$L \frac{di}{dt} = V_o$

$\Rightarrow \boxed{\frac{1}{C}\int i\, dt + R_{eq} \cdot i + L \cdot \frac{di}{dt} = 0}$ --- 1

$\boxed{L \cdot \frac{d^2 i}{dt^2} + R_{eq} \cdot \frac{di}{dt} + \frac{1}{C} \cdot i = 0}$ -- 2

$i'' + \frac{R_{eq}}{L} i' + \frac{1}{LC} i = 0$

$s^2 + 1000 s + 160000 = 0$

$\boxed{s_1 = -200 \text{ rad/s}, \ s_2 = -800 \text{ rad/s}}$ -- 2

$\boxed{i_o = A_1 e^{-200t} + A_2 e^{-800t}}$ -- 2

$i_o(0) = A_1 + A_2 = 1$

$\frac{di_o(0)}{dt} = -200 A_1 - 800 A_2 = \frac{1}{L}(-V_o - R_{eq} I_o) = -700$

$\Rightarrow i_o(t) = 166.67 e^{-200t} + 833.33 e^{-800t}$ (mA)

$\boxed{V_o(t) = L \frac{di_o}{dt} = -6.67 e^{-200t} - 133.33 e^{-800t} (V)}$ -- 4