(6 – 1) Kirchhoff's Rules

Kirchhoff's circuit is a circuit contains more than one battery .

The junction :

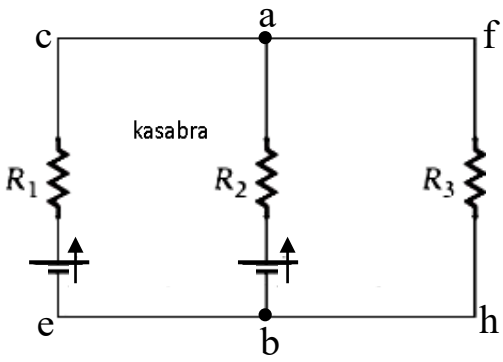
It is a point in circuit where three or more wires are connected to each other .

e.g : a and b

The branch :

It is a connection between two junctions and contains any number of different circuit elements and wires .

e.g : (a f h b) and (a b) and (a c e b)



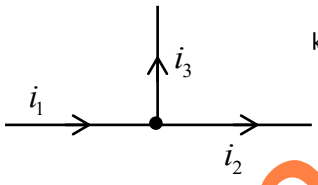
Kirchhoff's Junction Rule :

The sum of the current entering a junction must equal the sum of the currents leaving the junction because the junction do not have the capability of storing charge .

$$\sum i_{in} = \sum i_{out}$$

According to the figure :

$$i_1 = i_2 + i_3$$



شرح المذكرة وحل جميع أسئلتها على الموقع
kasabra.net

Kirchhoff's Junction Rule is a direct consequence of the conservation of electric charge .

The loop :

It is any set of connected wires and circuit elements forming a closed path (c a f h b e c) and (a f h b a) and (a c e b a)

يمنع نشر المذكرة على أي جروب أو موقع إلكتروني

Kirchhoff's Loop Rule

The potential difference around a complete circuit loop must sum to zero .

$$\sum iR = \sum V_{emf}$$

Kirchhoff's Junction Rule is adirect consequence of the conservation of energy .

(6 – 2) Single-Loop Circuits

- Contains one branch .
- No Junctions .
- The same current passes through all the circuit elements .
- Contains more than one battery .

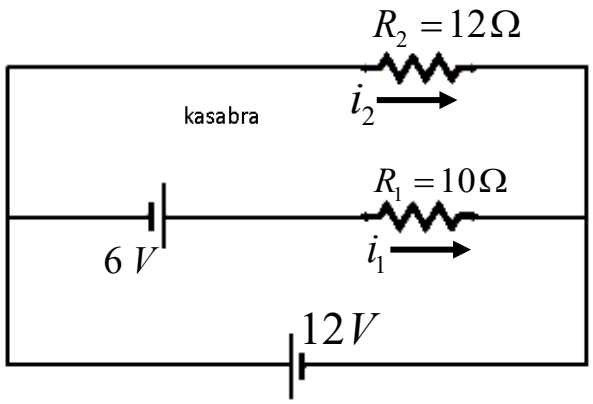
Q1) A $(12V)$ battery with internal resistance (0.2Ω) is being charged by a battery charger that is capable of delivering a current of magnitude $(6.0A)$, Calculate the minimum emf battery charger must supply to be able to charge the battery .

(6 – 2) Multi Loop Circuits

- Contains more than one branch .
- Contains Junctions .
- Each branch has its own current .
- Contains more than one battery .

kasabra.net

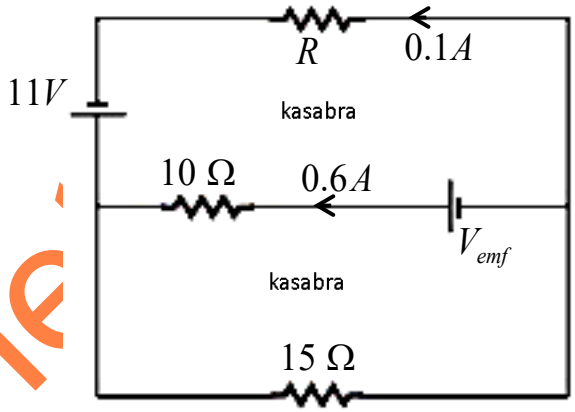
Q2) In the figure shown , answer the following :



1) Calculate each of (i_2) and (i_1) .

2) Calculate the power supplied by the battery $(12V)$.

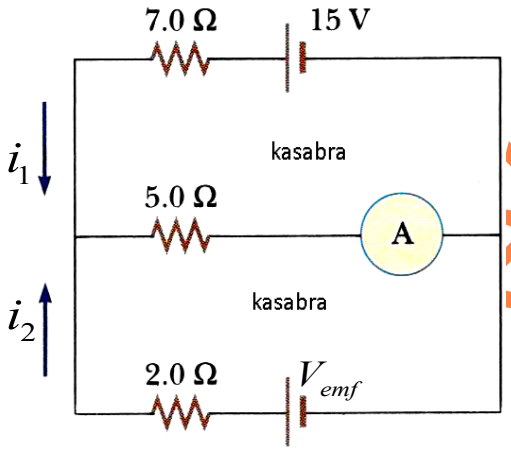
Q3) Depending on the circuit shown in the figure, answer the following:



1) Calculate the electromotive force (V_{emf}) .

2) Calculate the value of resistance (R) .

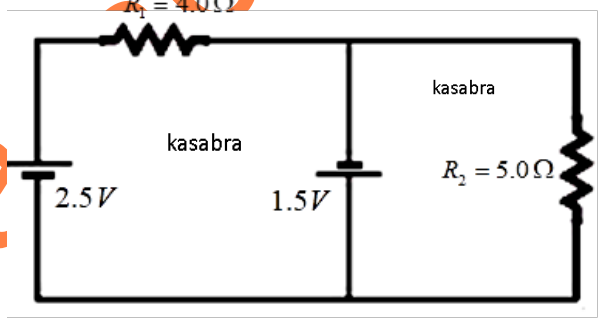
Q4) In the figure shown , the reading of the ammeter is equal to $(2.3\,A)$, answer the following:



1) Calculate each of the $(i_1\ ,\ i_2)$.

2) Calculate the electromotive force (V_{emf}) .

Q5) Depending on the circuit shown in the figure, answer the following :



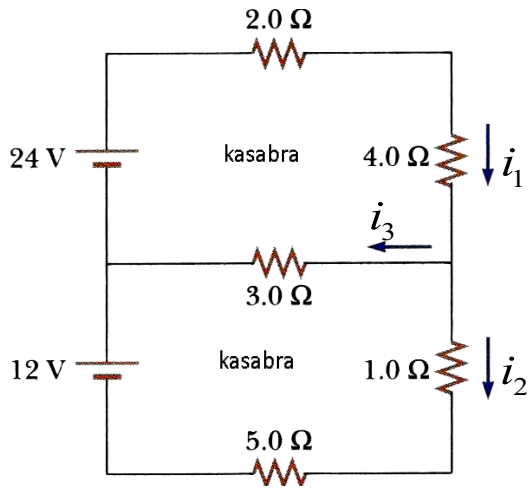
1) Calculate the current passing through the resistor (R_1).

2) Calculate the current through the resistor (R_2) .

3) Calculate the current passing through the battery $(1.5V)$.

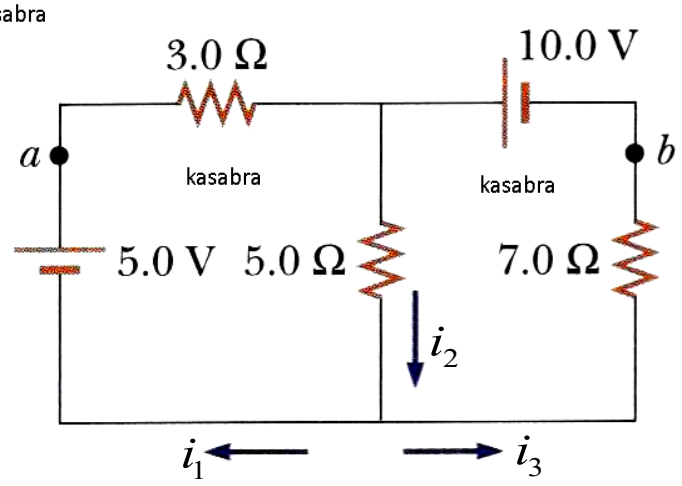
kasabra.net

Q6) In the circuit shown in the figure , Calculate each of the $(i_1 \ , \ i_2 \ , \ i_3)$



Q7) In the circuit shown in the figure :

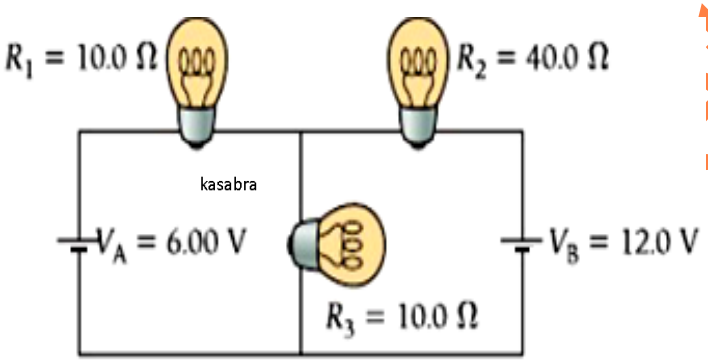
1) Calculate each of the $(i_1 \ , \ i_2 \ , \ i_3)$.



2) Calculate the potential difference between the two points (a) and (b) .

Q8) In the circuit shown in the figure :

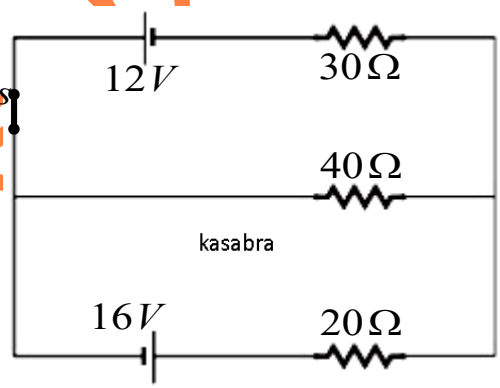
1) Calculate the power supplied by each battery .



2) Determine which bulb is the least brightness .

Q9) In the circuit shown in the figure :

1) Calculate the voltage drop across the resistor (40Ω) .

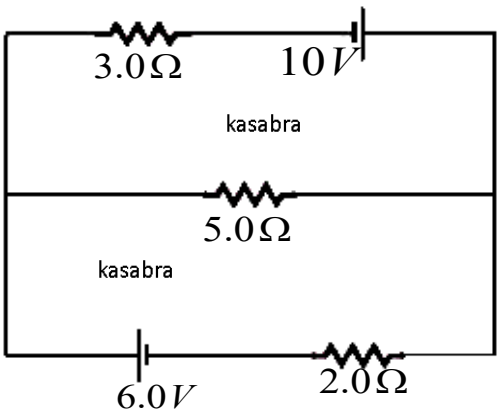


2) If the switch (s) is opened , how much the voltage across the resistor (40Ω) becomes .

kasabra.net

Q10) In the circuit shown in the figure :

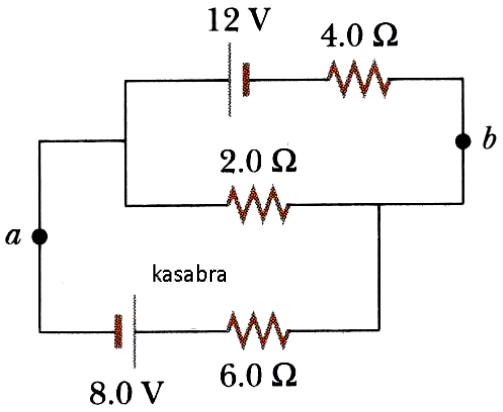
1) Calculate the current through the resistor (5.0Ω) **.**



2) Calculate the power dissipated in the (5.0Ω) **resistor .**

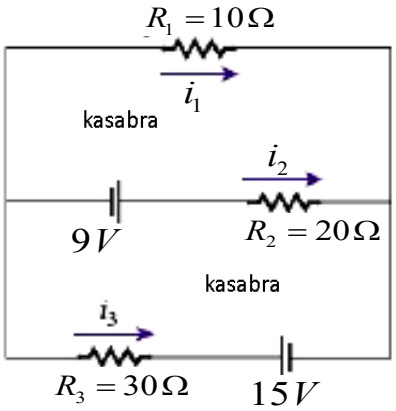
Q11) In the circuit shown in figure :

1) Calculate the current through the resistor (6.0Ω) **.**

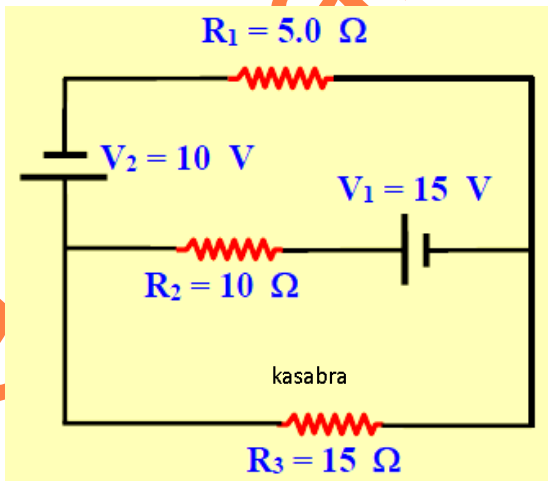


2) Calculate the potential difference between the two points (a) and (b) .

Q12) In the circuit shown in figure , Calculate the power dissipated in each of the three resistors .



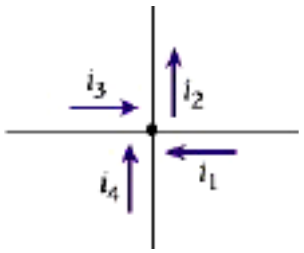
Q13) Depending on the circuit shown in the figure , Calculate the current in each of (R_1) **and** (R_2) **.**



kasabra.net

Q14) Choose the correct answer in the following

1) For the junction shown in the figure , which equation correctly express the sum of currents ?



a) $i_1 + i_2 + i_3 + i_4 = 0$

b) $i_1 - i_2 + i_3 + i_4 = 0$

c) $i_1 - i_2 - i_3 - i_4 = 0$

d) $i_1 + i_2 - i_3 - i_4 = 0$

2) Kirchhoff's junction rule states that :

a) The algebraic sum of the currents at any junction in a circuit must be zero

b) The algebraic sum of the potential change around any closed loop in a circuit must be zero

c) The current at a junction is given by the product of the resistance and the capacitance

d) The time for the current development at a junction is given by the product of the resistance and the capacitance

3) Kirchhoff's loop rule states that :

a) The algebraic sum of the currents around a complete circuit loop must be zero

b) The sources of emf around a complete circuit loop must sum to zero.

c) The sum of the potential difference around a complete circuit loop must be greater than zero

d) The potential differences around a complete circuit loop must sum to zero

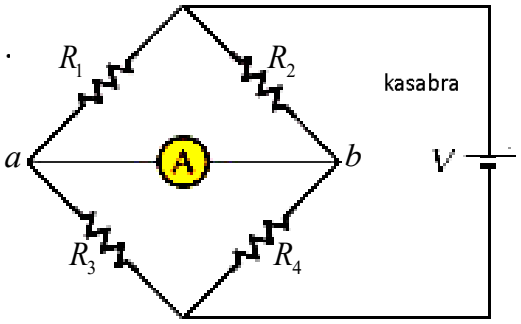
The Wheatstone Bridge

It is a particular circuit used to measure unknown resistances .

The Wheatstone bridge is balanced when the ammeter reading is zero or $\Delta V_{ab} = 0$

When the bridge is balanced it is :

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$



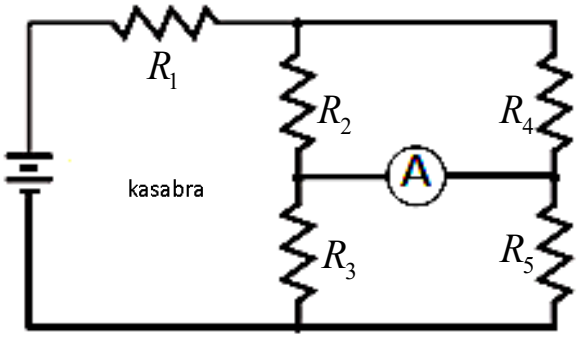
Q15) In figure shown , the ammeter reading is zero and $(R_2 = 20\Omega\ ,\ R_3 = 4\Omega\ ,\ R_5 = 2.6\Omega)$

1) Calculate the value of (R_4) **.**

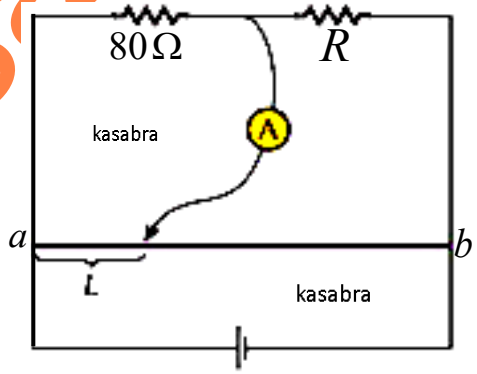
2) What will happen to the ammeter reading in the following cases :

a) Changing the magnitude of (R_1) **.**

b) Replacement the resistor (R_2) **by another resistor its magnitude** (22Ω) **.**

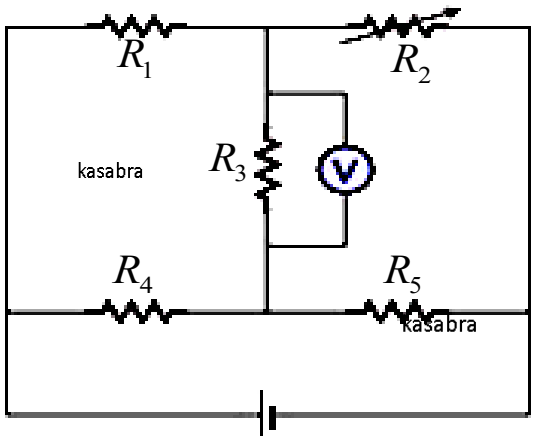


Q16) A whetstone bridge is constructed using a $(1.0\ m)$ **long nichrome wire (ab) with a conducting contact that can slide along the wire . A resistor** (80Ω) **is placed on one side of the bridge , and another resistor** (R) **of unknown resistance is placed on the other side . The contact is moved along the Nichrome wire , and it is found that the ammeter reading is zero for** $(L = 25\,cm)$**, Calculate the unknown resistance** (R) **.**



kasabra.net

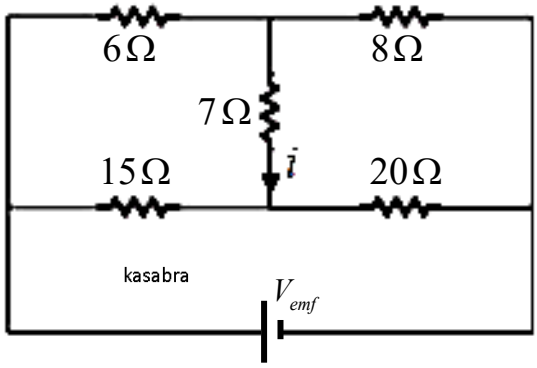
Q17) In the whetstone bridge shown in the figure $(R_5 = 6.0\Omega\ ,\ R_4 = 2.0\Omega\ ,\ R_1 = 8.0\Omega)$ **and the battery supplies** $(V_{emf} = 16V)$ **, the variabe resistance** (R_2) **is adjusted until the potential difference across is zero**



1) Calculate the magnitude of the resistance (R_2) **.**

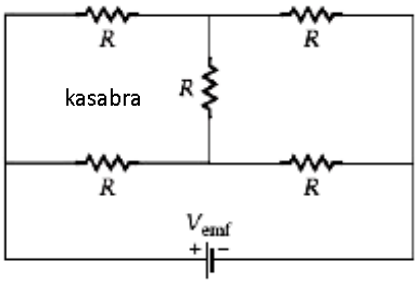
2) Calculate the current passes through (R_2) **.**

Q18) In the circuit shown in figure , Calculate the equivalent resistance for this circuit .



Q19) Choose the correct answer in the following

1) What is the equivalent resistance for the circuit shown in the figure .



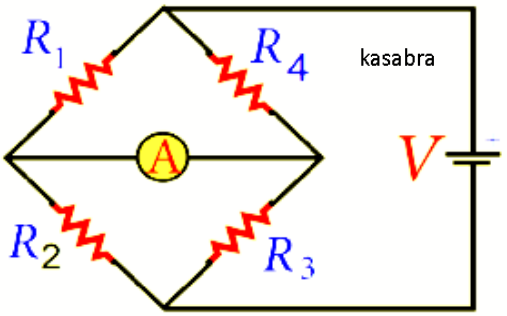
a) $5R$

b) $2R$

c) $4R$

d) R

2) In the electrical circuit in the figure, if the current through the ammeter is zero, which of the following statements is correct ?



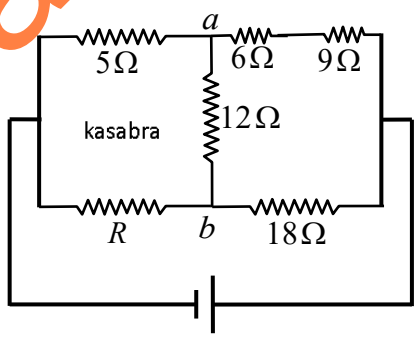
a) $R_2 = \frac{R_1}{R_4} \times R_3$

b) $R_2 = \frac{R_1}{R_3} \times R_4$

c) $R_2 = \frac{R_4}{R_3} \times R_1$

d) $R_2 = \frac{R_4}{R_1} \times R_3$

3) In the circuit shown in figure , if the potential difference between the points (a , b) is equal to zero , Calculate the value of (R) **.**



a) 50 Ω b) 6 Ω

c) 8 Ω d) 21 Ω

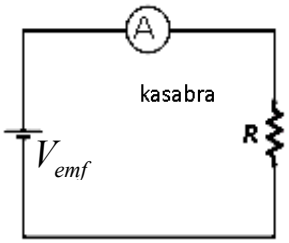
kasabra.net

(6 – 4) Ammeters and Voltmeters

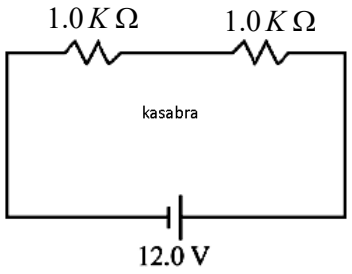
	Ammeter (A)	Voltmeter (V)
Purpose	Measures the current	Measures the potential difference
Connecting in the circuit	Series	Parallel
Resistance	Very low about $(1\ \Omega)$ Ideal ammeter : $(R = 0)$	Very high about $(10^7\ \Omega)$ Ideal Voltmeter : $(R = \infty)$
Effecting on the circuit	Decreases the battery current slightly	Increases the battery current slightly

Multimeter :
a device that can be switched between its function as an ammeter, voltmeter, and ohmmeter (ohmmeter measures the resistance)

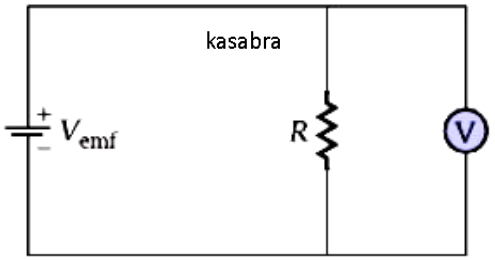
Q20) An ammeter with an internal resistance of (53Ω) measure a current of $(5.25\ mA)$ in a circuit containing a battery and a resistance of $(R = 1130\Omega)$.
Calculate the actual value of the current .



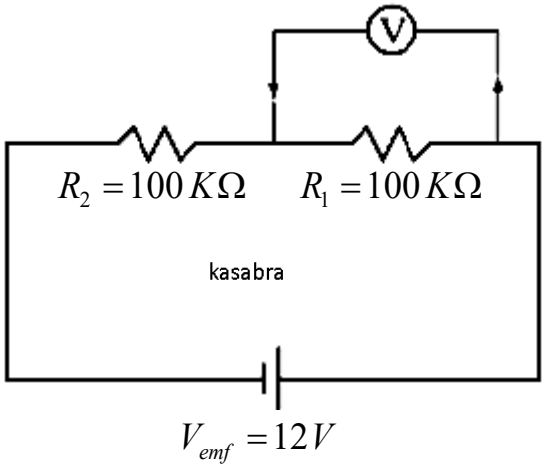
Q21) A circuit consists of two $(1.0\,K\,\Omega)$ resistor in series with an ideal $(12V\,\Omega)$ battery
a) Calculate the current through each resistor .
b) A student trying to measure the current through one of the resistor , inadvertently connects an ammeter in parallel with that resistor . How much current will flow through the ammeter, assuming that it has internal resistance of $(1.0\ \Omega)$?



Q22) In the figure shown , $(V_{emf} = 150V\ ,\ R = 100\,K\Omega)$ and a voltmeter with resistance $(10\,M\Omega)$
1) Calculate the current through the battery before connecting the voltmeter
2) Calculate the current in the battery when connecting the voltmeter with the resistor



Q23) In the figure shown , the internal resistance of voltmeter is equal to $(10\,M\Omega)$:
1) Calculate the voltage drop across (R_1) before connecting the voltmeter .
2) Calculate the voltage drop across (R_1) after connecting the voltmeter .
3) Calculate the percentage change in the voltage drop of (R_1) due to the voltmeter connection .



kasabra.net

Q24) Choose the correct answer in the Increasing the range of Ammeter :

1) Which of the following statement are true for ammeters and voltmeters ?

a) Both of them have little resistance

b) The ammeter has a small resistance, and the voltmeter has a large resistance

c) Both of them have great resistance

d) The ammeter has a large resistance, and the voltmeter has a small resistance

2) Which of the following statement are true for ideal ammeters and ideal voltmeters ?

a) Both have zero internal resistance

b) The resistance of the ideal ammeter is infinite , and the resistance of the ideal voltmeter is zero

c) Both of them are infinite internal resistance

d) The resistance of the ideal ammeter is zero and the resistance of the ideal voltmeter is infinite

3) Which of the following statement are true for ammeters and voltmeters ?

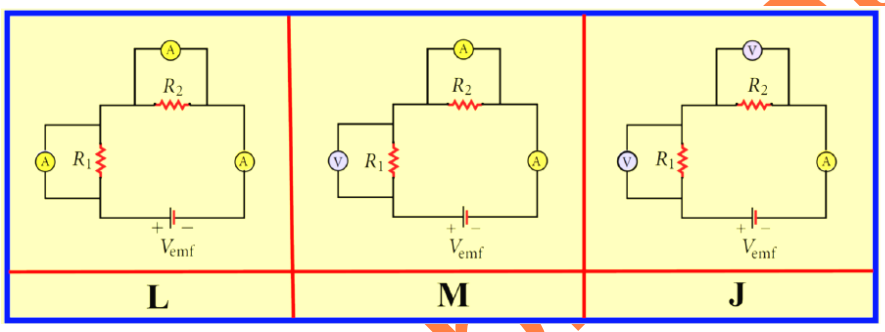
a) The resistance of an ideal ammeter is very large

b) The resistance of an ideal voltmeter is very low

c) The voltmeter causes a slight decrease in the circuit current

d) The voltmeter causes a slight increase in the circuit current

4) Which of the circuits shown in the figure will not function properly ?



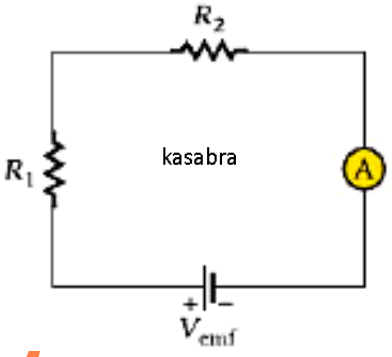
a) M , J

b) M , L

c) L , J

d) J only

5) In the figure shown $(R_1 = 3.0\ \Omega\ ,\ R_2 = 5.0\ \Omega\ ,\ V_{emf} = 8.0V)$ **and the ammeter has the resistance** $(1.0\ \Omega)$ **, what is the current measured by ammeter ?**



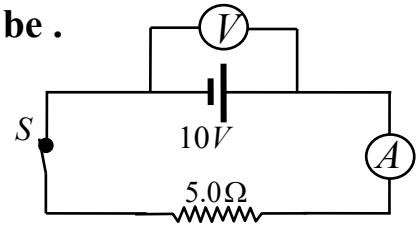
a) $0.5\,A$

b) $1.0\,A$

c) $1.5\,A$

d) $0.89\,A$

6) In the figure shown , when opening the switch (S) how much the reading of the ammeter and voltmeter will be .



a) Ammeter = 0 , Voltmeter = 10 V

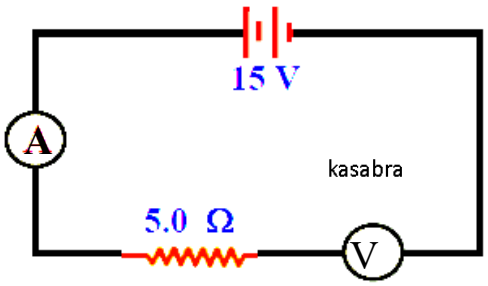
b) Ammeter = 2 A , Voltmeter = 10 V

c) Ammeter = 0 , Voltmeter = 0

d) Ammeter = 2 A , Voltmeter = 0

7) Maryam connected an electrical circuit as shown in the figure below. Which of the following is correct for the reading of the ammeter and voltmeter?

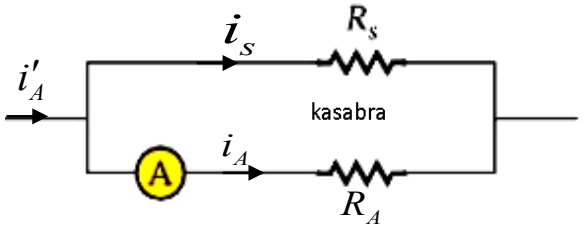
	voltmeter	ammeter
a)	$15V$	$3.0\,A$
b)	$0.0V$	$3.0\,A$
c)	$15V$	$0.0\,A$
d)	$0.0V$	$0.0\,A$



Increasing the range of Ammeter

To do that :
a very small resistance called a shunt resistor must be connected in parallel with the ammeter as shown in the figure .

$i_A R_A = i_s R_s$ $\quad i'_A = i_A + i_s$



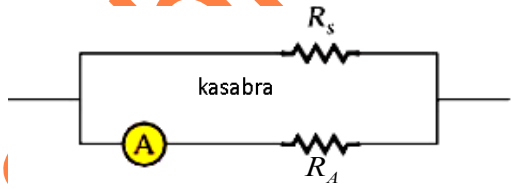
R_A : internal resistance of ammeter
R_s : shunt resistance
i_s : shunt current
i_A : full-scall current reading
i'_A : maximum current the ammeter can measure after expanding its range
The ammeter resistance after modification is R'_A where :

$$R'_A = \left(\frac{1}{R_A} + \frac{1}{R_s}\right)^{-1}$$

Q25) An ammeter has internal resistance of $(16.8\ \Omega)$ and produce a full-scall reading when a current of $(9.5\,mA)$ passes through it , to use this ammeter to measure a maximum current of $(20.2\,A)$ what should be the resistance of the shunt resistor and how it will be connected .

Q26) An ammeter has internal resistance of $(1.0\ \Omega)$ and produce a full-scall reading when a current of $(1.0A)$ passes through it , to extend useful range of the ammeter , a shunt resistor $(10.1m\Omega)$ is placed in parallel with the ammeter as shown in the figure :

1) Calculate the maximum current that the ammeter can measure after expanding its range .



2) What is the fraction of current flows through the shunt resistor .

3) What is the fraction of current flows through the internal resistance of the ammeter .

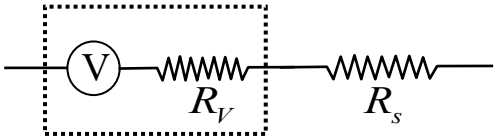
kasabra.net

Increasing the range of voltmeter

To do that : a very large resistance must be connected in series with the voltmeter as shown in the figure .

$$V_V' = V_V + V_s$$

$$\frac{V_V}{V_s} = \frac{R_V}{R_s}$$



R_V : internal resistance of voltmeter

R_s : resistance of added resistor in series

V_V : full-scall voltage reading

V_V' : maximum voltage the voltmeter can measure after expanding its range

---

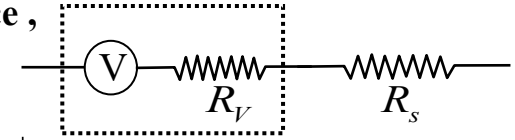
Q27) A voltmeter has internal resistance of $(1.0\ M\Omega)$ and produce a full-scall reading with $(1.0V)$ potential difference , if we want to extend the range of the voltmeter to be able to measure a voltage difference up to $(100V)$

1) Calculate the resistance of the additional resistor which should be placed in series with the voltmeter to extend its range .

2) What is the fraction of potential drop across the added series resistor .

3) What is the fraction of potential drop across the internal resistance of voltmeter .

Q28) A voltmeter has internal resistance of $(10^6\ \Omega)$ and produce a full-scall reading with $(4.0V)$ potential difference , to extend useful range of the voltmeter , an additional resistor $(4.9\times10^7\ \Omega)$ is placed in series with the voltmeter as shown in the figure , Calculate the maximum potential difference that the voltmeter can measure after expanding its range .



Q29) Choose the correct answer in the following :

1) An ammeter has internal resistance of $(75\ \Omega)$ and the maximum current it can measure $(1.5mA)$. Calculate the resistance of the shunt resistor needed to make the ammeter measures a current up to $(15A)$.

a) 7.5Ω b) $0.75\ \Omega$ c) $7.5m\Omega$ d) $7.5\times10^{-2}\ \Omega$

2) An ammeter has internal resistance of $(60\ \Omega)$ and produce a full-scall reading when a current of $(1.0\ mA)$ passes through it , to extend useful range of an ammeter , a shunt resistor $(5.0\times10^{-3}\ \Omega)$ is placed in parallel with the ammeter , what is the maximum current that the ammeter can measure after expanding its range .

a) $2.0\,A$ b) $12\,A$ c) $2.0\,mA$ d) $1.2\,A$

3) An ammeter has internal resistance (R_A) is connected in parallel with a shunt resistor (R_s) in order to extend the useful range of the ammeter by a factor N , which of the following representing the resistance of the shunt resistance .

a) $R_s = \frac{R_A}{N-1}$ b) $R_s = \frac{R_A}{N}$ c) $R_s = \frac{R_A}{N+1}$ d) $R_s = R_A(N-1)$

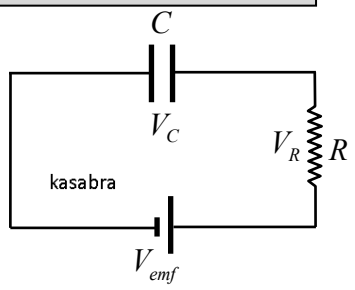
4) A voltmeter has internal resistance (R_V) is connected in series with a additional resistor (R_s) in order to extend the useful range of the voltmeter by a factor N , which of the following representing the resistance of the added resistance .

a) $R_s = \frac{R_V}{N-1}$ b) $R_s = N\,R_V$ c) $R_s = R_V(N+1)$ d) $R_s = R_V(N-1)$

kasabra.net

RC Circuits

It is a circuit contains a capacitor and a resistor connected in series.



1) Charging a Capacitor

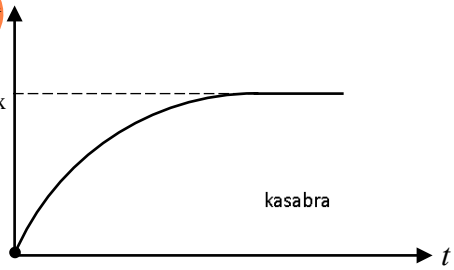
$$V_{emf} = V_C + V_R$$

$$V_{emf} = \frac{q}{C} + iR$$

kasabra

$$V_{emf} = \frac{q}{C} + R\frac{dq}{dt}$$ kasabra

$$CV_{emf} = q_{max}$$



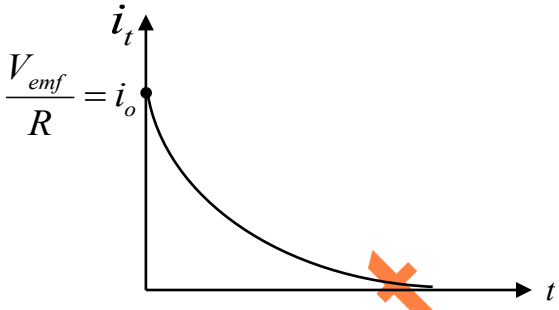
$$q_t = q_{max}(1 - e^{-t/\tau})$$

Time Constant $\tau = RC$

kasabra

$$i_t = i_o e^{-t/\tau}$$

kasabra



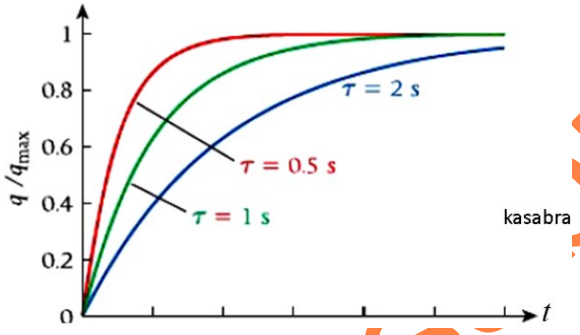
Time Constant (τ)

It is the time required for the capacitor's charge to reach (63%) of its maximum value .

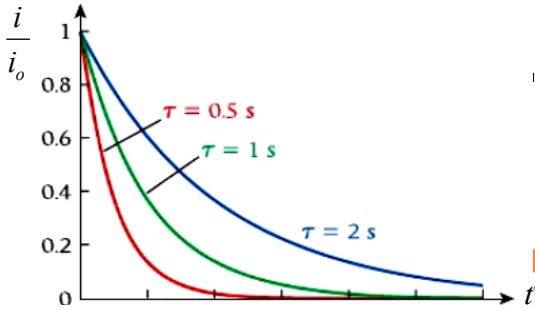
kasabra

A large time constant means : long time to charge the capacitor and long time to discharge it .

A small time constant means : short time to charge the capacitor and short time to discharge it .



kasabra

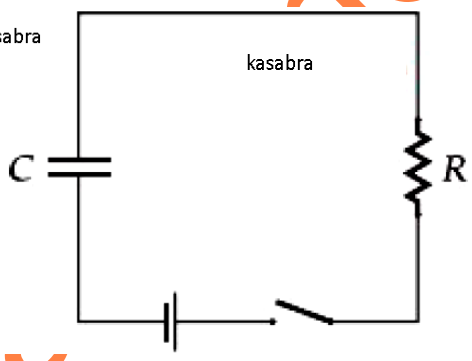


Q30) A circuit consists of a $(12V)$ battery a (50Ω) resistor and a $(100\,\mu F)$ capacitor wired in series , the capacitor is initially completely uncharged :

kasabra

1) Calculate the capacitor charge and current at $(t = 8\,ms)$ kasabra **after the switch is closed .**

kasabra



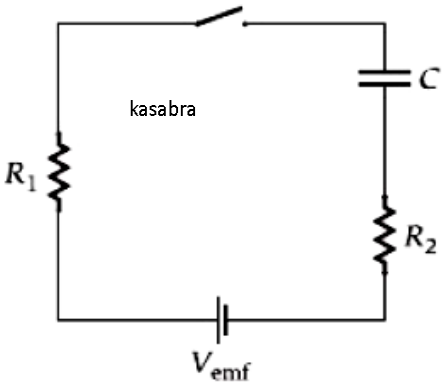
2) Calculate the time required for the capacitor's charge to reach $(1.0\,mC)$. kasabra

3) Calculate the current in the circuit when the capacitor's charge is $(4\times10^{-4}\,C)$. kasabra

kasabra.net

Q31) In the figure shown , $(R_1 = 1K\Omega \ , \ R_2 = 2K\Omega)$ and the capacitor has $(C = 20\mu F)$:

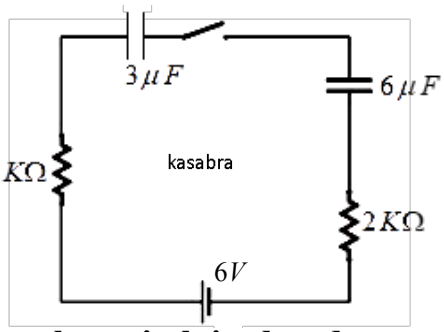
1) Calculate the time required for the current to become one-third of its initial value after the switch is closed .



2) Calculate the time required for the capacitor's charge to reach (90%) of its maximum value after the switch is closed .

Q32) Choose the correct answer in the following :

1) Calculate the time constant of the circuit shown in the figure .



a) $0.045\,s$
b) $0.03\,s$
c) $0.05\,s$
d) $0.01\,s$

2) In the previous circuit, what is the current in the circuit when the switch is closed .

a) $1.2\,A$ b) zero
c) $1.2\,mA$ d) $2\,mA$

3) A resistor and Capacitor are connected in series . If a second capacitor is connected in series in the same circuit , the time constant for the circuit will :

a) decrease b) increase c) stay the same d) None of the above

4) A resistor and Capacitor are connected in series . If a second resistor is connected in series in the same circuit , the time constant for the circuit will :

a) decrease b) increase c) stay the same d) None of the above

5) If the capacitor in an RC circuit is replaced with two identical capacitors connected in series , what happens to the time constant for the circuit ?

a) doubled b) halved
c) One-fourth d) stay the same

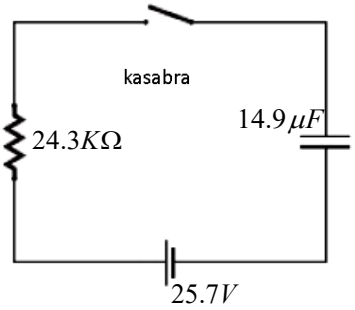
6) Which of the following will reduce the time constant in an RC circuit ?

a) increasing the dielectric constant of the capacitor .
b) adding an additional capacitor in parallel with the first capacitor.
c) adding an additional resistor in series with the first resistor .
d) adding an additional resistor in parallel with the first resistor .

7) How long will a capacitor in an RC circuit take to be (98%) charged .

a) 0.98τ b) 8τ
c) 3.9τ d) 9τ

8) In the figure shown , what is the charge of the capacitor at $(t = 0.36\,s)$ after the switch is closed.



a) $5.48\times10^{-5}\,C$
b) $7.94\times10^{-5}\,C$
c) $2.41\times10^{-4}\,C$
d) $1.66\times10^{-4}\,C$

kasabra.net

9) After an RC circuit is closed, what is capacitor's charge after a time equal the time constant ?

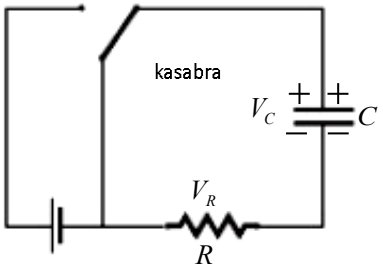
a) $q_{max}(1-1/e)$ b) $q_{max}(1-1/e)^2$

c) $\frac{q_{max}}{e}$ d) $q_{max}(1-e)$

---

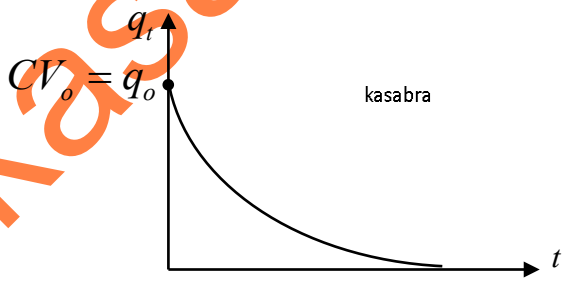
2) Discharging a Capacitor

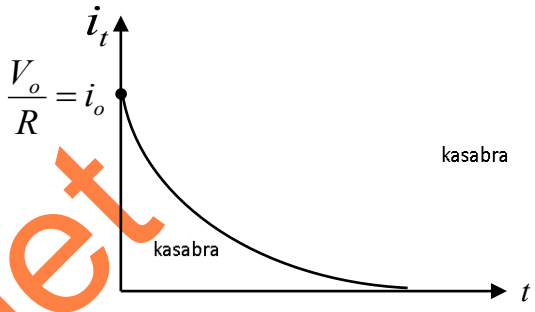
It is a connection of charged capacitor with a resistor without a battery as shown in the figure.



$$V_C + V_R = 0$$

$$\frac{q}{C} + iR = 0 \Rightarrow \frac{q}{C} + R\frac{dq}{dt} = 0$$





$$q_t = q_o\, e^{-t/\tau}$$

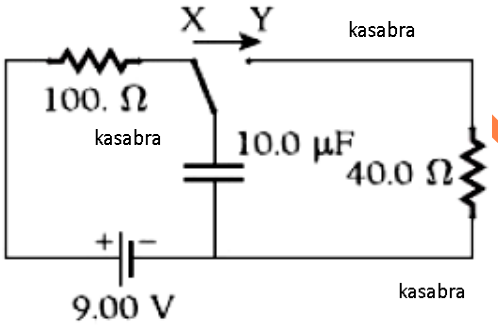
$$i_t = i_o\, e^{-t/\tau}$$

Q33) In the Circuit shown in the figure, a $(10\,\mu F)$ capacitor is charged by a $(9V)$ battery with two-way switch kept in position X for a long time . Then the switch is moved to Y :

1) Calculate the current in resistor (40Ω) immediately after the switch moves to position Y .

2) Calculate the current in resistor (40Ω) at $(t = 1ms)$ after the switch moves to position Y .

3) Calculate the capacitor's charge at $(t = 1ms)$ after the switch moves to position Y .



Q34) Choose the correct answer in the following :

1) To discharge a capacitor in an RC circuit, what should the values of the resistance and the capacitance be ?

a) Both should be as large as possible .

b) Resistance should be as large as possible and capacitance as small as possible .

c) Resistance should be as small as possible and capacitance as large as possible .

d) Both should be as small as possible .

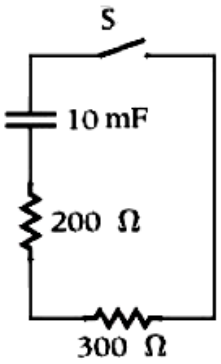
2) A $(15.2\,mF)$ capacitor is fully charged using a battery that supplies $(131V)$. The battery is disconnected and a (617Ω) resistor is connected across the capacitor. What current will be flowing through the resistor after $(3.87\,s)$.

a) $0.14\,A$ b) $0.10\,A$

c) $0.05\,A$ d) $0.21\,A$

kasabra.net

3) In the figure shown the capacitor's charge is $(0.5C)$, what is the current immediately after the switch closed ?



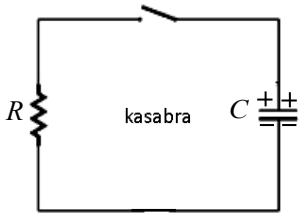
a) $1\times10^{-3}\,A$

b) $0.5\,A$

c) $0.1\,A$

d) $1\times10^{-4}\,A$

4) In the figure shown the capacitor is charged , when the switch is closed , how much the percentage of capacitor's charge after a time period equals the constant time.



a) 37%

b) 63%

c) 50%

d) 20%

5) A capacitor is fully charged using a battery that supplies $(133V)$. The battery is disconnected, and a (655Ω) resistor is connected across the capacitor. The current through the resistor after $(1.74s)$ is $(0.175A)$. What is the capacitance of the capacitor ?

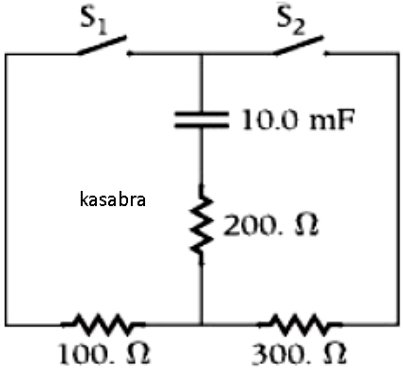
a) $4.81\times10^{-4}\,F$

b) $2.35\times10^{-2}\,F$

c) $1.79\times10^{-2}\,F$

d) $6.52\times10^{-3}\,F$

6) In the figure shown, the capacitor's charge is $(100mC)$. After (S_1) is closed, how long will the capacitor's charge take to drop to $(5mC)$.



a) $3.84s$

b) $6.25s$

c) $7.36s$

d) $8.99s$

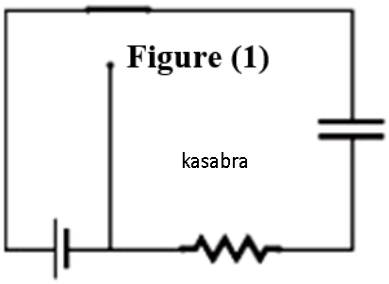
7) An RC circuit with a $(150\,\mu F)$ capacitor and a $(1.0\,M\Omega)$ resistor connected to a $(200V)$ battery for a long time as in figure (1) and then the switch is changed as in figure (2) . How long will the potential difference across the capacitor it be until the drops to $(50V)$.

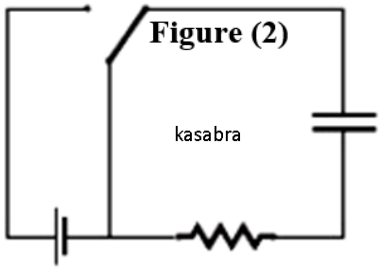
a) $123s$

b) $208s$

c) $89s$

d) $326s$





** محذوف : من ص158 إلى ص161 والتي تشمل مواضيع Neuron + Pacemaker

انتهت الوحدة السادسة

kasabra.net