

**19YEARS**  
PREVIOUS SOLVED PAPERS

# GATE 2020

## ELECTRONICS & COMMUNICATIONS ENGINEERING

(Fully Solved with Explanations)

*By  
Team of  
Engineers Academy*



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# ELECTRONICS & COMMUNICATION ENGINEERING

## NETWORK ANALYSIS

### GATE PREVIOUS YEARS TOPICWISE SOLVED QUESTIONS

*Fully Solved with Explanations*

#### Syllabus

Network solution methods: nodal and mesh analysis; Network theorems: superposition, Thevenin and Norton's, maximum power transfer; Wye-Delta transformation; Steady state sinusoidal analysis using phasors; Time domain analysis of simple linear circuits; Solution of network equations using Laplace transform; Frequency domain analysis of RLC circuits; Linear 2-port network parameters: driving point and transfer functions; State equations for networks.

Failed in an  
examination is not a failure,  
but compromise in  
your carrier is a real failure.



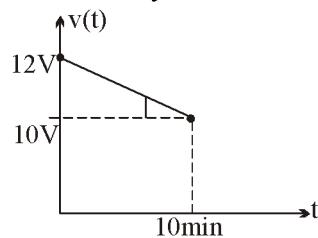


# NETWORK ELEMENTS

## OBJECTIVE QUESTIONS

1. A fully charged mobile phone with a 12 V battery is good for a 10 minute talk-time. Assume that, during the talk-time, the battery delivers a constant current of 2 A and its voltage drops linearly from 12 V to 10 V as shown in the figure. How much energy does the battery deliver during this talk-time?

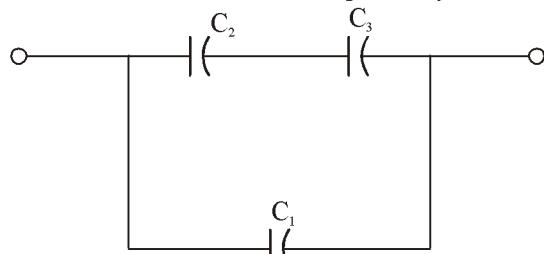
**NOTES**



- (a) 200 kJ  
(b) 12 kJ  
(c) 13.2 kJ  
(d) 14.4 kJ

[1 Mark : GATE-2009]

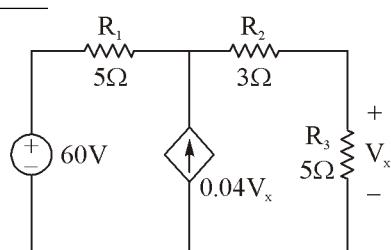
2. Three capacitors  $C_1$ ,  $C_2$  and  $C_3$  whose values are  $10\mu\text{F}$ ,  $5\mu\text{F}$  and  $2\mu\text{F}$  respectively, have breakdown voltages of 10V, 5V and 2V respectively. For the interconnection shown below, the maximum safe voltage in Volts that can be applied across the combination and the corresponding total charge in  $\mu\text{C}$  stored in the effective capacitance across the terminals are respectively



- (a) 2.8 and 36  
(b) 7 and 119  
(c) 2.8 and 32  
(d) 7 and 80

[2 Marks : GATE-2013]

3. In the circuit shown in the figure, the magnitude of the current (in amperes) through  $R_2$  is \_\_\_\_\_



[2 Marks : GATE-2016]

○○○

## ANSWERS AND EXPLANATIONS

**1. Ans. (c)**

$$P(t) = v(t) \cdot i(t)$$

$$E = v(t) \cdot i(t) \cdot t$$

$$1 \text{ min} = 60 \text{ sec}$$

$$\Rightarrow 10 \text{ min} = 600 \text{ sec.}$$

Area of  $v(t)$  v/s  $t$  graph

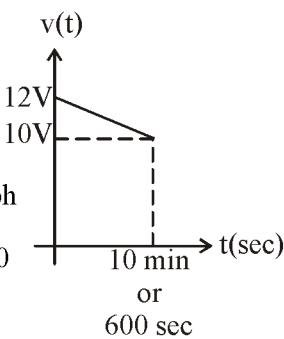
$$= \frac{1}{2} \times 600 \times 2 + 600 \times 10$$

$$= 6600$$

$$E = v \cdot i \cdot t$$

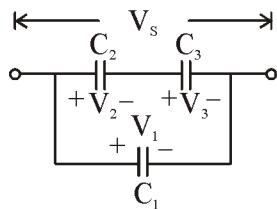
$$= vt \cdot i$$

$$= 6600 \times 2 = 13200 = 13.2 \text{ kJ}$$



or  
600 sec

**2. Ans. (c)**



Let  $V_s$  is total voltage across combination.

$$\text{Given, } C_1 = 10 \mu\text{F}, C_2 = 5 \mu\text{F}, C_3 = 2 \mu\text{F}$$

Break down voltage of  $C_1$  is 10V,  $C_2$  and  $C_3$  are 5 V and 2 V respectively.

Voltage across  $C_2$ ,

$$V_2 = \frac{C_3}{C_2 + C_3} \times V_s$$

$$= \frac{2}{5+2} \times V_s = \frac{2}{7} V_s \quad \dots(i)$$

Voltage Across  $C_3$ ,

$$V_3 = \frac{C_2}{C_2 + C_3} \times V_s$$

$$= \frac{5}{5+2} \times V_s = \frac{5}{7} V_s \quad \dots(ii)$$

Maximum voltage across  $C_2$ ,

$$V_{2 \text{ max}} = 5 \text{ V} = \text{Rating of } C_2$$

$$\text{Then } 5 = \frac{2}{7} V_{s,\text{max}}$$

$$\Rightarrow V_{s \text{ max}} = 17.5 \text{ V}$$

As total voltage across combination exceeds rating of  $C_1$  so it should not be applied across the combination. Maximum voltage across  $C_3$ ,  $V_{3 \text{ max}} = 2 \text{ V} = \text{Rating of } C_3$

$$\text{Then, } 2 = \frac{5}{7} V_{s \text{ max}}$$

$$\Rightarrow V_{s \text{ max}} = \frac{14}{5} = 2.8 \text{ V}$$

Maximum voltage across combination is less than rating of  $C_1$ . So, this voltage can be applied across the combination safely.

For such voltage,

$$V_2 = \frac{2}{7} \times 2.8 = 0.8 \text{ V}$$

$$V_3 = 2 \text{ V}$$

$$\text{and } V_1 = 2.8 \text{ V}$$

Now  $V_2$  is less than the rating of  $C_2$  so the maximum safe voltage which can be applied across combination is 2.8 V.

Total capacitance of the combination,

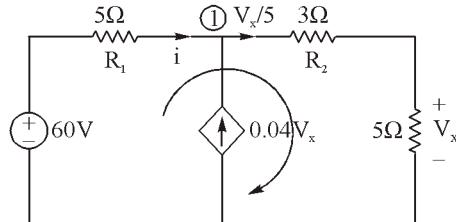
$$C_{\text{eq}} = C_1 + \frac{C_2 C_3}{C_2 + C_3}$$

$$= 10 + \frac{5 \times 2}{5+2} = \frac{80}{7} \mu\text{F}$$

Total charge stored,

$$q = C_{\text{eq}} V = \frac{80}{7} \times 2.8 = 32 \mu\text{C}$$

**3. Ans. (4.9 to 5.1)**



KCL at node (1)

$$0.04V_x + i = \frac{V_x}{5}$$

$$i = \frac{V_x}{5} - 0.04V_x = \frac{V_x}{5} - \frac{4V_x}{100}$$

$$= \frac{20V_x - 4V_x}{100} = 0.16V_x$$

KVL in loop

$$60 - 5i - \frac{3V_x}{5} - V_x = 0$$

$$60 - 5(0.16V_x) - 0.6V_x - V_x = 0$$

$$60 = 2.4 V_x$$

$$\Rightarrow V_x = \frac{60}{2.4} = 25 \text{ V}$$

$$i_{R_2} = \frac{25}{5} = 5 \text{ A}$$

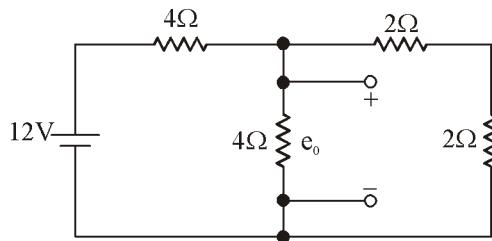
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## BASIC CIRCUIT LAW

### OBJECTIVE QUESTIONS

1. The voltage  $e_o$  in figure is



- (a) 2 V      (b)  $\frac{4}{3}$  V      (c) 4 V      (d) 8 V

**NOTES**

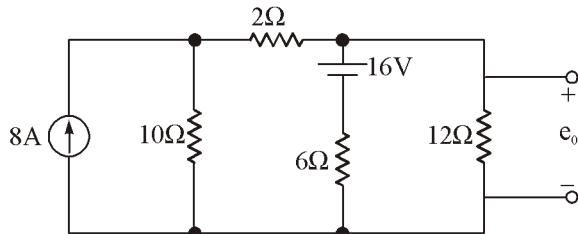
[1 Mark : GATE-2001]

2. If each branch of a Delta circuit has impedance  $\sqrt{3}Z$ , then each branch of the equivalent Star circuit has impedance

- (a)  $\frac{Z}{\sqrt{3}}$       (b) 3 Z      (c)  $3\sqrt{3}Z$       (d)  $\frac{Z}{3}$

[1 Mark : GATE-2001]

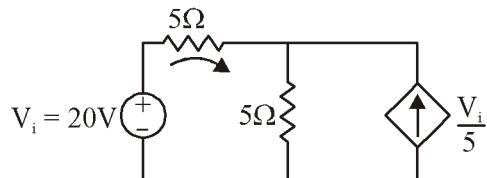
3. The voltage  $e_o$  in figure is



- (a) 48 V      (b) 24 V      (c) 36 V      (d) 28 V

[2 Marks : GATE-2001]

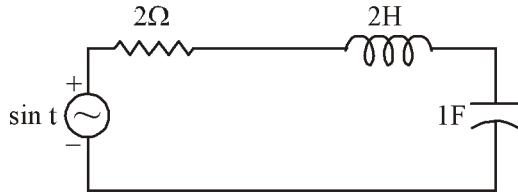
4. The dependent current source shown in given figure



- (a) delivers 80 W      (b) absorbs 80 W  
 (c) delivers 40 W      (d) absorbs 40 W

[1 Mark : GATE-2002]

5. The differential equation for the current  $i(t)$  in the circuit of the figure is



- (a)  $2\frac{d^2i}{dt^2} + 2\frac{di}{dt} + i(t) = \sin t$       (b)  $\frac{d^2i}{dt^2} + 2\frac{di}{dt} + 2i(t) = \cos t$   
 (c)  $2\frac{d^2i}{dt^2} + 2\frac{di}{dt} + i(t) = \cos t$       (d)  $\frac{d^2i}{dt^2} + 2\frac{di}{dt} + 2i(t) = \sin t$

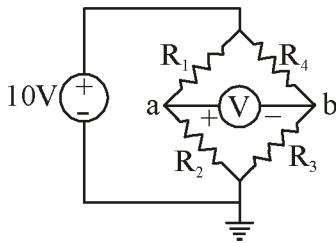
[1 Mark : GATE-2003]

6. Twelve  $1\Omega$  resistance are used as edges to form a cube. The resistance between two diagonally opposite corners of the cube is

- (a)  $\frac{5}{6}\Omega$       (b)  $1\Omega$       (c)  $\frac{6}{5}\Omega$       (d)  $\frac{3}{2}\Omega$

[2 Marks : GATE-2003]

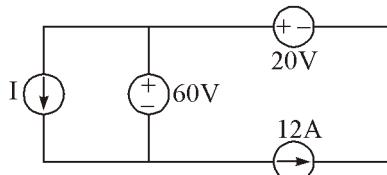
7. If  $R_1 = R_2 = R_4 = R$  and  $R_3 = 1.1R$  in the bridge circuit shown in figure, then the reading the ideal voltmeter V is



- (a)  $0.238\text{ V}$       (b)  $0.138\text{ V}$       (c)  $-0.238\text{ V}$       (d)  $1\text{ V}$

[2 Marks : GATE-2005]

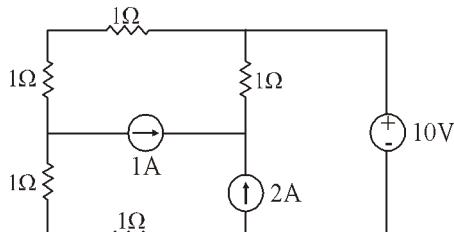
8. In the interconnection of ideal sources shown in the figure, it is known that the  $60\text{ V}$  source is absorbing power. Which of the following can be the value of the current source I ?



- (a)  $10\text{ A}$       (b)  $13\text{ A}$       (c)  $15\text{ A}$       (d)  $18\text{ A}$

[1 Mark : GATE-2009]

9. In the circuit shown, the power supplied by the voltage source is

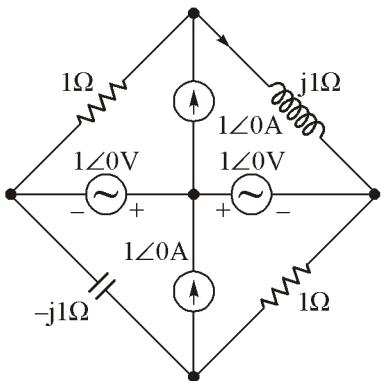


- (a)  $0\text{ W}$       (b)  $5\text{ W}$       (c)  $10\text{ W}$       (d)  $100\text{ W}$

[2 Marks : GATE-2010]

**NOTES**

10. In the circuit shown below, the current through the inductor is

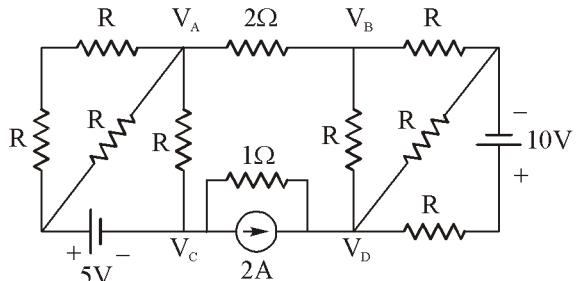


- (a)  $\frac{2}{1+j} \text{ A}$       (b)  $\frac{-1}{1+j} \text{ A}$       (c)  $\frac{1}{1+j} \text{ A}$       (d) 0 A

### NOTES

[1 Mark : GATE-2012]

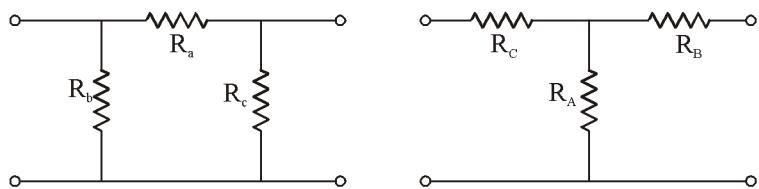
11. If  $V_A - V_B = 6 \text{ V}$ , then  $V_C - V_D$  is



- (a) -5 V      (b) 2V      (c) 3 V      (d) 6 V

[2 Marks : GATE-2012]

12. Consider a delta connection of resistors and its equivalent star connection as shown below. If all elements of the delta connection are scaled by a factor  $k$ ,  $k > 0$ , the elements of the corresponding star equivalent will be scaled by a factor of

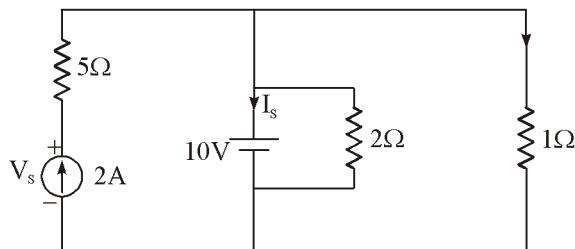


- (a)  $k^2$       (b)  $k$       (c)  $\frac{1}{k}$       (d)  $\sqrt{k}$

[1 Mark : GATE-2013]

**Common Data for Questions : 13 & 14**

Consider the following figure



13. The current in the  $1\Omega$  resistor in Amperes is

(a) 2      (b) 3.33      (c) 10      (d) 12

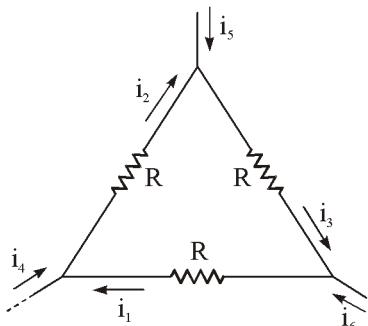
[2 Marks : GATE-2013]

14. The current  $I_S$  in Amperes in the voltage source, and voltage  $V_S$  in volts across the current source respectively, are

(a) 13, -20      (b) 8, -10      (c) -8, 20      (d) -13, 20

[2 Marks : GATE-2013]

15. Consider the configuration shown in the figure which is a portion of a larger electrical network

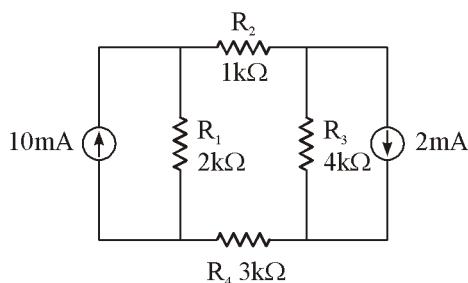


For  $R = 1 \Omega$  and currents  $i_1 = 2 \text{ A}$ ,  $i_4 = -1 \text{ A}$ ,  $i_5 = -4 \text{ A}$ , which one of the following is TRUE?

- (a)  $i_6 = 5\text{A}$   
 (b)  $i_3 = -4\text{A}$   
 (c) Data is sufficient to conclude that the supposed currents are impossible  
 (d) Data is insufficient to identify the currents  $i_2$ ,  $i_3$  and  $i_6$

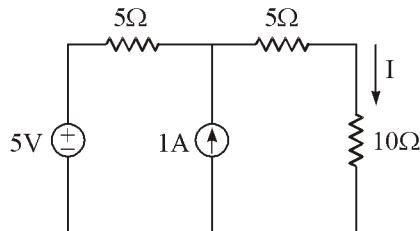
[1 Mark : GATE-2014]

16. The magnitude of current (in mA) through the resistor  $R_2$  in the figure shown is \_\_\_\_\_.



[1 Mark : GATE-2014]

17. In the figure shown, the value of the current I (in Amperes) is \_\_\_\_\_.



[1 Mark : GATE-2014]

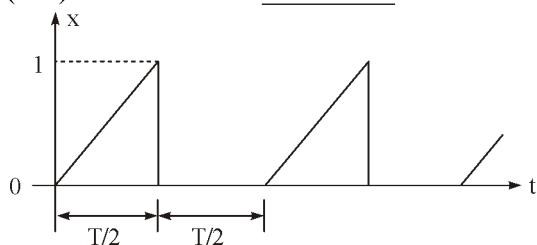
18. A Y-network has resistances of  $10\Omega$  each in two of its arms, while the third arm has a resistance of  $11\Omega$ . In the equivalent  $\Delta$  network, the lowest value (in  $\Omega$ ) among the three resistances is \_\_\_\_\_.

[2 Marks : GATE-2014]

## NOTES

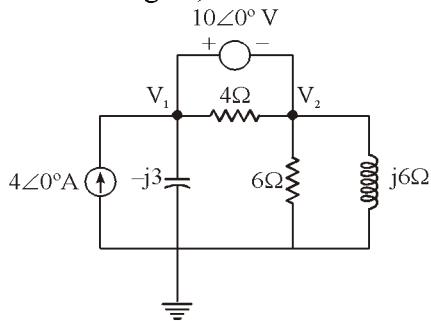
**NOTES**

19. A periodic variable  $x$  is shown in the figure as a function of time. The root-mean-square (rms) value of  $x$  is \_\_\_\_\_.



[2 Marks : GATE-2014]

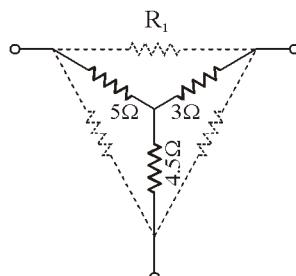
20. In the circuit shown in the figure, the value of node voltage  $V_2$  is



- (a)  $22 + j 2 \text{ V}$  (b)  $2 + j 22 \text{ V}$  (c)  $22 - j 2 \text{ V}$  (d)  $2 - j 22 \text{ V}$

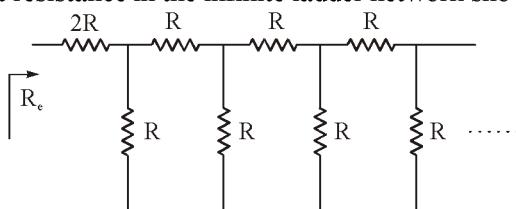
[2 Marks : GATE-2014]

21. For the Y-network shown in the figure, the value of  $R_1$  (in  $\Omega$ ) in the equivalent  $\Delta$ -network is \_\_\_\_\_.



[2 Marks : GATE-2014]

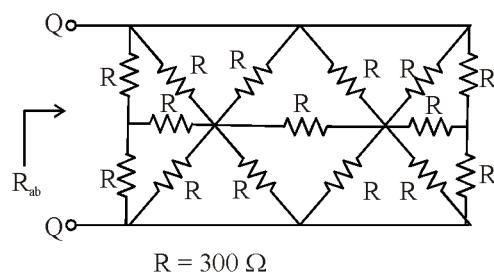
22. The equivalent resistance in the infinite ladder network shown in the figure, is  $R_e$ .



- The value of  $R_e/R$  is \_\_\_\_\_

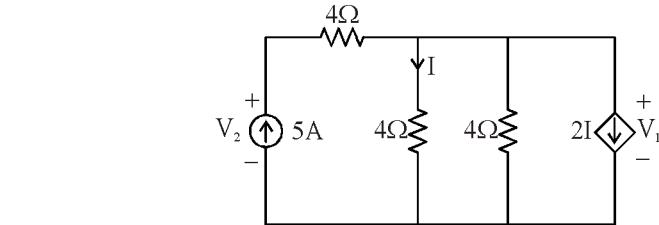
[2 Marks : GATE-2014]

23. In the network shown in the figure, all resistors are identical with  $R = 300 \Omega$ . The resistance  $R_{ab}$  (in  $\Omega$ ) of the network is \_\_\_\_\_.



[1 Mark : GATE-2015]

24. In the given circuit, the values of  $V_1$  and  $V_2$  respectively are

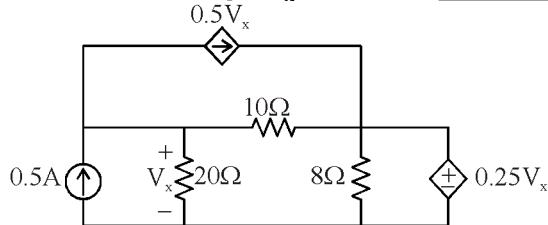


- (a) 5V, 25 V    (b) 10V, 30 V    (c) 15 V, 35 V    (d) 0V, 20V

[1 Mark : GATE-2015]

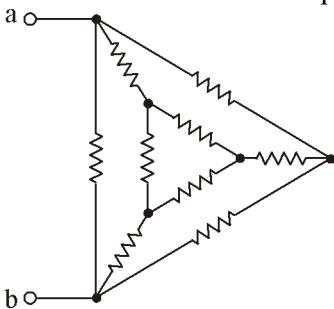
### NOTES

25. In the circuit shown, the voltage  $V_x$  (in volts) is \_\_\_\_\_



[1 Mark : GATE-2015]

26. In the given circuit, each resistor has a value equal to 1Ω.

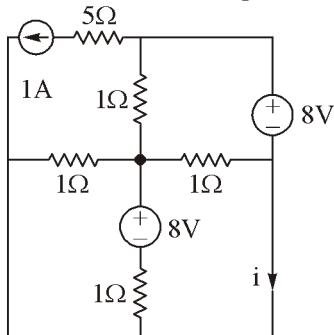


What is the equivalent resistance across the terminals a and b ?

- (a)  $\frac{1}{6}\Omega$     (b)  $\frac{1}{3}\Omega$     (c)  $\frac{9}{20}\Omega$     (d)  $\frac{8}{15}\Omega$

[2 Marks : GATE-2016]

27. In the figure shown, the current i (in ampere) is \_\_\_\_\_

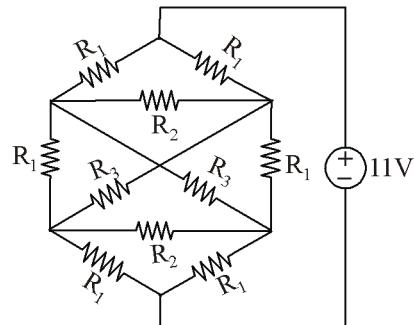


[2 Marks : GATE-2016]

28. A connection is made consisting of resistance A in series with a parallel combination of resistances B and C. Three resistors of value  $10\Omega$ ,  $5\Omega$ ,  $2\Omega$  are provided. Consider all possible permutations of the given resistors into the positions A, B, C, and identify the configurations with maximum possible overall resistance, and also the ones with minimum possible overall resistance. The ratio of maximum to minimum values of the resistances (up to second decimal place) is \_\_\_\_\_.

[1 Mark : GATE-2017]

29. Consider the network shown below with  $R_1 = 1\Omega$ ,  $R_2 = 2\Omega$  and  $R_3 = 3\Omega$ . the network is connected to a constant voltage source of 11 V.

**NOTES**

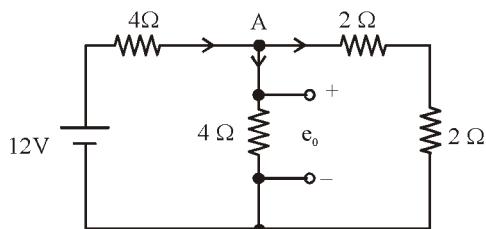
The magnitude of the current (in amperes, accurate to two decimal places) through the sources is \_\_\_\_\_.

[2 Mark : GATE-2018]

○○○

## ANSWERS AND EXPLANATIONS

1. Ans. (c)



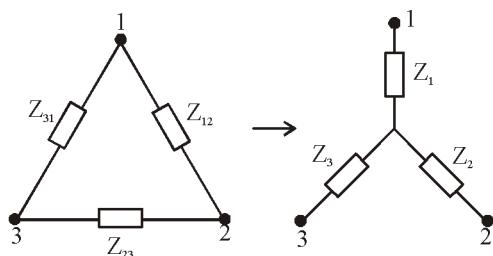
Applying KCL at node 'A' we have,

$$\frac{e_0 - 12}{4} + \frac{e_0}{4} + \frac{e_0}{4} = 0$$

$$\Rightarrow e_0 = 4 \text{ Volts}$$

2. Ans. (a)

$$\text{Give, } Z_{12} = Z_{23} = Z_{13} = \sqrt{3}Z$$



Using delta-star transformation, we have,

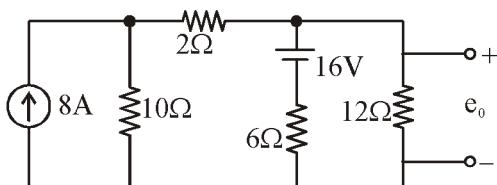
$$Z_1 = \frac{Z_{12} \cdot Z_{31}}{Z_{12} + Z_{23} + Z_{31}}$$

$$= \frac{(\sqrt{3}Z)^2}{3 \times \sqrt{3}Z} = \frac{Z}{\sqrt{3}}$$

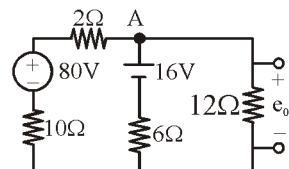
$$Z_2 = \frac{Z_{12} \cdot Z_{23}}{Z_{12} + Z_{23} + Z_{31}} = \frac{Z}{\sqrt{3}}$$

$$Z_3 = \frac{Z_{23} \cdot Z_{31}}{Z_{12} + Z_{23} + Z_{31}} = \frac{Z}{\sqrt{3}}$$

3. Ans. (d)



Converting 8A current source to voltage source, the circuit becomes as shown under.



Apply KCL at node 'A' we have,

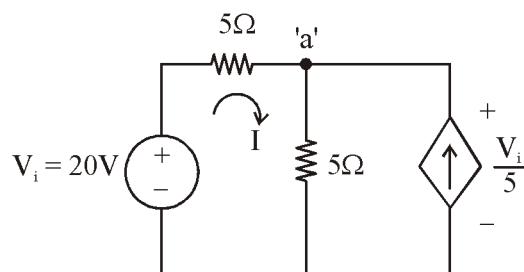
$$\frac{V_A - 80}{12} + \frac{V_A - 16}{6} + \frac{V_A}{12} = 0$$

$$\Rightarrow V_A = \frac{112}{4} = 28 \text{ V}$$

$$\text{Voltage, } e_0 = V_A$$

$$\Rightarrow e_0 = 28 \text{ V}$$

4. Ans. (a)



Applying KCL at node 'a', we have,

$$\frac{V_a - V_i}{5} + \frac{V_a}{5} - \frac{V_i}{5} = 0$$

$$\Rightarrow \frac{V_a - 20}{5} + \frac{V_a}{5} - \frac{20}{5} = 0$$

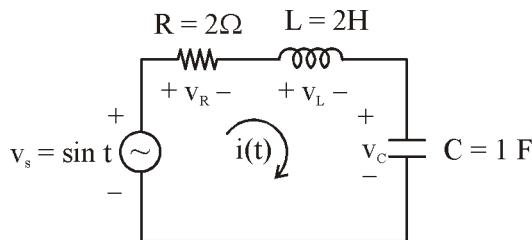
$$\frac{2}{5}V_a = 8$$

$$V_a = 20 \text{ V}$$

$V_a$  is a positive voltage. The power is delivered by a current source when current leaves the positive terminal of a voltage drop across source. The current of current source in the given circuit leaves the positive terminal so the source is delivering the power. The power delivered by the source can be given as,

$$P = V_a \times \frac{V_i}{5} = 20 \times \frac{20}{5} = 80 \text{ W}$$

5. *Ans. (c)*



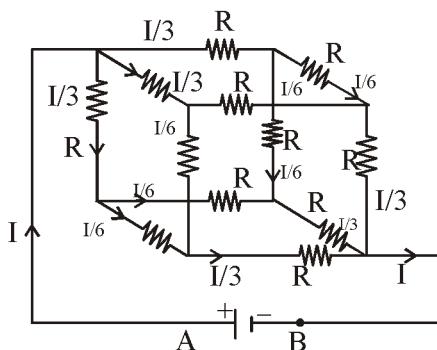
Applying KVL in loop,

$$\begin{aligned} v_s - v_R - v_L - v_C &= 0 \\ \Rightarrow v_R + v_L + v_C &= v_s \\ \Rightarrow iR + L \frac{di}{dt} + \frac{1}{C} \int idt &= \sin t \end{aligned}$$

Differentiating both sides, with respect to  $t$ ,

$$\begin{aligned} L \frac{d^2i}{dt^2} + R \frac{di}{dt} + \frac{i}{C} &= \cos t \\ \Rightarrow 2 \frac{d^2i}{dt^2} + 2 \frac{di}{dt} + i &= \cos t \end{aligned}$$

6. *Ans. (a)*



The above network is symmetrical and so the current incoming at a node gets divided equally among the outgoing branches.

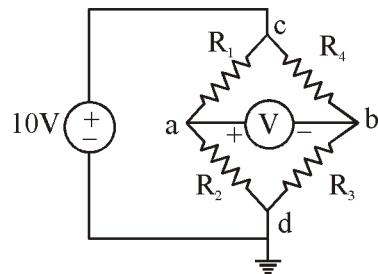
Applying KVL in one of the loop including voltage source, we have,

$$\begin{aligned} V - \frac{I}{3}R - \frac{I}{6}R - \frac{I}{3}R &= 0 \\ \Rightarrow V &= \frac{2I}{3}R + \frac{I}{6}R \\ \Rightarrow V &= \frac{5}{6}RI \end{aligned}$$

The equivalent resistance seen by the source,

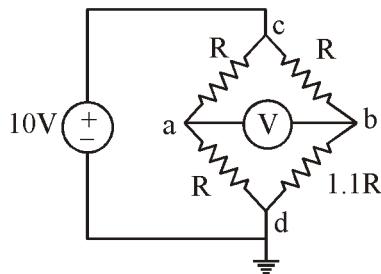
$$\begin{aligned} \Rightarrow R_{eq} &= \frac{V}{I} = \frac{5}{6}R \\ \text{Given, } R &= 1\Omega \\ \Rightarrow R_{eq} &= \frac{5}{6} \times 1 = \frac{5}{6}\Omega \end{aligned}$$

7. *Ans. (c)*



$$\begin{aligned} \text{Given, } R_1 &= R_2 = R_4 = R \\ R_3 &= 1.1 R \end{aligned}$$

Ideal voltmeter has infinite internal impedance. So, opening the terminals of voltmeter, the circuit becomes as under,



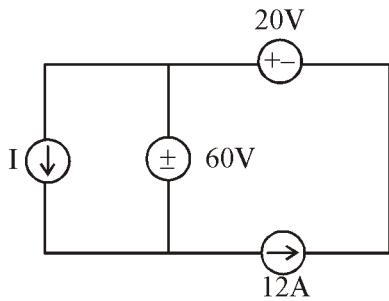
Applying voltage divider rule we have,

$$\begin{aligned} V_{ad} &= \frac{R}{R+R} \times 10 \\ &= 5 \text{ volts} \end{aligned}$$

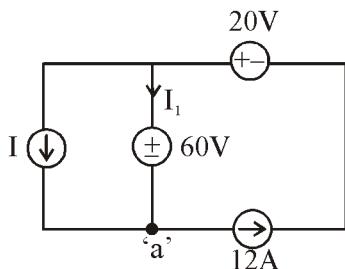
$$\begin{aligned} \text{and } V_{bd} &= \frac{1.1R}{1.1R+R} \times 10 \\ &= 5.238 \text{ volts} \end{aligned}$$

$$\begin{aligned} \text{Then } V_{ab} &= V_{ad} - V_{bd} \\ &= 5 - 5.238 \\ &= -0.238 \end{aligned}$$

8. Ans. (a)



A voltage source supplies the power when current leaves the source from positive terminal of source and it absorbs the power when current enters at positive terminal of source. Here 60 V source is absorbing the power so current must be entering at the positive terminal. Then the direction of current in branches of given network will be as shown below,



Applying KCL at node 'a',

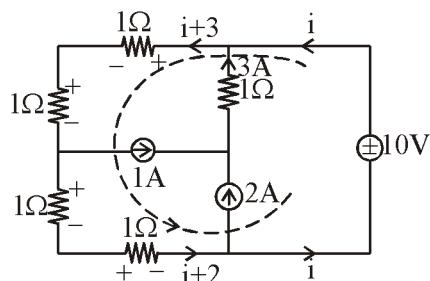
$$I + I_1 = 12$$

$$\Rightarrow I = 12 - I_1$$

So, current I must be less than 12 A. Out of given options only option 'a' gives current less than 12A. So, current I can be

$$I = 10 \text{ A}$$

9. Ans. (a)



Applying KVL in outermost loop have,

$$10 = (i + 3) 2 + (i + 2) 2$$

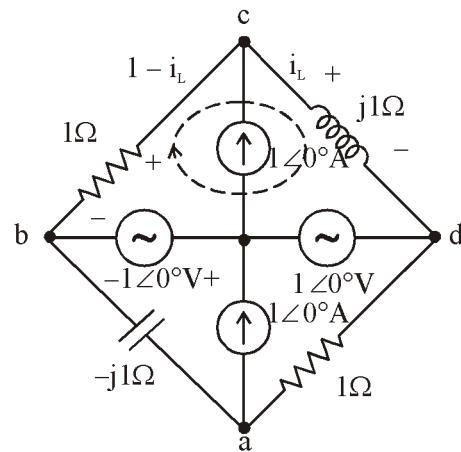
$$\Rightarrow 4i + 10 = 10$$

$$\Rightarrow i = 0$$

So power supplied by voltage Source,

$$P = 10i = 10 \times 0 = 0 \text{ W}$$

10. Ans. (c)

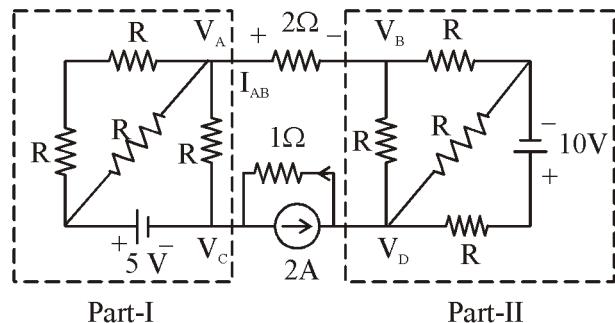


Let current through inductor is  $i_L$ . Then current in  $1\Omega$  resistance in branch bc is  $1 - i_L$ . Applying KVL in loop shown, we have,

$$1\angle 0^\circ - 1\angle 0^\circ + (1 - i_L)1 - j1 \times i_L = 0$$

$$\Rightarrow i_L = \frac{1}{1+j}$$

11. Ans. (a)



$$\text{Given, } V_A - V_B = 6V$$

Current from A to B,

$$I_{AB} = \frac{V_A - V_B}{2}$$

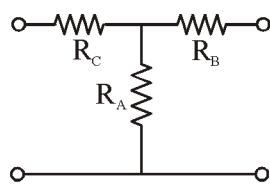
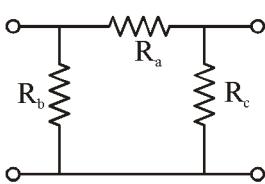
$$= \frac{6}{2} = 3A$$

The current always flows in the closed path. The total current from part-I to part-II of network is 3A + 2A (=5A) so same current should return from part-I to the part-II of the circuit. So current through  $1\Omega$  resistance is 5A from part-II to part-I

$$\therefore V_C - V_D = -5 \times 1$$

$$= -5 \text{ V}$$

12. Ans. (b)



According to delta to star conversion,

$$R_A = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_B = \frac{R_a R_c}{R_a + R_b + R_c}$$

$$R_C = \frac{R_b R_a}{R_a + R_b + R_c}$$

If elements of delta connection are scaled by factor k then,

$$R'_a = kR_a$$

$$R'_b = kR_b$$

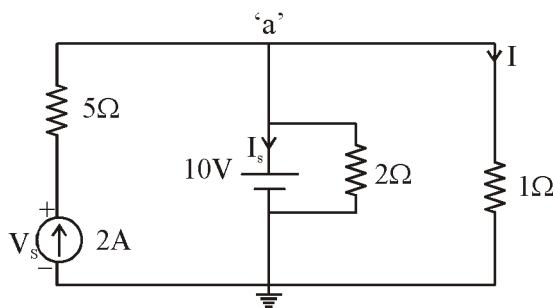
$$R'_c = kR_c$$

Then  $R'_A = \frac{R'_b R'_c}{R'_a + R'_b + R'_c}$

$$= k \left( \frac{R_b R_c}{R_a + R_b + R_c} \right) = k R_A$$

Similarly  $R'_B = kR_B$   
and  $R'_C = kR_C$

13. Ans. (c)



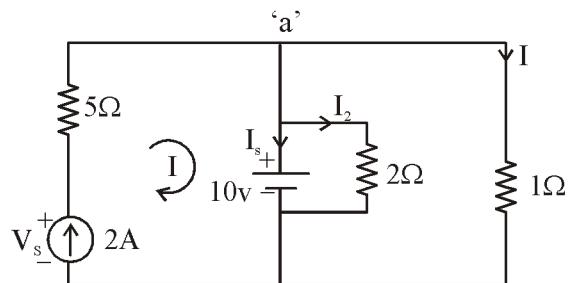
Voltage at node 'a',

$$V_a = 10 \text{ V}$$

$\therefore$  Current through  $1\Omega$  resistance,

$$I = \frac{V_a}{1} = \frac{10}{1} = 10 \text{ A}$$

14. Ans. (d)



Voltage at node 'a',  $V_a = 10 \text{ V}$

Applying KCL at node 'a', we have,

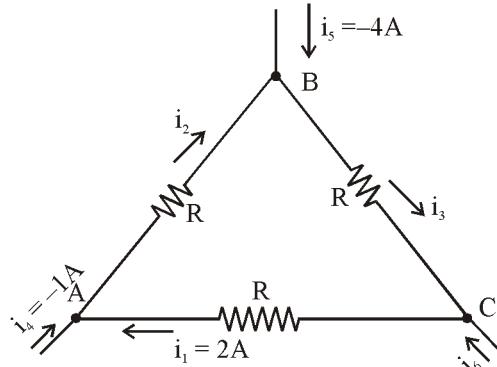
$$\begin{aligned} \frac{V_a}{1} + \frac{V_a}{2} + I_s - 2 &= 0 \\ \Rightarrow \frac{10}{1} + \frac{10}{2} + I_s - 2 &= 0 \\ \Rightarrow I_s &= -13 \text{ A} \end{aligned}$$

Applying KVL in loop 1, we have,

$$V_s - 5 \times 2 - 10 = 0$$

$$V_s = 20 \text{ V}$$

15. Ans. (a)



$$R = 1\Omega; i_1 = 2\text{A}; i_5 = -4\text{A}$$

$$i_4 = -1\text{A}$$

KCL at Node (A)

$$i_1 + i_4 = i_2$$

$$i_2 = 2 - 1 = 1\text{A}$$

$$i_2 = 1\text{A}$$

KCL at node (B)

$$i_2 + i_5 = i_3$$

$$i_3 = 1 - 4 = -3\text{ A}$$

$$i_3 = -3\text{ A}$$

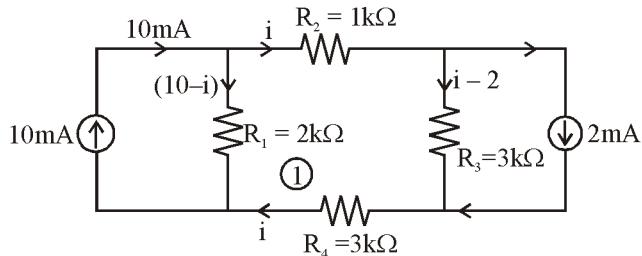
KCL at node (C)

$$i_3 + i_6 = i_1$$

$$i_6 = 2 - (-3) = 5$$

$$i_6 = 5\text{ A}$$

16. Ans. (2.8)



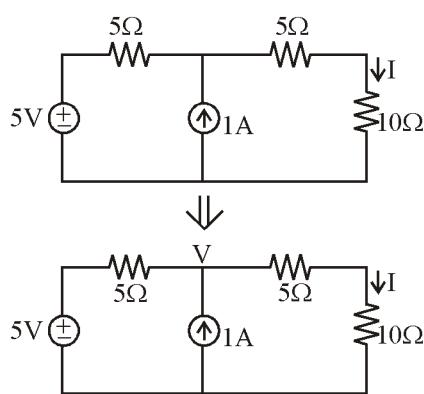
So closed loop (1),

$$2k(10 \text{ mA} - i) - (3k)i + (2 - i)(4k) - (1k)i = 0$$

$$20 - 2ki - 3ki + 8 - 4ki - 1ki = 0$$

$$i = 2.8 \text{ mA}$$

17. Ans. (.50)

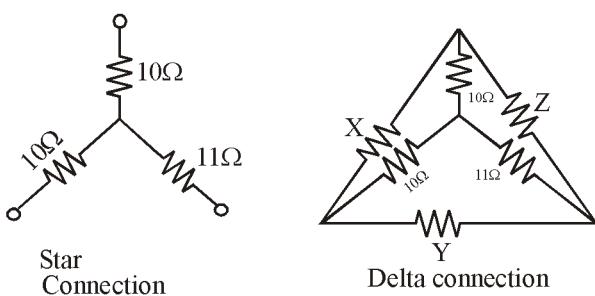


Apply KCL at Node (V)

$$\frac{V-5}{5} - 1 + \frac{V}{15} = 0 \Rightarrow V = \frac{30}{4} \text{ volts}$$

$$I = \frac{V}{15} = \frac{2}{4} = 0.50 \text{ Amp}$$

18. Ans. (29.09)



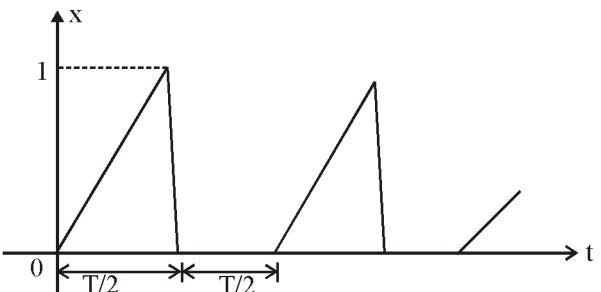
$$X = \frac{10 \times 10 + 10 \times 11 + 10 \times 11}{11} = 29.09\Omega$$

$$Y = \frac{10 \times 10 + 10 \times 11 + 10 \times 11}{10} = 32\Omega$$

$$Z = \frac{10 \times 10 + 10 \times 11 + 10 \times 11}{10} = 32\Omega$$

Lowest value = 29.09Ω

19. Ans. (.408)



Root Mean Square (rms) value

$$X_{\text{rms}} = \sqrt{\frac{1}{T} \int_0^T (x(t))^2 dt}$$

$$x(t) = \begin{cases} \frac{2}{T}t & 0 \leq t < T/2 \\ 0 & T/2 \leq t < T \end{cases}$$

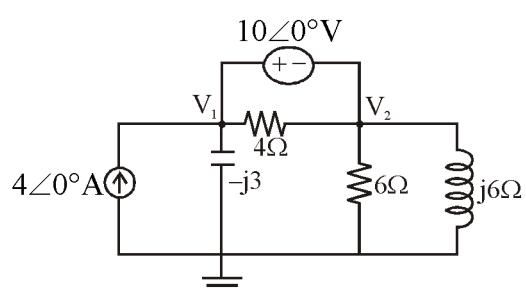
$$\sqrt{\frac{1}{T} \left[ \int_0^{T/2} \left( \frac{2}{T} \cdot t \right)^2 dt + \int_{T/2}^T (0)^2 dt \right]}$$

$$= \sqrt{\frac{1}{T} \cdot \frac{7}{T^2} \left[ \frac{t^3}{3} \right]_0^{T/2}}$$

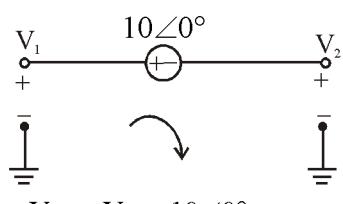
$$X_{\text{rms}} = \sqrt{\frac{4}{3T^3} \cdot \frac{T^3}{8}}$$

$$\Rightarrow \sqrt{\frac{1}{6}} = 0.408$$

20. Ans. (d)



KVL for V1 &amp; V2



$$V_1 = V_2 + 10∠0^\circ$$

...(1)

KCL at super node

$$-4\angle 0^\circ + \frac{V_1}{-j3} + \frac{V_2}{6} + \frac{V_2}{j6} = 0$$

$$\frac{V_2}{6} + \frac{V_1}{-j3} + \frac{V_2}{j6} = 4\angle 0^\circ \quad \dots(2)$$

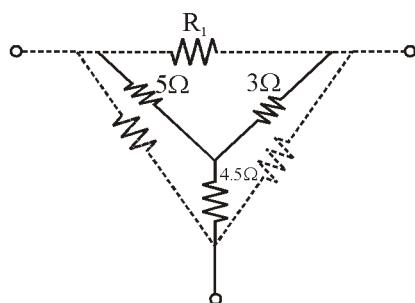
Form equation (1) & (2)

$$\frac{V_2 + 10\angle 0^\circ}{-j3} + \frac{V_2}{6} + \frac{V_2}{j6} = 4\angle 0^\circ$$

$$V_2 \left[ \frac{1}{-j3} + \frac{1}{6} + \frac{1}{6} + \frac{1}{j6} \right] = 4\angle 0^\circ + \frac{10}{j3}$$

$$V_2 = (2 - j22) \text{ volts}$$

21. Ans. (11.33)



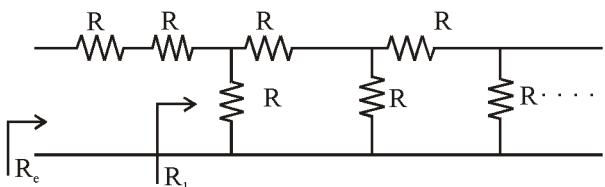
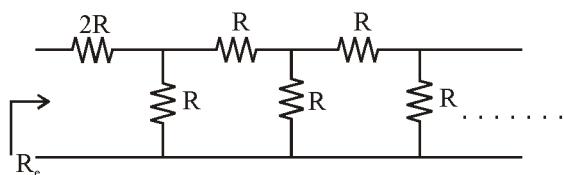
Value of ( $R_1$ ) in the equivalent delta network is

$$R_1 = \frac{4.5 \times 5 + 3 \times 5 + 4.5 \times 3}{4.5}$$

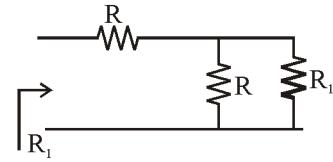
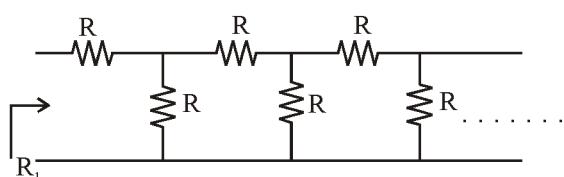
$$= \frac{22.5 + 15 + 13.5}{4.5}$$

$$R_1 = 11.33\Omega$$

22. Ans. (2.618)



So,



$$R_1 = R + \frac{RR_1}{R+R_1}$$

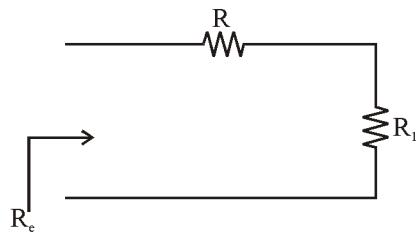
$$R_1 = \frac{R^2 + 2RR_1}{R+R_1}$$

$$RR_1 + R^2 = R^2 + 2RR_1$$

$$R_1^2 - RR_1 - R^2 = 0$$

$$R_1 = \left[ \frac{1+\sqrt{5}}{2} \right] R$$

[neglect “-” sign because R cannot be negative]  
So,



$$R_e = R + R_1$$

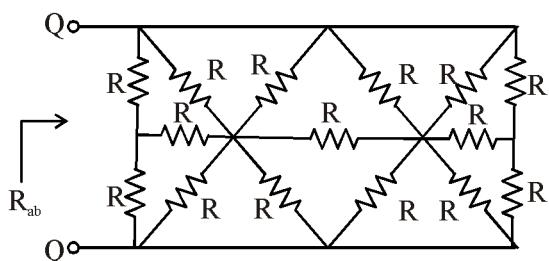
$$= R + \left[ \frac{1+\sqrt{5}}{2} \right] R$$

$$R_e = \left[ \frac{3+\sqrt{5}}{2} \right] R$$

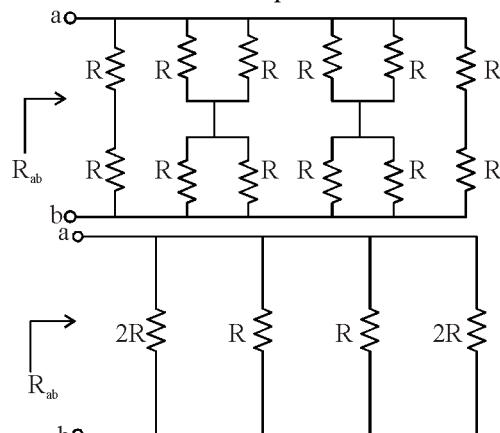
$$\frac{R_e}{R} = \frac{3+\sqrt{5}}{2} = 2.618$$

23. Ans. (100)

Modifying the given circuit



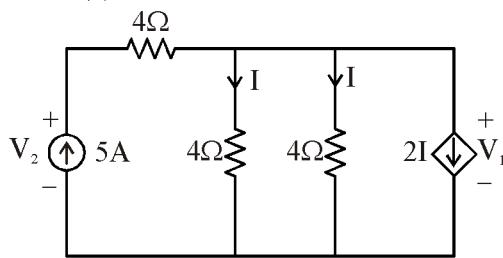
Bridge is balanced so current through diagonal elements is zero so equivalent circuit becomes



$$R_{ab} = \left( \frac{1}{2R} + \frac{1}{R} + \frac{1}{R} + \frac{1}{2R} \right)^{-1} = \frac{R}{3}$$

$$= \frac{300}{3} = 100\Omega$$

24. Ans. (a)



Current flowing through both the parallel  $4\Omega$  will be  $I$ .

$$\text{So, } V_2 = 4(I + I + 2I) + 4I \quad \text{by KVL}$$

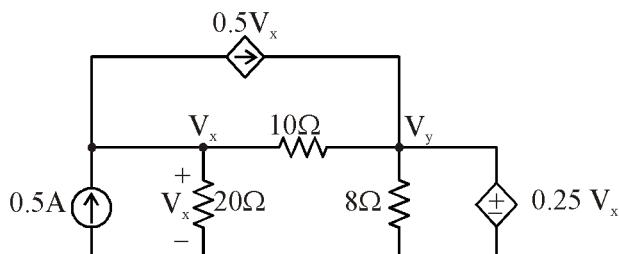
$$I + I + 2I = 5 \quad \text{by KCL}$$

$$I = \frac{5}{4} \text{ A}$$

$$V_2 = 4 \times 5 + \frac{4 \times 5}{4} = 25 \text{ V}$$

$$V_1 = 4I = \frac{4 \times 5}{4} = 5 \text{ V}$$

25. Ans. (8)

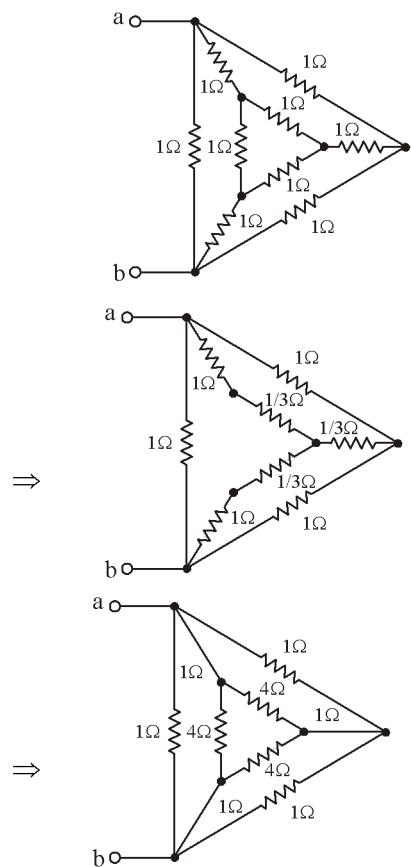


$$\frac{V_x}{20} + \frac{V_x - V_y}{10} + 0.5V_x = 0.5$$

$$V_y = 0.25 V_x$$

$$V_x = 8 \text{ Volts}$$

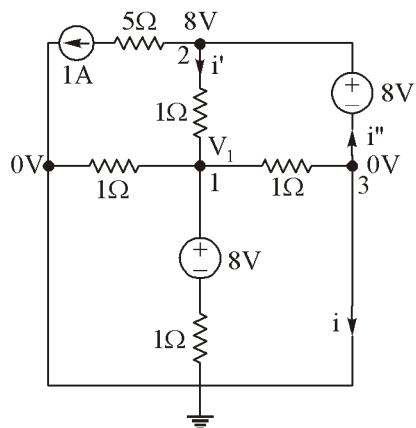
26. Ans. (d)



$$R_{ab} = \{(4\parallel 1) + (4\parallel 1)\} \parallel \frac{4}{5}$$

$$\left( \frac{4}{5} + \frac{4}{5} \right) \parallel \frac{4}{5} = \frac{8}{5} \parallel \frac{4}{5} = \frac{8}{15} \Omega$$

27. Ans. (-1.05) to (-0.95)



Apply nodal analysis at node 1

$$\frac{V_1 - 0}{1} + \frac{V_1 - 8}{1} + \frac{V_1 - 0}{1} + \frac{V_1 - 8}{1} = 0$$

$$V_1 = 4 \text{ V}$$