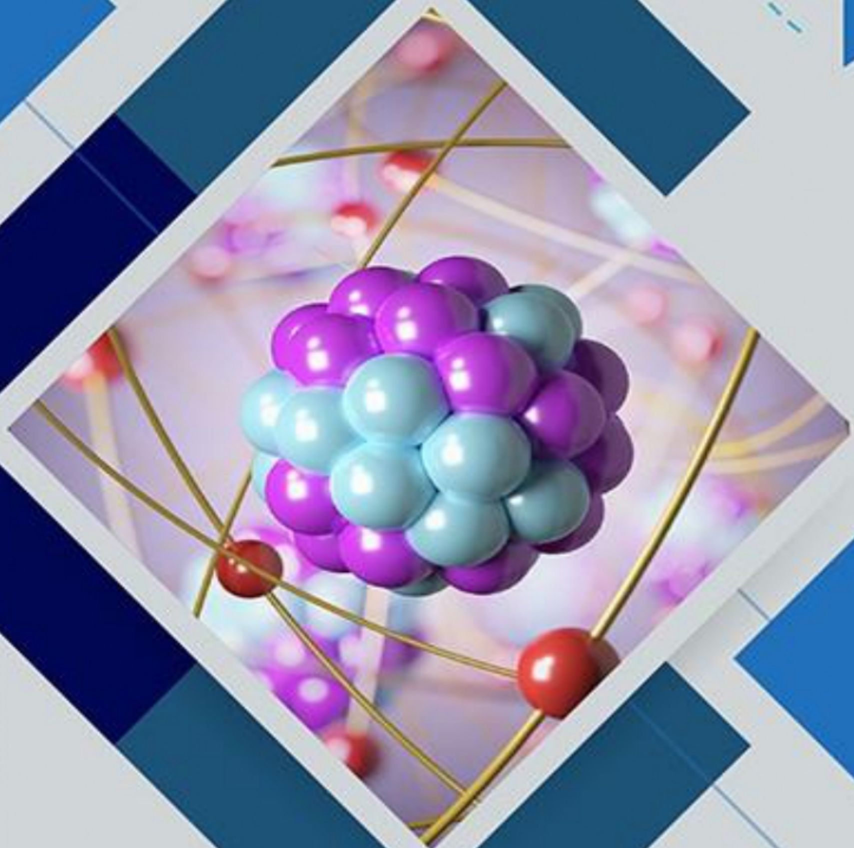

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CHAPTER 25:

CURRENT, RESISTANCE AND ELECTROMOTIVE FORCE

CURRENT, RESISTANCE AND ELECTROMOTIVE FORCE

Chapter 25: Current, Resistance and Electromotive force

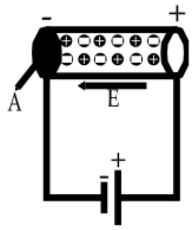
ينشأ التيار(current) عن حركة الشحنات الكهربائية باتجاه واحد عبر وسط يسمح للشحنات الكهربائية بالانتقال عبره (conducting materials).

*ناقلات الشحنة (conducting materials): النحاس والفضة والفلزات جميعها.

*ناقلات الشحنة تحتوي على الكترونات حرة في حالة حركة عشوائية بسرعات مختلفة مقدارا واتجاها الا ان معدل هذه السرعات يساوي صفر؛ لان متوسط عدد الالكترونات الحرة التي تعبر أي مقطع من الموصل باتجاه ما يساوي متوسط عدد الالكترونات التي تعبره بالاتجاه المعاكس وهكذا لا ينتج تيار كهربائي عن الحركة العشوائية.

*عند وصل طرفا الموصل مع بطارية فسوف ينشأ ين طرفيه فرق في الجهد الكهربائي يؤدي الى توليد مجال كهربائي (electric field) داخل الموصل فيؤثر على الشحنات الكهربائية تؤدي الى اندفاعها في اتجاه واحد.

التيار الكهربائي (current): هو كمية الشحنة التي تعبر مقطع الموصل في وحدة الزمن.



$I_{ave} = \frac{\triangle Q}{\triangle t}$

$I_{ins} = \frac{dq}{dt}$

$Q = \int I.dt$

Where:

I_{ave}: average electric current

I_{ins}: instantance current (التيار اللحظي).

Unit of $[I]$: Ampere (A)

$1\text{Ampere} = 1\frac{coulomb}{second}$

Ex: if $q = 3t^2 + t + 3$, find the current (I) at $t = 2s$

Solution:

$I_{ins} = \frac{dq}{dt} \Rightarrow I_{ins} = 6t + 1$

$I_{ins}|_{t=2s} = 6*(2) + 1 \Rightarrow I_{ins}|_{t=2s} = 13\ A$

Ex: if $I = 4t - 2$, find (q) from $t = 0$ to $t = 3\ s$

Solution:

$Q = \int I.dt \Rightarrow\ q = \int_0^3 (4t - 2)dt\ \Rightarrow\ q = 2t^2 - 2t\ |_0^3$

$q = \left(2 * (3)^2 - 2 * (3)\right) - (0)$

$q = 12\ C$

Drift velocity (السرعة الانسياقية) (v_d):

متوسط سرعة الالكترونات الحرة داخل الموصل عندما تنساق بعكس اتجاه المجال الكهربائي المؤثر فيها.

لحساب التيار من حركة الالكترونات في مقطع موصل طوله (Δl) ومساحته (A)، فيكون حجمه ($\Delta v = A * \Delta l$)

يرمز لعدد الالكترونات الحرة في وحدة الحجوم (n') وهو ثابت للمادة الواحدة عند ثبات درجة الحرارة وبذلك فإن عدد الالكترونات الحرة الكلي الذي يعبر هذا الحجم من الموصل (n)؛ حيث ($n = \Delta v * n'$). وبالتالي ($n = \Delta l * A * n'$).

$v_d = \frac{\Delta l}{\Delta t}$ (السرعة الانسياقية)

$\Delta q = ne$ (مبدأ تكمية الشحنة)

$\Delta q = \Delta l * A * n' * e$ ... divide over Δt

$$\frac{\Delta q}{\Delta t} = \frac{n'(\Delta l.A)e}{\Delta t}$$

$I = n' v_d Ae$

Where:

n':electron density

v_d :drift velocity

A:area of cross section

e:electron charge

Current density (J):

The current per unit cross-sectional area is called the current density J:

$$J = \frac{I}{A}$$

$$J = \frac{n' v_d Ae}{A}$$

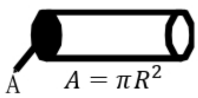
$$J = n' v_d e$$

Unit of [J]: $A/\ m^2$

Ex: in the figure shown, diameter of wire is 3 mm and current (I) = 1.5 A, find:

1) current density (J).

2)drift velocity (v_d) if electron density (n') = 12*10^{27} e/m^3



Solution:

1) $J = \frac{I}{A} \Rightarrow A = \pi R^2, R = \frac{d}{2}$

$A = \pi \left(\frac{3}{2} * 10^{-3}\right)^2 \Rightarrow A = 7.068 * 10^{-6}\ m^2$

$J = \frac{1.5}{7.068*10^{-6}} \Rightarrow J = 21.22 * 10^4\ A/m^2$

2) $J = n' v_d e \Rightarrow v_d = \frac{J}{n'e} \Rightarrow v_d = \frac{21.22*10^4}{12*10^{27}*1.6*10^{-19}}$

$v_d = 1.12 * 10^{-4}\ m/s$

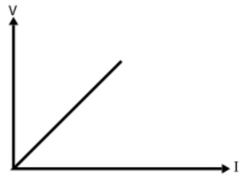
Ohm's law and resistance (قانون أوم والمقاومة):

أثناء حركة الالكترونات داخل الموصل فإنها تواجه تصادمات عدة مع بعضها البعض ومع ذرات الموصل ما يعيق حركتها، ويطلق على إعاقة حركة الإلكترونات الحرة في الموصل عند مرور تيار كهربائي في المقاومة الكهربائية (Electric resistance).

* Resistor (—WW—)

* relationship between I & V is linear (من خلال التجربة وجد أن العلاقة بين الجهد والتيار خطية).

$$R = \frac{V}{I} \Rightarrow V = IR \quad \text{ohm's law}$$



Where:

R: Resistance of a conductor
I: the current
V: the potential difference

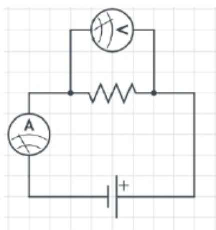
تختلف المقاومات عن بعضها في الطول ومساحات المقطع ونوع المادة، فكلما زاد طول الموصل(L) زادت فرصة حدوث تصادمات وبالتالي زيادة الإعاقة فتزيد المقاومة الكهربائية (Electric resistance)، بينما تقل مقاومة الموصل عند زيادة مساحة المقطع (A) وتختلف المقاومة الكهربائية باختلاف نوع المادة (ρ) التي يصنع منها الموصل.

$$\rho = \frac{E}{J}$$

ρ: resistivity.

E: electric field.

J: current density.



$$E = \frac{\triangle V}{L} \qquad J = \frac{I}{A} \qquad R = \frac{V}{I}$$

$$\rho = \frac{E}{J} = \frac{\triangle V}{J * L} = \frac{\triangle V * A}{I * L} = \frac{R * A}{L}$$

الوقت: أكثر ما نحتاج وأسوء ما نستخدم

$$R = \frac{\rho L}{A}$$

Where:

ρ: Resistivity of a material (المقاومية قدرة الموصل على ممانعة مرور التيار)
L: Length of conductor
A: Cross-sectional area of conductor

$\frac{1}{\rho} = \sigma$, σ: conductivity(الموصلية).

Unit of $[R]$: ohm (Ω)

Unit of $[\rho]$:$(\Omega.m)$

An 18-gauge copper wire (the size usually used for lamp cords), with a diameter of 1.02 mm, carries a constant current of 1.67 A to a 200-W lamp. The free-electron density in the wire is $8.5 * 10^{28}$ per cubic meter and the $\rho = 1.72 * 10^{-8}$ $(\Omega.m)$. Find:

(a) the current density and

(b) the drift speed.

(c) the electric-field magnitude in the wire.

(d) the potential difference between two points in the wire 50.0 m apart.

(e) the resistance of a 50.0 m length of this wire

Solution: diameter (القطر) $= 1.02 * 10^{-3}$ $n' = 8.5 * 10^{28}$ $I = 1.67$ A

a)

$$A = \frac{\pi * (1.02 * 10^{-3})^2}{4} = 8.17 * 10^{-7} m^2$$

$$J = \frac{I}{A} = \frac{1.67}{8.17 * 10^{-7}} = 2.04 * 10^6 \frac{A}{m^2}$$

b)

$$J = n' v_d e$$

$$v_d = \frac{2.04 * 10^6}{8.5 * 10^{28} * 1.06 * 10^{-19}} = 1.5 * 10^{-4} \frac{m}{s}$$

c)

$$\rho = \frac{E}{J}$$

$$E = \rho * J = 1.72 * 10^{-8} * 2.04 * 10^{6} = 0.035\ v/m$$

d)

$$v = E * L = 0.035 * 50 = 1.75\ \mathrm{V}$$

e)

$$R = \frac{\rho L}{A} = \frac{1.72 * 10^{-8} * 50}{8.17 * 10^{-7}} = 1.05\Omega$$

Or

$$R = \frac{V}{I} = \frac{1.75}{1.67} = 1.05\Omega$$

Resistance & Resistivity (المقاومة والمقاومية):

$R = \frac{\rho L}{A}$

$*\ \rho$ affected by temperature (تتأثر بدرجة الحرارة).

$*\ \rho$ affected by material type (تتأثر بنوع المادة).

$*\ R$ affected by material type (تتأثر بأبعاد الجسم المساحة والطول).

τ: average time between collision in wire.

$\rho = \frac{m}{n' e^2 \tau}$, (for find ρ if you have τ)

Where:

τ: average time between collision in wire (معدل زمن التصادمات في السلك).

m: mass of electron

Resistance & Temperature (المقاومة والحرارة):

بما أن المقاومية (ρ) تتأثر بالحرارة فهي تتغير بتغير درجة الحرارة لهذه المادة. ويتم حساب المقاومية عند درجة حرارة مختلفة اعتمادا على المقاومية عند درجة حرارة الغرفة (ρ_0).

$$\rho(T) = \rho_0\big(1 + \alpha(T - T_0)\big) \;\Rightarrow \frac{l}{A} * \Big(\rho = \rho_0\big(1 + \alpha(T - T_0)\big)\Big)$$

$$R(T) = R_0\big(1 + \alpha(T - T_0)\big)$$

Where:

ρ_0: Resistivity at reference temperature T_0.

T_0: The reference temperature T_0 is often taken as 0°C or 20°C.

T: the temperature T may be higher or lower than T_0.
α: Temperature coefficient of resistivity

Ex: wire its $R = 12\,\Omega$ at $T = 40\ c^{\circ}$, R is became 24 Ω,find T if $\alpha = 1 * 10^{-3}\ c^{\circ -1}$.

Solution:

$$R(T) = R_0\big(1 + \alpha(T - T_i)\big) \Rightarrow 24 = 12\big(1 + 1 * 10^{-3}(T - 40)\big)$$

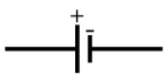
$$2 = 1 + 1 * 10^{-3}(T - 40) \Rightarrow \frac{1}{1 * 10^{-3}} = T - 40$$

$$T - 40 = 1000 \;\Rightarrow\; T = 960\ c^{\circ}$$

Electromotive Force (القوة الدافعة الكهربائية):emf (ε)

القوة الدافعة الكهربائية (Electromotive Force): وهي الشغل الذي تبذله البطارية لدفع وحدة الشحنات الموجبة من القطب السالب الى القطب الموجب داخلها.

$$\boldsymbol{\varepsilon} = \frac{U}{q}$$



ideal battery

Where:

U: the work done by the battery.

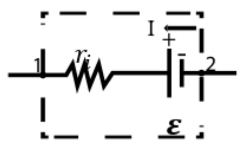
$\boldsymbol{\varepsilon}$: Electromotive Force (emf).

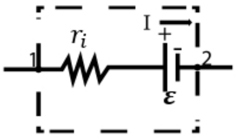
Unit of [$\boldsymbol{\varepsilon}$]: volt

تستهلك معظم الطاقة التي تنتجها البطارية في المقاومات الخارجية (R)، إلا أن جزءا صغيرا من هذه الطاقة يستهلك داخل البطارية، لوجود مقاومة تعيق حركة الشحنات عند مرورها عبر البطارية، تسمى هذه المقاومة بالمقاومة الداخلية للبطارية (r_i: $internal\ resistor$).

- ❖ $V_{12} = \varepsilon - Ir_i$ (حالة تفريغ يكون التيار خارج من القطب الموجب للبطارية)

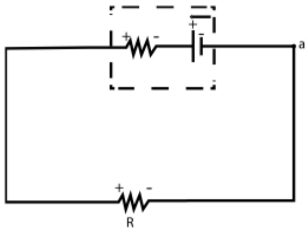
$V_{battery} < \varepsilon$





- $V_{12} = \varepsilon + Ir_i$ (حالة شحن يكون التيار داخل في القطب الموجب للبطارية)

$V_{battery} > \varepsilon$



(في حالة التفريغ)

$\varepsilon = IR + Ir_i$

$I = \dfrac{\varepsilon}{R + r_i}$

تكون $(V_{battery} = \varepsilon)$ في عدة حالات:

1) إذا كانت المقاومة الداخلية تساوي صفر $(r_i = 0)$ وتسمى البطارية (ideal battery).
2) أن تكون الدارة مفتوحة وبالتالي التيار يساوي صفر $(I = 0)$.

Electric power (القدرة الكهربائية): (P)

القدرة الكهربائية (electric power): هي الشغل المبذول (P) لنقل شحنة بين نقطتين بينهما فرق في الجهد في وحدة الزمن (t).

$P = \frac{U}{t}$

Unit of $[P]$: $Watt$

Where:

U: the energy $(Joul)$

t: $the\ time$

The Power for Battery (generated (البطارية)).

بما أن البطارية في دارة مغلقة فإنها تبذل شغلا لتحريك الشحنات عبر الدارة فإن المعدل الزمني للشغل الذي تبذله البطارية يعبر عن القدرة المنتجة من البطارية.

$U = Vq$

$$P = \frac{U}{t} = \frac{Vq}{t} = VI$$

$P = VI$

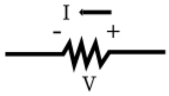
Where:

P: electric power for Battery

Power input to a Pure resistance (المقاومات).

$P = VI$

Form ohm's law $V = IR$



$P = \frac{V^2}{R}, P = I^2R$

Only for resistors (للمقاومات فقط)

من قانون حفظ الطاقة فإن القدر التي تنتجها البطارية مساوية للقدرة التي تستهلكها المقاومات.

القدرة المنتجة = القدرة المستهلكة

$$\varepsilon * I - I^2 r_i = I^2 R$$

Ex: wire its length L=8m and radius= $\frac{4}{\sqrt{\pi}} cm$ and $\rho = 25 \cdot 10^{-7}\, \Omega.m$ connected to battery $V = 15\, V$, find:

1) resistance.
2) power of R.
3) energy if it connected to battery for 5s.

Solution:

1) $R = \frac{\rho L}{A}$, $A = \pi R^2 \Rightarrow A = \pi.\left(\frac{4}{\sqrt{\pi}}\right)^2 \Rightarrow A = 16 * 10^{-4}\, m^2$

$R = \frac{25*10^{-7}*8}{16*10^{-4}} \Rightarrow R = 12.5 * 10^{-3} \Rightarrow R = 12.5\, m\Omega$

2) $P = \frac{V^2}{R} \Rightarrow P = \frac{15^2}{12.5 \cdot 10^{-3}} \Rightarrow P = 18000\, watt$

$P = 18\, kwatt$

3) $P = \frac{U}{t} \Rightarrow U = P.t \Rightarrow U = 18000 * 5 \Rightarrow U = 90000\, J$

$U = 90\, kJ$

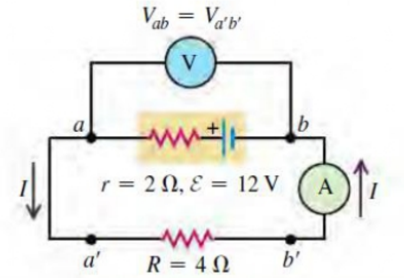
As shows a source (a battery) with emf $\varepsilon = 12\ V$ and internal resistance $r = 2\Omega$ and connected with resistance $R = 4\Omega$ find:

a) What are the voltmeter and ammeter readings V_{ab} and I now.

b) if replace the 4Ω resistor with a zero-resistance conductor. What are the meter readings now?

c) find the rates of energy conversion (chemical to electrical) and energy dissipation in the battery, the rate of energy dissipation in the 4 Ω resistor, and the battery's net power output.

solution:



a)

$$I = \frac{\varepsilon}{R + r_i} = \frac{12}{4+2} = 2A$$

$$V_{ab} = \varepsilon - I * r_i = 12 - 2 * 2 = 8V$$

b)

$$I = \frac{\varepsilon}{R + r_i} = \frac{12}{0+2} = 6A$$

C) the rate of energy conversion in the battery is

$$P = \varepsilon * I = 12 * 2 = 24\ W$$

The rate of energy dissipation in the battery is

$$p = I^2 r_i = 2^2 * 2 = 8\ w$$

the rate of energy dissipation in the 4 Ω resistor

$$p = I^2 R = 2^2 * 4 = 16\ w$$

The net electrical power output of the battery is

القدرة المنتجة = القدرة المستهلكة

$$P = \varepsilon * I - I^2 r_i = 16\ w$$

Or

$$p = I^2 R = 16w$$

أهم القوانين

Current

$$I_{ave} = \frac{\triangle Q}{\triangle t}$$

$$I_{ins} = \frac{dq}{dt}$$

$$Q = \int I.dt$$

Current density (J)

$$I = n' v_d Ae$$

$$J = \frac{I}{A}$$

Resistance & Resistivity

$$R = \frac{V}{I}$$

$$\rho = \frac{\mathrm{E}}{J} = \frac{\triangle V}{J * L} = \frac{\triangle V * A}{I * L} = \frac{\mathrm{R} * A}{L}$$

Resistance & Temperature (المقاومة والحرارة):

$$\rho(T) = \rho_0\big(1 + \alpha(T - T_0)\big)$$

$$R(T) = R_0\big(1 + \alpha(T - T_0)\big)$$

القدرة المنتجة = القدرة المستهلكة

$$\sum\varepsilon = I^2 * \sum R + I^2 * \sum r_i$$

Problems

Book & more

1- An electrical device a current of 3.9 A for 3.4 seconds. How many electrons flow through this device?

a. $9.7*10^{19}$ **b.** $1.1*10^{20}$ **c.** $1.24*10^{20}$ **d.** $6.71*10^{19}$ **e.** $8.29*10^{20}$

$I = \frac{Q}{t} \rightarrow Q = 13.26$

$Q = ne$

$n = 8.29*10^{20}$

2-An electric device, which heats water by immersing a resistance wire in the water, generates 50 cal of heat per second when an electric potential difference of 12 V is placed across its leads. What is the resistance of the heater wire? (Note: 1 cal = 4.186 J)

a. 0.94Ω **b.** 0.81 Ω **c.** 0.58 Ω **d.** 0.69 Ω **e.** 1.5 Ω

3- An electrical device a current of 3.9 A for 3.4 seconds. How many electrons flow through this device?

a. $3.37*10^{20}$ **b.** $4.48*10^{20}$ **c.** $2.73*10^{20}$ **d.** $5.06*10^{20}$ **e.** $3.95*10^{20}$

4- A silver wire 2.6 mm in diameter transfers a charge of 420 C in 80 min. Silver contains $5.8 * 10^{28}$ free electrons per cubic meter. What is the current in the wire?

Answer: ……….

5A 56 kΩ resistor is connected across 145 V. the current in the resistor (in mA) equals:

a. 3.03 **b.** 1.63 **c.** 2.59 **d.** 3.7 **e.** 2.15

$I = \frac{V}{R} = 2.59$

6- What maximum power can be generated from an 18-V emf using any combination of a 6.0- Ω resistor and a 9.0- Ω resistor?

a. 54 W **b.** 71 W **c.** 90 W **d.** 80 W **e.** 22 W

تكون أكبر عندما توصل على التوازي لأنها تعطي قيمة مقاومة أصغر

$R_{eq} = 3.5$

$P = \frac{v^2}{R_{eq}} = 90W$

7- How much energy is dissipated as heat during a two-minute time interval by a 1.5-k Ω resistor which has a constant 20-V potential difference across its leads?

a. 58 J **b.** 46 J **c.** 32 J **d.** 72 J **e.** 16 J

8-Copper has $8.5 * 10^{28}$ free electrons per cubic meter. A 71.0-cm length of 12-gauge copper wire that is 2.05 mm in diameter carries 4.85 A of current. How much time does it take for an electron to travel the length of the wire?

Answer: ……….

9- If $5.0 * 10^{21}$ electrons pass through a 20- Ω resistor in 10 min, what is the potential difference across the resistor?

a. 21 V **b.** 32 V **c.** 27 V **d.** 37 V **e.** 54 V

$Q = ne = 800$

$I = \frac{Q}{t} = \frac{800}{600} = \frac{4}{3} A$

$V = R * I = 27$

10-Current passes through a solution of sodium chloride. In 1.00 s, $2.68 * 10^{16}$ Na+ ions arrive at the negative electrode and $3.92 * 10^{16}$ Cl- ions arrive at the positive electrode. What is the current passing between the electrodes?

Answer: ……….

11-A 30 V voltage is applied across the two ends of a wire of length 2m whose electrical resistivity $\rho = 2 * 10^{-8}\ \Omega.m$. the current density in the wire (in A/m^2) is:

a. $7.5*10^8$ **b.** $5*10^8$ **c.** $7.5*10^{-8}$ **d.** $2.5*10^8$ **e.** $2.5*10^{-8}$

$\rho = \frac{\triangle V}{J * L} \to J = \frac{30}{2 * 10^{-8} * 2} = 7.5 * 10^8$

12-the resistivity of gold is $2.44*10^{-8}$ Ωm at room temperature. A gold wire that is 0.6 mm in diameter and 14 cm long carries a current of 1167 mA. What is the electric field in the wire (in units of v/m)?

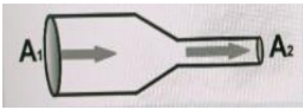
a. 0.08359 **b.** 0.1440 **c.** 0.06345 **d.** 0.1007 **e.** 0.1239

13- What is the resistance of a wire made of a material with a resistivity of ($3.2 *10^{-8}$ Ω.m) if it has dimensions length = 2.5 m, and diameter = 0.50 mm?

a. 0.16 Ω **b.** 0.10 Ω **c.** 1.28 Ω **d.** 0.41 Ω **e.** 0.81 Ω

14-electric charges flow through a wire shaped as shown in the figure below. The cross-sectional areas are $A_1 = 7.8\ mm^2$ and $A_2 = 1.56\ mm^2$ respectively. What is the drift velocity (in mm/s) of electrons in the narrow section of the wire if their velocity is 5.4 mm/s in the wider region?

a. 33.21 **b.** 27.00 **c.** 38.61 **d.** 44.01 **e.** 20.79



15-the temperature coefficient of resistivity for copper is 0.0069 $(°C)^{-1}$. If a copper wire has a resistance of 164Ω at 20°C, what is its resistance in ohm at 20°C?

a. 311.73 **b.** 399.48 **c.** 353.3 **d.** 270.17 **e.** 230.91

$R(T) = R_0(1 + \alpha(T - T_0)) = 164(1 + 0.0068(80 - 20))$

$R(T) = 230.91$

القراءة التحليلية تجعلك قادرا على إجابة ما يتعلق بموضوعك

16- Most telephone cables are made of copper wire of either 24 or 26 gauge. If the resistance of 24-gauge wire is 137 Ω /mile and the resistance of 26-gauge wire is 220 Ω /mile, what is the ratio of the diameter of 24-gauge wire to that of 26-gauge wire?

a. 1.6 **b.** 1.3 **c.** 0.62 **d.** 0.79 **e.** 0.88

17- A wire, whose material has temperature coefficient of resistivity $= 4 * 10^{-3°}C^{-1}$, *is* heated sothat its temperature is raised by 80°C. the fractional change in its resistance is:

a. 0.2 **b.** 0.32 **c.** 0.16 **d.** 0.24 **e.** 1.5

18- A copper wire has a square cross section 2.3 mm on a side. The wire is 4.0 m long and carries a current of 3.6 A. The density of free electrons is $8.5 * 10^{28} / m^3$. Find the magnitudes of the current density in the wire?

Answer: ……….

19- A 50-V potential difference is maintained across a 2.0-m length wire that has a diameter of 0.50 mm. If the wire is made of material that has a resistivity of $7.0 * 10^{-8}$ Ω .m, what is the current in the wire?

a. 70 A **b.** 65 A **c.** 61 A **d.** 58 A **e.** 280 A

20- A ductile metal wire has resistance R. What will be the resistance of this wire in terms of R if it is stretched to three times its original length, assuming that the density and resistivity of the material do not change when the wire is stretched? (*Hint:* The amount of metal does not change, so stretching out the wire will affect its cross-sectional area.)

Answer: ……….

21the resistivity of the material of a wire is $9.6*10^{-6}$ Ωm. if the radius of the wire is $3.2*10^{-3}m$ and its length is 181 m, what is its resistance?

a. 54.01 **b.** 44.83 **c.** 66.44 **d.** 34.03 **e.** 23.23

$$R = \frac{\rho * L}{A} = \frac{9.6 * 10^{-6} * 181}{\pi * (3.2 * 10^{-3})^2} = 54.01$$

22- A conductor of radius r, length L and resistivity ρ has resistance R. What is the new resistance if it is stretched to 4 times its original length?

a. $\frac{1}{16}R$ **b.** $\frac{1}{4}R$ **c.** R **d.** $4R$ **e.** $16R$

حجم الأول يساوي حجم الثاني

$V_{old} = V_{\text{new}} \rightarrow \pi L r^2 = \pi L_2 {r_2}^2$

$r_2 = 0.5r$

$L_2 = 4L$ $\quad R = \frac{\rho * L}{\pi r^2}$ $\quad R_2 = \frac{\rho_2 * L_2}{\pi {r_2}^2}$

$$\frac{R_2}{R} = \frac{\frac{\rho_2 * L_2}{A_2}}{\frac{\rho * L}{A}} \rightarrow R_2 = 16R$$

23- What diameter must a copper wire have if its resistance is to be the same as that of an equal length of aluminum wire with diameter 2.14 mm? $\rho_{\text{copper}} = 1.72 * 10^{-8}$ $\quad \rho_{\text{aluminum}} = 2.75 * 10^{-8}$

Answer: ……….

24-A conductor of radius r, length L and resistivity ρ has resistance R. It is melted down and formed into a new conductor, also cylindrical, with one fourth the length of the original conductor. The resistance of the new conductor is:

a. $\frac{1}{16}R$ **b.** $\frac{1}{4}R$ **c.** R **d.** $4R$ **e.** $16R$

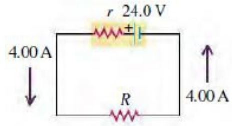
25- Light bulb A is rated at 60 W and light bulb B is rated at 100 W. Both are designed to operate at 110 V. Which statement is correct?

a. The 60 W bulb has a greater resistance and greater current than the 100 W bulb.
b. The 60 W bulb has a greater resistance and smaller current than the 100 W bulb.
c. The 60 W bulb has a smaller resistance and smaller current than the 100 W bulb.
d. The 60 W bulb has a smaller resistance and greater current than the 100 W bulb.
e. We need to know the resistivities of the filaments to answer this question.

26- A carbon resistor is to be used as a thermometer. On a winter day when the temperature is 4.0°C, the resistance of the carbon resistor is 217.3 Ω . What is the temperature on a spring day when the resistance is 215.8 Ω? (Take the reference temperature T_0 to be 4.0°C.) ($\alpha = -0.00050 ({C^{\circ}}^{-1})$)

Answer: ……….

27- Consider the circuit shown in figure. The terminal voltage of the 24.0-V battery is 21.2 V. What is the internal resistance r of the battery?



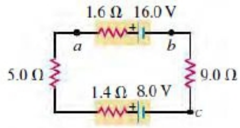
Answer: ……….

$V_{12} = \varepsilon - Ir_i$

$24 = 24 - 4r_i$

$r_i = 5.3$

28- The circuit shown in figure contains two batteries, each with an emf and an internal resistance, and two resistors. Find the current in the circuit (magnitude *and* direction)?



Answer: ……….

القدرة المنتجة = القدرة المستهلكة

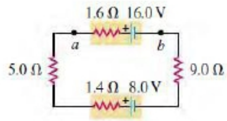
$\sum\varepsilon * I = I^2 * \sum R + I^2 * \sum r_i$

$(16 - 8) * I = I^2 * (5 + 9) + I^2 * (1.4 + 1.6)$

$(16 - 8)$(لانهم متعاكسات)

$I = 0.471$

29- The circuit shown in figure contains two batteries, each with an emf and an internal resistance, and two resistors. Find the terminal voltage *Vab* of the 16.0-V battery?

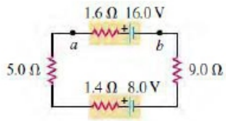


Answer: ……….

30- The power rating of a light bulb (such as a 100-W bulb) is the power it dissipates when connected across a 120-V potential difference. What is the resistance of a 100-W bulb?

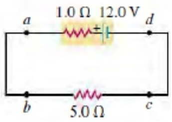
Answer: ……….

31- Consider the circuit of figure. What is the total rate at which electrical energy is dissipated in the 5.0 Ω and 9.0 Ω resistors?



Answer: ……….

32- In the circuit in figure, find the rate of conversion of internal (chemical) energy to electrical energy within the battery?



Answer: ……….

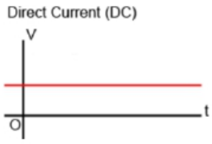
1.	**e.** $8.29*10^{20}$	11.	**a.** $7.5*10^{8}$	21.	$a)54.01$
2.	**d.** $0.69\ \Omega$	12.	**d.** 0.1007	22.	**e.** $16R$
3.	**a.** $3.37*10^{20}$	13.	**d.** 0.41	23.	$d = 1.69\ mm$
4.	$I = 8.75 * 10^{-2}\ A$	14.	**b.** 27.00	24	**e.** 230.91
5.	**c.** 2.59	15.	**e.** 230.91	25	**b.**
3.	**c.** 90 W	16.	**b.** 1.3	26	$T = 17.80\ c°$
4.	**c.** 32 J	17.	**b.** 0.32	27	$r = 0.7\ \Omega$
5.	$t = 109.5\ min$	18.	$J = 6.8 \cdot 10^{5}\ A/m^{2}$	28	$I = 0.471\ A$
6.	**c.** 27 V	19.	**a.** 70 A	29	$V_{ab} = 15.2\ V$
7.	$I = 10.56\ mA$	20.	9R	30	$R = 144\ \Omega$
				31	$P = 3.1\ W$
				32	$P = 24\ W$

CHAPTER 26:

DIRECT-CURRENT CIRCUITS

Chapter 26: Direct Current Circuits

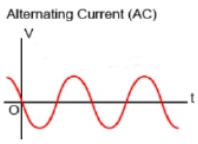
يوجد نوعين من التيارات (types of current):



1)التيار الكهربائي المستمر (Direct Current):
يرمز له بـ DC، وهو تيار يتدفق بشكلٍ منتظمٍ وثابتٍ من الاتجاه السالب للاتجاه الموجب.

2)التيار الكهربائي المتناوب (Alternating current):

يرمز له بـAC ، وهو التيار الذي يتدفق بشكلٍ متناوبٍ، وهو متغير الشدة والاتجاه بشكل دوري؛ حيث يتغير اتجاهه تارةً من القطب الموجب إلى السالب، وتارةً من القطب السالب للقطب الموجب.

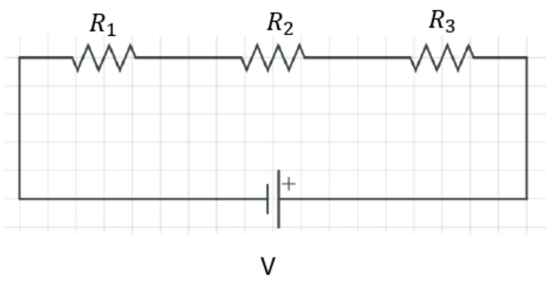


Resistors in series and Parallel:

Resistors in series (التوصيل على التوالي):

توصل المقاومات على التوالي بحيث يمر التيار (I) نفسه في المقاومات جميعها بينما يتجزأ فرق جهد المصدر بنسبة طردية مع مقدار المقاومة.

- ‘I’ is same for all resistor in series.
- ‘V’ is different if ‘R’ is different in series.



$I = I_1 = I_2 = I_3$

$V = V_1 + V_2 + V_3$

$R\ equivalent$:

$V = V_1 + V_2 + V_3$ $\quad\quad * V = IR$

$IR_{eq} = IR_1 + IR_2 + IR_3$

$IR_{eq} = I(R_1 + R_2 + R_3)$

$R_{eq} = (R_1 + R_2 + R_3)$

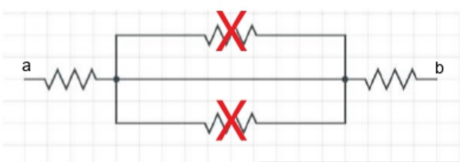
تكون المقاومة المكافئة أكبر من أكبر مقاومة في المجموعة.

إذا قطع سلك إحدى المقاومات فإن مرور التيار الكهربائي يتوقف فيها جميعها.

التوصيل على التوالي يعمل على تقليل التيار الكهربائي المار في الدارة وتجزئة الجهد.

يوصل جهاز الأميتر ذي المقاومة الصغيرة جدا على التوالي ليقيس التيار الكهربائي من غير ان يؤثر فيه.

التيار يسلك المسار الأقل مقاومة.



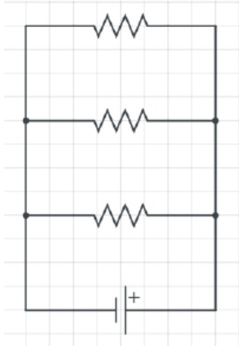
القراءة المقارنة تعمق المعلومة لديك وتفتح لك أفاقا جديدة

Resistors in Parallel (التوصيل على التوازي):

توصل المقاومات على التوالي بحيث تشترك المقاومات في نقطتي البداية والنهاية، فيكون فرق الجهد بين طرفي كل فرع مساويا فرق الجهد بين طرفي المصدر، ويتجزأ تيار الدارة عند نقطة التفرع بنسبة عكسية مع مقدار المقاومة.

- 'V' is same for all resistor in parallel.

- 'I' is different if 'R' is different in parallel.



$I = I_1 + I_2 + I_3$

$V = V_1 = V_2 = V_3$

$R\ equivalent$:

$I = I_1 + I_2 + I_3$ $\qquad\qquad$ $* V = IR$

$\frac{V}{R_{eq}} = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$ $\qquad\qquad$ $* I = \frac{V}{R}$

$\frac{V}{R_{eq}} = V(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3})$

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$R_{eq} = \frac{R_1 * R_2}{R_1 + R_2}$ (حالة خاصة عند وجود مقاومتين على التوازي فقط)

تكون المقاومة المكافئة أصغر مقاومة في المجموعة.

إذا قطع سلك إحدى المقاومات فإن مرور التيار الكهربائي يتوقف في تلك المقاومة فقط أما باقي الدارة فإنها تبقى تعمل.

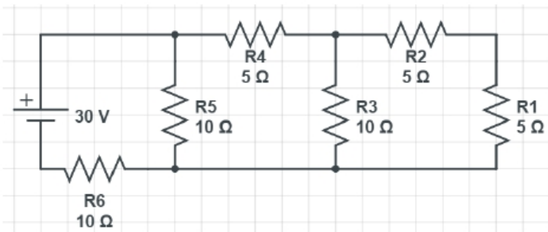
يوصل جهاز الفولتميتير ذي المقاومة الكبيرة جدا على التوالي ليقيس فرق الجهد بين طرفي أي عنصر من غير ان يؤثر في التيار المار فيه.

Ex: In circuit shown, find:

1) R_{eq}.

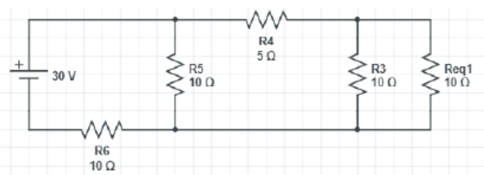
2) Power on R_4.

3) $I\ on\ R_3$.



Solution:

1)



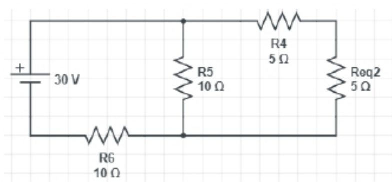
$R_1\ and\ R_2\ in\ series$

$R_{eq1} = R_1 + R_2 \Rightarrow \quad R_{eq1} = 5 + 5$

$R_{eq1} = 10\ \Omega$

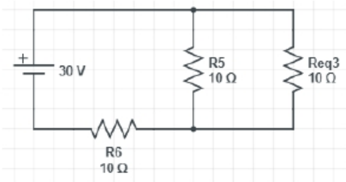
$R_{eq1}\ and\ R_3\ in\ parallel$

$\frac{1}{R_{eq2}} = \frac{1}{R_{eq1}} + \frac{1}{R_3} \Rightarrow \frac{1}{R_{eq2}} = \frac{1}{10} + \frac{1}{10}$



$R_{eq2} = 5\,\Omega$

R_{eq2} *and* R_4 *in series*

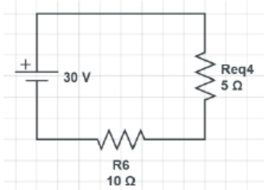


$R_{eq3} = R_{eq2} + R_4 \Rightarrow R_{eq3} = 5 + 5 = 10\,\Omega$

R_{eq3} *and* R_5 *in parallel*

$$R_{eq4} = \frac{R_{eq3} * R_5}{R_{eq3} + R_5} = \frac{10 * 10}{10 + 10} = 5\,\Omega$$

R_{eq4} *and* R_6 *in series*



$R_{eq} = R_{eq4} + R_6 \Rightarrow R_{eq} = 5 + 10 = 15\,\Omega$

2)

$R_{eq} = \frac{V}{I} \Rightarrow I = \frac{30}{15} = 2A$

$I_{Req} = 2\text{ A} = I_{Req4} = I_{R_6}$

$V_{R_{eq4}} = R_{eq4} * I_{R_{eq4}} = 5 * 2 = 10v$

$V_{R_{eq4}} = 10\,V = V_{R_5} = V_{R_{eq3}}$

$V_{R_{eq3}} = R_{eq3} * I_{R_{eq3}}$

$10 = 10 * I_{R_{eq3}}$

$I_{R_{eq3}} = 1\text{ A} = I_{R_4} = I_{R_{eq2}}$

$P_{R_4} = I^2 * R_4$

$P_{R_4} = 1^2 * 5 = 5\,watt$

3)

$V_{R_{eq2}} = R_{eq2} * I_{R_{eq2}} = 5 * 1 = 5v$

$V_{R_{eq2}} = 5\,V = V_3 = V_{R_{eq1}}$

$V_{R_3} = R_3 * I_{R_3}$

$5 = 10 * I_{R_3}$

$I_{R_3} = 0.5\,A$

Simple electric circuit equation (الدارة الكهربائية البسيطة):

الدارة التي يمكن اختصارها في عروة واحدة ($one\ loop$) تسمى الدارة الكهربائية البسيطة.

(Has only one current ... تيار واحد في الدارة)

$$I = \frac{\sum \varepsilon}{\sum R + \sum r_i}$$

$where$:

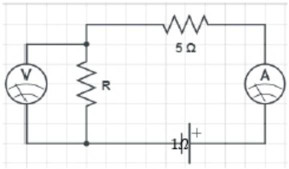
r_i: $internal\ resistor\ of\ battery$

*Attention to the polarity of battery for $\sum \varepsilon$.

Voltage for battery:

$V = \varepsilon \pm I r_i$ from ch25

Ex: in circuit shown the ammeter A reads $I = 4A$ and the voltmeter V reads $V = 12v$, find:



1)R.

2) ε (emf).

Solution:

1)

$V = I * R$

$12 = R * 4$

$R = 3\Omega$

2)

$V = \varepsilon * I_r , V = R_{eq} * I$

$V = (3 + 5) * 4$

$V = 32\ volt$

$32 = \varepsilon - 4 * 1$

$\varepsilon = 36\ volt$

2) complex circuit:

*كثيرا من الدارات لا يمكن تبسيطها الى عروة واحدة فقط، ولذلك تم وضع قاعدتين عرفتا بقاعدتي كيرشوف لتحليل الدارات الكهربائية.

*التيار متفرع في الدوائر المعقدة

{Done by: Omar Mohammad}

(Kirchhoff's laws):

First law (kcl):

اعتمادا على مبدأ حفظ الشحنة، فإن كمية الشحنات الداخلة في النقطة (J) تساوي كمية الشحنات الخارجة منها.

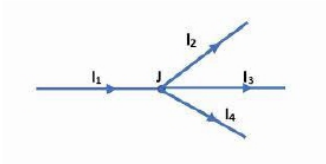
$$\Delta q_{enter} = \Delta q_{exit}$$

$\Delta q_{enter(1)} = \Delta q_2 + \Delta q_3 + \Delta q_4$ (اقسم على الزمن المستغرق لعبور الشحنات Δt)

$$I_1 = I_2 + I_3 + I_4$$

$$\sum I_{enter} = \sum I_{exit}$$

$$\sum I_{tot\,(at\,point\,J)} = 0$$



The sum of the currents into any nod equals zero.

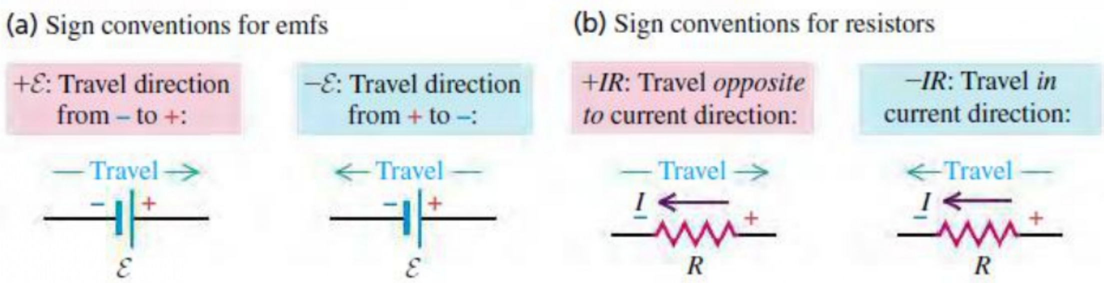
Second law (kvl):

المجموع الجبري للتغيرات في الجهد الكهربائي عبر عناصر أي مسار مغلق في دارة كهربائية يساوي صفرا.

$\sum V = 0$ *in loop* , L_1 *and* L_2 *are loops*

خطوات الحل:

- تحديد ال nods (هي نقطة تجمع 3 تفرعات أو أكثر).
- تحديد اتجاه التيار (إذا ما كان محدد بالدارة).
- تحدد ال polarity (حسب اتجاه التيار).



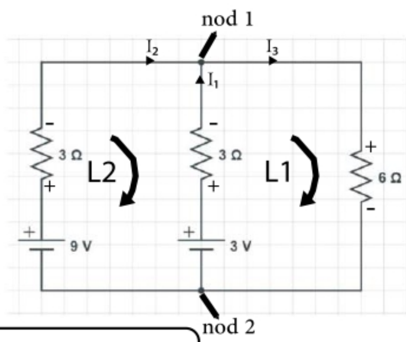
EX: In figure shown find the currents.

Solution:

At nod 1: from first law

$I_1 + I_2 = I_3$ ...1 *first equation*

From second law:



القاعدة الذهبية في الحفظ هي: العلم إذا تكرر في الناس تقرر

Loop 1 (L1):

$-3 + 3I_1 + 6I_3 = 0 \ldots 2\ second\ \ equation$

Loop 2 (L2):

$-9 + 3I_2 - 3\ I_1 - 6 = 0 \ldots 3\ third\ \ equation$

Solve the 3 equations on calculator.

$I_1 + I_2 - I_3 = 0 \ldots 1$

$I_1 + 2I_3 = 1 \ldots 2$

-$I_1 + I_2 = 2 \ldots 3$

*المعدلات بأبسط صورة

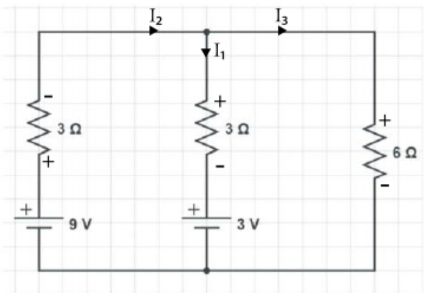
*ترتيب المتغيرات بهذا الشكل مهم لإيجاد الحل على الآلة الحاسبة

$I_1 = -0.6\ A$

$I_2 = 1.4\ A$

$I_3 = 0.8\ A$

* if the sign of any current was negative the direction of current in the opposite direction of the imposition.



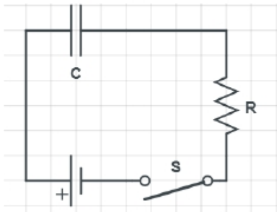
Resistor – capacitor circuit (RC circuit):

Two cases:

1) charging.

2) discharging.

1) charging:



$V_c = \frac{Q}{C}$

$V_R = I * R$

$\varepsilon = V_c + V_R$

At t = 0: (at the moment switch is closing)

$Q_c = 0$, in charge in capacitor

then $V_c = 0$

$V_{R\,max} = \varepsilon$

$I_{max} = \frac{\varepsilon}{R}$

At t = ∞ (after long time from switch closed)

The capacitor is fully charged.

V_C will increases and ε is constant, then V_R will decreases even become zero.

Q_C is max, then V_C is max.

$V_{C\,max} = \varepsilon$

At this time when capacitor is fully charged there is not current I at circuit $I = 0$

Then $V_R = 0$, $I_R = 0$

From t=0 to t=∞ the Q and V of capacitor and resistor

$Q(t) = Q_{max}\,(1 - e^{-t/RC})$

This equation from:(للفهم فقط)

$\varepsilon = V_c + V_R$

$V_c + V_R - \varepsilon = 0$

$\frac{Q}{C} - IR - \varepsilon = 0$

RC: time constant $\equiv \tau$

$\frac{Q}{C} - \frac{dq}{dt}R - \varepsilon = 0$ ... divide over R.

$\frac{Q}{CR} - \frac{dq}{dt} - \frac{\varepsilon}{R} = 0$

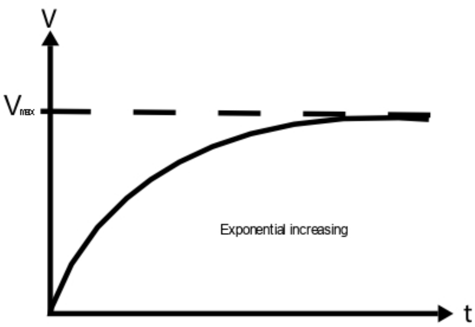
Then solve it as differential equation to get $Q(t)$

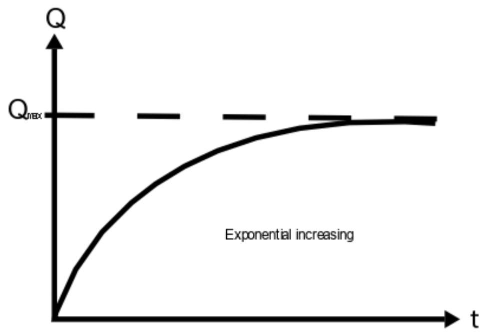
$Q(t) = Q_{max}\,(1 - e^{-t/RC})$, $Q_{max} = C\,\varepsilon$

$Q(t) = Q_{max}\,(1 - e^{-t/RC})$ ... divide over C

$V(t) = V_{max}\,(1 - e^{-t/RC})$ $V_{max} = \varepsilon$

τ: is the time that Qis equal 63% of Q_{max}





For resistor:

$V_R = \varepsilon - V_C$

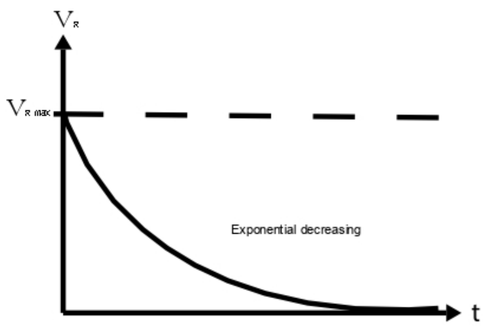
$V_R = \varepsilon - \varepsilon\,(1 - e^{-t/RC})$

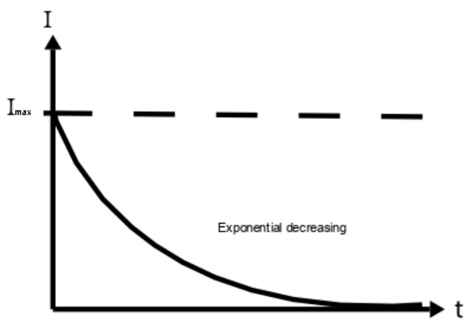
$V_R = \varepsilon - \varepsilon + \varepsilon e^{-t/RC}$

$V_R = \varepsilon e^{-t/RC}$, $\varepsilon = V_{R\,max}$

$V_R = I\,R$

$I(t) = I_{max}e^{-t/RC}$



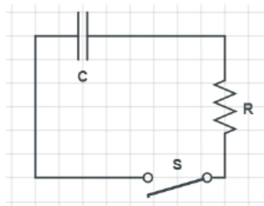


2)discharging:

at t=0 Q is max, and it start discharge in R.

and at t=∞ Q is zero and V_R is max.

from t=0 to t=∞



$Q(t) = Q_{max}\,(e^{-t/RC})$

$V_C(t) = V_{C_{max}}\,(e^{-t/RC})$

Relation between C and R in this circuit

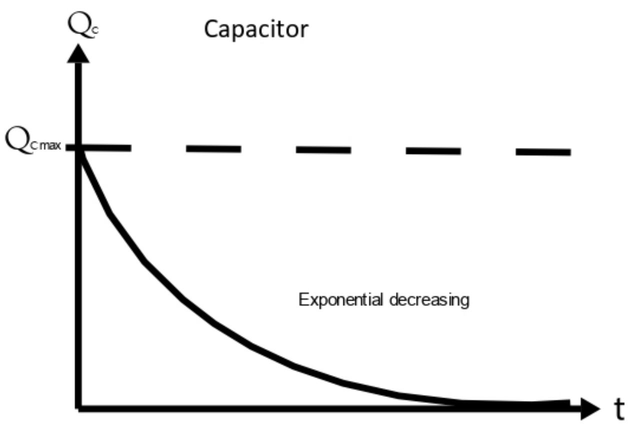
$I = \frac{dq}{dt}$

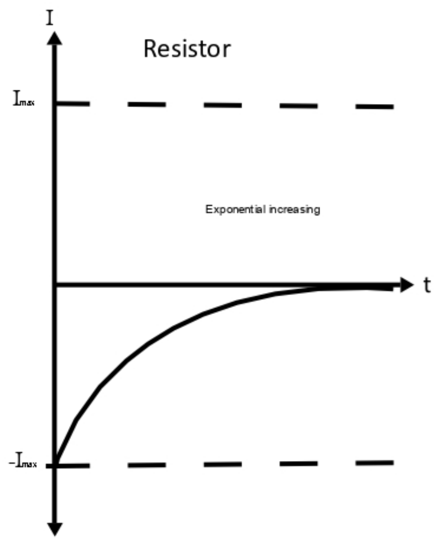
$I(t) = \frac{d}{dt}(Q_{max}\,(e^{-t/RC}))$

$I(t) = -\frac{Q_{max}}{RC}\,(e^{-t/RC})\,,\ \frac{Q_{max}}{C} = V \Rightarrow \frac{V}{R} = I$

$I(t) = -I_{max}\,(e^{-t/RC})$

$V_R(t) = -V_{R_{max}}\,(e^{-t/RC})$v



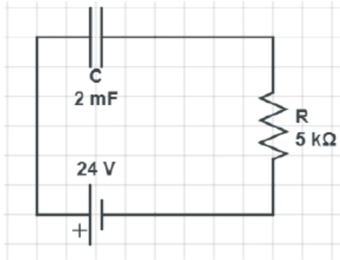


Ex1: in figure shown, find:

1) time constant (τ)

2) Q at t=35-sec

3) I at t=35-sec



Solution:

1)

$\tau = RC$

$\tau = 5 * 10^3 * 2 * 10^{-3}$

$\tau = 10 - sec$

2)

$Q(t) = Q_{max}\ (1 - e^{-t/RC})$

$Q_{max} = C\ \varepsilon$

$Q_{max} = 2 * 10^{-3} * 24$

$Q_{max} = 48\ mC$

$Q(35) = 48 * 10^{-3}\ (1 - e^{-35/10})$

$Q(35) = 46.5\ mC$ less than Q_{max} it is true.

3)

$I(t) = I_{max} e^{-t/RC}$

$I_{max} = \frac{\varepsilon}{R}$

$I_{max} = \frac{24}{5 * 10^3}$

$I_{max} = 4.8\ mA$

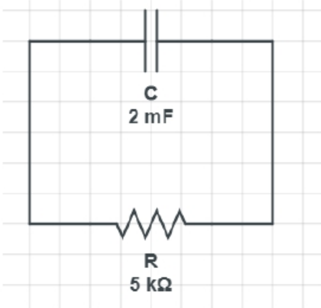
$I(35) = 4.8 * 10^{-3} e^{-35/10}$

$I(35) = 0.145\ mA$ less than I_{max} it is true.

Ex2: in figure shown if $Q_{max} = 8\ mC$, find: (capacitor initially fully charged)

1) t if $Q = 3\ mC$

2) I at that time (t at $Q = 3\ mC$)



Solution:

1)

$Q(t) = Q_{max}\ (e^{-t/RC})$

$3 * 10^{-3} = 8 * 10^{-3}\ (e^{-t/10})$

$e^{-t/10} = \frac{3}{8}$

$-\frac{t}{10} = \ln\frac{3}{8}$

$t = -10\ln\frac{3}{8}$

$t = 9.8 - sec$

2)

$I(t) = -I_{max}\ (e^{-t/RC})$

$I(9.8) = -\frac{Q_{max}}{RC}(e^{-9.8/10})$

$I(9.8) = -\frac{8 * 10^{-3}}{10}(e^{-9.8/10})$

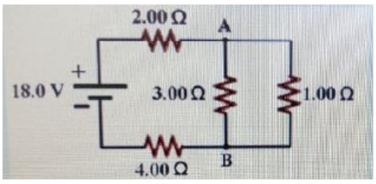
$I(9.8) = -3.06 * 10^{-4}\ A$

Problems

Book & more

أسئلة سنوات محلولة:

Q1 for the circuit shown, the potential of point A is zero. Determine the potential of point B (in V).



a. +2 **b.** -6 **c.** +6 **d.** +4 * **e.** -2

(1 and 3 parallel) $R_{eq1} = \frac{3}{4}$

$(R_{eq1}\ and\ 2\ and\ 4\ series)$

$R_{eq} = \frac{27}{4}$

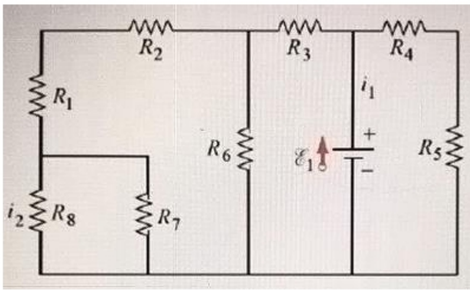
$I_{tot} = \frac{v}{R_{eq}} = \frac{18*4}{27} = \frac{8}{3}$

$V_{ab} = I_{tot} * R_{eq1} = \frac{8}{3} * \frac{3}{4} = 2$

$V_a - V_b = 2 \rightarrow V_b = -2$

Q2 the circuit shown a network of 8 identical resisters, each with resistance R, connected to the power supply ε_1. What is their equivalent resistance?

a. 2R/9 **b.** 8R/9 **c.** 2R/3 ***d.** 12R/13 **e.** 12R/7



$R_8\ and\ R_7\ parallel = R_{eq1} = 0.5R$

$R_{eq1} and\ R_2\ and\ R_1 series = R_{eq2} = 2.5R$

$R_{eq2}\ and\ R_6\ parallel = R_{eq3} = \frac{5}{7}R$

$R_{eq3}\ and\ R_3\ series = R_{eq4} = \frac{12}{7}R$

$R_4\ and\ R_5\ series = R_{eq5} = 2R$

$R_{eq4}\ and\ R_{eq5}\ parallel = 12R/13$

Q3 two resistors, 2Ω and 5Ω, are connected to 12 V battery. The minimum power (in W) that can be generated from any combination of the two resistors is:

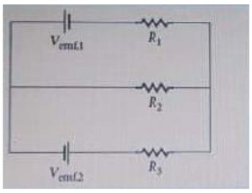
1)84 2) 100.8 3)28.8 *4)20.6 5)72

In series: $R_{eq} = 7 \rightarrow p = \frac{v^2}{R} = \frac{144}{7} = 20.6$

In parallel: $R_{eq} = \frac{10}{7} \rightarrow p = \frac{v^2}{R} = \frac{144*7}{10} = 100.8$

q5 For the circuit shown, $R_1 = 30\Omega$, $R_2 = 40\Omega, R_3 = 20\Omega$, $V_{emf1} = 12\ v, V_{emf2} = 16\ v$.determine the power (in W) delivered to R_2?

*a. 0.34 b. 0.021 c. 0.092 d. 0.065 e. 11.743



kvl:

Loop 1 (L1):

$-12 + 70I_1 - 40I_2 = 0 \ldots 1$

Loop 2 (L2):

$-16 - 40I_1 + 60\, I_2 = 0 \ldots 2$

Solve the 2 equations on calculator.

$I_1 = \frac{34}{65} \quad I_2 = \frac{8}{13}$

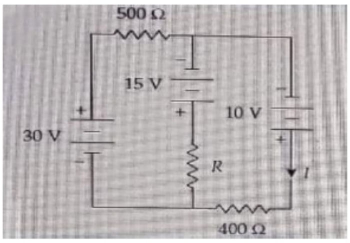
$I_{R_2} = \frac{8}{13} - \frac{34}{65} = \frac{6}{65}$

$p = I_{R_2}{}^2 * R_2 = \left(\frac{6}{65}\right)^2 * 40 = 0.34$

Q6 two resistors, 2Ω and 5Ω, are connected to 12 V battery. The maximum power (in W) that can be generated from any combination of the two resistors is:

1)25 *2) 58.3 3)33.3 4)14.3 5)70

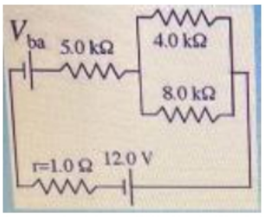
Q7Determine the magnitude and sense (direction) of the current in the 500Ω resistor when $I = 30mA$



a. $56\ mA$ left to right *b. $56\ mA$ right to left.
c. $104\ mA$ left to right. d. $104mA$ right to left
e. $28\,mA$ left to right

Q10The current through the 4 kΩ resistors is 5 mA. The current (in mA) that flows through the battery with unknown terminal voltage V_{ba}:

a. 4 b. 3 * c. 7.5 d. 6 e. 5.5



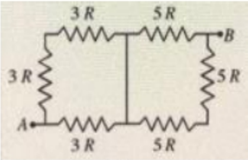
$V_{4\,k} = 5\,m * 4\,k = 20V$

4 k and 8 k parallel $\rightarrow R_{eq} = \frac{8}{3}$

$I_{tot} = \frac{V_{4\,k}}{R_{eq}} = \frac{20 * 3}{8} = 7.5$

q12In the figure, if R = 12 - Ω, what is the equivalent resistance between points a and b?

a. 96 Ω **b.** 110 Ω **c.** 48 Ω ***d.** 64 Ω **e.** 80 Ω



$3R\ and\ 3R\ series = R_{eq1} = 6R$

$(5R\ ,5R\ and\ R_1)series = R_{eq2} = 10R$

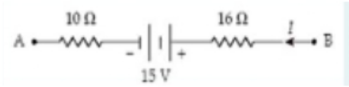
$R_{eq1}\ and\ 3R\ parallel = R_{eq3} = 2R$

$R_{eq2}\ and\ 5R\ parallel = R_{eq4} = \frac{10}{3}R$

$R_{eq3}\ and\ R_{eq4}\ series = 64$

q15In the figure, if I = 1.5 A in the circuit segment shown, what is the potential difference Vb – VA?

***a.** +28 V **b.** +2 V **c.** -28 V **d.** -2 V **e.** -18 V

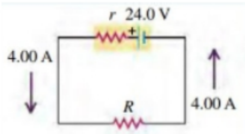


$V_B - 16\,I - 15 - 10I = V_A$

$V_B - V_A = +28$

q16 consider the circuit shown. The terminal voltage of the 24 V battery is 21.2 volts. The external resistance (R in ohm) is:

a. 8 **b.** 0.7 **c.** 6 *** d.** 5.3 **e.** zero



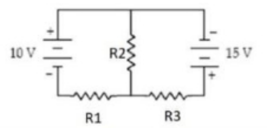
$R = \frac{V}{I} = \frac{21.2}{4} = 5.3$

$21.2 = 24 - 4r$

$r = 0.7$

q19in the circuit shown, $R_1 = R_2 = R_3 = 5\Omega$ What is the circuit in the 15 V battery?

a. 2.3 **b.** 2.7 **c.** 1.3 **d.** 0.3 **e.** 2.5



Loop 1 (L1):

$-10 + 10I_1 - 5I_2 = 0 \ldots 1$

Loop 2 (L2):

$-15 - 5I_1 + 10\,I_2 = 0 \ldots 2$

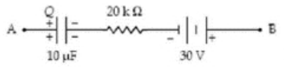
Solve the 2 equations on calculator.

$I_1 = 2.33 \quad I_2 = 2.7$

القاعدة الذهبية في الفهم هي: ربط المقدمات بالنتائج يكشف أسرارها

17-In the figure, if $Va - Vb = -10$, $Q = 400$ μCin the circuit segment shown below, what is the current in the resistor?

***a.** $1\ mA$ **b.** $3mA$ **c.** $2.5mA$ **d.** $3.5mA$ **e.** $1.5\ mA$



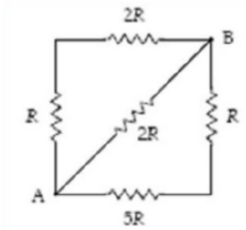
$$V_{ON\,C} = \frac{Q}{C} = \frac{400}{10} = 40V$$

$$V_B - 30 - 20 * 10^3 * I + 40 = V_A$$

$$I = 1m\,A$$

q24 what is the equivalent resistance between points A and B in the figure when R= 25Ω?

a. 10 * **b.** 25 **c.** 15 **d.** 3.2 **e.** 20



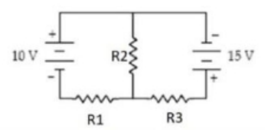
$R\ and\ 2R\ series = R_{eq1} = 3R$

$(5R\ and\ R)series = R_{eq2} = 6R$

$(R_{eq1}\ , R_{eq2}\ and\ 2R)\ parallel = R_{eq} = 25$

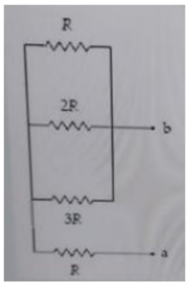
q31in the circuit shown, $R_1 = R_2 = R_3 = 5\Omega$ What is the power dissipated in the resistor?

a. 0.6 W **b.** 35.6 W * **c.** 27.2 W **d.** 20 W **e.** 30 W



q32what is the equivalent resistance between points a and b when R= 17Ω?

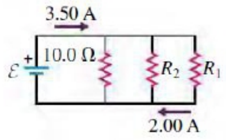
a. 20.88 **b.** 4.6 **c.** 29 **d.** 23.4 ***e.** 26.27



$(R\ , 2R\ and\ 3R)\ parallel = R_{eq} = 0.55R$

$R_{eq}\ and\ R\ series = R_{eq1} = 26.27$

q36 knowing that the power delivered to resistor, R_1 is 20 W, the resistance (in Ω) of the resistor R_2 is:



a. 15 **b.** 25 * **c.** 20 **d.** 10 **e.** 12

$p = I_{R_2}{}^2 * R_1 \rightarrow R_1 = \frac{20}{4} = 5$

$p = \frac{V_1{}^2}{R_1} \rightarrow V_1 = 10\,V$

$V_{R_1} = V_{R_2} = V_{10\Omega} = 10V$

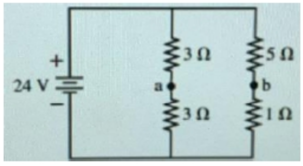
$I_{tot} = I_{R_1} + I_{R_2} + I_{10\Omega} = 3.5$

$I_{10\Omega} = \frac{V_{R_1}}{10} = 1A$

$I_{tot} = 2 + I_{R_2} + 1 = 3.5 \rightarrow I_{R_2} = 0.5A$

$R_2 = \frac{10}{0.5} = 20$

for the points a and b shown in the circuit, the potential difference Va-Vb (in V) is:



***a.** 8 **b.** 6.9 **c.** 7.1 **d.** 8.8 **e.** 6.2

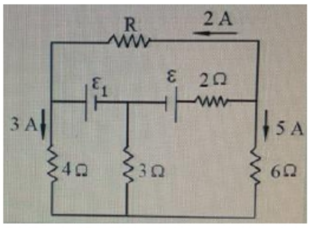
$R_{eq} = 3\Omega \rightarrow I_{tot} = \frac{24}{3} = 8A$

$I_{tot} = I_1 + I_2 = 4 + 4 = 8$(التيار ينقسم لقيمتين متساويتين لان المقاومتين على السلكين متساويتين)

$V_a + 3I_1 - 5I_2 = V_b$

$V_{ab} = 8$

q41 for the circuit shown, the emf ε_1 (in V) is:



***a.** 36 **b.** 68 **c.** 46 **d.** 38 **e.** 60

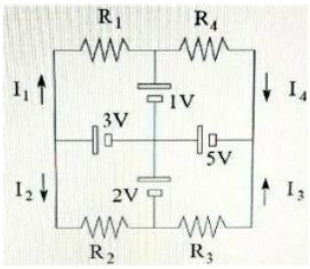
وزع التيارات على الأسلاك:

$I_{3\Omega} = 8A$

$\varepsilon_1 - 3 * 4 - 3 * 8 = 0$

$\varepsilon_1 = 36\,V$

q42for the circuit shown, $R_1 = 1\Omega, R_2 = 2\Omega, R_3 = 3\Omega, R_4 = 4\Omega$. The potential difference (in V) across $R_4$is:

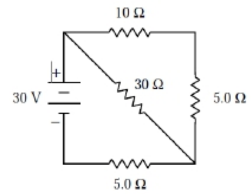


a. 5 **b.** 7 * **c.** 6 **d.** 8 **e.** 3

تمرينات:

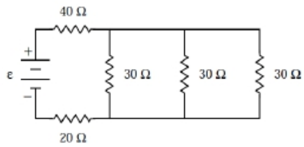
1-What is the rate at which thermal energy is generated in the 30-Ω resistor shown?

a. 20 W **b.** 27 W **c.** 60 W **d.** 13 W **e.** 30 W



2- If ε = 20 V, at what rate is thermal energy being generated in the 20 - Ω resistor shown in the circuit?

a. 6.5 W **b.** 1.6 W **c.** 15 W **d.** 26 W **e.** 5.7 W

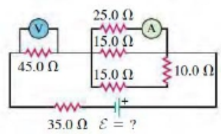


3- A resistor of unknown resistance and a 15- Ω resistor are connected across a 20-V emf in such a way that a 2.0 A current is observed in the emf. What is the value of the unknown resistance?

a. 75 – Ω **b.** 12 – Ω **c.** 7.5 – Ω **d.** 5.0 – Ω **e.** 30 – Ω

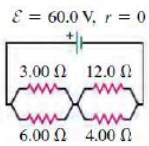
4- For the circuit shown in figure both meters are idealized, the battery has no appreciable internal resistance, and the ammeter reads 1.25 A. What does the voltmeter read? What is the emf ε of the battery?

Answer: ………………… / ………………



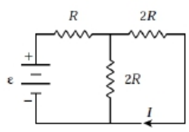
5- Compute the equivalent resistance of the network in figure and find the current in each resistor. The battery has negligible internal resistance.

Answer: ……………………………………………



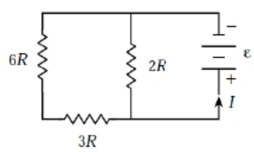
6- In the figure shown, if I = 0.50 A and R = 12– Ω , determine ε.

a. 12 V **b.** 24 V **c.** 30 V **d.** 15 V **e.** 6.0 V



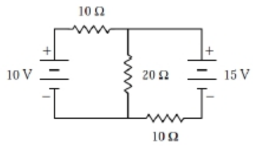
7- In the figure shown, if R = 50 – Ω and I = 20 mA, determine ε.

a. 18 V **b.** 27 V **c.** 45 V **d.** 36 V **e.** 6.0 V



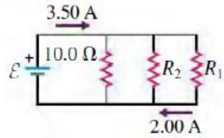
8- What is the magnitude of the current in the 20 – Ω resistor shown?

a. 0.75 A **b.** 0.00 A **c.** 0.25 A **d.** 0.50 A **e.** 1.00 A



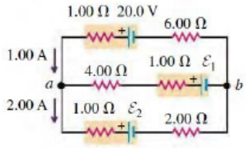
9- In the circuit shown in figure, the rate at which $R1$ is dissipating electrical energy is 15.0 W. Find $R1$ and $R2$. What is the emf of the battery? Find the current through both $R2$ and the 10.0-Ω resistor.

Answer: ……………………………………/…………………………/……………………………………



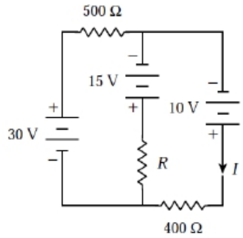
10- Find the emfs ε_1 and ε_2 in the circuit of figure, and find the potential difference of point b relative to point a.

Answer: ……………/………………/……………



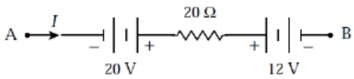
11-In the figure, if I = 30 mA, determine the magnitude and sense (direction) of the current in the 500 – Ω resistor.

a. 56 mA left to right. **b.** 56 mA right to left. **c.** 48 mA left to right.
d. 48 mA right to left. **e.** 26 mA left to right.



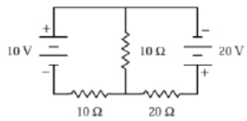
12- In the figure, if I = 1.5 A in the circuit segment shown, what is the potential difference Vb – VA?

a. +22 V **b.** –22 V **c.** –38 V **d.** +38 V **e.** +2.0 V



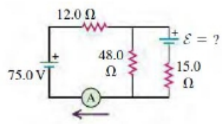
13- What power is supplied by the 10-V emf shown?

a. –10 W **b.** -20 W **c.** zero **d.** +20 W **e.** +10 W



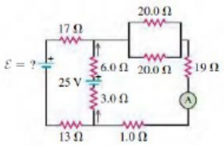
14- In the circuit shown in figures both batteries have insignificant internal resistance, and the idealized ammeter reads 1.50 A in the direction shown. Find the emf E of the battery. Is the polarity shown, correct?

Answer: ……………/……………



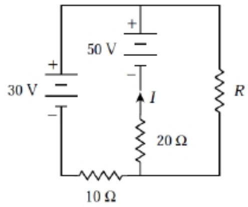
15- In the circuit shown in figure, the 6.0-Ω resistor is consuming energy at a rate of 24 J/s when the current through it flows as shown. Find the current through the ammeter A. What are the polarity and emf ε of the unknown battery, assuming it has negligible internal resistance?

Answer: ……………/…………….



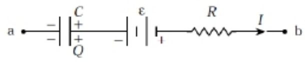
16- In the figure, if $I = 1.8$ A, determine the magnitude and sense (direction) of the current in the 10- Ω resistor.

a. 1.6 A right to left. **b.** 1.6 A left to right. **c.** 1.2 A right to left.
d. 1.2 A left to right. **e.** 1.8 A left to right.



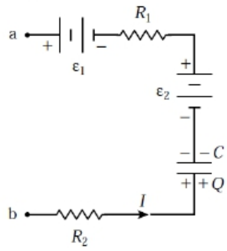
17-In the figure, if $R = 3.0$ k – Ω, $C = 5.0$ mF, $\varepsilon = 6.0$ V, $Q = 15$ mC, and $I = 4.0$ mA, what is the potential difference $Vb - Va$?

a. +21 V **b.** +9.0 V **c.** –15 V **d.** –3.0 V **e.** –6.0 V



18- In the figure, if $\varepsilon_1 = 4.0$ V, $\varepsilon_2 = 12.0$ V, $R_1 = 4 - \Omega$, $R_2 = 12 - \Omega$, $C = 3\ \mu$F, $Q = 18\ \mu$C, and $I = 2.5$A, what is the potential difference $Va - Vb$?

a. –30 V **b.** 30 V **c.** 5.0 V **d.** –5.0 V **e.** –1.0 V

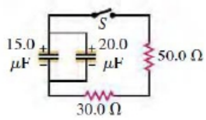


19- A capacitor is charged to a potential of 12.0 V and is then connected to a voltmeter having an internal resistance of 3.40 M-Ω After a time of 4.00 s the voltmeter reads 3.0 V. What are the capacitance and the time constant of the circuit?

Answer: ……………/…………….

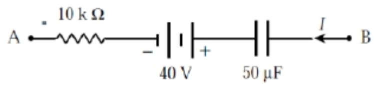
20- In the circuit shown in figure both capacitors are initially charged to 45.0 V. How long after closing the switch S will the potential across each capacitor be reduced to 10.0 V, and what will be the current at that time?

Answer: ……………/…………….



تذوق العلم قد يصنع منك عالما، وتذوق الشعر قد يصنع منك شاعرا

21- If I = 2.0 mA and the potential difference, VA – VB = +30V in the circuit segment shown, determine the charge and polarity of the capacitor.

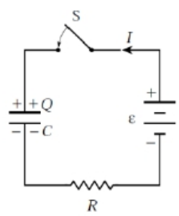


a. 0.50 mC, left plate is positive
b. 1.5 mC, right plate is positive
c. 1.5 mC, left plate is positive
d. 0.50 mC, right plate is positive
e. None of the above

22- In an RC circuit, how many time-constants must elapse if an initially uncharged capacitor is to reach 80% of its final potential difference?

a. 2.2 **b.** 1.9 **c.** 5.0 **d.** 3.0 **e.** 1.6

23- In the figure, at t = 0 the switch S is closed with the capacitor uncharged. If C = 30 μF, ε = 30 V, and R = 5.0 kΩ, at what rate is energy being stored in the capacitor when I = 2.0 mA?

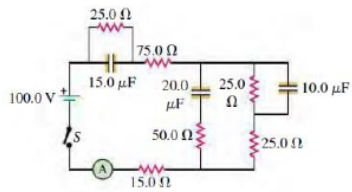


a. 32 mW **b.** 40 mW **c.** 44 mW **d.** 36 mW **e.** 80 mW

24-An emf source with ε = 120 V, a resistor with R = 80.0 - Ω, and a capacitor with C = 4.00 mF are connected in series. As the capacitor charges, when the current in the resistor is 0.900 A, what is the magnitude of the charge on each plate of the capacitor?

Answer: …………….

25- In the circuit in figure the capacitors are initially uncharged, the battery has no internal resistance, and the ammeter is idealized. Find the ammeter reading just after the switch S is closed and after S has been closed for a very long time.

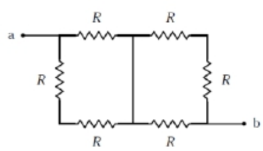


Answer: ……………/…………….

26- A capacitor in a single-loop RC circuit is charged to 85% of its final potential difference in 2.4 s. What is the time constant for this circuit?

a. 1.5 s **b.** 1.9 s **c.** 1.7 s **d.** 1.3 s **e.** 2.9 s

27- In the figure, if R = 12 - Ω, what is the equivalent resistance between points a and b?



a. 20 Ω **b.** 16 Ω **c.** 24 Ω **d.** 28 Ω **e.** 6.0 Ω

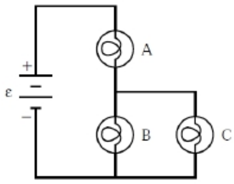
28- A 12.0-mF capacitor is charged to a potential of 50.0 V and then discharged through a 225-Ω resistor. How long does it take the capacitor to lose half of its charge and half of its stored energy?

Answer: ……………/…………….

29- The algebraic sum of the changes of potential around any closed circuit loop is:

a. zero.
b. maximum.
c. zero only if there are no sources of emf in the loop.
d. maximum if there are no sources of emf in the loop.
e. equal to the sum of the currents in the branches of the loop.

30- The circuit below contains three 100 - watt light bulbs. Σ = 110 V. Which light bulb(s) is(are) the brightest?



a. A
b. B
c. C
d. B and C
e. All three are equally bright.

1.	**d.** 13 W	11.	**a.** 56 mA left to right.	21.	**c.** 1.5 mC, left plate is positive
2.	**b.** 1.6 W	12.	**b.** –22 V	22.	**e.** 1.6
3.	**e.** 30 – Ω	13.	**e.** +10 W	23.	**b.** 40 mW
4.	206.1 V / 397.65	14.	$\varepsilon = 52.35\ V\ , is\ correct$	24.	192 μC
5.	$R_{eq} = 5\ \Omega$ $I_1 = 8\ A\ \ , I_2 = 4A\ , I_3 = 3A$ $I_4 = 9\ A$	15.	0.223 A / $\varepsilon = \ -46$ The polarity is the opposite direction for ε	25.	0.937 A / 0.606 A
6.	**b.** 24 V	16.	**a.** 1.6 A right to left	26.	**d.** 1.3 s
7.	**a.** 18 V	17.	**d.** –3.0 V	27.	**b.** 16 Ω
8.	**d.** 0.50 A	18.	**a.** –30 V	28.	1.87 ms / 0.936 ms
9.	$R_1 = 3.75\ \Omega\ , R_1 = 10\ \ \Omega$ $\varepsilon = 7.5\ V$ $I_{R_2} = I_{10} = 0.75\ A$	19.	0.849μF / 2.89 s	29.	**a.** zero.
10.	$\varepsilon_1 = 18\ V\ , \varepsilon_2 = 7\ V$ $V_{ab} = 13\ V$	20.	4.21 ms / 0.125 A	30.	**a.** A