Short Answer Questions – I (PYQ)

Q. 1. Define the terms

(i) Drift velocity,
(ii) Relaxation time. [CBSE Delhi 2011, (AI) 2013]

Ans. (i) Drift Velocity: The average velocity acquired by the free electrons of a conductor in a direction opposite to the externally applied electric field is called drift velocity. The drift velocity will remain the same with lattice ions/atoms.

(ii) Relaxation Time: The average time of free travel of free electrons between two successive collisions is called the relaxation time.

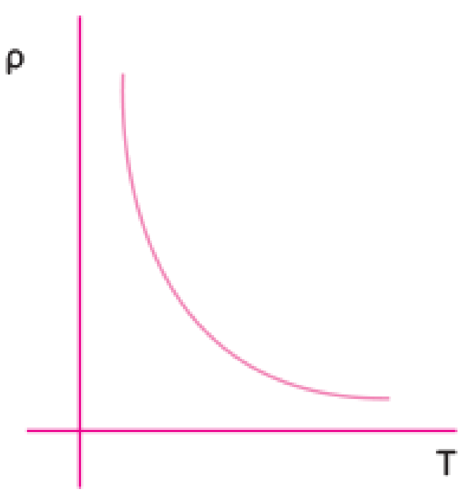
Q. 2. Sketch a graph showing the variation of resistivity of carbon with temperature.

OR

Plot a graph showing temperature dependence of resistivity for a typical semiconductor. How is this behaviour explained? [CBSE Delhi 2012, (F) 2011]

Ans. The resistivity of a typical semiconductor (carbon) decreases with increase of temperature. The graph is shown in figure.

Explanation: In semiconductor the number density of free electrons (n) increases with increase in temperature (T) and consequently the relaxation period decreases. But the effect of increase in n has higher impact than decrease of τ. So, resistivity decreases with increase in temperature.



Q. 3. (a) You are required to select a carbon resistor of resistance 47 kΩ ± 10% from a large collection. What should be the sequence of colour bands used to code it?

(b) Write the characteristics of manganin which make it suitable for making standard resistance. [CBSE (F) 2011]

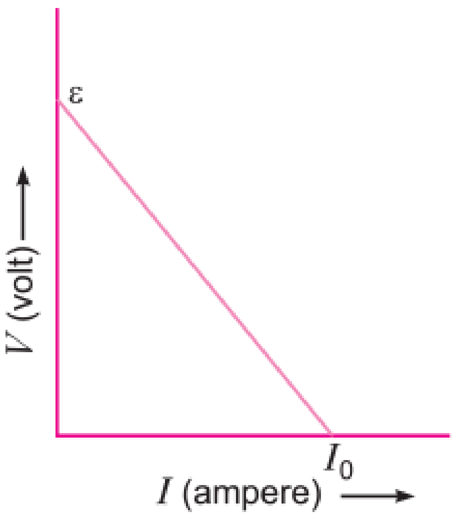
Ans. (a) Resistance $= 47\ k\Omega \pm 10\% = 47 \times 10^3 \Omega \pm 10\%$

Sequence of colour should be: Yellow, Violet, Orange and Silver

(b) (i) Very low temperature coefficient of resistance.

(ii) High resistivity

Q. 4. Plot a graph showing variation of voltage Vs the current drawn from the cell. How can one get information from this plot about the emf of the cell and its internal resistance? [CBSE (F) 2016]



Ans.

$$V = \varepsilon - \mathrm{Ir} \Rightarrow r = \frac{\varepsilon - V}{I}$$

At $I = 0,\ V = \varepsilon$

When $V = 0, \qquad I = I_0,\ r = \frac{\varepsilon}{I_0}$

The intercept on y-axis gives the emf of the cell. The slope of graph gives the internal resistance.

Q. 5. Two cells of emfs 1.5 V and 2.0 V having internal resistances 0.2Ω and 0.3Ω respectively are connected in parallel. Calculate the emf and internal resistance of the equivalent cell. [CBSE Delhi 2016]

Ans.

$$E_1 = 1.5V, \qquad r_1 = 0.2\Omega$$

$$E_2 = 2.0V, \qquad r_2 = 0.3\Omega$$

emf of equivalent cell

$$E = \frac{\frac{E_1}{r_1}+\frac{E_2}{r_2}}{\frac{1}{r_1}+\frac{1}{r_2}} = \frac{E_1r_2+E_2r_1}{r_1+r_2} = \left(\frac{1.5\times0.3+2\times0.2}{0.2+0.3}\right) = \frac{0.45+0.40}{0.5}V = 1.7V$$

Internal resistance of equivalent cell

$$\frac{1}{r} = \frac{1}{r_1}+\frac{1}{r_2} \Rightarrow r = \frac{r_1r_2}{r_1+r_2} = \left(\frac{0.2\times0.3}{0.2+0.3}\right)\Omega = \frac{0.06}{0.5}\Omega = 0.12\ \Omega$$

Q. 6. When 5 V potential difference is applied across a wire of length 0.1 m, the drift speed of electrons is 2.5 × 10^{-4} m/s. If the electron density in the wire is 8 × 10^{28} m^{-3}, calculate the resistivity of the material of wire. [CBSE (North) 2016]

Ans.

We know $I = \text{neAv}_d,\ I = \frac{V}{R}$ and $R = \rho\frac{l}{A}$

So $\quad \frac{V}{R} = \text{neAv}_d$

$$\frac{V}{\text{nev}_d\ l} = \frac{\text{RA}}{l} \Rightarrow \rho = \frac{V}{\text{nev}_d\ l}$$

$$\rho = \frac{5}{8\times10^{28}\times1.6\times10^{-19}\times2.5\times10^{-4}\times0.1}\Omega m = 1.56\times10^{-5}\Omega\text{m}$$

$$\approx 1.6\times10^{-5}\Omega m$$

Q. 7. Two conducting wires X and Y of same diameter but different materials are joined in series across a battery. If the number density of electrons in X is twice that in Y, find the ratio of drift velocity of electrons in the two wires. [CBSE (AI) 2011]

Ans. In series current is same,

So, $I_A = I_B = I = \text{neAv}_d$

For same diameter, cross-sectional area is same

$$A_A = A_B = A$$

$\therefore \quad I_A = I_B \quad \Rightarrow \quad n_x \,\text{eAv}_x = n_y \,\text{eAv}_y$

Given $n_x = 2n_y \quad \Rightarrow \quad \frac{v_x}{v_y} = \frac{n_y}{n_x} = \frac{n_y}{2n_y} = \frac{1}{2}$

Q. 8. A conductor of length 'l' is connected to a dc source of potential 'V'. If the length of the conductor is tripled by gradually stretching it, keeping 'V' constant, how will (i) drift speed of electrons and (ii) resistance of the conductor be affected? Justify your answer. [CBSE (F) 2012]

Ans.

(*i*) We know that $v_d = -\frac{\text{eV}\tau}{\text{ml}} \propto \frac{1}{l}$

When length is tripled, the drift velocity becomes one-third.

(*ii*) $R = \rho \frac{l}{A}, \qquad l' = 3l$

New resistance

$$R' = \rho \frac{l'}{A'} = \rho \times \frac{3l}{A/3} = 9R \qquad \Rightarrow \qquad R' = 9R$$

Hence, the new resistance will be 9 times the original.

Q. 9. A potential difference V is applied across the ends of copper wire of length l and diameter D. What is the effect on drift velocity of electrons if [CBSE Ajmer 2015]

(i) V is halved
(ii) l is doubled.
(iii) D is halved.

Ans.

$$\text{Drift velocity, } v_d = \frac{I}{\text{neA}} = \frac{V/R}{\text{neA}} = \frac{V}{\text{neA}\left(\frac{\rho l}{A}\right)} = \frac{V}{\text{ne}\,\rho\, l}$$

i. As $v_d \propto V$, when V is halved the drift velocity is halved.

ii. As $v_d \propto \frac{1}{l}$, when l is doubled the drift velocity is halved.

iii. As v_d is independent of D, when D is halved drift velocity remains unchanged.

Q. 10. Estimate the average drift speed of conduction electrons in a copper wire of cross-sectional area 1.0 × 10^{-7} m^2 carrying a current of 1.5 A. Assume the density of conduction electrons to be 9 × 10^{28} m^{-3}. [CBSE (AI) 2014]

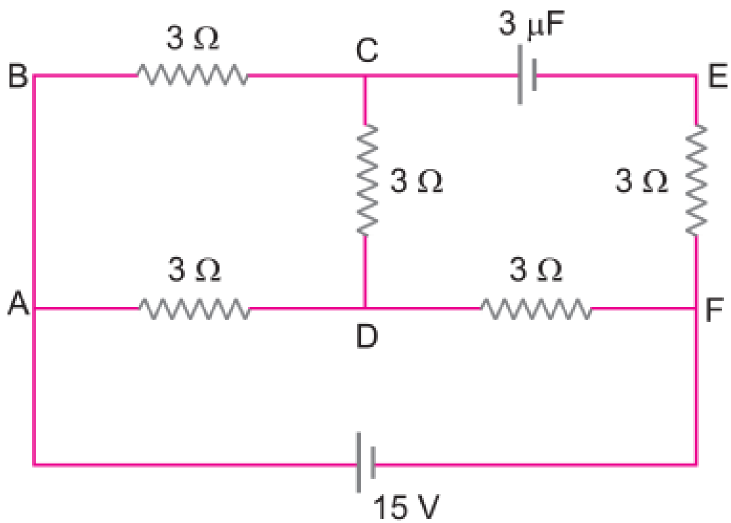
Ans. Flow of current in the conductor due to drift velocity of the free electrons is given by

$I = neAv_d$

$$v_d = \frac{I}{\text{neA}} = \frac{1.5}{9\times10^{28}\times1.6\times10^{-19}\times1.0\times10^{-7}}$$

$$= 1.048\times10^{-3} m/s \simeq 1\,\text{mm}/s$$

Q. 11. In the circuit shown in the figure, find the total resistance of the circuit and the current in the arm CD. [CBSE (F) 2014]



Ans. It can be seen that resistances BC and CD are in series and their combination is in parallel with AD.

$$\text{Then } \frac{1}{R_P} = \frac{1}{6} + \frac{1}{3} \quad \Rightarrow \quad R_P = 2\Omega$$

Total resistance of circuit is 2+ 3 = 5Ω

(Due to capacitor, resistor 3Ω in EF will not be counted)

$$\text{Total current} = \frac{15}{5} = 3A.$$

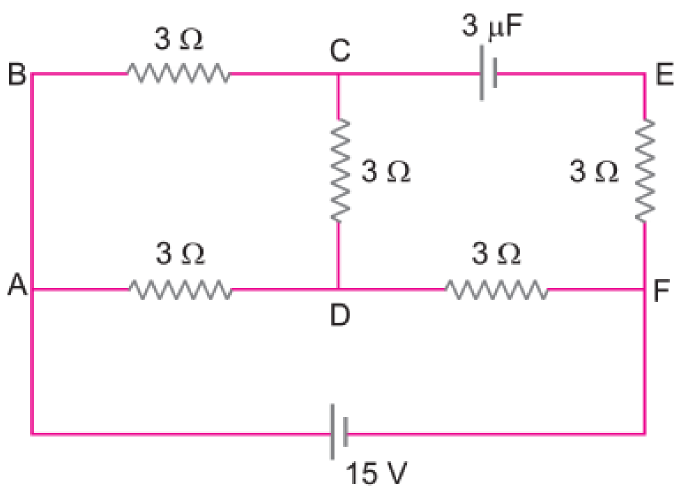
This current gets divided at junction A.

Voltage across DF = 3 Ω × 3 A = 9 V and Voltage across AD = 15 – 9 = 6 V

$$I \text{ across } CD = \frac{6\ V}{3+3} = 1\ A$$

Hence, current through arm CD = 1 A.

Q. 12. Use Kirchhoff's laws to determine the value of current I1 in the given electrical circuit. [CBSE Delhi 2007]



Ans. From Kirchhoff's first law at junction C

$$I_3 = I_1 + I_2 \qquad \text{...(i)}$$

Applying Kirchhoff's second law in mesh CDFEC

$$40I3 – 40 + 20I1 = 0 \text{ or } 20 (2I3 + I1) = 40$$

$$\Rightarrow \qquad I_1 + 2I_3 = 2 \qquad \text{...(ii)}$$

Applying Kirchhoff's second law to mesh ABFEA

$$80 – 20I_2 + 20I_1 = 0$$

$$\Rightarrow \qquad 20 (I_1 – I_2) = – 80$$

$$\Rightarrow \qquad I_2 – I_1 = 4 \qquad \text{...(iii)}$$

Substituting value of I3 from (i) in (ii), we get

$$I_1 + 2(I_1 + I_2) = 2 \quad \Rightarrow \quad 3I_1 + 2I_2 = 2 \qquad \ldots(iv)$$

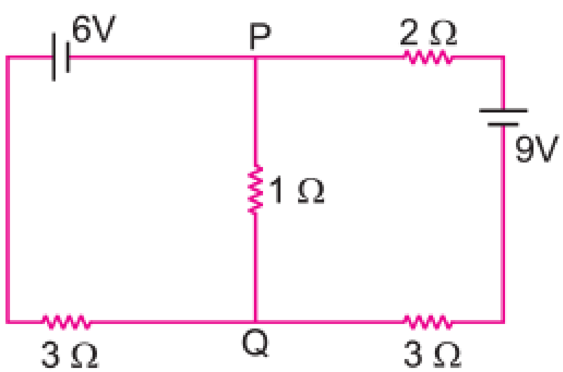
Multiplying equation (iii) by 2, we get

$$2I_2 - 2I_1 = 8 \qquad \ldots(v)$$

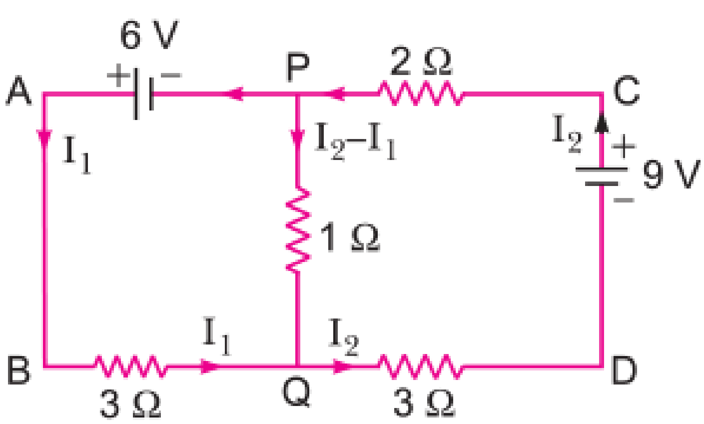
Subtracting (v) from (4), we get

$$5I_1 = -6 \Rightarrow I_1 = -\frac{6}{5}A = -1.2\ A$$

Q. 13. Find the magnitude and direction of current in 1Ω resistor in the given circuit.
[CBSE (South) 2016]



Ans.



For the mesh APQBA

$$-6 - 1(I_2 - I_1) + 3I_1 = 0$$

Or $\quad -I_2 + 4I_1 = 6 \qquad \ldots(1)$

For the mesh PCDQP

$$2I_2 - 9 + 3I_2 + 1(I_2 - I_1) = 0$$

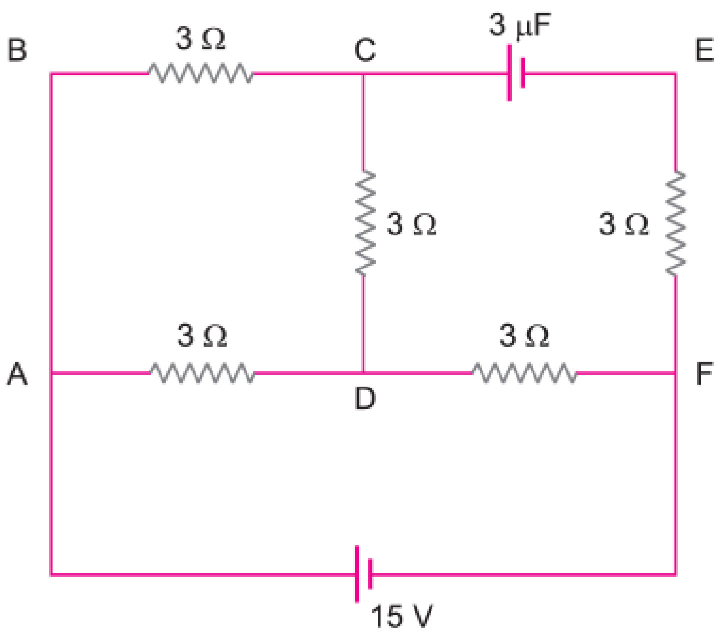
Or $\quad 6I_2 - I_1 = 9 \qquad \ldots(2)$

Solving (1) and (2), we get

$$I_1 = \frac{45}{23} A \qquad \text{and} \qquad I_2 = \frac{42}{23} A$$

$\therefore$ Current through the 1 Ω resistor $= (I_2 - I_1) = \frac{-3}{23} A$

Q. 14. In the circuit shown in the figure, find the total resistance of the circuit and the current in the arm AD. [CBSE (AI) 2014]



Ans. Since BC and CD are in series,

So, R_{BCD} = 3 Ω + 3 Ω = 6 Ω

Also AD is parallel with the combination of BC and CD.

$$\therefore \quad \frac{1}{Rp} = \frac{1}{6} + \frac{1}{3} = \frac{6+3}{6 \times 3}$$

$$R_p = 2\ \Omega$$

Then DF is in series,

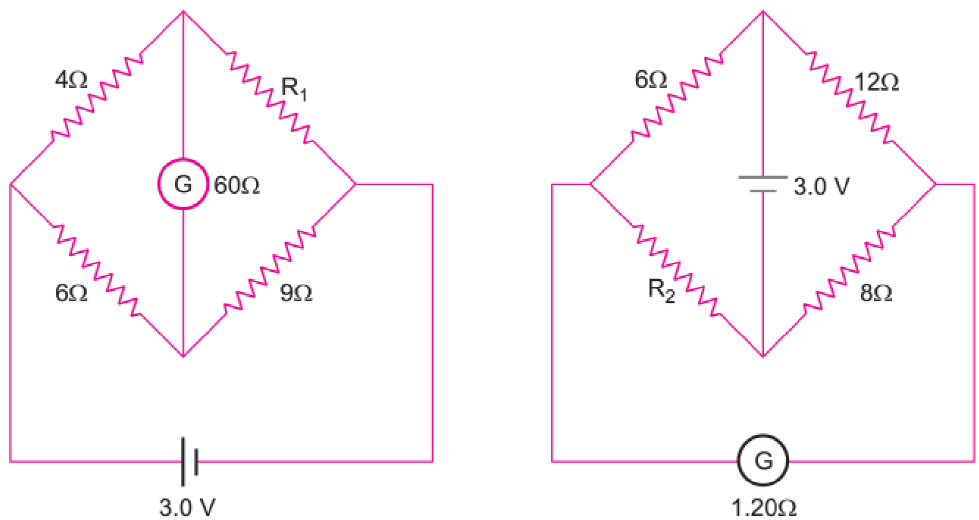
$$R_{eq} = 2 + 3 = 5\ \Omega$$

Net current $I = \frac{V}{R_{eq}} = \frac{15}{5} = 3A$

$$\therefore \quad I_{AD} = 2\text{A}.$$

Q. 15. Figure shows two circuits each having a galvanometer and a battery of 3 V. When the galvanometers in each arrangement do not show any deflection, obtain the ratio $\frac{R_1}{R_2}$. [CBSE (AI) 2013]

Ans.



Ans. For balanced Wheatstone bridge, if no current flows through the galvanometer

$$\frac{4}{R_1} = \frac{6}{9}$$

$$\Rightarrow \qquad R_1 = \frac{4\times9}{6} = 6\,\Omega$$

For another current

$$\frac{6}{12} = \frac{R_2}{8} \quad \Rightarrow \quad R_2 = \frac{6\times8}{12} = 4\,\Omega$$

$$\therefore \qquad \frac{R_1}{R_2} = \frac{6}{4} = \frac{3}{2}$$

Q. 16. A potentiometer wire of length 1 m has a resistance of 10 Ω. It is connected to a 6 V battery in series with a resistance of 5Ω. Determine the emf of the primary cell which gives a balance point at 40 cm. [CBSE Delhi 2014]

Ans. Here, l = 1m, R_1 = 10, V = 6V, R_2 = 5Ω

Current flowing in potentiometer wire,

$$I = \frac{V}{R_1+R_2} = \frac{6}{10+5} = \frac{6}{15} = 0.4\,A$$

Potential drop across the potentiometer wire

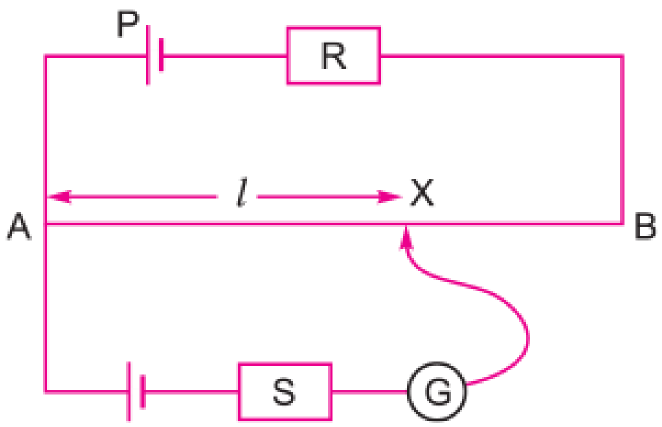
$V' = IR = 0.4 \times 10 = 4V$

Potential gradient, $K = \frac{V'}{l} = \frac{4}{1} = 4V/m$

Emf of the primary cell = $KI = 4 \times 0.4 = 1.6$ V

Q. 17. In the potentiometer circuit shown, the null point is at X. State with reason, where the balance point will be shifted when:

(a) Resistance R is increased, keeping all other parameters unchanged;
(b) Resistance S is increased, keeping R constant. [CBSE Bhubaneshwar 2015]



Ans. Let l be the balance length of the segment AX on the potentiometer wire for given resistance R and S.

(a) If resistance R is increased, the current flow in the main circuit (or wire AB) will decrease. From relation K = $\frac{\rho I}{L}$ the potential gradient along the wire AB will decrease. To balance the emf of the cell, the point X will shift toward the point B, i.e.,

$$\varepsilon = kl = k'l'$$

If $k' < k$, so $\quad l' > l$

(b) For the given resistance R, the potential gradient along the wire remain same. Balance length 'l' remain constant. $\varepsilon = kl$

And no current flows in the resistance S. If resistance S is increased/decreased there is no change in the balance length.

Q. 18. State the underlying principle of a potentiometer. Write two factors by which current sensitivity of a potentiometer can be increased. Why is a potentiometer preferred over a voltmeter for measuring the emf of a cell? [CBSE Patna 2015]

Ans. Principle: The potential drop across a part of the potentiometer wire is directly proportional to the length of that part of the wire of uniform cross section.

$$V = kl$$

Where k is potential gradient.

Current sensitivity of potentiometer wire is also known as potential gradient, and it can be increased.

(i) By increasing the total length of the wire, keeping terminal voltage constant.

(ii) By connecting a suitable extra resistance R in series with the potentiometer. So, less amount of the current flows through the potentiometer wire.

Reasons: At the balance point, there is no net current drawn from the cell, and cell is in open circuit condition. Voltmeter has some resistance, when connected across the cell. Some current is drawn, as a result emf of the cell decreases. Hence, emf of the cell cannot be measured by the voltmeter.

Q. 19. Answer the following:

(i) Why are the connections between the resistors in a meter bridge made of thick copper strips?

(ii) Why is it generally preferred to obtain the balance point in the middle of the meter bridge wire?

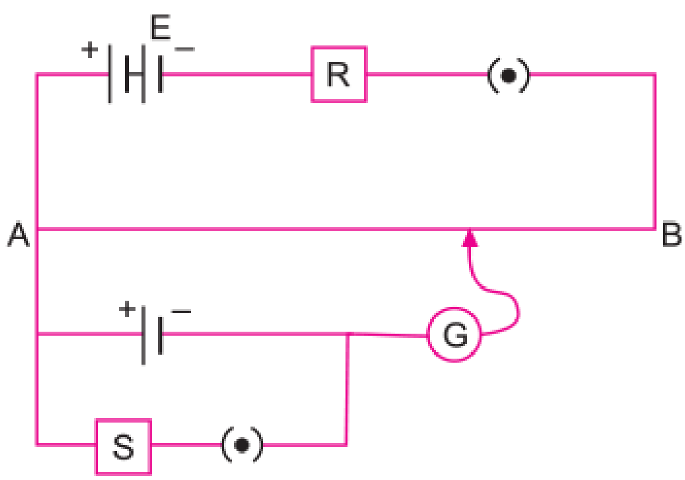
(iii) Which material is used for the meter bridge wire and why?
[CBSE (AI) 2014] [HOTS]

Ans. (i) A thick copper strip offers a negligible resistance, so does not alter the value of resistances used in the meter bridge.

(ii) If the balance point is taken in the middle, it is done to minimise the percentage error in calculating the value of unknown resistance.

(iii) Generally alloys magnin/constantan/nichrome are used in Meter Bridge, because these materials have low temperature coefficient of resistivity.

Q. 20. Two students X and Y perform an experiment on potentiometer separately using the circuit diagram shown here. Keeping other things unchanged (i) X increases the value of resistance R. (ii) Y decreases the value of resistance S in the set up. How would these changes affect the position of the null point in each case and why?
[CBSE (South) 2016] [HOTS]

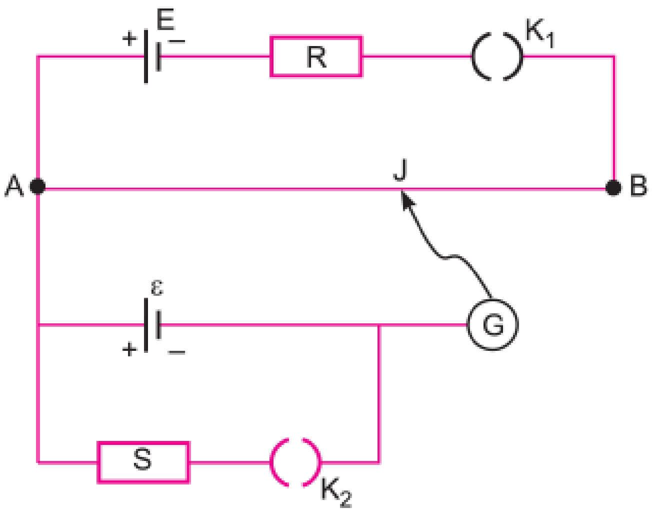


Ans. (i) By increasing resistance R, the current in main circuit decreases, so potential gradient decreases. Hence a greater length of wire would be needed for balancing the same potential difference. So, the null point would shift towards right (i.e., towards B).

(ii) By decreasing resistance S, the terminal potential difference V = ε – Ir, where I = $\frac{\varepsilon}{(r + S)}$ $V = \frac{\varepsilon}{1+\frac{r}{S}}$ across cell decreases, so balance is obtained at small length i.e., point will be obtained at smaller length. So, the null point would shift towards left (i.e., towards A).

Q. 21. Two students 'X' and 'Y' perform an experiment on potentiometer separately using the circuit given.

Keeping other parameters unchanged, how will the position of the null point be affected if



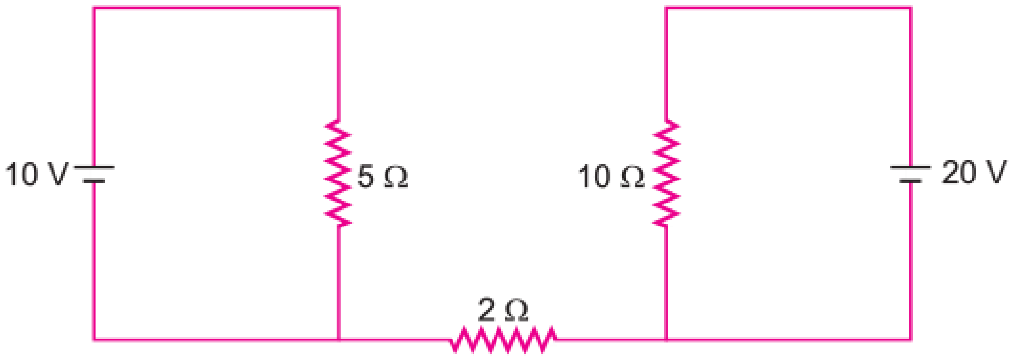
(i) 'X' increases the value of resistance R in the set-up by keeping the key K1 closed and the key K2 open?

(ii) 'Y' decreases the value of resistance S in the set-up, while the key K2 remain open and the key K1 closed? Justify your answer in each case. [CBSE (F) 2012] [HOTS]

Ans. (i) By increasing resistance R the current through AB decreases, so potential gradient decreases. Hence a greater length of wire would be needed for balancing the same potential difference. So the null point would shift towards B.

(ii) By decreasing resistance S, the current through AB remains the same, potential gradient does not change. As K_2 is open so there is no effect of S on null point.

Q. 22. What will be the value of current through the 2Ω resistance for the circuit shown in the figure? Give reason to support your answer. [CBSE (F) 2013] [HOTS]

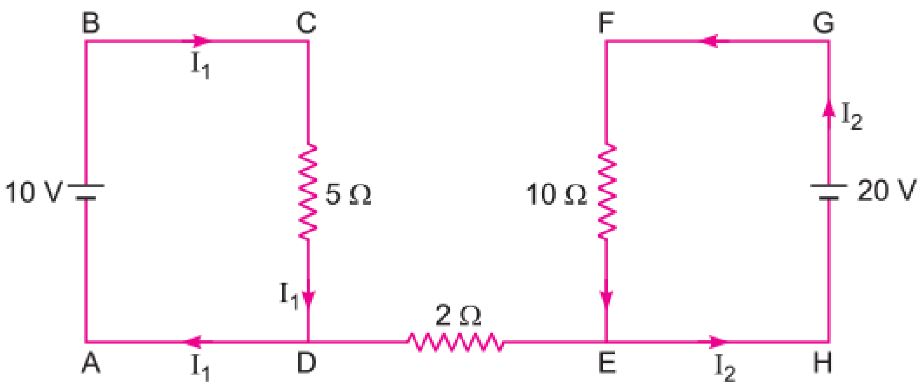


Ans. No current will flow through 2Ω resistor, because in a closed loop, total p.d. must be zero. So

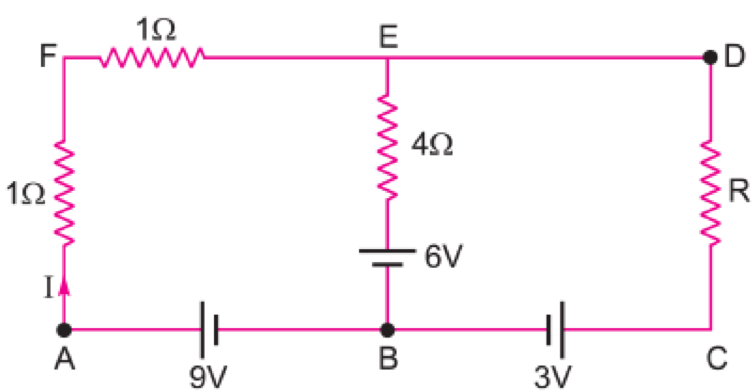
$$10V - 5I_1 = 0 \quad ...(1)$$

$$20V - 10I_2 = 0 \quad ...(2)$$

And resistor 2Ω is not part of any loop ABCD and EFGH



Q. 23. Using Kirchoff's rules determine the value of unknown resistance R in the circuit so that no current flows through 4Ω resistance. Also find the potential difference between A and D. [CBSE Delhi 2012] [HOTS]



Ans. Applying Kirchhoff's loop rule for loop ABEFA,

$$-9 + 6 + 4 \times 0 + 2I = 0$$

$I = 1.5$ A ...(i)

For loop BCDEB

$3 + IR + 4 \times 0 - 6 = 0$

$\therefore$ $IR = 3$

Putting the value of I from (i) we have

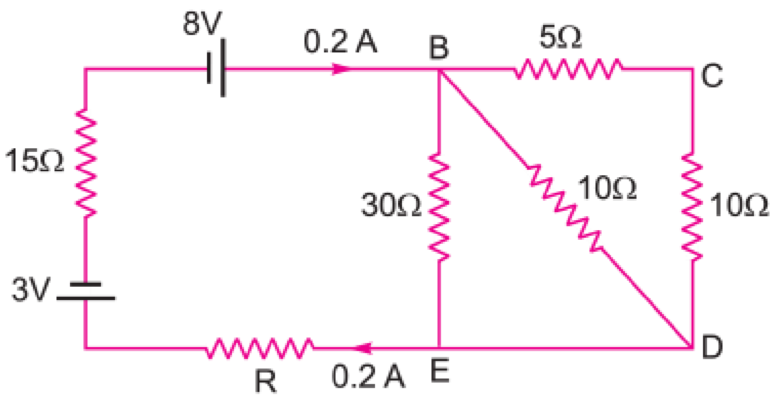
$$\frac{3}{2} \times R = 3 \quad \Rightarrow \quad R = 2\Omega$$

Potential difference between A and D through path $ABCD$

$$9 - 3 - IR = V_{AD}$$

or $$9 - 3 - \frac{3}{2} \times 2 = V_{AD} \quad \Rightarrow \quad V_{AD} = 3V$$

Q. 24. Calculate the value of the resistance R in the circuit shown in the figure so that the current in the circuit is 0.2 A. What would be the potential difference between points B and E? [CBSE (AI) 2012] [HOTS]



Ans.

Here, $R_{BCD} = 5\Omega + 10\Omega = 15\ \Omega$

Effective resistance between B and E

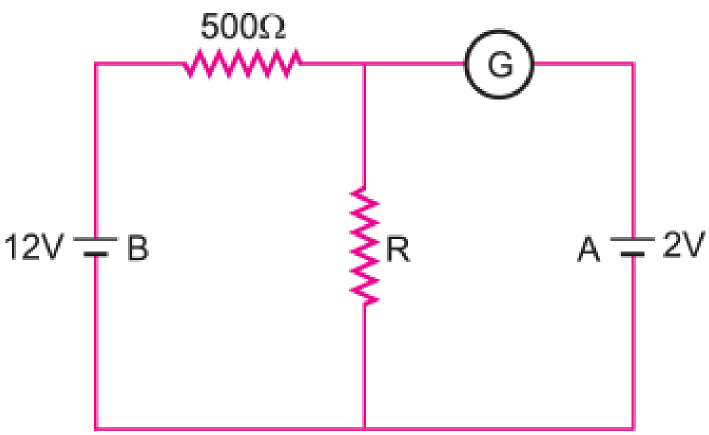
$$\frac{1}{R_{BE}} = \frac{1}{30} + \frac{1}{10} + \frac{1}{15} \quad \Rightarrow \quad R_{BE} = 5\Omega$$

Applying Kirchhoff's Law

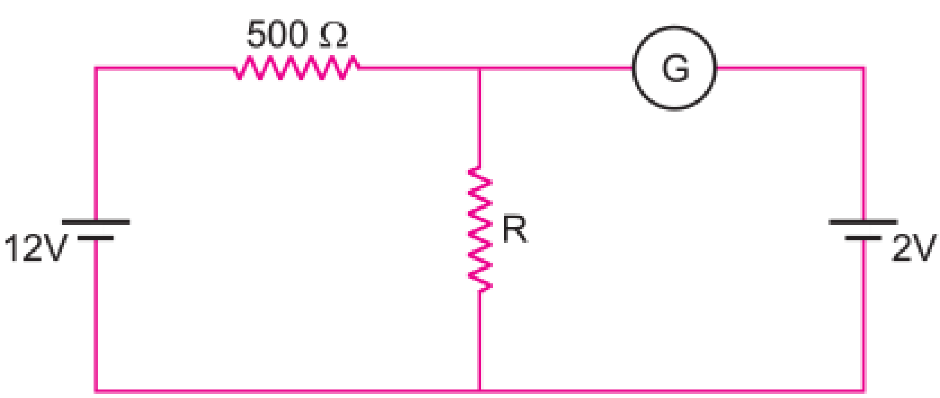
$$5 \times 0.2 + R \times 0.2 + 15 \times 0.2 = 8 - 3 \quad \Rightarrow \quad R = 5\ \Omega$$

Hence, $V_{BE} = IR_{BE} = 0.2 \times 5 = 1$ volt

Q. 25. In the circuit shown in the figure, the galvanometer 'G' gives zero deflection. If the batteries A and B have negligible internal resistance, find the value of the resistor R. [CBSE (F) 2013] [HOTS]



Ans. If galvanometer G gives zero deflection, than current of source of 12 V flows through R, and voltage across R becomes 2 V.



Current in the circuit $I = \frac{\varepsilon}{R_1 + R_2} = \frac{12}{500 + R}$

and $V = IR = 2$

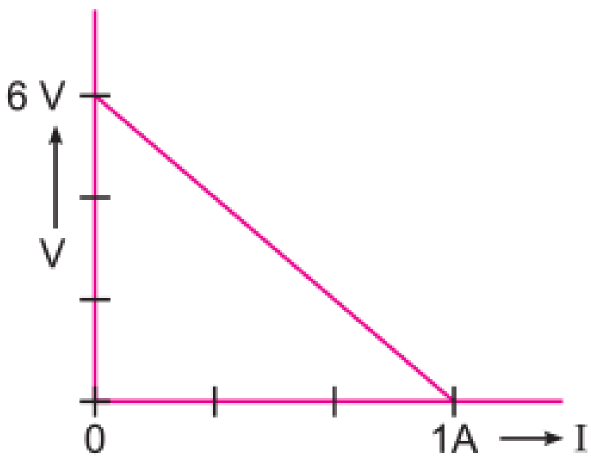
$$\left(\frac{12.0\ V}{500\ +\ R}\right) R = 2$$

$$12R = 1000 + 2R$$

$$10R = 1000$$

$\Rightarrow$ $R = 100\ \Omega$

Q. 26. The plot of the variation of potential difference across a combination of three identical cells in series, versus current is shown alongside. What is the emf and internal resistance of each cell? [CBSE (Central) 2016] [HOTS]



Ans.

We know that for a circuit

$$V = E_{eq} - Ir_{eq} \quad ...(i)$$

From graph, when $I = 0$ A, then $V = 6$ V and when $I = 1$ A then $V = 0$ V

Putting, $V = 6$ V and $I = 0$ A in eq. (i)

$$6 = E_{eq} - 0.\, r_{eq} \quad \Rightarrow \quad E_{eq} = 6\text{ V}$$

$$E_{eq} = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 \quad \Rightarrow \quad \varepsilon_1 = \varepsilon_2 = \varepsilon_3 = \varepsilon = \frac{E}{3} = 2\text{ V}$$

And, when $I = 1$ A, and $V = 0$ V

$$0 = 6 - 1.\, r_{eq} \quad \Rightarrow \quad r_{eq} = 6\ \Omega$$

$$r_{eq} = r_1 + r_2 + r_3 \Rightarrow \quad r_1 = r_2 = r_3 = r = \frac{R}{3} = 2\text{ ohm}$$

Short Answer Questions – I (OIQ)

Q. 1. Write the mathematical relation between mobility and drift velocity of charge carriers in a conductor. Name the mobile charge carriers responsible for conduction of electric current in (i) an electrolyte (ii) an ionised gas.

Ans. The mathematical relation between mobility and drift velocity of charge carriers in a conductor is given by

$$\mu = \frac{|v_d|}{E} = \frac{\text{magnitude of the drift velocity}}{\text{electric field}}$$

(i) In an electrolyte, the mobile charge carriers are both positive and negative ions.

(ii) In an ionised gas, the mobile charge carriers are electrons and positive ions.

Q. 2. Name the charge carriers of electric current in

(i) Silver foil
(ii) Hydrogen discharge tube
(iii) Germanium semiconductor
(iv) Wire made of alloy nichrome
(v) Superconductor

Ans. (i) Charge carriers in silver foil are **free electrons.**

(ii) Charge carriers in hydrogen discharge tube are **electrons** (e–) and **positive hydrogen ions** (H+).

(iii) Charge carriers in germanium semiconductor are **electrons** (e–) and **holes** (o+)

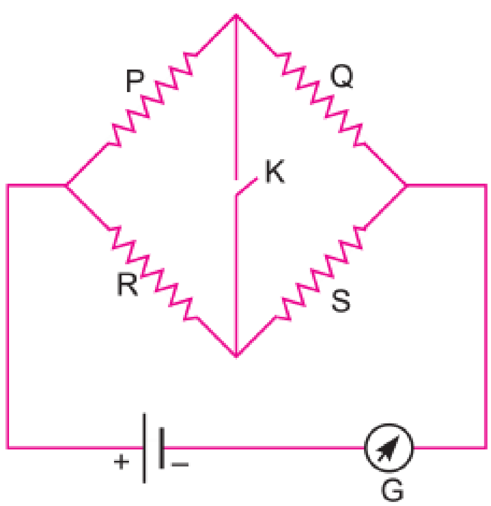
(iv) Charge carriers in nichrome wire are **electrons.**

(v) Charge carriers in superconductor are **electrons.**

Q. 3. Electrons are continuously in motion within a conductor but there is no current in it unless some source of potential is applied across its ends. Give reason.

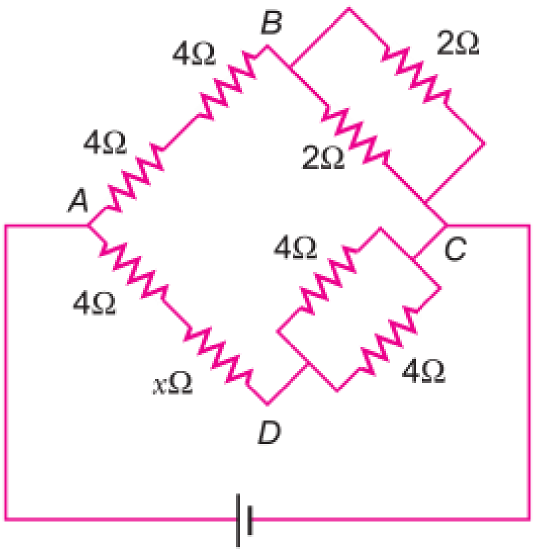
Ans. In the absence of any external source the motion of electrons in a conductor is random and electrons collide continuously with the positive ions of metal. This causes a random change in direction of motion. The average velocity of random motion of electrons in any direction is zero, hence current is zero.

Q. 4. In a Wheatstone's bridge experiment, a student by mistake, connects key (K) in place of galvanometer and galvanometer (G) in place of key (K). What will be the test for the balance of the bridge?



Ans. When the bridge is balanced, there will be no current in key, therefore a constant current will flow in the galvanometer. In balanced position, there will be a constant deflection in galvanometer and hence no change in its deflection on pressing the key.

Q. 5. The given circuit represents a balanced Wheatstone's bridge. Calculate the value of resistance x.



Ans. In the balanced condition,

$$\frac{P}{Q} = \frac{R}{S}$$

$$\therefore \qquad \frac{4+4}{1} = \frac{4+x}{2} \quad \Rightarrow \quad x = 12\Omega$$

Q. 6. Why is Wheatstone bridge (Metre Bridge) method not suitable for measurement of very low and very high resistances?

Ans. Because, in order to ensure sensitivity of the bridge, all other resistances used should either have low value or very high value. This also requires a galvanometer of very low resistance or very high resistance and introduces error in the results.

Q. 7. Two electric bulbs have the following specifications.

(i) 100 W at 220 V
(ii) 1000 W at 220 V.

Which bulb has higher resistance? What is the ratio of their resistances?

Ans. The resistance of filament,

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

At constant voltage V, the resistance

$$R \propto \frac{1}{P}$$

That is the resistance of filament of 100 W bulb is greater than that of 1000 W bulb.

$$\text{The ratio of resistances} = \frac{R_1}{R_2} = \frac{P_2}{P_1} = \frac{1000}{100} = \frac{10}{1} = 10 : 1$$

Q. 8. Two heated wires of the same dimensions are first connected in series and then in parallel to a source of supply. What will be the ratio of heat produced in the two cases?

Ans.

$$Q = \frac{V^2}{R} t \propto \frac{1}{R}$$

For same voltage

$$\frac{Q_{\text{series}}}{Q_{\text{parallel}}} = \frac{R_{\text{parallel}}}{R_{\text{series}}} = \frac{(R.R)/(R+R)}{R+R} = \frac{R/2}{2R} = \frac{1}{4}$$

Q. 9. A heater coil is cut in two parts and only one of them is used in the heater. What is the ratio of the heat produced by this half coil to that by the original coil if the voltage applied is the same?

Ans. For same p.d. the heat produced per second

$$H = \frac{V^2}{R} \propto \frac{1}{R}.$$

As the one part of heater coil has resistance R_2=R/2 being the resistance of original coil; therefore the ratio of heat produced

$$\frac{H_2}{H_1} = \frac{R_1}{R_2} = \frac{R}{R/2} = 2 : 1$$

Q. 10. Two wires A and B of the same material and having same length, have their cross sectional areas in the ratio 1 : 6. What would be the ratio of heat produced in these wires when same voltage is applied across each? [CBSE Sample Paper 2017]

Ans.

$A_A : A_B = 1 : 6$

$H = V^2 t/R$ and $R = \frac{\rho l}{A}$

$H_A = \frac{V^2 t}{\rho l/A_A}$; $H_B = \frac{V^2 t}{\rho l/A_B}$

$= \frac{H_A}{H_B} = \frac{V^2 t \times A_A}{\rho l} \times \frac{\rho l}{V^2\, \mathrm{t} A_B} \Rightarrow \frac{H_A}{H_B} = \frac{A_A}{A_B} = 1{:}6$

Q. 11. A (i) series (ii) parallel combination of two given resistors is connected, one by one, across a cell. In which case will the terminal potential difference, across the cell have a higher value?

Ans. Terminal potential difference across a cell

$V = \varepsilon - Ir$

i. In series arrangement, current, $I_S = \frac{E}{R_1 + R_2 + r}$

ii. In parallel arrangement, current, $I_P = \frac{E}{\frac{R_1 R_2}{R_1 + R_2} + r}$

Obviously, $I_P > I_S$, so $V_P < V_S$

That is **series arrangement will have higher terminal potential difference.**

Q. 12. A voltage of 30 V is applied across a carbon resistor with first, second and third rings of blue, black and yellow colours respectively. Calculate the value of current in mA, through the resistor.

Ans. Value of first digit (blue ring) = 6

Value of second digit (black ring) = 0

Multiplier (yellow ring) = 10^4

∴ Resistance, $R = 60 \times 10^4\ \Omega$, Voltage, $V = 30$ V

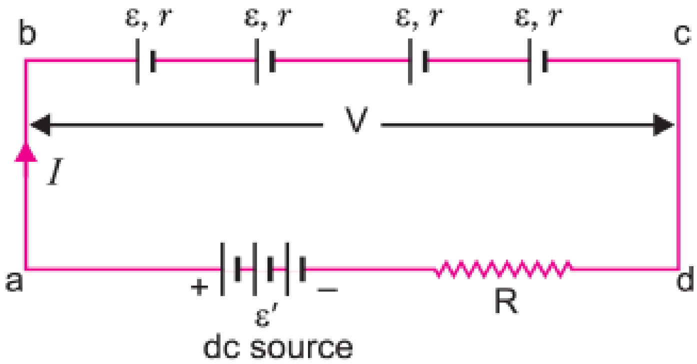
$$\text{Current } I = \frac{V}{R} = \frac{30}{60 \times 10^4} = 0.5 \times 10^{-4}\ A = 0.05\ \text{mA}.$$

Q. 13. n-identical cells, each of emf ε, internal resistance r connected in series are charged by a dc source of emf ε' using a resistance R.

(i) Draw the circuit arrangement.

(ii) Deduce expressions for (a) the charging current and (b) the potential difference across the combination of cells.

Ans. The circuit arrangement is shown in figure.



Applying Kirchhoff's second law to the circuit abcda

$-n\varepsilon - I(nr) - IR + \varepsilon' = 0$

$$\Rightarrow \qquad I = \frac{\varepsilon' - n\varepsilon}{R + nr}$$

(a) Charging current, $I = \dfrac{\varepsilon' - n\varepsilon}{R + nr}$ ...(i)

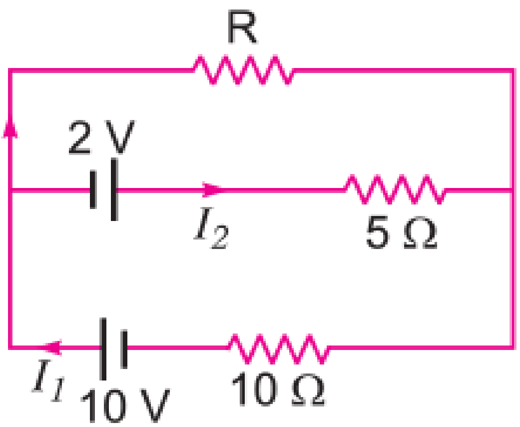
(b) Potential difference across the combination V is given by

$$-V - IR + \varepsilon' = 0$$

$$\Rightarrow \quad V = \varepsilon' - IR \qquad \Rightarrow \quad V = \varepsilon' - \frac{(\varepsilon' - n\varepsilon)}{R + nr}$$

$$\Rightarrow \quad V = \frac{\varepsilon'(R + nr) - \varepsilon' + n\varepsilon}{R + nr} \qquad \Rightarrow \quad V = \frac{\varepsilon'(R + nr - 1) + n\varepsilon}{R + nr}$$

Q. 14. Two cells of emf 10 V and 2 V and internal resistance 10 Ω and 5Ω respectively, are connected in parallel as shown. Find the effective voltage across R.
[CBSE Sample Paper 2016]

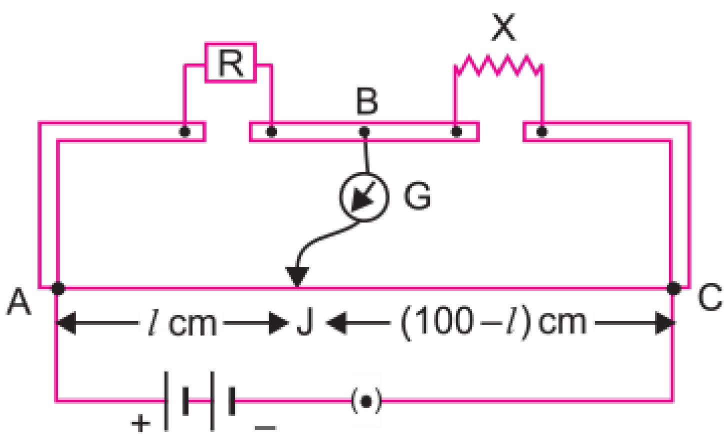


Ans.

The effective voltage across R is given by $\varepsilon_{eq} = \dfrac{\left(\frac{\varepsilon_1}{r_1}+\frac{\varepsilon_2}{r_2}\right)}{\left(\frac{1}{r_1}+\frac{1}{r_2}\right)} = \dfrac{\left(\frac{10}{10}-\frac{2}{5}\right)}{\left(\frac{1}{10}+\frac{1}{5}\right)}$

$\Rightarrow \qquad \varepsilon_{eq} = 2\text{ V}$

Q. 15. A resistance R = 4Ω is connected to one of the gaps in a meter bridge, which uses a wire of length 1 m. An unknown resistance X > 4Ω is connected in the other gap as shown in the figure. The balance point is noticed at 'l' cm from the positive end of the battery. On interchanging R and X, it is found that the balance point further shifts by 20 cm (away from the end A). Neglecting the end correction calculate the value of unknown resistance 'X' used.



Ans.

From 'meter bridge' formula

$$\frac{R}{X} = \frac{l}{100 - l} \quad \Rightarrow \quad X = \frac{100 - l}{l} R$$

Given $R = 4\Omega$

$$\therefore \qquad X = \frac{(100 - l)}{l} \times 4\Omega \qquad \ldots(i)$$

On interchanging R and X, the balance point is obtained at a distance $(l+20)$ cm from end A, so

$$\frac{X}{R} = \frac{l+20}{100 - (l+20)} \quad \Rightarrow \quad X = \frac{l+20}{80 - l} \times 4\Omega \qquad \ldots(ii)$$

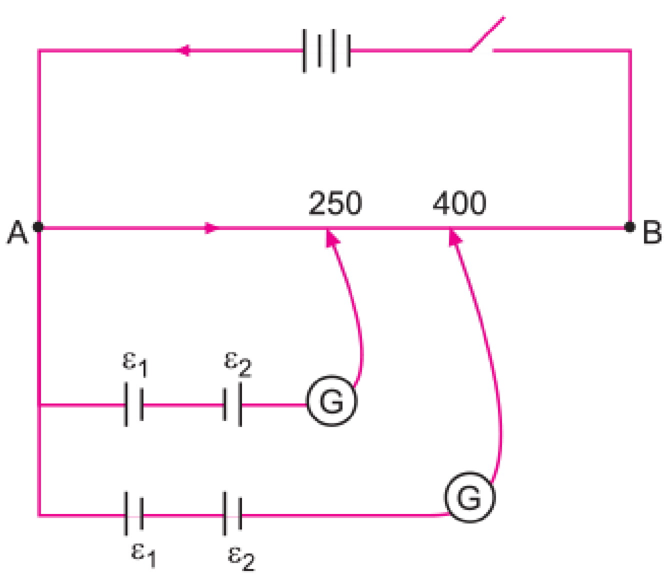
Equating (i) and (ii)

$$\frac{(100 - l)}{l} \times 4 = \frac{l+20}{80 - l} \times 4$$

Solving we get $l = 40$ cm

$$\therefore \quad \text{Unknown resistance, } X = \frac{100 - l}{l} \times 4\Omega = \frac{100 - 40}{40} \times 4\Omega \quad \Rightarrow \quad X = 6\Omega$$

Q. 16. Two primary cells of emfs wire ε_1 and ε_2 ($\varepsilon_1 > \varepsilon_2$) are connected to a potentiometer wire AB as shown in fig. If the balancing lengths for the two combinations of the cells are 250 cm and 400 cm, find the ratio of ε_1 and ε_2.



Ans. In first combination ε_1 and ε_2 are opposing each other while in second combination ε_1 and ε_2 are adding each other, so

$$\varepsilon_1 - \varepsilon_2 = kl_1$$

$$\varepsilon_1 + \varepsilon_2 = kl_2$$

$$\frac{\varepsilon_1 - \varepsilon_2}{\varepsilon_1 + \varepsilon_2} = \frac{l_1}{l_2}$$

$$\Rightarrow \quad \frac{\varepsilon_1 - \varepsilon_2}{\varepsilon_1 + \varepsilon_2} = \frac{250}{400} \quad \Rightarrow \quad \frac{\varepsilon_1 - \varepsilon_2}{\varepsilon_1 + \varepsilon_2} = \frac{5}{8}$$

$$\Rightarrow \quad 8\varepsilon_1 - 8\varepsilon_2 = 5\varepsilon_1 + 5\varepsilon_2 \Rightarrow 3\varepsilon_1 = 13\varepsilon_2$$

$$\therefore \quad \frac{\varepsilon_1}{\varepsilon_2} = \frac{13}{3} \quad \therefore \quad \varepsilon_1 : \varepsilon_2 = 13 : 3$$

Q. 17. A cylindrical metallic wire is stretched to increase its length by 10%. Calculate the percentage increase in its resistance. [HOTS]

Ans. When the same wire is stretched, its length increases but cross-sectional area decreases. The change in resistance is due to both increase in length and decrease in cross-sectional area.

Volume $V = lA =$ constant, $A = \frac{V}{l} =$ constant

$$\therefore \quad R = \frac{\rho l}{A} = \frac{\rho l^2}{V} \propto l^2$$

$$\therefore \quad \frac{R'}{R} = \left(\frac{l'}{l}\right)^2$$

Given $\quad l' = l + \frac{10}{100}l = 1.1\,l \quad \Rightarrow \quad \frac{l'}{l} = 1.1$

$$\frac{R'}{R} = (1.1)^2 = 1.21$$

% increase in resistance

$$\frac{R' - R}{R} \times 100\% = \left(\frac{R'}{R} - 1\right) \times 100\% = (1.21 - 1) \times 100\% = 21\%$$

Q. 18. You are given n resistors each of resistance r. They are first connected to get the minimum possible resistance. In the second case, these are again connected differently to get the maximum possible resistance. Calculate the ratio between minimum and maximum values of resistance so obtained. [HOTS]

Ans. For minimum possible resistance, the resistors should be connected in parallel

$$\frac{1}{r_P} = \frac{1}{r} + \frac{1}{r} + \ldots .\ n \text{ times}$$

or $$\frac{1}{r_P} = \frac{n}{r}$$

or $$r_P = \frac{r}{n}$$

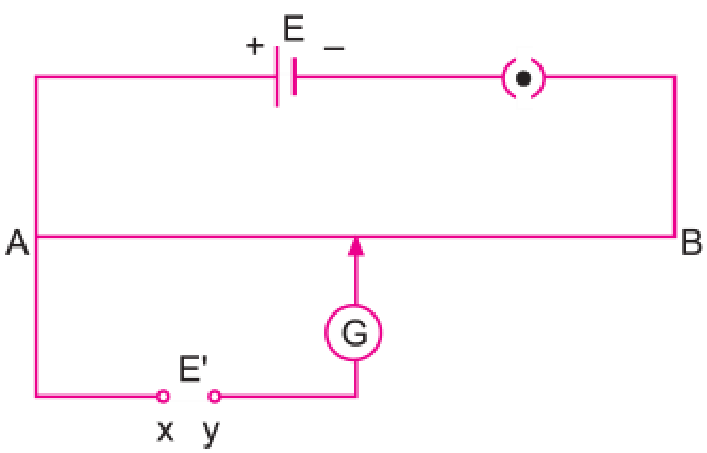
For maximum possible resistance, the resistors should be connected in series

$$r_s = r + r + \ldots\ldots..\ n \text{ times}$$

or $$r_s = nr$$

$$\text{Ratio } \frac{r_P}{r_s} = \frac{r}{n} \times \frac{1}{\text{nr}} = \frac{1}{n^2}$$

Q. 19. For the potentiometer circuit shown in the given figure, points X and Y represent the two terminals of an unknown emf E'. A student observed that when the jockey is moved from the end A to the end B of the potentiometer wire, the deflection in the galvanometer remains in the same direction.



What may be the two possible faults in the circuit that could result in this observation?

If the galvanometer deflection at the end B is (i) more, (ii) less than at the end A, which of the two faults, listed above, would be there in the circuit? Give reason in support of your answer in each case. [HOTS]

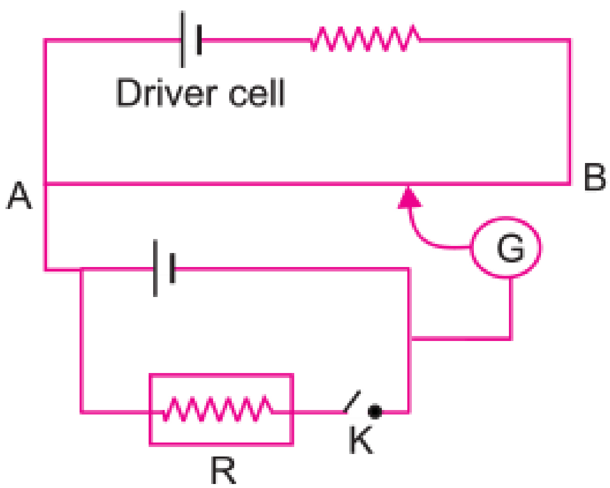
Ans. The two possible faults in the circuit may be (i) emf E′ is greater than emf E.

(ii) Terminal X of unknown emf is negative (while it should be positive).

If galvanometer deflection at end B is more than that at end A, then terminal X is negative, because in this case net current in galvanometer along AB due to both cells is additive.

If galvanometer deflection at end B is less than that at end A, then E′> E, because net current in galvanometer due to both cells' emfs E and E′ is subtractive.

Q. 20. The following circuit shows the use of potentiometer to measure the internal resistance of a cell



(i) When the key is open, how does the balance point change, if the current from the driver cell decreases?

(ii) When the key K is closed, how does the balance point change if R is increased keeping current from the driver cell constant? [HOTS]

Ans. (i) When current through driver cell decreases, the potential gradient across potentiometer wire decreases; so the balancing length $l = \frac{E}{k}$ increases, so balance point is shifted to the right.

(ii) With increase of R, the terminal p.d. across cell E increases and hence balancing length l = $\frac{V}{k} \propto V$ increases. So the balance point is shifted to the right.

Q. 21. First a set of n equal resistors of R each are connected in series to a battery of emf E and internal resistance R. A current I is observed to flow. Then the n resistors are connected in parallel to the same battery. It is observed that the current is increased 10 times. What is n? [NCERT Exemplar] [HOTS]

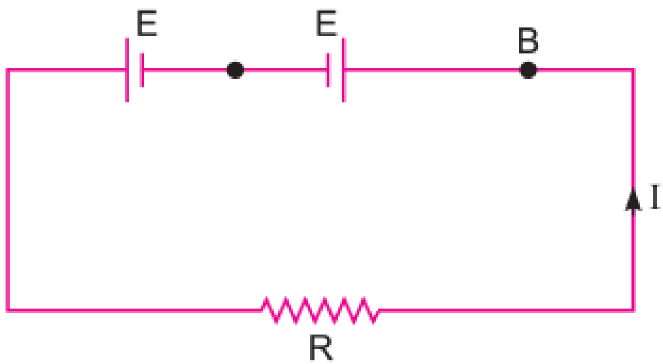
Ans.

When n resistors are in series, $I = \frac{E}{R+nR}$;

When n resistors are in parallel, $\frac{E}{R + \frac{R}{n}} = 10I$

$$\frac{1+n}{1+\frac{1}{n}} = 10 \Rightarrow \frac{1+n}{n+1}n = 10 \quad \Rightarrow \quad n = 10.$$

Q. 22. Two cells of same emf E but internal resistance r1 and r2 are connected in series to an external resistor R (Fig.). What should be the value of R so that the potential difference across the terminals of the first cell becomes zero. [NCERT Exemplar] [HOTS]



Ans.

$$I = \frac{E+E}{R+r_1+r_2}$$

$$V_1 = E - Ir_1 = E - \frac{2E}{r_1+r_2+R} r_1 = 0$$

or $$E = \frac{2\,Er_1}{r_1+r_2+R}$$

$\Rightarrow$ $r_1 + r_2 + R = 2r_1$ $\Rightarrow$ $R = r_1 - r_2$

Q. 23. Calculate the temperature at which the resistance of a conductor becomes 20% more than its resistance at 27°C. The value of the temperature coefficient of resistance of the conductor is 2.0 × 10^{-4}/K. [HOTS]

Ans.

Given $R_{27} = R$ (say), $R_T = R + \frac{20}{100} R = 1.2R$, $T_1 = 27 + 273 = 300\ K$

From relation,

$$R_T = R_{27}\left[1 + \alpha\left(T_2 - 300\right)\right]$$

$\Rightarrow$ $$1.2R = R\left[1 + 2.0 \times 10^{-4}\left(T_2 - 300\right)\right]$$

$\Rightarrow$ $$1 + 2.0 \times 10^{-4}\left(T_2 - 300\right) = 1.2$$

or $$2.0 \times 10^{-4}\left(T_2 - 300\right) = 0.2$$

$$T_2 - 300 = \frac{0.2}{2.0 \times 10^{-4}}$$

$$T_2 = 1000 + 300 = \mathbf{1300\ K}$$

Q. 24. The potential difference across a resistor ‘r’ carrying current ‘I’ is Ir.

(i) Now if the potential difference across ‘r’ is measured using a voltmeter of resistance ‘RV’, show that the reading of voltmeter is less than the true value.

(ii) Find the percentage error in measuring the potential difference by a voltmeter.

(iii) At what value of RV, does the voltmeter measures the true potential difference?
[CBSE Sample Paper 2016] [HOTS]

Ans. (i)

$$V = Ir \text{ (without voltmeter } R_V\text{)}$$

$$V' = \frac{\mathrm{IrR}_V}{r+R_V} = \frac{\mathrm{Ir}}{1+\frac{r}{R_V}}$$

$$V' < V$$

(ii)

Percentage error

$$\left(\frac{V - V'}{V}\right) \times 100 = \left(\frac{r}{r+R_V}\right) \times 100$$

(iii) $R_V \to \infty,\ V' = Ir = V$