Exercise-1

Marked Questions can be used as Revision Questions.

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Definition of Current, Current densities & Drift velocities

A-1. The current through a wire depends on time as $i = i_0 + \alpha \sin \pi t$, where $i_0 = 10$ A and $\alpha = \frac{\pi}{2}$ A. Find the charge crossed through a section of the wire in 3 seconds, and average current for that interval.

A-2. 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 that each copper atom contributes roughly one conduction electron. The density of copper is 9.0×10^3 kg m^{-3} and its atomic mass is 63.5 amu.

A-3. A current of 5 A exists in a 10 Ω resistance for 4 minutes.
(i) How many coulombs and
(ii) How many electrons pass through any cross section of the resistor in this time?
Charge of the electron = 1.6×10^{-19} C.

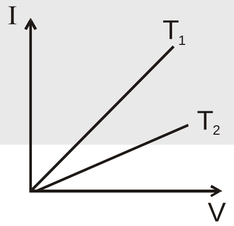
Section (B) : Resistance

B-1. A cyllindrical conducting wire of radius 0.2 mm is carrying a current of 20 mA.
(a) How many electrons are transferred per second between the supply and the wire at one end?
(b) Write down the current density in the wire.

B-2. A battery sets up an electric field of 25 N/C inside a uniform wire of length 2 m and a resistance of 5 Ω. Find current through the wire.

B-3. (i) A potential difference of 200 volt is applied to a coil at a temperature of 15ºC and the current is 10 A. What will be the temperature of the coil when the current has fallen to 9 A, the applied voltage being the same as before? Temperature coefficient of resistance $(\alpha) = \frac{1}{234}$ ºC^{-1}.
(ii) A platinum wire has resistance of 10 ohm at 0ºC and 20 ohm at 273 ºC. Find the value of temperature coefficient of resistance.

B-4. The current-voltage graphs for a given metallic wire at two different temperature T_1 and T_2 are shown in the figure. Which one is higher, T_1 or T_2.

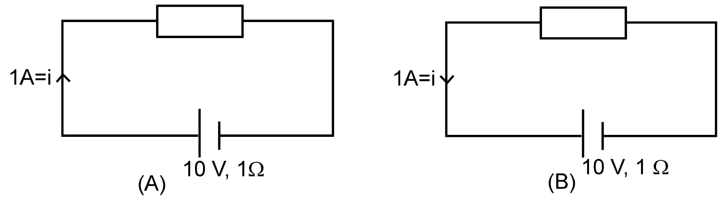


B-5. If a copper wire is stretched to make it 0.1% longer, what is the percentage change in its resistance ?

B-6 A rectangular carbon block has dimensions 1.0 cm × 1.0 cm × 50 cm.
(i) What is the resistance measured between the two square ends?
(ii) Between two opposing rectangular faces?
Resistivity of carbon at 20º C is 3.5×10^{-5} Ωm.

Section (C) : Power, Energy, Battery, EMF, Terminal voltage & Kirchoff's laws

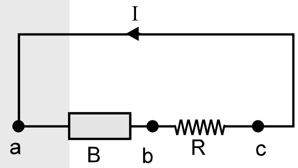
C-1. In following diagram boxes may contain resistor or battery or any other element



then determine in each case
(a) E.m.f. of battery
(b) Battery is acting as a source or load
(c) Potential difference across each battery
(d) Power input to the battery or output by the battery.
(e) The rate at which heat is generated inside the battery.
(f) The rate at which the chemical energy of the cell is consumed or increased.
(g) Potential difference across box
(h) Electric power output across box.

C-2. A resistor with a current of 3 A through it converts 500 J of electrical energy to heat energy in 12 s. What is the voltage across the resistor?

C-3. The figure shows the current I in a single-loop circuit with a battery B and resistance R (and wires of negligible resistance). Then find the order of following at the point a,b and c

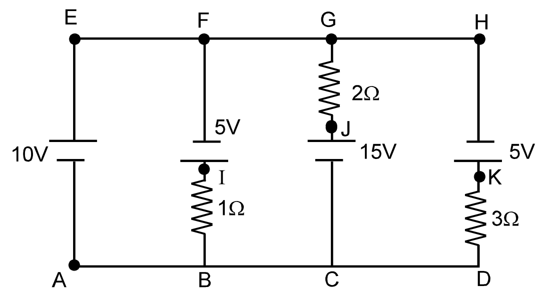


(a) The magnitude of the current,
(b) The electric potential, and
(c) The electric potential energy of the charge carriers (electron), greatest first.

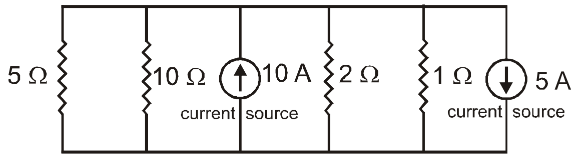
C-4. (a) A car has a fresh storage battery of emf 12 V and internal resistance 5.0×10^{-2} Ω. If the starter draws a current of 90 A, what is the terminal voltage of the battery when the starter is on?
(b) After long use, the internal resistance of the storage battery increases to 500 Ω. What maximum current can be drawn from the battery? Assume the emf of the battery to remain unchanged.
(c) If the discharged battery is charged by an external emf source, is the terminal voltage of the battery during charging greater or less than its emf 12 V?

C-5. 1 kW, 220 V electric heater is to be used with 220 V D.C. supply.
(a) What is the current in the heater?
(b) What is its resistance?
(c) What is the power dissipated in the heater.
(d) How much heat in calories is produced per second?
(e) How many grams of water at 100º C will be converted per minute into steam at 100º C with the heater. (latent heat of vaporisation of water = 540 cal/g)] [J = 4.2 J/cal]

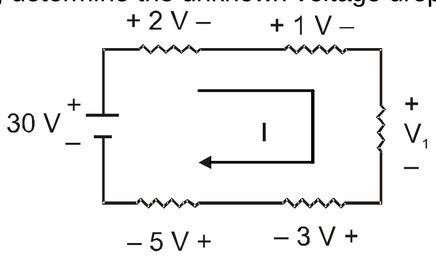
C-6. In following circuit potential at point 'A' is zero then determine
(a) Potential at each point
(b) Potential difference across each resistance
(c) Identify the batteries which act as a source
(d) Current in each battery
(e) Which resistance consumes maximum power
(f) Which battery consume or gives maximum power.



C-7. For the circuit shown in figure, find the voltage across 10 Ω resistor and the current passing through it.

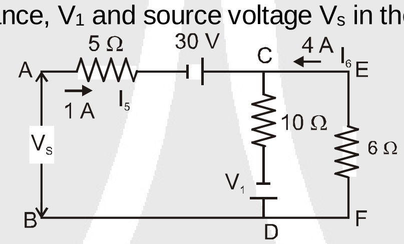


C-8. For the circuit shown in figure, determine the unknown voltage drop V_1



C-9. A resistor develops 400 J of thermal energy in 10 s when a current of 2 A is passed through it.
(a) Find its resistance.
(b) If the current is increased to 4 A, what will be the energy developed in 20 s.

C-10. Find the current in 10 Ω resistance, V_1 and source voltage V_s in the circuit shown in figure ($V_s = V_A - V_B$)

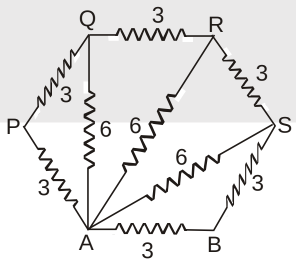


Section : (D) Combination of Resistance

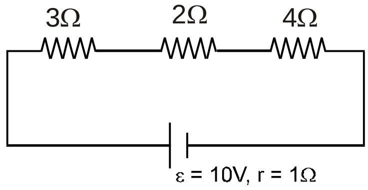
D-1. Two electric bulbs, each designed to operate with a power of 500 watts in 220 volt line, are connected in series with a 110 volt line. What will be the power generated by each bulb? **[JEE 1977]**

D-2. Two (non-physics) students, A and B living in neighboring hostel rooms, decided to economies by connecting their bulbs in series. They agreed that each would install a 100 W bulb in their own rooms and that they would pay equal shares of the electricity bill. However, both decided to try to get better lighting at the other's expense; A installed a 200 W bulb and B installed a 50 W bulb. Which student is more likely to fail the end-of-term examinations?

D-3. All resistance in diagram (fig.) are in ohms. Find the effective resistance between the points A and B.

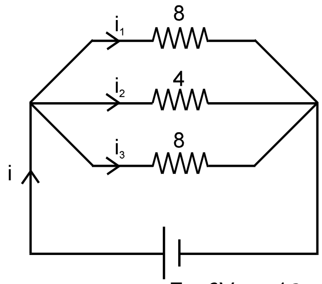


D-4. In the given circuit determine
(a) Equivalent resistance (Including internal resistance).
(b) Current in each resistance
(c) Potential difference across each resistance
(d) The rate at which the chemical energy of the cell is consumed
(e) The rate at which heat is generated inside the battery
(f) Electric power output
(g) Potential difference across battery
(h) Which resistance consumes maximum power?
(i) Power dissipated in 3 Ω resistance.

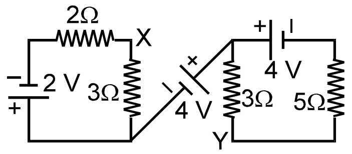


D-5. In given circuit determine

(a) Equivalent resistance (Including internal resistance).
(b) Current i, i_1, i_2 and i_3
(c) Potential difference across battery and each resistance
(d) The rate at which the chemical energy of the cell is consumed
(e) The rate at which heat is generated inside the battery
(f) Electric power output
(g) Which resistance consumes maximum power ?
(h) Power dissipated across 4Ω resistance



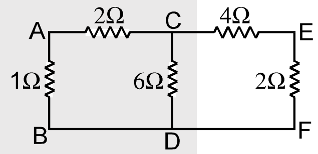
D-6. (a) Determine the potential difference between X and Y in the circuit shown in Figure



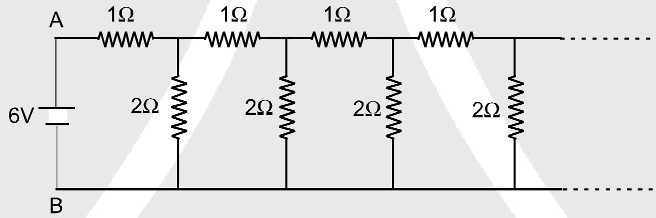
(b) If intermediate cell has internal resistance r = 1Ω then determine the potential difference between X and Y.

D-7. Find the equivalent resistance of the circuit given in figure between the following point :

(i) A and B
(ii) C and D
(iii) E and F
(iv) A and F
(v) A and C

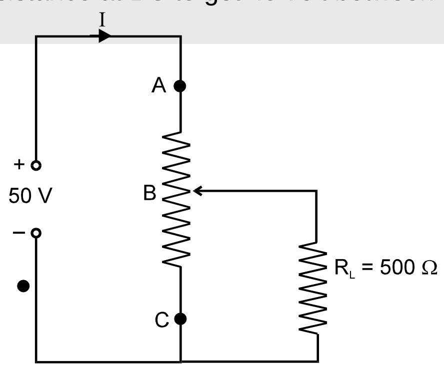


D-8. An infinite ladder network of resistance is constructed with 1Ω and 2Ω resistance, as shown in figure.



(i) Show that the effective resistance between A and B is 2Ω.
(ii) What is the current that passes through the 2Ω resistance nearest to the battery?

D-9. As shown in figure a variable rheostat of 2 kΩ is used to control the potential difference across 500 ohm load. (i) If the resistance AB is 500 Ω, what is the potential difference across the load? (ii) If the load is removed, what should be the resistance at BC to get 40 volt between B and C?

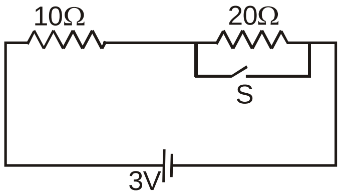


D-10. ABCD is a square where each side is uniform wire of resistance 1 Ω. Find a point E on CD such that if a uniform wire of resistance 1 Ω is connected across AE and a potential difference is applied across A and C, the points B and E will be equipotential.

D-11. Suppose you have three resistors of 20 Ω, 50 Ω and 100 Ω. What minimum and maximum resistances can you obtain from these resistors ?

D-12. Three bulbs, each having a resistance of 180 Ω, are connected in parallel to an ideal battery of emf 60 V. Find the current delivered by the battery when (a) all the bulbs are switched on, (b) two of the bulbs are switched on and (c) only one bulb is switched on.

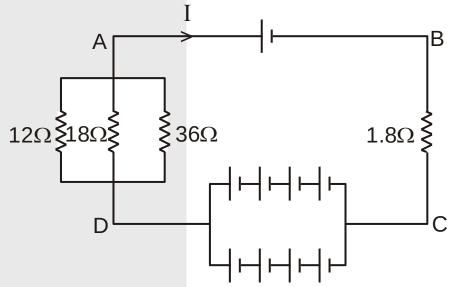
D-13. Consider the circuit shown in figure. Find the current through the 10Ω resistor when the switch S is (a) opened (b) closed.



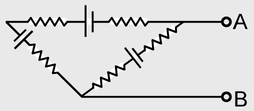
Section (E) : Combination of Cells

E-1. Six lead-acid type of secondary cells, each of emf 2.0 V and internal resistance 0.015 Ω, are joined in series to provide a supply to a resistance of 8.5 Ω. Determine : (i) the current drawn from the supply and (ii) its terminal voltage.

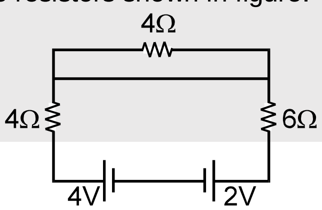
E-2. In the figure each cell has an emf of 1.5 V and internal resistance of 0.40 Ω. Calculate:
(i) current I
(ii) current in the 36 Ω resistor
(iii) potential difference across A and B.



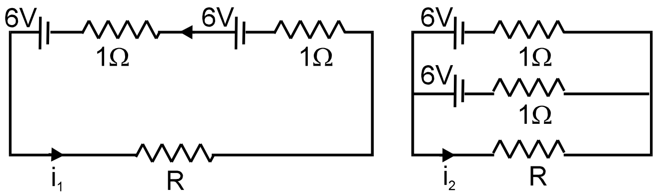
E-3. In the circuit shown all five resistors have the same value 200 ohms and each cell has an emf 3 volts. Find the open circuit voltage and the short circuit current for the terminals A and B.



E-4. Find the currents through the three resistors shown in figure.



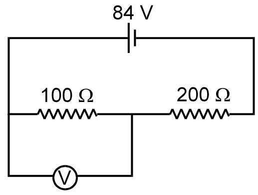
E-5. Find the value of i_1/i_2 in figure if (a) R = 0.1 Ω, (b) R = 1Ω (c) R = 10 Ω. Note from your answer that in order to get more current from a combination of two batteries they should be joined in parallel if the external resistance is small and in series if the external resistance is large as compared to the internal resistances.



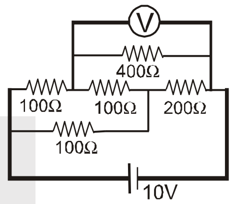
Section (F) : Instrument

F-1. A galvanometer has a resistance of 30 ohm and a current of 2 mA is needed to give a full scale deflection. What is the resistance needed and how is it to be connected to convert the galvanometer.
(a) Into an ammeter of 0.3 ampere range ?
(b) Into a voltmeter of 0.2 volt range ?

F-2. A voltmeter of resistance 400Ω is used to measure the potential difference across the 100Ω resistor in the circuit shown in the figure. (a) What will be the reading of the voltmeter? (b) What was the potential difference across 100 Ω before the voltmeter was connected?

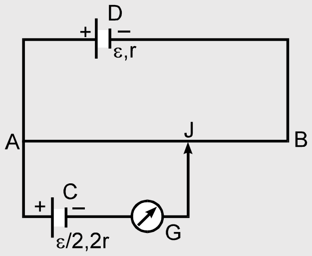


F-3. An electrical circuit is shown in the figure. Calculate the potential difference across the resistance of 400 ohm, as will be measured by the voltmeter V of resistance 400 ohm, either by applying Kirchhoff's rules or otherwise.

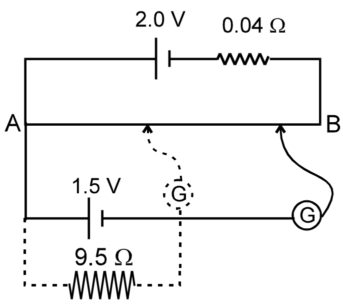


F-4. A battery of emf 1.4 V and internal resistance 2 Ω is connected to a resistor of 100 Ω through an ammeter. The resistance of the ammeter is 4/3 Ω. A voltmeter has also been connected to find the potential difference across the resistor.
(i) Draw the circuit diagram.
(ii) The ammeter reads 0.02 A. What is the resistance of the voltmeter?
(iii) The voltmeter reads 1.10 V, what is the zero error in the voltmeter?
(Hint : zero error = observed reading – actual reading)

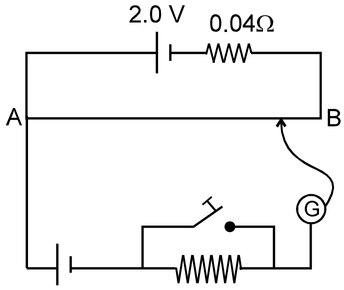
F-5. In the figure the potentiometer wire AB of length L & resistance 9 r is joined to the cell D of e.m.f. ε & internal resistance r. The cell C's e.m.f. is ε/2 and its internal resistance is 2 r. The galvanometer G will show no deflection then find length AJ :



F-6. Figure shows a 2.0 V potentiometer used for the determination of internal resistance of 1.5 V cell. The balance point of the cell without 9.5 Ω in the external circuit is 70 cm. When a resistor of 9.5 Ω is used in the external circuit of the cell, the balance point shifts to 60 cm length of the potentiometer wire. Determine the internal resistance of the secondary cell.

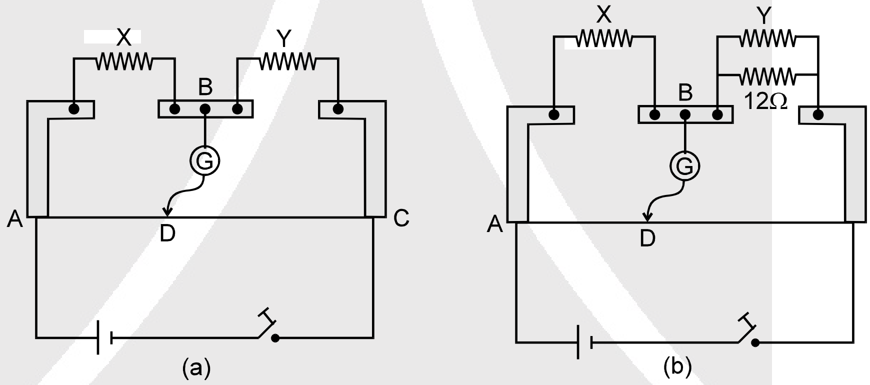


F-7. Figure shows a potentiometer with a cell of emf 2.0 V and internal resistance 0.04 Ω maintaining a potential drop across the potentiometer wire AB. A standard cell which maintains a constant emf of 1.02 V (for very moderate currents up to a few ampere) gives a balance point of 67.3 cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600 kΩ is put in series with it which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown emf E and the balance point found similarly turns out to be at 82.3 cm length of the wire.

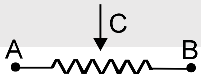


(a) What is the value of E ?
(b) What purpose does the high resistance of 600 kΩ have ?
(c) Is the balance point affected by this high resistance?
(d) Is the balance point affected by the internal resistance of the driver cell?
(e) Would the method work in the above situation if the driver cell of the potentiometer had an emf of 1.0 V instead of 2.0 V?
(f) Would the circuit work well for determining extremely small emf, say, of the order of few mV (such typical emf of thermocouple)?

F-8. Figure shows a metre bridge (which is nothing but a practical Wheatstone Bridge) consisting of two resistors X and Y together in parallel with a metre long constantan wire of uniform cross-section. With the help of a movable contact D, one can change the ratio of the resistances of the two segments of the wire until a sensitive galvanometer G connected across B and D shows no deflection. The null point is found to be at a distance of 30 cm from the end A. The resistor Y is shunted by a resistance of 12.0 Ω and the null point is found to shift by a distance of 10 cm. Determine the resistance of X and Y.



F-9. Connect a battery to the terminals and complete the circuit diagram so that it works as a potential divider meter. Indicate the output terminals also. **[IIT-JEE (Main) 2003, 2/60]**



PART - II : ONLY ONE OPTION CORRECT TYPE

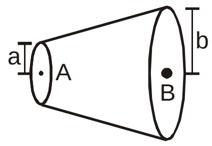
Section (A) : DefinItion of current, Current densities, Drift

A-1. The drift velocity of electrons in a conducting wire is of the order of 1mm/s, yet the bulb glows very quickly after the switch is put on because
(A) The random speed of electrons is very high, of the order of 10^6 m/s
(B) The electrons transfer their energy very quickly through collisions
(C) Electric field is set up in the wire very quickly, producing a current through each cross section, almost instantaneously
(D) All of above

A-2. In the presence of an applied electric field ($\vec{E}$) in a metallic conductor.
(A) The electrons move in the direction of $\vec{E}$
(B) The electrons move in a direction opposite to $\vec{E}$
(C) The electrons may move in any direction randomly, but slowly drift in the direction of $\vec{E}$.
(D) The electrons move randomly but slowly drift in a direction opposite to $\vec{E}$.

A-3. The potential difference applied to an X-ray tube is 5 kV and the current through it is 3.2 mA. Then the number of electrons striking the target per second is **[IIT-JEE(Scr.) - 2002,3/105]**
(A) 2×10^{16} (B) 5×10^{16} (C) 1×10^{17} (D) 4×10^{15}

A-4 An electric current passes through non uniform cross-section wire made of homogeneous and isotropic material. If the j_A and j_B be the current densities and E_A and E_B be the electric field intensities at A and B respectively, then

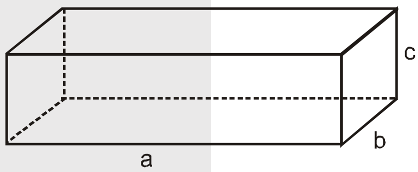


(A) $j_A > j_B$; $E_A > E_B$ (B) $j_A > j_B$; $E_A < E_B$ (C) $j_A < j_B$; $E_A > E_B$ (D) $j_A < j_B$; $E_A < E_B$

Section (B) : Resistance

B-1. A piece of copper and another of germanium are cooled from room temperature to 80 K. The resistance of :
(A) each of the them increases (B) each of them decreases
(C) copper increases and germanium decreases (D) copper decreases and germanium increases

B-2. All the edges of a block in cuboidal shape with parallel faces are equal. Its longest edge is twice its shortest edge. The ratio of the maximum to minimum resistance between parallel faces is:

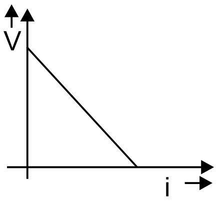


(A) 2
(B) 4
(C) 8
(D) indeterminate unless the length of the third edge is specified.

Section (C) : Power, Energy, Battery, EMF and Terminal voltage

C-1. In an electric circuit containing battery, the positive charge inside the battery
(A) always goes from the positive terminal to the negative terminal
(B) may go from the positive terminal to the negative terminal
(C) always goes from the negative terminal to the positive terminal
(D) does not move.

C-2. If internal resistance of a cell is proportional to current drawn from the cell. Then the best representation of terminal potential difference of a cell with current drawn from cell will be:

(A)


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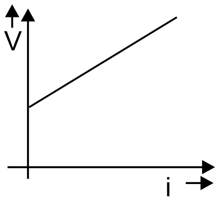
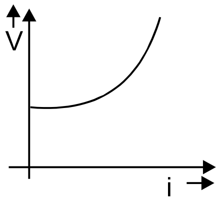
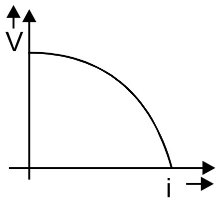
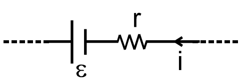


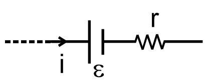
(C)


(D)


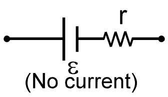
C-3.



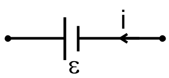
(a)



(b)



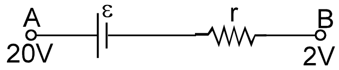
(c)



(b)

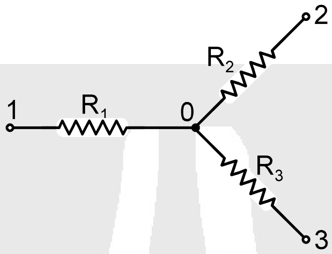
In which of the above cells, the potential difference between the terminals of a cell exceeds its emf.
(A) a (B) b (C) c (D) d

C-4. A resistor of resistance R is connected to a cell of internal resistance 5 Ω. The value of R is varied from 1 Ω to 5 Ω. The power consumed by R:
(A) increases continuously
(B) decreases continuously
(C) first decreases then increases
(D) first increases then decreases.

C-5. In the figure a part of circuit is shown :


(A) current will flow from A to B
(B) current may flow from A to B
(C) current will flow from B to A
(D) the direction of current will depend on *r*.

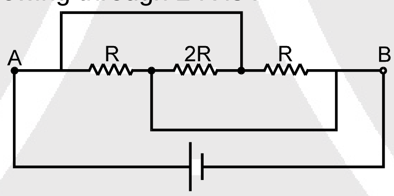
C-6. **(i)** Find the current flowing through the resistance R_1 of the circuit shown in figure if the resistances are equal to $R_1 = 10\ \Omega$, $R_2 = 20\ \Omega$, and $R_3 = 30\ \Omega$, and the potentials of points 1, 2 and 3 are equal to $\varphi_1 = 10$ V, $\varphi_2 = 6$ V, and $\varphi_3 = 5$ V.



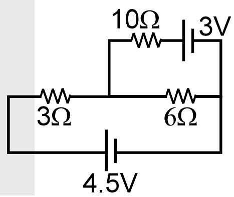
(A) 0.1 A (B) 0.2 A (C) 0.3 A (D) 0.4 A

(ii) In the previous question potential at point 0 is
(A) 15 V (B) 20 V (C) 25 V (D) 8 V

C-7. In the figure shown the current flowing through 2 R is :



(A) from left to right (B) from right to left (C) no current (D) None of these

C-8. Find the current through the 10 Ω resistor shown in figure


(A) zero
(B) 1A
(C) 2A
(D) 5A

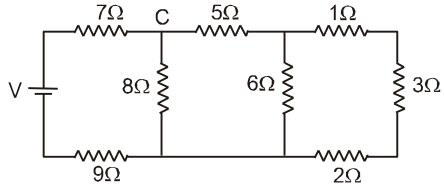
C-9. The efficiency of a cell when connected to a resistance R is 60%. What will be its efficiency if the external resistance is increased to six times?
(A) 80 % (B) 90% (C) 55% (D) 95%

Section (D) : Combination of Resistance

D-1. Two coils connected in series have resistances 600 Ω and 300 Ω at 20°C and temperature coefficient of resistivity $0.001\ K^{-1}$ and $0.004\ K^{-1}$ respectively.
(a) The resistance of the combination at temperature 50°C is
(A) 426 Ω (B) 954 Ω (C) 1806 Ω (D) 214 Ω

(b) The effective temperature coefficient of the combination is
(A) $\frac{1}{1000}$ degree^{-1} (B) $\frac{1}{250}$ degree^{-1} (C) $\frac{1}{500}$ degree^{-1} (D) $\frac{3}{1000}$ degree^{-1}

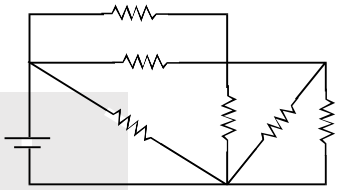
D-2. In the ladder network shown, current through the resistor 3 Ω is 0.25 A. The input voltage 'V' is equal to



(A) 10 V (B) 20 V (C) 5 V (D) $\frac{15}{2}$ V

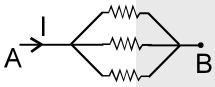
D-3. If 2 bulbs rated 2.5 W – 110 V and 100 W – 110 V are connected in series to a 220 V supply then
(A) 2.5 W bulb will fuse (B) 100 W bulb will fuse
(C) both will fuse (D) both will not fuse

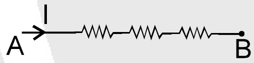
D-4. In the figure shown each resistor is of 20 Ω and the cell has emf 10 volt with negligible internal resistance. Then rate of joule heating in the circuit is (in watts)

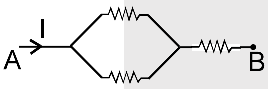


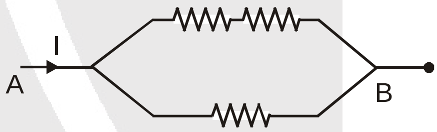
(A) 100/11
(B) 10000/11
(C) 11
(D) None of these

D-5. Arrange the order of power dissipated in the given circuits, if the same current is passing through the system. The resistance of each resistor is ' r '. **[IIT-JEE(Scr.) 2003, 3/84]**

(i) 

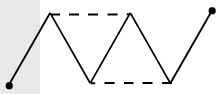
(ii) 

(iii) 

(iv) 

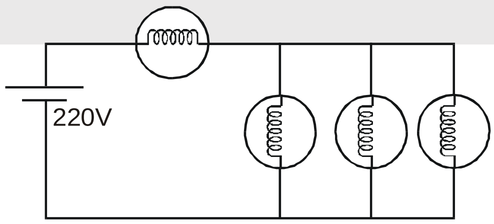
(A) $P_2 > P_3 > P_4 > P_1$ (B) $P_1 > P_4 > P_3 > P_2$ (C) $P_1 > P_2 > P_3 > P_4$ (D) $P_4 > P_3 > P_2 > P_1$

D-6. Five identical resistors each of resistance 1 Ω are initially arranged as shown in the figure by clear lines. If two similar resistances are added as shown by the dashed lines then change in resistance in final and initial arrangement is



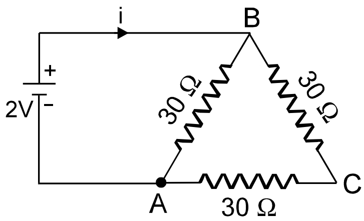
(A) 2 Ω (B) 1 Ω (C) 3 Ω (D) 4 Ω

D-7. Four identical bulbs each rated 100 watt, 220 volts are connected across a battery as shown. The total electric power consumed by the bulbs is:



(A) 75 watt (B) 400 watt (C) 300 watt (D) 400/3 watt

D-8. The current i in the circuit of figure is - **[JEE 1983]**



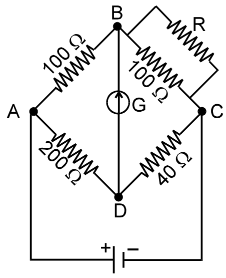
(A) $\frac{1}{45}$ amp. (B) $\frac{1}{15}$ amp.
(C) $\frac{1}{10}$ amp. (D) $\frac{1}{5}$ amp.

D-9. Three equal resistors connected in series across a source of emf together dissipate 10 watts of power. What would be the power dissipated if the same resistors are connected in parallel across the same source of emf ? **[JEE 1972]**

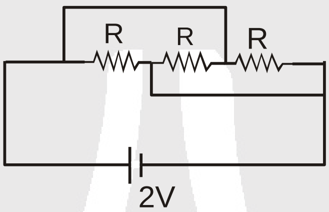
(A) 60 watt (B) 90 watt (C) 100 watt (D) 30 watt

D-10. The given Wheatstone bridge is showing no deflection in the galvanometer joined between the points B and D (Figure). Calculate the value of R.

(A) 25 Ω
(B) 50 Ω
(C) 40 Ω
(D) 100 Ω



D-11. Three equal resistance each of R ohm are connected as shown in figure. A battery of 2 volts of internal resistance 0.1 ohm is connected across the circuit. Calculate the value of R for which the heat generated in the exeternal circuit is maximum. **[REE 1990]**

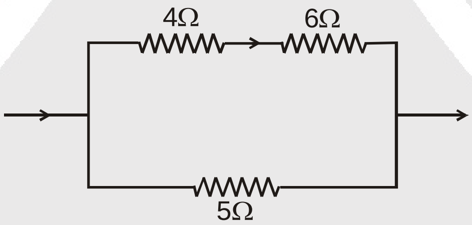


(A) 0.1 Ω (B) 0.2 Ω (C) 0.3 Ω (D) 0.4 Ω

D-12. A wire of resistance 0.1 ohm cm^{-1} bent to form a square ABCD of side 10 cm. A similar wire is connected between the corners B and D to form the diagonal BD. Find the effective resistance of this combination between corners A and C. If a 2V battery of negligible internal resistance is connected across A and C calculate the total power dissipated. **[JEE 1971]**

(A) 1 Ω, 3 W (B) 1 Ω, 4 W (C) 2 Ω, 3 W (D) 2 Ω, 4 W

D-13. In the circuit shown in figure the heat produced in the 5Ω resistor due to the current flowing through it is 10 calories per second. **[JEE 1981; 2M]**



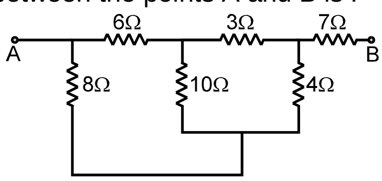
The heat generated in the 4Ω resistor is :

(A) 1 cal/s (B) 2 cal/s (C) 3 cal/s (D) 4 cal/s

D-14. A 50 W bulb is in series with a room heater and the combination is connected across the mains. To get max. heater output, the 50 W bulb should be replaced by :

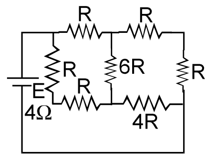
(A) 25 W (B) 10 W (C) 100 W (D) 200 W

D-15. The equivalent resistance between the points A and B is :



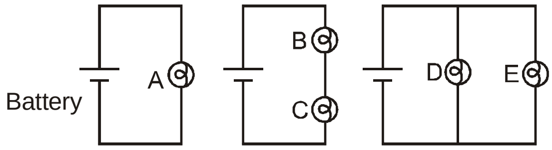
(A) $\frac{36}{7}$ Ω (B) 10 Ω (C) $\frac{85}{7}$ Ω (D) none of these

D-16. A battery of internal resistance 4 ohm is connected to the network of resistance as shown. In the order that the maximum power can be delivered to the network, the value of R in ohm should be :



(A) 4/9 (B) 2 (C) 8/3 (D) 18

D-17. In these three circuits all the batteries are identical and have negligible internal resistance, and all the light bulbs are identical. Rank all 5 light bulbs (A, B, C, D, E) in order of brightness from brightness to dimmest.



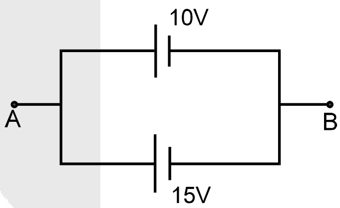
(A) A = B = C > D = E (B) A > B = C > D = E
(C) A = D = E > B = C (D) A = D = E > B > C

Section (E) : Combination of Cells

E-1. Two nonideal batteries are connected in parallel. Consider the following statements
(I) The equivalent emf is smaller than either of the two emfs.
(II) The equivalent internal resistance is smaller than either of the two internal resistance.
(A) Both I and II are correct (B) I is correct but II is wrong
(C) II is correct but I is wrong (D) Each of I and II is wrong.

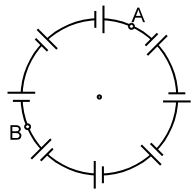
E-2. 12 cells each having the same emf are connected in series and are kept in a closed box. Some of the cells are wrongly connected. This battery is connected in series with an ammeter and two cells identical with each other and also identical with the previous cells. The current is 3 A when the external cells support this battery and is 2 A when the cells oppose the battery. How many cells in the battery are wrongly connected?
(A) one (B) two (C) three (D) none of these

E-3. Two cells of e.m.f. 10 V & 15 V are connected in parallel to each other between points A & B. The cell of e.m.f. 10 V is ideal but the cell of e.m.f. 15 V has internal resistance 1Ω. The equivalent e.m.f. between A and B is:



(A) $\frac{25}{2}$ V (B) not defined
(C) 15 V (D) 10 V

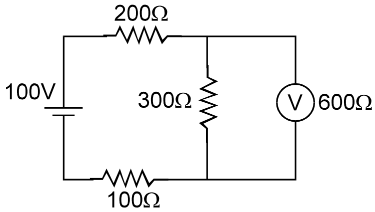
E-4. N sources of current with different emf's are connected as shown in figure. The emf's of the sources are proportional to their internal resistances, i.e. E = αR, where α is an assigned constant. The connecting wire resistance is negligible. The potential difference between points A and B dividing the circuit in n and N – n links



(A) 0 (B) nE/2
(C) NE (D) (N – n)E

Section (F) : Instrument

F-1. The reading of voltmeter is



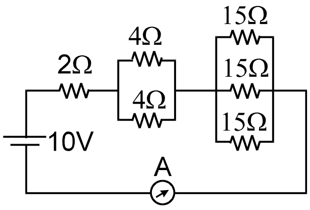
(A) 50V (B) 60 V (C) 40V (D) 80 V

F-2. The length of a wire of a potentiometer is 100 cm, and the emf of its standard cell is E volt. It is employed to measure the emf of a battery whose internal resistance is 0.5 ohm. If the balance point is obtained at 30 cm from the positive end, the emf of the battery is **[AIEEE 2003, 4/300]**

(A) $\frac{30E}{100}$ (B) $\frac{30E}{100.5}$ (C) $\frac{30E}{(100-0.5)}$

(D) $\frac{30(E-0.5i)}{100}$, $\frac{30(E-0.5i)}{100}$, where i is the current in the potentiometer

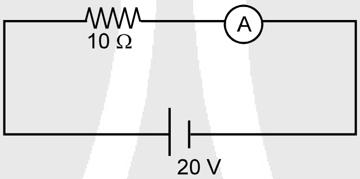
F-3. The current through the ammeter shown in figure is 1 A. If each of the 4Ω resistor is replaced by 2Ω resistor, the current in circuit will become nearly :



(A) $\frac{10}{9}$ A (B) $\frac{5}{4}$

(C) $\frac{9}{8}$ A (D) $\frac{5}{8}$ A

F-4. The ammeter shown in figure consists of a 480 Ω coil connected in parallel to a 20 Ω shunt. Find the reading of the ammeter.



(A) $\frac{50}{73}$ A (B) $\frac{40}{53}$ A (C) $\frac{50}{93}$ A (D) $\frac{73}{50}$ A

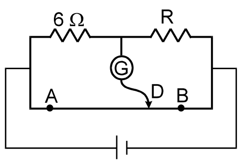
F-5. A galvanometer together with an unknown resistance in series is connected to two identical batteries each of 1.5 V. When the batteries are connected in series, the galvanometer records a current of 1A, and when the batteries are in parallel the current is 0.6 A. What is the internal resistance of the battery? **[JEE 1973]**

(A) $r = \frac{2}{3}\Omega$ (B) $r = \frac{2}{5}\Omega$ (C) $r = \frac{1}{3}\Omega$ (D) $r = \frac{3}{2}\Omega$

F-6. A potentiometer wire of length 100 cm has a resistance of 10 ohm. It is connected in series with a resistance and an accumulator of emf 2V and of negligible internal resistance. A source of emf of 10 mV is balanced against a length of 40 cm of the potentiometer wire. What is the value of external resistance ? **[JEE 1976]**

(A) 890 Ω (B) 600 Ω (C) 650 Ω (D) 790 Ω

F-7. The meter-bridge wire AB shown in figure is 50 cm long. When AD = 30 cm, no deflection occurs in the galvanometer. Find R.



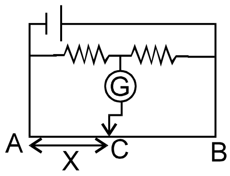
(A) 1 Ω (B) 2 Ω

(C) 3 Ω (D) 4 Ω

F-8. The current in a conductor and the potential difference across its ends are measured by an ammeter and a voltmeter. The meters draw negligible currents. The ammeter is accurate but the voltmeter has a zero error (that is, it does not read zero when no potential difference is applied). Then the zero error is (if the readings for two different conditions are 1.75 A, 14.4 V and 2.75 A, 22.4 V.)

(A) 0.4 volt (B) 0.8 volt (C) –0.4 volt (D) –0.8 volt

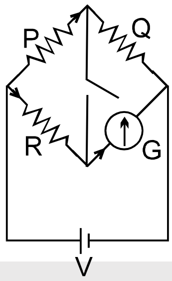
F-9. In the given circuit, no current is passing through the galvanometer. If the cross-sectional diameter of the wire AB is doubled, then for null point of galvanometer, the value of AC would be: **[IIT-JEE(Scr.) 2003, 3/84]**



(A) 2 X (B) X

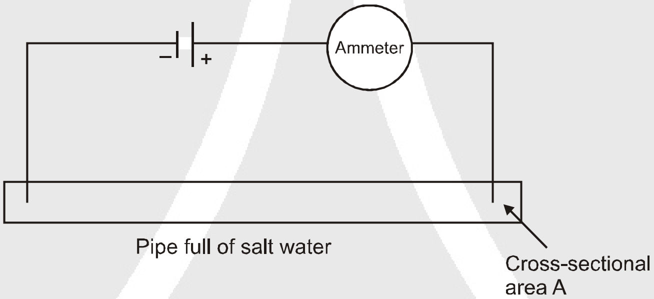
(C) $\frac{X}{2}$ (D) None of these

F-10. In the circuit shown, P ≠ R, the reading of the galvanometer is same with switch S open or closed. Then **[IIT-JEE 1999, 2/200]**



(A) $I_R = I_G$ (B) $I_P = I_G$ (C) $I_Q = I_G$ (D) $I_Q = I_R$

F-11. Salt water contains n sodium ions (Na+) per cubic meter and n chloride ions (Cl^-) per cubic meter. A battery is connected to metal rods that dip into a narrow pipe full of salt water. The cross sectional area of the pipe is A. The magnitude of the drift velocity of the sodium ions is V_{Na} and the magnitude of the drift velocity of the chloride ions is V_{Cl}. Assume that $V_{Na} > V_{Cl}$ (+e is the charge of a proton).



What is the magnitude of the ammeter reading ?

(A) $enAV_{Na} – enAV_{Cl}$ (B) $enAV_{Na} + enAV_{Cl}$ (C) $enAV_{Na}$ (D) $enAV_{Cl}$

PART - III : MATCH THE COLUMN

1. Match the following :

The following table gives the lengths of four copper rods at the same temperature, their diameters, and the potential differences between their ends.

Rod	Length	Diameter	Potential Difference
1	L	3d	V
2	2L	d	3V
3	3L	2d	2V
4	3L	d	V

Correctly match the physical quantities mentioned in the left column with the rods as marked.

Column - I	**Column - II**
(A) Greatest Drift speed of the electrons.	(p) Rod 1
(B) Greatest Current	(q) Rod 2
(C) Greatest rate of thermal energy produced	(r) Rod 3
(D) Greatest Electric field	(s) Rod 4

2. Match the statements in Column I with the current element in Column II

	Column - I	Column - II
(A)	Current always flows from higher potential to lower potential	(p) A Resistor
(B)	Energy dissipated in an element is always zero	(q) Ideal cell/Battery
(C)	Current flow through the element is always zero	(r) Non-Ideal cell/Battery
(D)	Potential difference may/will be zero	(s) Short-circuited resistor

Exercise-2

Marked Questions can be used as Revision Questions.

PART - I : ONLY ONE OPTION CORRECT TYPE

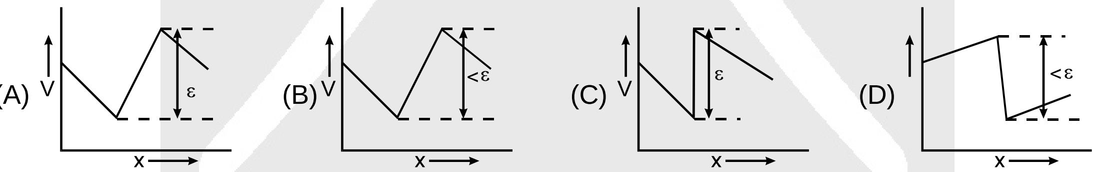
1. If a copper wire is stretched to make its radius decrease by 0.1%, the percentage change in its resistance is approximately.

(A) – 0.4% (B) + 0.8% (C) + 0.4% (D) + 0.2%

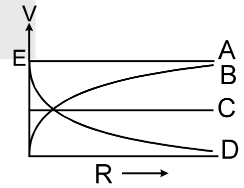
2. The potential difference between the terminals of a battery of emf 10 V and internal resistance 1Ω drops to 9.8 V when connected across an external resistance. The resistance of the external resistor is

(A) 49 Ω (B) 25 Ω (C) 31 Ω (D) 43 Ω

3. The two ends of a uniform conductor are joined to a cell of emf ε and some internal resistance. Starting from the midpoint P of the conductor, we move in the direction of the current and return to P. The potential V at every point on the path is plotted against the distance covered (x). Which of the following best represents the resulting curve?



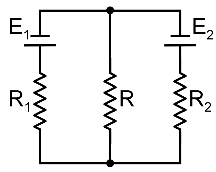
4. A cell of emf E having an internal resistance r is connected to an external resistance R. The potential difference V across the resistance R varies with R as shown in figure by the curve :



(A) A (B) B

(C) C (D) D

5. In a circuit shown in figure resistances R_1 and R_2 are known, as well as emf's E_1 and E_2. The internal resistances of the sources are negligible. At what value of the resistance R will the thermal power generated in it be the highest ?



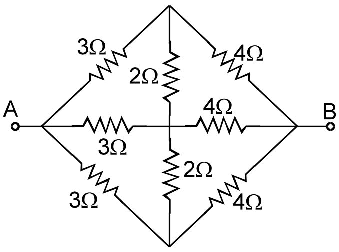
(A) $R_1 + R_2$ (B) $R_1 - R_2$

(C) $\sqrt{R_1R_2}$ (D) $\frac{R_1R_2}{R_1+R_2}$

6. A resistor R is connected to a parallel combination of two identical batteries each with emf E and an internal resistance r. The potential drop across the resistance R is. **[Olympiad 2016, Stage-1]**

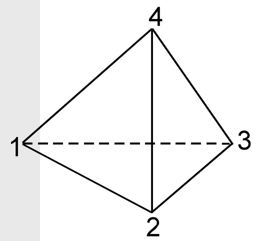
(A) $\frac{2ER}{2R+r}$ (B) $\frac{ER}{R+2r}$ (C) $\frac{ER}{2R+r}$ (D) $\frac{2ER}{R+2r}$

7. The equivalent resistance between A and B will be (in Ω)



(A) 2/7 (B) 8 (C) 4/3 (D) 7/3

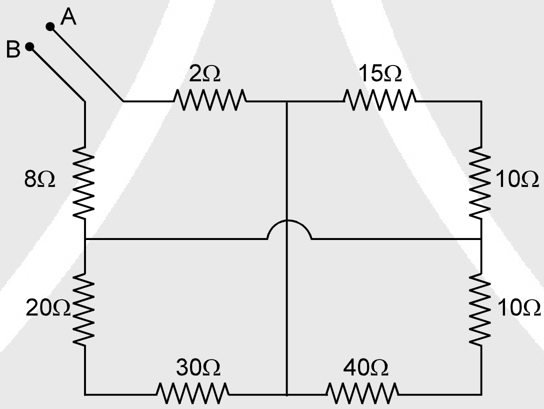
8. A wire is in the form of a tetrahedron. The resistance of each edge is r. The equivalent resistances between corners 1–2 and 1–3 are respectively



(A) $\frac{r}{2},\frac{r}{2}$ (B) r, r

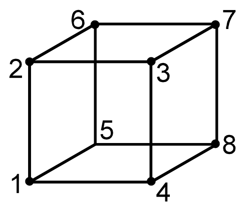
(C) $\frac{r}{2}$, r (D) r, $\frac{r}{2}$

9. The equivalent resistance between points A and B is :



(A) $\frac{65}{2}\Omega$ (B) $\frac{45}{2}\Omega$ (C) $\frac{5}{2}\Omega$ (D) $\frac{91}{2}\Omega$

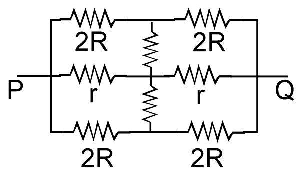
10. In the question find the resistance between points 1 – 3.



(A) $\frac{3}{4}R$ (B) $\frac{5}{6}R$

(C) $\frac{3}{5}R$ (D) $\frac{6}{5}R$

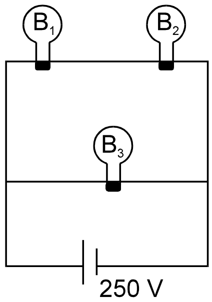
11. The effective resistance between points P and Q of the electrical circuit shown in the figure is: **[IIT-JEE(Scr.) 2002, 3/105]**



(A) $\frac{2Rr}{R+r}$ (B) $\frac{2R(R+r)}{3R+r}$

(C) $2r + 4R$ (D) $\frac{5R}{2} + 2r$

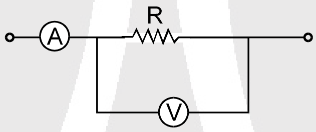
12. A 100 W bulb B_1 and two 60 W bulbs B_2 and B_3 are connected to a 250 V source as shown in the figure. Now W_1, W_2 and W_3 are the output powers of the bulbs B_1, B_2 and B_3 respectively. Then:
[IIT-JEE (Scr.) 2002, 3/105]



(A) $W_1 > W_2 = W_3$ (B) $W_1 > W_2 > W_3$ (C) $W_1 < W_2 = W_3$ (D) $W_1 < W_2 < W_3$

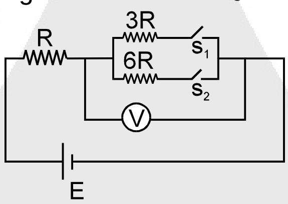
13. When a galvanometer is shunted with a 4Ω resistance, the deflection is reduced to one-fifth. If the galvanometer is further shunted with a 2Ω wire, determine current in galvanometer now if initially current in galvanometer is I_0 (given main current remain same).
(A) $I_0/13$ (B) $I_0/5$ (C) $I_0/8$ (D) $5I_0/13$

14. In the circuit shown the readings of ammeter and voltmeter are 4A and 20V respectively. The meters are non-ideal, then R is



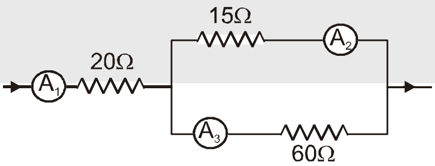
(A) 5 Ω (B) less than 5Ω (C) greater than 5Ω (D) between 4Ω and 5Ω.

15. In the circuit shown in figure reading of voltmeter is V_1 when only S_1 is closed, reading of voltmeter is V_2 when only S_2 is closed and reading of voltmeter is V_3 when both S_1 and S_2 are closed. Then



(A) $V_3 > V_2 > V_1$ (B) $V_2 > V_1 > V_3$ (C) $V_3 > V_1 > V_2$ (D) $V_1 > V_2 > V_3$

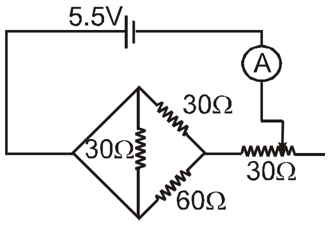
16. If the reading of ammeter A_3 in figure is 0.75 A. Neglecting the resistances of the ammeters, the reading of ammeter A_2 will be :



(A) 1.5 A (B) 3 A (C) 4.5 A (D) 6 A

17. In the previous question the reading of ammeter A_1 will be :
(A) 6.75 A (B) 5.25 A (C) 3.75 A (D) 2.25 A

18. The resistance of the rheostat shown in figure is 30 Ω. Neglecting the ammeter resistance, the ratio of minimum and maximum currents through the ammeter, as the rheostat is varied, will be :



(A) $\frac{2}{5}$ (B) $\frac{83}{15}$

(C) $\frac{9}{43}$ (D) $\frac{19}{43}$

19. An ammeter and a voltmeter are joined in series to a cell. Their readings are A and V respectively. If a resistance is now joined in parallel with the voltmeter,

(A) both A and V will increase (B) both A and V will decrease

(C) A will decrease, V will increase (D) A will increase, V will decrease

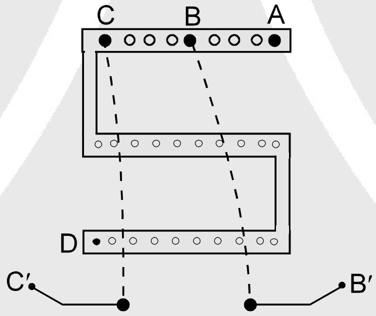
20. An ammeter and a voltmeter are connected in series to a battery with an emf ε = 6.0 V. When a certain resistance is connected in parallel with the voltmeter, the reading of the voltmeter decrease η = 2.0 times, whereas the reading of the ammeter increase the same number of times. Find the voltmeter reading after the connection of the resistance.

(A) 2 V (B) 4V (C) 8V (D) 18V

21. A galvanometer has resistance 100Ω and it requires current 100μA for full scale deflection. A resistor 0.1Ω is connected in parallel to make it an ammeter. The smallest current required in the circuit to produce the full scale deflection is **[IIT-JEE (Scr.) - 2005, 3/84]**

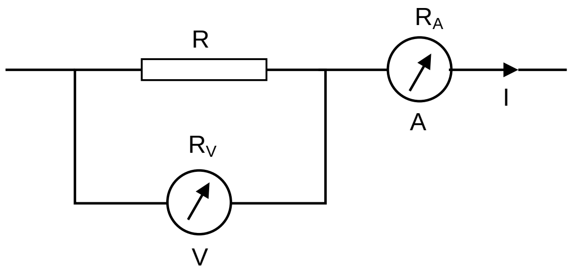
(A) 1000.1 mA (B) 1.1 mA (C) 10.1 mA (D) 100.1 mA

22. Between which points should the terminals of unknown resistance be connected in a post office box arrangement to get its value **[IIT-JEE(Scr.) - 2004, 3/84]**



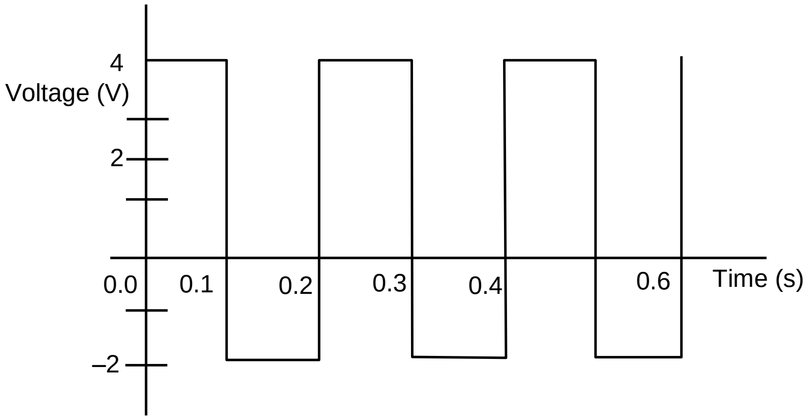
(A) A and B (B) B and C (C) C and D (D) A andD

23. Let V and I be the readings of the voltmeter and the ammeter respectively as shown in the figure. Let R_V and R_A be their corresponding resistance Therefore, **[Olympiad (Stage-1) 2017]**



(A) $R = \frac{V}{I}$ (B) $R = \frac{V}{I - \left(\frac{V}{R_V}\right)}$ (C) $R = R_V - R_A$ (D) $R = \frac{V(R + R_A)}{IR_A}$

24. A 10 ohm resistor is connected to a supply voltage alternating between +4V and –2V as shown in the following graph. The average power dissipated in the resistor per cycle is **[Olympiad (Stage-1) 2017]**

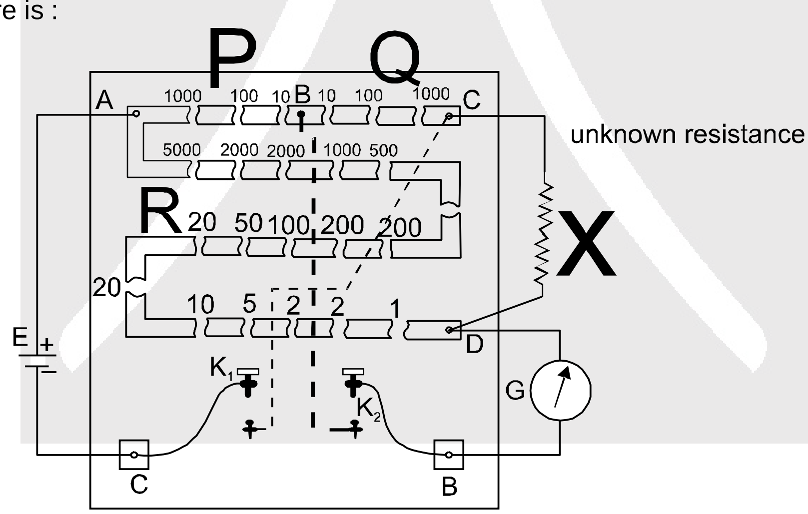


(A) 1.0 W (B) 1.2 W (C) 1.4W (D) 1.6W

25. Two cells each of emf E and internal resistance r_1 and r_2 respectively are connected in series with an external resistance R. The potential difference between the terminals of the first cell will be zero when R is equal to **[Olympiad (Stage-1) 2017; AIEEE-2005, 4/300]**

(A) $\frac{r_1 + r_2}{2}$ (B) $\sqrt{r_1^2 - r_2^2}$ (C) $r_1 - r_2$ (D) $\frac{r_1 r_2}{r_1 + r_2}$

26. In the post office box circuit, 10 Ω plug is taken out in arm AB and 100 Ω plug is taken out in arm BC. If the unknown resistor is kept in melting ice chamber, 600 Ω resistance is required in arm AD for zero deflection in galvanometer. Now if the unknown resistor is kept at 100° C (steam chamber), 630 Ω resistance is required in arm AD for zero deflection. Temprature coefficient of resistance of the unknown wire is :



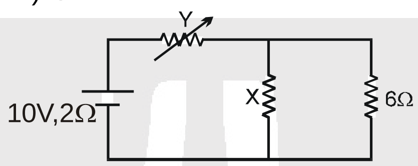
(A) 2.5×10^{-4} / C° (B) 5×10^{-4}/ C° (C) 7.5×10^{-4} / C° (D) 8×10^{-4} / C°

PART – II : NUMERICAL VALUE

1. (a) The current density in a cylindrical conductor of radius R varies according to the equation $J = J_0\left(1 - \frac{r}{R}\right)$, where r = distance from the axis. Thus the current density is a maximum J_0 at the axis r = 0 and decreases linearly to zero at the surface $r = \frac{2}{\sqrt{\pi}}$. Current in terms of J_0 is given by $n\left(\frac{J_0}{6}\right)$ then value of n will be.

2. 1 m long metallic wire is broken into two unequal parts P and Q. P of the wire is uniformly extended into another wire R. Length of R is twice the length of P and the resistance of R is equal to that of Q. Find the ratio of the length of Q and P **[REE 1996]**

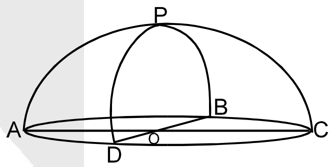
3. For a given resistance X in the figure shown the thermal power generated in ' Y ' is maximum when Y = 4 Ω. Then resistance X (in Ω) is:



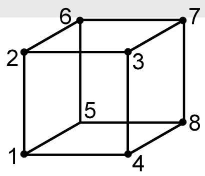
4. A series parallel combination of batteries consisting of a large number N = 300 of identical cells, each with an internal resistances r = 0.3 Ω, is loaded with an external resistance R = 10 Ω. Find number 'n' of parallel groups consisting of an equal number of cells connected in series, at which the external resistance generates the highest thermal power.

5. The internal resistance of an accumulator battery of emf 6V is 10Ω when it is fully discharged. As the battery gets charged up, its internal resistance decreases to 1Ω. The battery in its completely discharged state is connected to a charger which maintains a constant potential difference of 9V. The current through the battery just after the connections are made is I_1 and after a long time when it is completely charged is I_2. Find $10I_1 + I_2$ in amperes.

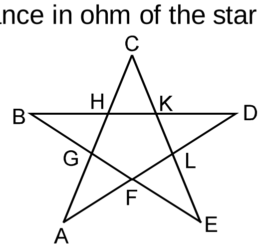
6. A hemispherical network of radius a is made by using a conducting wire of resistance per unit length 'r'. The equivalent resistance across OP is given by $\left[\frac{\pi + n}{8}\right]$ ar the value of n will be :



7. Find the resistance in ohm of a wire frame shaped as a cube (figure) when measured between points 1-7 if each resistance is 6Ω



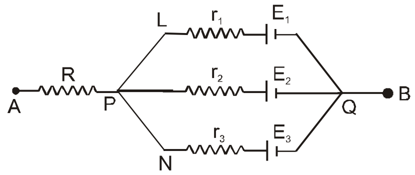
8. The figure is made of a uniform wire and represents a regular five pointed star. The resistance of a section EL is 2 ohm. Find the resistance in ohm of the star across F and C. (sin 18º ~ 1/3)



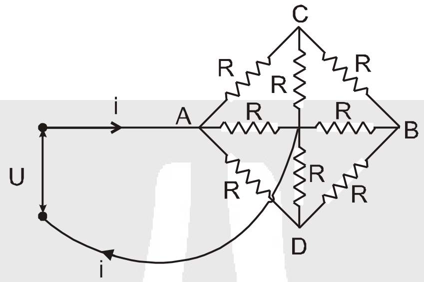
9. In the circuit shown in fig. E_1 = 3 volt, E_2 = 2 volt, E_3 = 1 volt and R = r_1 = r_2 = r_3 = 1 ohm. **[JEE 1981]**

(i) Find potential difference in Volt between the points A and B with A & B unconnected.

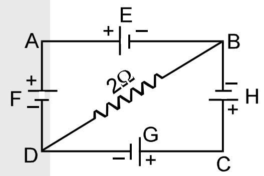
(ii) If r_2 is short circuited and the point A is connected to point B through a zero resistance wire, find the current through R in ampere.



10. The resistance of each resistor in the circuit diagram shown in figure is the same and equal to R = 1Ω. The voltage across the terminals is U = 7V. Determine the current i (Ampere) the leads if their resistance can be neglected.



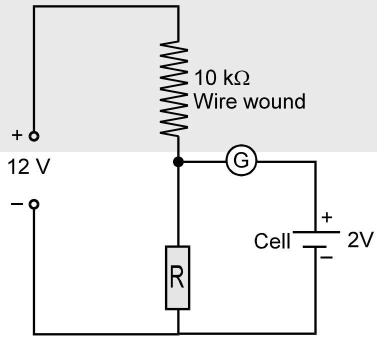
11. In the circuit shown in fig. E, F, G and H are cells of emf 2, 1, 3 and 1 volts and their internal resistances are 2, 1, 3 and 1 ohm respectively. Calculate. **[JEE 1981]**



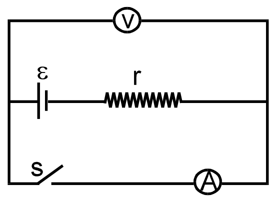
(i) The potential difference between B and D is given by $\left(\frac{13-n}{13}\right)$ Volt then valu of n will be.

(ii) The ratio of potential difference across the terminals of the cell G to cell H is given by $\left(\frac{n+2}{19}\right)$ the value of n will be.

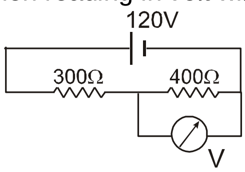
12. If the galvanometer in the circuit of figure reads zero, calculate the value of the resistor R (in kΩ) assuming that the 12 V source has negligible internal resistance.



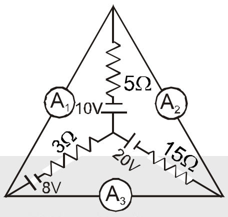
13. Figure shows an arrangement to measure the emf ε and internal resistance r of a battery. The voltmeter has a very high resistance and the ammeter has a very small resistance. The voltmeter reads 1.52 V when the switch S is open. When the switch is closed the voltmeter reading drops to 1.45 V and the ammeter reads 1.0 A. The internal resistance of the battery in mΩ will be ?



14. In the circuit shown, reading of the voltmeter connected across 400Ω resistance is 60V. If it is connected across 300 Ω resistance then reading in volt will be



15. In the given circuit the ammeter A_1 and A_2 are ideal and the ammeter A_3 has a resistance of 1.9×10^{-3} Ω. If sum of readings of all three meters is given by $\left(\frac{2n}{27}\right)$ Ampere the value of n will be.

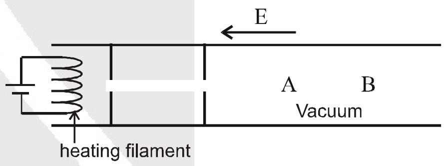


16. Two resistors, 400 Ω, and 800 Ω are connected in series with a 6 V battery. It is desired to measure the current in the circuit. An ammeter of 10 Ω resistance is used for this purpose. The reading of ammeter will be $\frac{N}{1210}$ A. Similarly, if a voltmeter of 1000 Ω resistance is used to measure the potential difference across the 400 Ω resistor, the reading of voltmeter is $\frac{P}{19}$ V. Then the value of N and P are :

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. A continuous beam of electrons emitted by a heating filament are accelerated in free space by an electric field as shown in figure. The two stops at the left ensure that the electron beam has a uniform cross-section. Which of the following is/are correct :

(A) Linear momentum of electron increases from A to B.
(B) The electric current is from right to left
(C) The magnitude of the current is same at A and B.
(D) The current density is same at A and B.



2. A current passes through a wire of non-uniform cross-section. Which of the following quantities are independent of the cross-section?

(A) the charge crossing in a given time interval (B) drift speed
(C) current density (D) free-electron density.

3. When no current is passed through a conductor

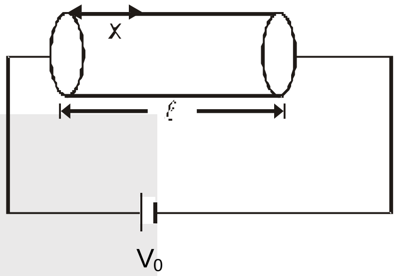
(A) the free electrons do not move
(B) the average speed of a free electron over a large period of time is zero
(C) the average velocity of a free electron over a large period of time is zero
(D) the average of the velocities of all the free electrons at an instant is zero

4. The current density in a wire is 10 A/cm^2 and the electric field in the wire is 5 V/cm. If ρ = resistivity of material, σ = conductivity of the material then (in S.I. units) :

(A) $\rho = 5 \times 10^{-3}$ (B) $\rho = 200$ (C) $\sigma = 5 \times 10^{-3}$ (D) $\sigma = 200$

5. A bulb is connected to an ideal battery of emf 10 V so that the resulting current is 10 mA. When the bulb is connected to 220 V mains (ideal), the current is 50 mA. Choose the correct alternative (s)
(A) In the first case, the resistance of the bulb is 1kΩ and in second case, it is 4.4 kΩ.
(B) It is not possible since ohm's law is not followed
(C) The increase in resistance is due to heating of the filament of the bulb when it is connected to 220 V mains
(D) None of these

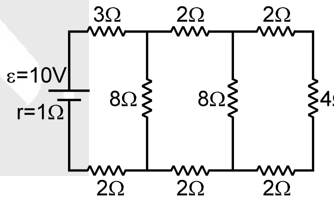
6. The cross section area and length of a cylindrical conductor are A and ℓ respectively is connected with a voltage source V_0. The conductivity varies as, $\sigma = \sigma_0 \frac{\ell}{x}$ where x ($0 < x < \ell$) is the distance along the axis of the cylinder from one of its end as shown in the figure. Choose the **correct** option :



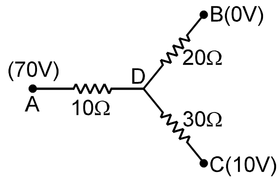
(A) The electric resistance of cylinder along its axis is $\frac{\ell}{2\sigma_0 A}$
(B) The electric current in the wire will be $\frac{V_0\sigma_0 A}{2\ell}$
(C) The current density in the wire will be $\frac{2V_0\sigma_0}{\ell}$
(D) The electric field in the wire at x in cylinder will be $\frac{2V_0}{\ell^2}x$

7. N cells each of e.m.f. E & identical resistance r are grouped into sets of K cells connected in series. The (N/K) sets are connected in parallel to a load of resistance R, then;
(A) Maximum power is delivered to the load if $K = \sqrt{\frac{NR}{r}}$.
(B) Maximum power is delivered to the load if $K = \sqrt{\frac{r}{NR}}$
(C) Maximum power delivered to the load is $\frac{E^2}{4Nr}$
(D) Maximum power delivered to the load is $\frac{NE^2}{4r}$

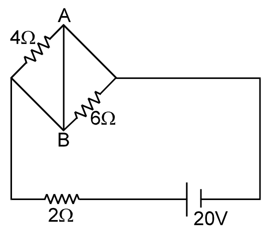
8. In the circuit shown, the cell has emf = 10 V and internal resistance = 1 Ω
(A) The current through the 3 Ω resistor is 1 A.
(B) The current though the 3 Ω resistor is 0.5 A
(C) The current through the 4 Ω resistor is 0.5 A.
(D) The current through the 4 Ω resistor is 0.25 A



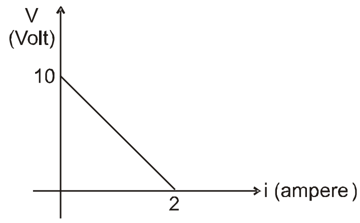
9. In the network shown, points A, B and C are potentials of 70 V, zero and 10 V respectively.
(A) Point D is at a potential of 40 V
(B) The currents in the sections AD, DB, DC are in the ratio 3 : 2 : 1
(C) The currents in the sections AD, DB, DC are in the ratio 1 : 2 : 3
(D) The network draws a total power of 200 W.



10. In the circuit shown in figure
(A) power supplied by the battery is 200 watt
(B) current flowing in the circuit is 5 A
(C) potential difference across 4 Ω resistance is equal to the potential difference across 6Ω resistance
(D) current in wire AB is zero



11. A battery of emf E and internal resistance r is connected across a resistance R. Resistance R can be adjusted to any value greater than or equal to zero. A graph is plotted between the current (i) passing through the resistance and potential difference (V) across it. Select the correct alternative (s)

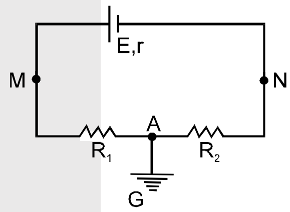


(A) internal resistance of the battery is 5Ω
(B) emf of the battery is 10 V
(C) maximum current which can be taken from the battery is 2 A
(D) V-i graph can never be a straight line as shown in figure.

12. Potential difference across the terminals of a non ideal battery is
(A) zero when it is short circuited
(B) less than its emf when current flows from negative terminal to positive terminal inside the battery
(C) zero when no current is drawn from the battery
(D) greater than its emf when current flows from positive terminal to negative inside the battery.

13. A cell of emf ε and internal resistance r drives a current i through an external resistance R.
(A) The cell is generating εi power
(B) Heat is produced in R at the rate εi
(C) Heat is produced in R at the rate $\varepsilon i \left(\frac{R}{R+r}\right)$
(D) Heat is produced in the cell at the rate $\varepsilon i \left(\frac{r}{R+r}\right)$

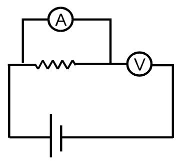
14. In the given figure, E = 12V, R_1 = 3Ω, R_2 = 2Ω and r = 1Ω. Then choose the correct option/s



(A) potential of point M is 6V
(B) potential of point N is – 4V
(C) potential of point M is 12V
(D) current in wire AG is zero

15. In a potentiometer wire experiment the emf of a battery in the primary circuit is 20volt and its internal resistance is 5Ω. There is a resistance box (in series with the battery and the potentiometer wire) whose resistance can be varied from 120Ω to 170Ω. Resistance of the potentiometer wire is 75Ω. The following potential differences can be measured using this potentiometer
(A) 5V (B) 6V (C) 7V (D) 8V

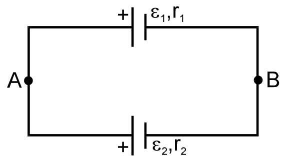
16. By mistake, a voltmeter is placed in series and an ammeter in parallel with a resistance in an electric circuit, with a cell in series.



(A) The main current in the circuit will be very low and almost all current will flow through the ammeter, if resistance of ammeter is much smaller than the resistance in parallel.
(B) If the devices are ideal, a large current will flow through the ammeter and it will be damaged
(C) If the devices (including battery) are ideal, ammeter will read zero current and voltmeter will read the emf of cell
(D) The devices may get damaged if emf of the cell is very high and the meters are nonideal.

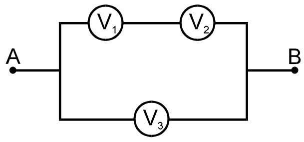
17. A micro-ammeter has a resistance of 100 Ω and full scale range of 50 μA. It can be used as a voltmeter and an ammeter of a higher range provided a resistance is added to it. Pick the correct range and resistance combination (s) :
(A) 50 V range with 10 kΩ resistance is series (B) 10 V range with 200 kΩ resistance in series
(C) 5 mA range with 1 Ω resistance in parallel (D) 10 mA range with 1 Ω resistance in parallel

18. Two cells of unequal emfs ε_1 and ε_2, and internal resistances r_1 and r_2 are joined as shown. V_A and V_B are the potentials at A and B respectively.



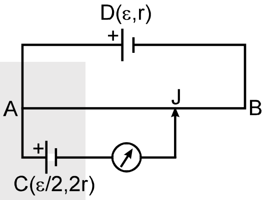
(A) One cell will supply energy to the other
(B) The potential difference across both the cells will be equal
(C) The potential difference across one cell will be greater than its emf.
(D) $V_A - V_B = \dfrac{(\varepsilon_1 r_2 + \varepsilon_2 r_1)}{r_1 + r_2}$

19. Three voltmeters, all having different resistances, are joined as shown. When some potential difference is applied across A and B, their readings are V_1, V_2, V_3 :



(A) $V_1 = V_2$
(B) $V_1 \neq V_2$
(C) $V_1 + V_2 = V_3$
(D) $V_1 + V_2 > V_3$

20. In the potentiometer arrangement shown, the driving cell D has emf ε and internal resistance r. The cell C, whose emf is to be measured, has emf $\varepsilon/2$ and internal resistance 2r. The potentiometer wire is 100-cm long. If balance is obtained at the length AJ = ℓ.



(A) ℓ = 50 cm
(B) ℓ> 50 cm
(C) Balance will be obtained only if resistance of AB is $\geq$ r.
(D) Balance cannot be obtained.

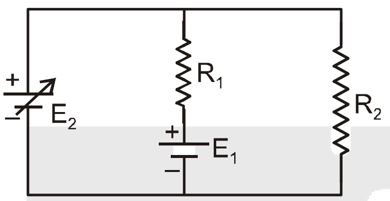
21. Choose the correct alternatives
(A) It is easier to start a car engine on a warm day than on a chilly cold day because the internal resistance of battery decreases with rise in temperature
(B) It is more economical to transmit electric power at high voltage and low current rather than at low voltage and high current because heat loss is proportional to square of current.
(C) The heating coil of an electric iron is enclosed in mica sheets because mica is a bad conductor of heat and good conductor of electricity
(D) The heating coil of an electric iron is enclosed in mica sheets because mica is a good conductor of heat and bad conductor of electricity.

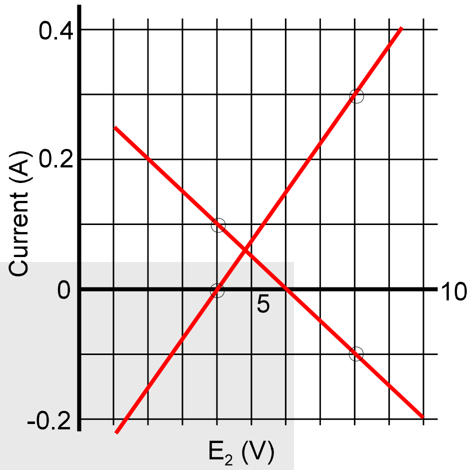
22. Which of the following statement/s is/are correct of a source of emf (such as a primary cell) ?
[Olympiad 2015 (stage-1)]
(A) Inside the cell there always exist an electrostatic field and a non-electrostatic field of equal magnitude directed opposite to it.
(B) Potential difference is the work of an electrostatic field whereas electromotive force is the work of a non-electrostatic field.
(C) Under certain condition current can flow from positive terminal to negative terminal within the cell.
(D) When an external resistance is connected to the cell, the electrostatic field inside the cell decreases in magnitude compared to the non-electrostatic field.

PART - IV : COMPREHENSION

COMPREHENSION-1

In the circuit given below, both batteries are ideal. Emf E_1 of battery 1 has a fixed value, but emf E_2 of battery 2 can be varied between 1.0 V and 10.0 V. The graph gives the currents through the two batteries as a function of E_2, but are not marked as which plot corresponds to which battery. But for both plots, current is assumed to be negative when the direction of the current through the battery is opposite the direction of that battery's emf. (Direction of emf is from negative to positive)





1. The value of emf E_1 is

(A) 8 V (B) 6 V (C) 4 V (D) 2V

2. The resistance R_1 has value

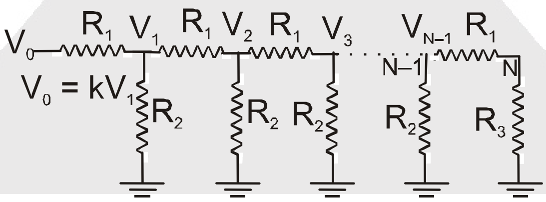
(A) 10 Ω (B) 20 Ω (C) 30 Ω (D) 40 Ω

3. The resistance R_2 is equal to :

(A) 10 Ω (B) 20 Ω (C) 30 Ω (D) 40 Ω

COMPREHENSION-2

A network of resistance is constructed with R_1 and R_2 as shown in the figure. The potential at the points 1, 2, 3,........, N are V_1, V_2, V_3,........., V_n respectively each having a potential K time smaller than previous one. Find:



4. $\left(\frac{R_1}{R_2}\right) \times \left(\frac{R_2}{R_3}\right)$ in terms of K.

(A) K–1 (B) $K^2 - 1$ (C) $\frac{1}{K+1}$ (D) $\frac{K-1}{K+1}$

5. Current that passes through the resistance R_2 nearest to the V_0 in terms V_0, K and R_3.

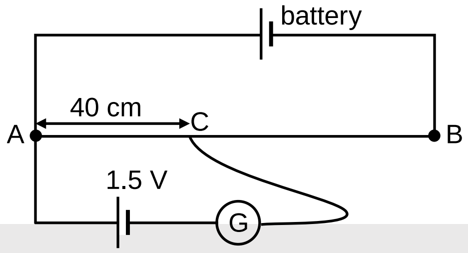
(A) $\left[\frac{(K+1)}{K^2}\right]\frac{V_0}{R_3}$ (B) $\left[\frac{(K-1)}{K}\right]\frac{V_0}{R_3}$ (C) $\left[\frac{(K-1)}{K^2}\right]\frac{V_0}{R_3}$ (D) $\left[\frac{(K+1)}{K^2}\right]\frac{V_0}{R_3}$

COMPREHENSION-3

A nichrome wire AB, 100 cm long and of uniform cross section is mounted on a meter scale the points A and B coinciding with 0 cm and 100 cm marks respectively. The wire has a resistance S = 50 ohm. Any point C along this wire, between A and B is called a variable point to which on end of and electrical element is connected. In the following questions this arrangement will be referred to as 'wire AB'.

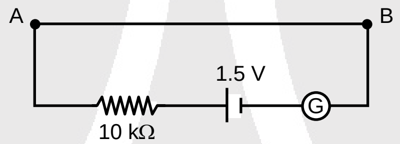
[Olympiad 2016 Stage-1]

6. The emf of a battery is determined using the following circuit with 'wire AB'. The galvanometer shows zero deflection when one of its terminals is connected to point C. If the internal resistance of the battery is 4 ohm, its emf is **[Olympiad 2016 Stage-1]**



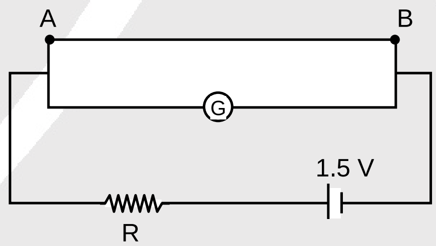
(A) 3.75 volt (B) 4.05 volt (C) 2.50 volt (D) 9.0 volt

7. In the circuit adjacent arrangement it is found that deflection in the galvanometer is 10 divisions. Also the voltage across the 'wire AB' is equal to the across the galvanometer. Therefore, the current sensitivity of the galvanometer is about. **[Olympiad 2016 Stage-1]**



(A) 0.050 div/μA. (B) 0.066 div/μA (C) 0.0140 div/μA (D) data insufficient

8. In the adjacent circuit a resistance R is used. Initially with 'wire AB' not in the circuit, the galvanometer shows a deflection of d divisions. Now, the 'wire AB' is connected parallel to the galvanometer and the galvanometer shows a deflection nearly d/2 divisions. Therefore : **[Olympiad 2016 Stage-1]**



(A) R = G (B) R << G (C) R >> G (D) $R = \frac{SG}{S+G}$

COMPREHENSION-4

Group of question Nos 9 to 12 are based on the following paragraph and its subsequent continuation of after some question.

The following question are concerned with experiments of the characterization and use of a moving coil galvanometer.

The series combination of variable resistance R, one 100 Ω resistor and moving coil galvanometer is connected to a mobile phone charger having negligible internal resistance. The zero of the galvanometer lies at the centre and the pointer can move 30 division full scale on either side depending on the direction of current. The reading of the galvanometer is 10 divisions and the voltages across the galvanometer and 100 Ω resistor are respectively 12 mV and 16 mV.

9. The figure of merit of the galvanometer is microampere per division is :

(A) 16 (B) 20 (C) 32 (D) 10

10. The resistance of the galvanometer is ohm is :

(A) 50Ω (B) 75 Ω (C) 100 Ω (D) 80 Ω

The series combination of the galvanometer with a resistance of R is connected across an ideal voltage supply of 12 V and this time the galvanometer shows full scale deflection of 30 divisions.

11. The value of R is nearly

(A) 12.5 kΩ (B) 25 kΩ (C) 75 kΩ (D) 100 kΩ

12. A 24 Ω resistance is connected to a 5 V battery with internal resistance of 1Ω. A 25 kΩ resistance is connected in series with the galvanometer and this combination is used to measure the voltage across the 24 Ω resistance. The number of divisions shown in the galvanometer is

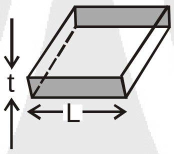
(A) 6 (B) 8 (C) 10 (D) 12

Exercise-3

✍ Marked Questions can be used as Revision Questions.
*** Marked Questions may have more than one correct option.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. Consider a thin square sheet of side L and thickness t, made of a material of resitivity ρ. The resistance between two opposite faces, shown by the shaded areas in the figure is : **[IIT-JEE 2010; 3/163, –1]**

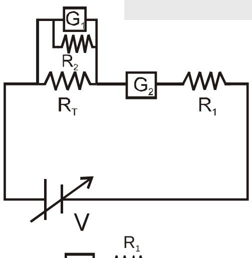


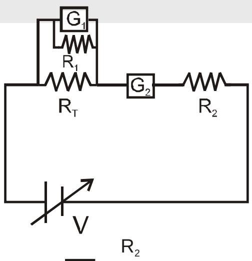
(A) directly proportional to L (B) directly proportional to t
(C) independent of L (D) independent of t

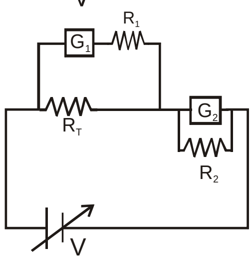
2. Incandescent bulbs are designed by keeping in mind that the resistance of their filament increases with increase in temperature. If at room temperature, 100 W, 60 W and 40 W bulbs have filament resistances R_{100}, R_{60} and R_{40}, respectively, the relation between these resistance is :
[IIT-JEE 2010; 3/163, –1]

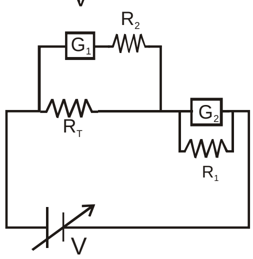
(A) $\frac{1}{R_{100}} = \frac{1}{R_{40}} + \frac{1}{R_{60}}$ (B) $R_{100} = R_{40} + R_{60}$ (C) $R_{100} > R_{60} > R_{40}$ (D) $\frac{1}{R_{100}} > \frac{1}{R_{60}} > \frac{1}{R_{40}}$

3. To verify Ohm's law, a student is provided with a test resistor R_T, a high resistance R_1, a small resistance R_2, two identical galvanometers G_1 and G_2, and a variable voltage source V. The correct circuit to carry out the experiment is : **[IIT-JEE 2010; 3/163, –1]**

(A)


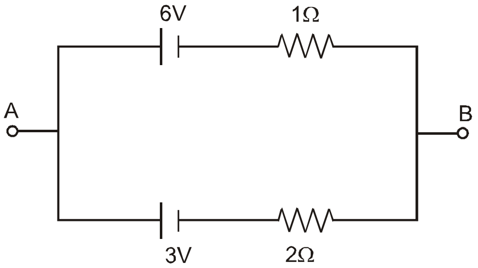
(B)


(C)


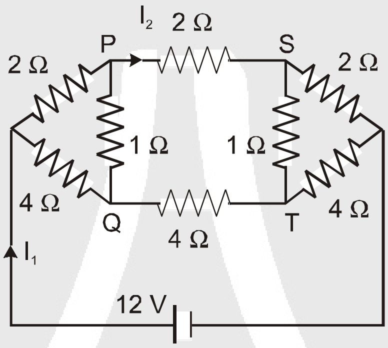
(D)


4. When two identical batteries of internal resistance 1Ω each are connected in series across a resistor R, the rate of heat produced in R is J_1. When the same batteries are connected in parallel across R, the rate is J_2. If $J_1 = 2.25\, J_2$ the value of R in Ω is : **[IIT-JEE 2010; 3/163]**

5. Two batteries of different emfs and different internal resistances are connected as shown. The voltage across AB in volts is **[IIT-JEE 2011; 4/160]**



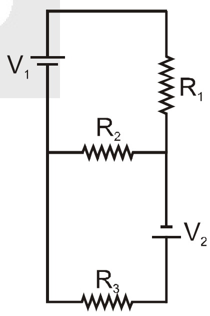
6*. For the resistance network shown in the figure, choose the correct option(s).
[JEE 2012; Paper-1, 4/66]



(A) The current through PQ is zero. (B) $I_1 = 3$ A.
(C) The potential at S is less than that at Q. (D) $I_2 = 2$ A.

7*. Heater of electric kettle is made of a wire of length L and diameter d. It takes 4 minutes to raise the temperature of 0.5 kg water by 40K. This heater is replaced by a new heater having two wires of the same material, each of length L and diameter 2d. The way these wires are connected is given in the options. How much time in minutes will it take to raise the temperature of the same amount of water by 40K ? **[JEE (Advanced) 2014, 3/60, –1]**
(A) 4 if wires are in parallel (B) 2 if wires are in series
(C) 1 if wires are in series (D) 0.5 if wires are in parallel.

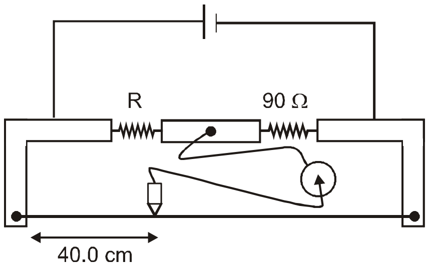
8*. Two ideal batteries of emf V_1 and V_2 and three resistances R_1, R_2 and R_3 are connected as shown in the figure. The current in resistance R_2 would be zero if **[JEE (Advanced) 2014, 3/60, –1]**



(A) $V_1 = V_2$ and $R_1 = R_2 = R_3$
(B) $V_1 = V_2$ and $R_1 = 2R_2 = R_3$
(C) $V_1 = 2V_2$ and $2R_1 = 2R_2 = R_3$
(D) $2V_1 = V_2$ and $2R_1 = R_2 = R_3$

9. A galvanometer gives full scale deflection with 0.006 A current. By connecting it to a 4990Ω resistance, it can be converted into a voltmeter of range 0-30 V. If connected to a $\frac{2n}{249}\Omega$ resistance, it becomes an ammeter of range 0-1.5 A. The value of n is. **[JEE (Advanced) 2014, 3/60]**

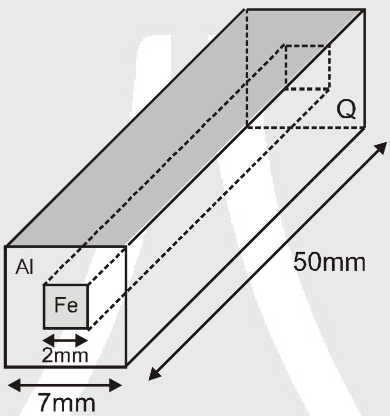
10. During an experiment with a metre bridge, the galvanometer shows a null point when the joceky is pressed at 40.0 cm using a standard resistance of 90 Ω, as shown in the figure. The least count of the scale used in the meter bridge is 1 mm. The unknown resistance is **[JEE (Advanced) 2014, 3/60, –1]**



(A) $60 \pm 0.15\Omega$ (B) $135 \pm 0.56\Omega$ (C) $60 \pm 0.25\Omega$ (D) $135 \pm 0.23\Omega$

11. In an aluminum (Al) bar of square cross section, a square hole is drilled and is filled with iron (Fe) as shown in the figure, The electrical resistivities of Al and Fe are 2.7×10^{-8} Ω m and 1.0×10^{-7} Ω m, respectively. The electrical resistance between the two faces P and Q of the composite bar is

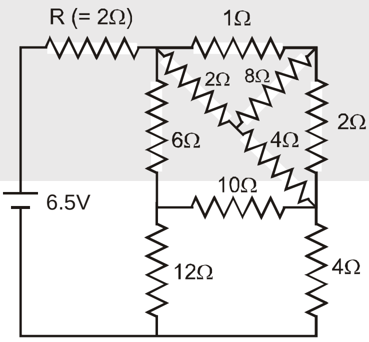
[JEE (Advanced) 2015 ; 4/88, –2]



(A) $\frac{2475}{64}\mu\Omega$ (B) $\frac{1875}{64}\mu\Omega$ (C) $\frac{1875}{49}\mu\Omega$ (D) $\frac{2475}{132}\mu\Omega$

12. In the following circuit, the current through the resistor R (= 2Ω) is I Amperes. The valeu of I is :

[JEE (Advanced) 2015 ; P-2,4/88]



13. Consider two identical galvanometers and two identical resistors with resistance R. If the internal resistance of the galvanometers R_C < R/2, which of the following statement(s) about any one of the galvanometers is(are) true ? **[JEE (Advanced) 2016 ; P-2, 4/62, –2]**

(A) The maximum voltage range is obtained when all the components are connected in series

(B) The maximum voltage range is obtained when the two resistors and one galvanometer are connected in series, and the second galvanometer is connected in parallel to the first galvanometer

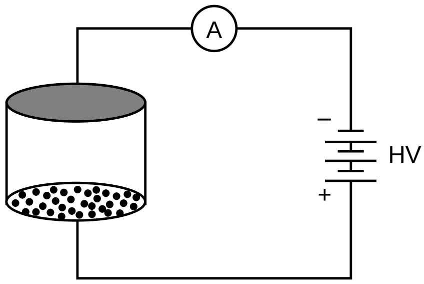
(C) The maximum current range is obtained when all the components are connected in parallel

(D) The maximum current range is obtained when the two galvanometers are connected in series, and the combination is connected in parallel with both the resistors.

Paragraph for Question Nos. 14 to 15

Consider an evacuated cylindrical chamber of height h having rigid conducting plates at the ends and an insulating curved surface as shown in the figure. A number of spherical balls made of a light weight and soft material and coated with a conducting material are placed on the bottom plate. The balls have a radius r << h.

Now a high voltage source (HV) is connected across the conducting plates such that the bottom plate is at $+V_0$ and the top plate at $-V_0$. Due to their conducting surface the balls will get charged, will become equipotential with the plate and are repelled by it. The balls will eventually collide with the top plate, where the coefficient of restitution can be taken to be zero due to the soft nature of the material of the balls. The electric field in the chamber can be considered to be that of a parallel plate capacitor. Assume that there are no collisions between the balls and the interaction between them is negligible. (Ignore gravity) **[JEE (Advanced) 2016 ; P-2, 3/62]**



14. Which one of the following statements is correct?
(A) The balls will execute simple harmonic motion between the two plates
(B) The balls will bounce back to the bottom plate carrying the opposite charge they went up with
(C) The balls will bounce back to the bottom plate carrying the same charge they went up with
(D) The balls will stick to the top plate and remain there

15. The average current in the steady state registered by the ammeter in the circuit will be
(A) proportional to V_0^2 (B) proportional to $V_0^{1/2}$
(C) proportional to the potential V_0 (D) zero

16. A moving coil galvanometer has 50 turns and each turn has an area 2×10^{-4} m^2. The magnetic field produced by the magnet inside the galvanometer is 0.02T. The torsional constant of the suspension wire is 10^{-4} Nm rad^{-1}. When a current flows through the galvanometer, a full scale deflection occurs if the coil rotates by 0.2 rad. The resistance of the coil of the galvanometer is 50Ω. This galvanometer is to be converted into an ammeter capable of measuring current in the range 0 – 1.0A. For this purpose, a shunt resistance is to be added in parallel to the galvanometer. The value of this shunt resistance, in ohms, is __________. **[JEE (Advanced) 2018 ; P-2, 3/60]**

17. Two identical moving coil galvanometers have 10 Ω resistance and full scale deflection at 2μA current. One of them is converted into a voltmeter of 100 mV full scale reading and the other into an Ammeter of 1mA full scale current using appropriate resistors. These are then used to measure the voltage and current in the Ohm's law experiment with R = 1000Ω resistor by using an ideal cell. Which of the following statement(s) is/are correct ? **[JEE (Advanced) 2019 ; P-1, 4/62, –1]**
(A) The resistance of the Voltmeter will be 100 kΩ
(B) The resistance of the Ammeter will be 0.02 Ω (round off to 2nd decimal place)
(C) If the ideal cell is replaced by a cell having internal resistance of 5Ω then the measured value of R will be more than 1000 Ω
(D) The measured value of R will be 978Ω < R < 982 Ω

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. Two conductors have the same resistance at 0ºC but their temperature coefficients of resistance are α_1 and α_2. The respective temperature coefficients of their series and parallel combinations are nearly **[AIEEE 2010, 8/144]**

(1) $\frac{\alpha_1+\alpha_2}{2}$, $\alpha_1 + \alpha_2$ (2) $\alpha_1 + \alpha_2$, $\frac{\alpha_1+\alpha_2}{2}$ (3) $\alpha_1 + \alpha_2$, $\frac{\alpha_1\alpha_2}{\alpha_1+\alpha_2}$ (4) $\frac{\alpha_1+\alpha_2}{2}$, $\frac{\alpha_1+\alpha_2}{2}$

2. If a wire is stretched to make it 0.1% longer, its resistance will : **[AIEEE 2011, 4/120, –1]**
(1) increase by 0.05% (2) increase by 0.2% (3) decrease by 0.2% (4) decrease by 0.05%

3. The current in the primary circuit of a potentiometer is 0.2 A. The specific resistance and cross-section of the potentiometer wire are 4×10^{-7} ohm metre and 8×10^{-7} m^2 respectively. The potential gradient will be equal to : **[AIEEE 2011, 11 May; 4/120, –1]**
(1) 1 V/ m (2) 0.5 V/m (3) 0.1 V/m (4) 0.2 V/m

4. Two electric bulbs marked 25W – 220V and 100W – 220 V are connected in series to a 440 V supply. Which of the bulbs will fuse ? **[AIEEE 2012 ; 4/120, –1]**
(1) both (2) 100W (3) 25W (4) neither

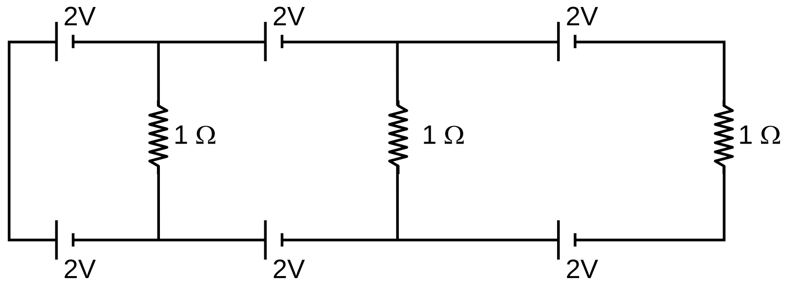
5. The supply voltage to room is 120 V. The resistance of the lead wires is 6 Ω. A 60 W bulb is already switched on. What is the decrease of voltage across the bulb, when a 240 W heater is switched on in parallel to the bulb ? **[JEE (Main) 2013, 4/120]**
(1) zero Volt (2) 2.9 Volt (3) 13.3 Volt (4) 10.04 Volt

6. This questions has Statement I and Statement II. Of the four choices given after the Statements, choose the one that best describes the two Statements. **[JEE (Main) 2013, 4/120]**
Statement-I : Higher the range, greater is the resistance of ammeter.
Statement-II : To increase the range of ammeter, additional shunt needs to be used across it.
(1) Statement-I is true, Statment -II is true, Statement -II is the correct explanation of Statement-I.
(2) Statement-I is true, Statment - II is true, Statement - II is not the correct explanation of Statement-I.
(3) Statement-I is true, Statment - II is false.
(4) Statement-I is false, Statment - II is true.

7. In a large building, there are 15 bulbs of 40W, 5 bulbs of 100 W, 5 fans of 80 W and 1 heater of 1 kW. The voltage of the electric mains is 220 V. The minimum capacity of the main fuse of the building will be: **[JEE (Main) 2014 ; 4/120, –1]**
(1) 8 A (2) 10 A (3) 12 A (4) 14 A

8. When 5V potential difference is applied across a wire of length 0.1 m, the drift speed of electrons is 2.5×10^{-4} ms^{-1}. If the electron density in the wire is 8×10^{28} m^{-3}, the resistivity of the material is close to : **[JEE (Main) 2015; 4/120, –1]**
(1) 1.6×10^{-8} Ωm (2) 1.6×10^{-7} Ωm (3) 1.6×10^{-6} Ωm (4) 1.6×10^{-5} Ωm

9. A galvanometer having a coil resistance of 100 Ω gives a full scale deflection, when a current of 1 mA is passed through it. The value of the resistance, which can convert this galvanometer into ammeter giving a full scale deflection for a current of 10 A, is : **[JEE (Main) 2016; 4/120, –1]**
(1) 2 Ω (2) 0.1 Ω (3) 3 Ω (4) 0.01 Ω

10.


In the above circuit the current in each resistance is : **[JEE (Main) 2017, 4/120, –1]**
(1) 0 A (2) 1 A (3) 0.25 A (4) 0.5 A

11. Which of the following statements is false ? **[JEE (Main) 2017, 4/120, –1]**

(1) Krichhoff's second law represents energy conservation.

(2) Wheatstone bridge is the most sensitive when all the four resistance are of the same order of magnitude

(3) In a balanced wheatstone bridge if the cell and the galvanometer are exchanged, the null point is disturbed

(4) A rheostat can be used as a potential divider.

12. When a current of 5mA is passed through a galvanometer having a coil of resistance 15Ω, it shows full scale defection. The value of the resistance to be put in series with the galvanometer to convert it into a voltmeter of range 0 – 10 V is : **[JEE (Main) 2017, 4/120, –1]**

(1) $4.005 \times 10^3\,\Omega$ (2) $1.985 \times 10^3\,\Omega$ (3) $2.045 \times 10^3\,\Omega$ (4) $2.535 \times 10^3\,\Omega$

13. Two batteries with e.m.f 12V and 13V are connected in parallel across a load resistor of 10Ω. The internal resistance of the two batteries are 1Ω and 2Ω respectively. The voltage across the load lies between **[JEE (Main) 2018, 4/120, –1]**

(1) 11.4V and 11.5 V (2) 11.7V and 11.8V (3) 11.6V and 11.7V (4) 11.5V and 11.6V

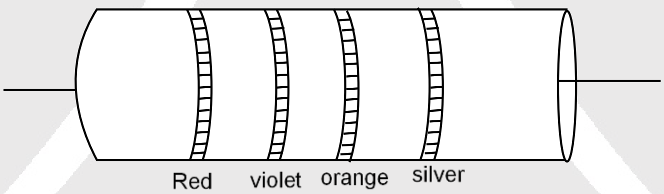
14. In a potentiometer experiment, it is found that no current passes through the galvanometer when the terminals of the cell are connected across 52cm of the potentiometer wire. If the cell is shunted by resistance of 5 Ω, a balance is found when the cell is connected across 40 cm of the wire. Find the internal resistance of the cell. **[JEE (Main) 2018; 4/120, –1]**

(1) 2 Ω (2) 2.5 Ω (3) 1 Ω (4) 1.5 Ω

15. On interchanging the resistances, the balance point of a meter bridge shifts to the left by 10 cm. The resistance of their series combination is 1KΩ. How much was the resistance on the left slot before interchanging the resistances ? **[JEE (Main) 2018; 4/120, –1]**

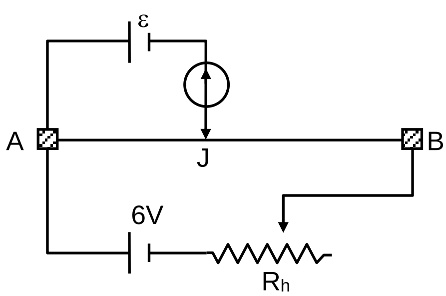
(1) 550 Ω (2) 910 Ω (3) 990 Ω (4) 505Ω

16. A resistance is shown in the figure. Its value and tolerance are given respectively by : **[JEE (Main) 2019; 4/120, –1]**



(1) 270Ω, 5% (2) 27 kΩ, 20% (3) 270 Ω, 10% (4) 27 kΩ, 10%

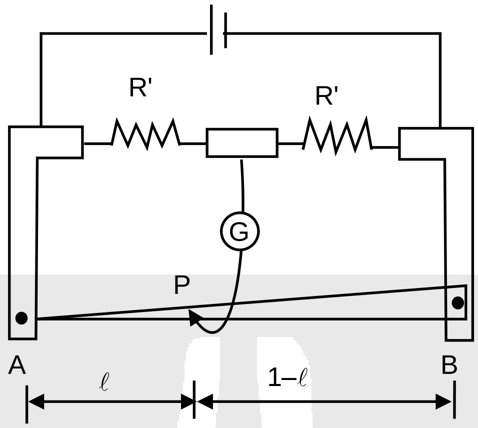
17. The resistance of the meter bridge AB in given figure is 4Ω. With a cell of emf ε = 0.5 V and rheostat resistance R_h = 2Ω the null point is obtained at some point J. When the cell is replaced by another one of emf $\varepsilon = \varepsilon_2$ the same null point J is found for R_h = 6 Ω. The emf ε_2 is, : **[JEE (Main) 2019; 4/120, –1]**



(1) 0.5 V (2) 0.3 V (3) 0.4 V (4) 0.6 V

18. In a meter bridge, the wire of length 1m has a non–uniform cross–section such that, the variation $\frac{dR}{d\ell}$ of its resistance R with length ℓ is $\frac{dR}{d\ell} \propto \frac{1}{\sqrt{\ell}}$. Two equal resistances are connected as shown in the figure. The galvanometer has zero deflection when the jockey is at point P. What is the length AP ?

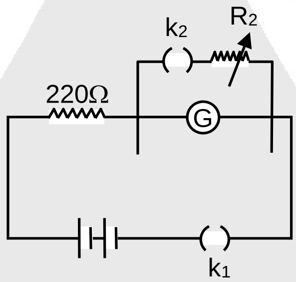
[JEE (Main) 2019; 4/120, –1]



(1) 0.2 m (2) 0.3 m (3) 0.25 m (4) 0.35 m

19. The galvanometer deflection when key K_1 is closed but K_2 is open, equals θ_0 (see figure). On closing K_2 also and adjusting R_2 to 5Ω, the deflection in galvanometer becomes $\frac{\theta_0}{5}$. The resistance of the galvanometer is, then, given by [Neglect the internal resistance of battery] :

[JEE (Main) 2019; 4/120, –1]



(1) 5 Ω (2) 12Ω (3) 25Ω (4) 22 Ω

20. In a building there are 15 bulbs of 45 W, 15 bulbs of 100 W, 15 small fans of 10 W and 2 heaters of 1 kW. The voltage of electric main is 220 V. The minimum fuse capacity (rated value) of building will be:

[JEE (Main) 2020, 07 January; 4/100, –1]

(1) 20 A (2) 15 A (3) 10 A (4) 25 A

21. The length of a potentiometer wire is 120 cm and it carries a current of 60 mA. For a cell of emf 5V and internal resistance of 20Ω, the null point on it is found to be at 1000 cm. The resistance of whole wire is:

[JEE (Main) 2020, 08 January; 4/100, –1]

(1) 60Ω (2) 120Ω (3) 100Ω (4) 80Ω

22. A galvanometer having a coil resistance 100Ω gives a full scale deflection when a current of 1mA is passed through it. What is the value of the resistance which can convert this galvanometer into a voltmeter giving full scale deflection for a potential difference of 10 V ?

[JEE (Main) 2020, 08 January; 4/100, –1]

(1) 8.9 kΩ (2) 10 kΩ (3) 9.9 kΩ (4) 7.9 kΩ

Answers

EXERCISE-1

PART - I

Section (A)

A-1. 31 C, $\frac{31}{3}$ A

A-2. 1.1×10^{-3} ms^{-1} or 1.1 mm s^{-1}

A-3. (i) Q = 1200 C (ii) n = 75 x 10^{20}

Section (B)

B-1. **(a)** $n = \frac{2}{1.6} \times 10^{17} = 1.25 \times 10^{17}$ **(b)** $\frac{1}{2\pi} \times 10^{6}$ A/m^2

B-2. 10 A. **B-3.** **(i)** 41ºC **(ii)** $\frac{\ell n2}{273}$ $^{o}C^{-1}$.

B-4. T_2 **B-5.** 0.2 %

B-6 (i) $R = \frac{0.35}{2} = 0.175\ \Omega$ (ii) $R = 7 \times 10^{-5}\ \Omega$

Section (C)

C-1. (a) E = 10 V each
(b) (A) act as a source and (B) act as load
(c) V_A = 9V, V_B = 11 V
(d) P_A = 9 W, P_B = 11 W
(e) Heat rate = 1 W each
(f) 10 W each
(g) 9V, 11V
(h) –9W, 11 W

C-2. $\frac{125}{9}$ V

C-3. **(a)** all equal **(b)** b, then a and c equal
(c) a, c equal, b

C-4. **(a)** 7.5 V, **(b)** 24 mA **(c)** greater than 12 V.

C-5. **(a)** $\frac{50}{11}$ = 4.55 A **(b)** $\frac{22 \times 11}{5} = 48.4\ \Omega$
(c) 1000 W **(d)** 240 cal s^{-1}
(e) 80/3 gm

C-6. (a) $V_A = V_B = V_C = V_D$ = 0 V,
$V_E = V_F = V_G = V_H$ = 10 V, $V_I = V_J = V_K$ = 15 V
(b) V_1 = 15 V, V_2 = 5V, V_3 = 15 V
(c) each act as a source
(d) 17.5 A (↑), 15A(↓) 2.5 A (↑), 5A (↓) from left to right in given circuit.
(e) 1 Ω resistance
(f) left most battery.

C-7. $\frac{25}{9}$ V = 2.78 V, $\frac{5}{18}$ A = 0.278 A **C-8.** 19 V

C-9. (a) 10 Ω. (b) 3200 J

C-10. 5 A, 74 V, 49 V (+ve terminal is connected at point B)

Section (D)

D-1. $\frac{125}{4}$ = 31.25 watt

D-2. P_A = 8 W & P_B = 32 W, A is more likely to fail his examinations

D-3. R_f = 2Ω.

D-4. (a) R = 10 Ω (b) 1A in each (c) V_3 = 3V, V_2 = 2V, V_4 = 4V (d) 10 W (e) 1 W (f) 9W
(g) 9V (h) 4 Ω resistance (i) 3 W.

D-5. (a) R = 3 Ω
(b) i = 2A, $i_1 = \frac{1}{2}$ A, i_2 = 1A, $i_3 = \frac{1}{2}$ A
(c) V = 4V in each (d) 12 W
(e) 4W (f) 8 W (g) 4Ω (h) 4W

D-6. (a) 3.7 V (b) 3.7 V

D-7. (i) R_{AB} = 5/6 Ω (ii) R_{CD} = 1.5 Ω
(iii) R_{EF} = 1.5 Ω (iv) R_{AF} = 5/6 Ω
(v) R_{AC} = 4/3 Ω

D-8. (ii) 1.5 A **D-9.** **(i)** $\frac{150}{7}$ = 21.43 V **(ii)** 1600 Ω

D-10. CE: ED = $\sqrt{2}$: 1 **D-11.** 12.5 Ω, 170 Ω.

D-12. (a) 1 A (b) 2/3 A (c) 1/3 A

D-13. (a) 0.1 A (b) 0.3 A

Section (E)

E-1. (i) $\frac{12}{8.59}$ = 1.4 A, (ii) $\frac{12 \times 8.5}{8.59}$ = 11.9 V

E-2. (i) $\frac{1}{2}$ = 0.5 A (ii) $\frac{1}{12}$ = 0.0833 A
(iii) $1.5 + \frac{1}{2} \times 0.4$ = 1.7 V

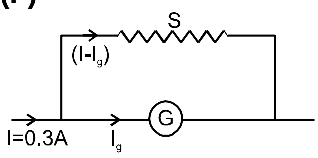
E-3. $V_B - V_A$ =21/5 = 4.2 V,
I = 35/2 mA = 17.5 mA (B to A)

E-4. zero in the upper 4Ω resistor and 0.2 A in the rest two.

E-5. (a) $\frac{1.2}{2.1}$ = 0.57 (b) 1 (c) $\frac{10.5}{6}$ =1.75

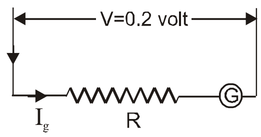
Section (F)

F-1.



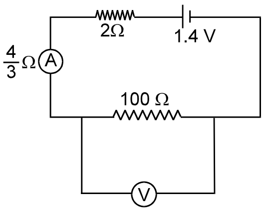
(a) $S = \frac{30 \times 2 \times 10^{-3}}{0.3 - 2 \times 10^{-3}} = 0.2013\ \Omega$

(b) R = 70 Ω



F-2. (a) 24 V, (b) 28 V **F-3.** $\frac{20}{3}$ V

F-4. (i)



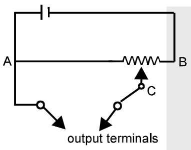
(ii) 200 Ω (iii) $1.1 - \frac{4}{3} = -0.23$ V

F-5. 5L/9 **F-6.** $\left(\frac{70}{60} - 1\right) \times 9.5 = \frac{9.5}{6}$ ohm

F-7. (a) 1.25 V, (b) saving of galvanometer from damage and to prevent the cell discharging fast (c) No, (d) Yes, (e) No, (f) No

F-8. $x = \frac{20}{7}\ \Omega$, $Y = \frac{20}{3}\ \Omega$

F-9.



PART - II

Section (A)

A-1.	(C)	**A-2.**	(D)	**A-3.**	(A)
A-4	(A)				

Section (B)

B-1.	(D)	**B-2.**	(B)

Section (C)

C-1.	(B)	**C-2.**	(D)	**C-3.**	(B)
C-4.	(A)	**C-5.**	(B)	**C-6. (i)**	(B)
(ii)	(D)	**C-7.**	(B)	**C-8.**	(A)
C-9.	(B)				

Section (D)

D-1.	**(a)**	(B)	**(b)**	(C)	**D-2.**	(B)	
D-3.	(A)	**D-4.**	(C)	**D-5.**	(A)		
D-6.	(A)	**D-7.**	(A)	**D-8.**	(C)		
D-9.	(B)	**D-10.**	(A)	**D-11.**	(C)		
D-12.	(B)	**D-13.**	(B)	**D-14.**	(D)		
D-15.	(C)	**D-16.**	(B)	**D-17.**	(C)		

Section (E)

E-1.	(C)	**E-2.**	(A)	**E-3.**	(D)
E-4.	(A)				

Section (F)

F-1.	(C)	**F-2.**	(A)	**F-3.**	(A)
F-4.	(A)	**F-5.**	(C)	**F-6.**	(D)
F-7.	(D)	**F-8.**	(A)	**F-9.**	(B)
F-10.	(A)	**F-11.**	(B)		

PART - III

1. (A) q, (B) p, (C) p, (D) q

2. (A) p ; (B) q, s ; (C) s ; (D) p, r, s

EXERCISE-2

PART - I

1.	(C)	**2.**	(A)	**3.**	(B)
4.	(B)	**5.**	(D)	**6.**	(A)
7.	(D)	**8.**	(A)	**9.**	(B)
10.	(A)	**11.**	(A)	**12.**	(D)
13.	(A)	**14.**	(C)	**15.**	(B)
16.	(B)	**17.**	(C)	**18.**	(A)
19.	(D)	**20.**	(A)	**21.**	(D)
22.	(D)	**23.**	(B)	**24.**	(A)
25.	(C)	**26.**	(B)		

PART - II

1.	08.00	**2.**	04.00	**3.**	03.00
4.	03.00	**5.**	06.00	**6.**	02.00
7.	05.00	**8.**	02.00		
9.	(i) 02.00		(ii) 02.00	**10.**	15.00
11.	(i) 11.00		(ii) 19.00	**12.**	02.00
13.	70.00	**14.**	45.00	**15.**	58.00
16.	6.00 & 30.00				

PART - III

1.	(A)(B)(C)(D)	**2.**	(A)(D)	**3.**	(C)(D)
4.	(A)(D)	**5.**	(A)(C)	**6.**	(A)(C)(D)
7.	(A)(D)	**8.**	(A)(D)	**9.**	(A)(B)(D)
10.	(A)(C)	**11.**	(A)(B)(C)	**12.**	(A) (B) (D)
13.	(A)(C)(D)	**14.**	(A)(B)(D)		
15.	(A)(B)(C)	**16.**	(A)(C)(D)		
17.	(B)(C)	**18.**	(A)(B)(C)(D)	**19.**	(B)(C)
20.	(B) (C)	**21.**	(A)(B)(D)	**22.**	(B) (C) (D)

PART - IV

1.	(B)	**2.**	(B)	**3.**	(D)
4.	(A)	**5.**	(C)	**6.**	(B)
7.	(B)	**8.**	(C)	**9.**	(A)
10.	(B)	**11.**	(B)	**12.**	(D)

EXERCISE-3

PART - I

1.	(C)	**2.**	(D)	**3.**	(C)
4.	4	**5.**	5	**6.**	(A)(B)(C)(D)
7.	(B)(D)	**8.**	(A)(B)(D)	**9.**	5
10.	(C)	**11.**	(B)	**12.**	1
13.	(B)(C)	**14.**	(B)	**15.**	(A)
16.	5.56 or 5.55	**17.**	(2) (4)		

PART - II

1.	(4)	**2.**	(2)	**3.**	(3)
4.	(3)	**5.**	(4)	**6.**	(4)
7.	(3)	**8.**	(4)	**9.**	(4)
10.	(1)	**11.**	(3)	**12.**	(2)
13.	(4)	**14.**	(4)	**15.**	(1)
16.	(4)	**17.**	(2)	**18.**	(3)
19.	(4)	**20.**	(1)	**21.**	(3)
22.	(3)				