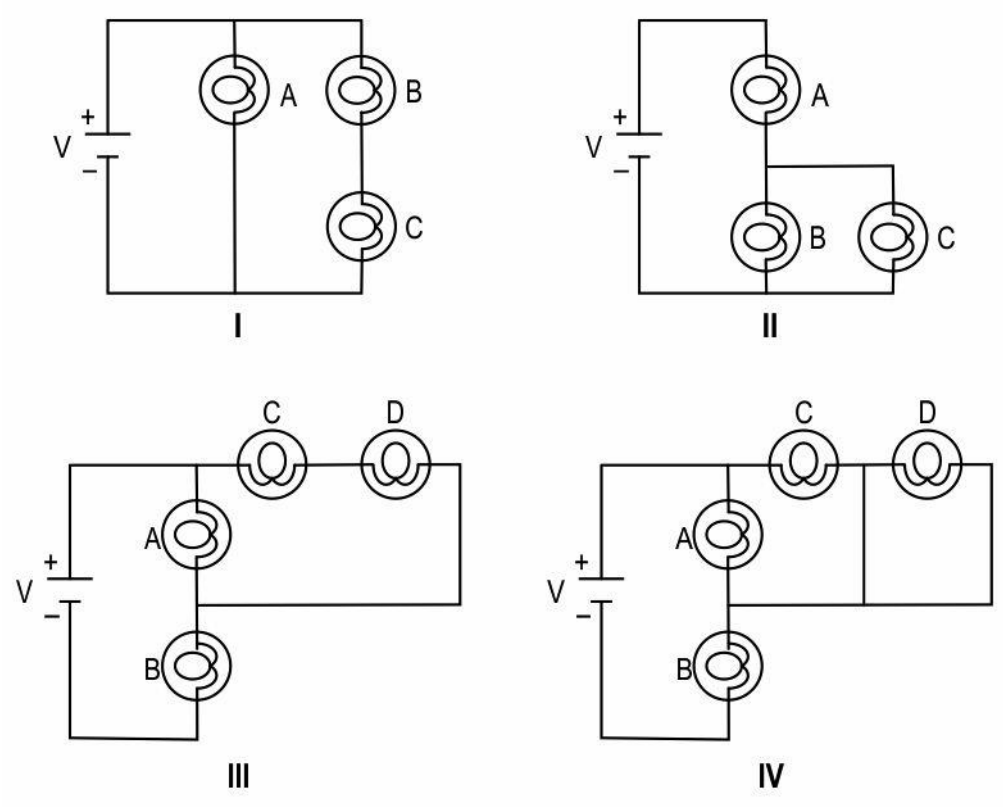
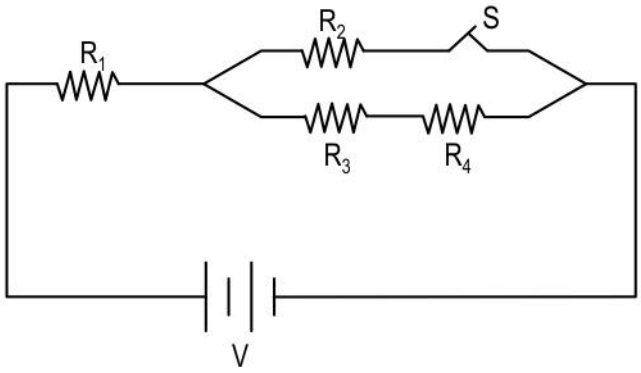
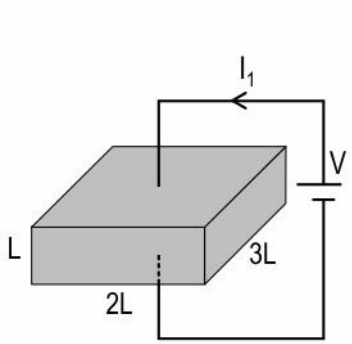
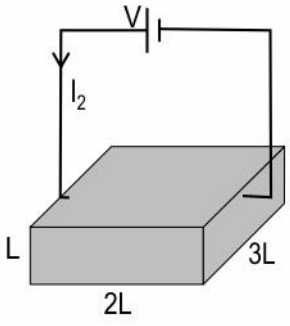
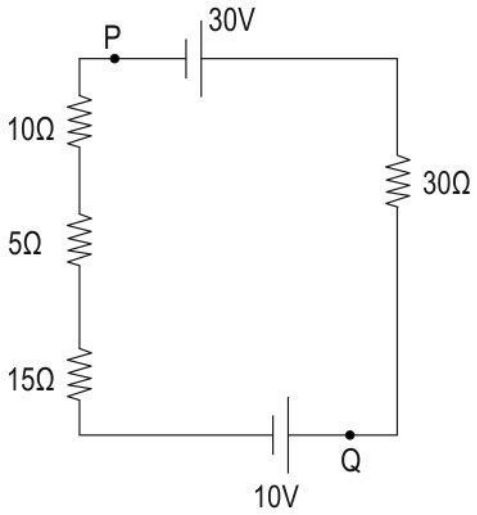
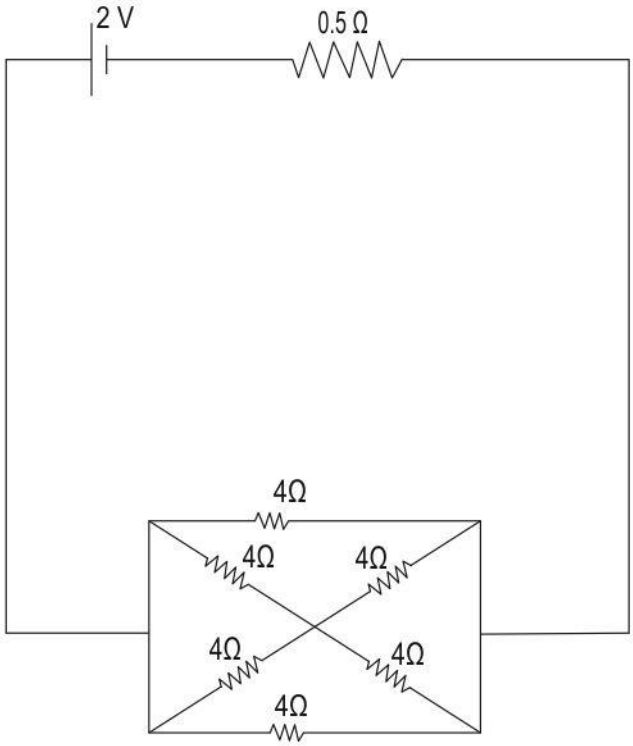
Current Electricity

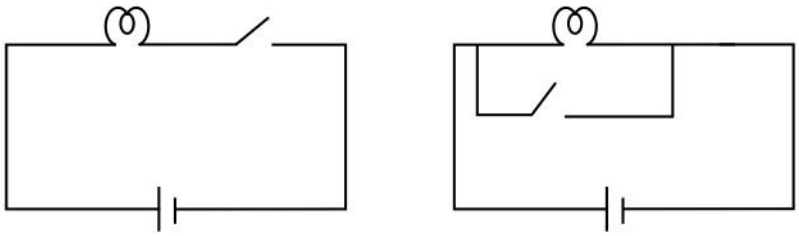
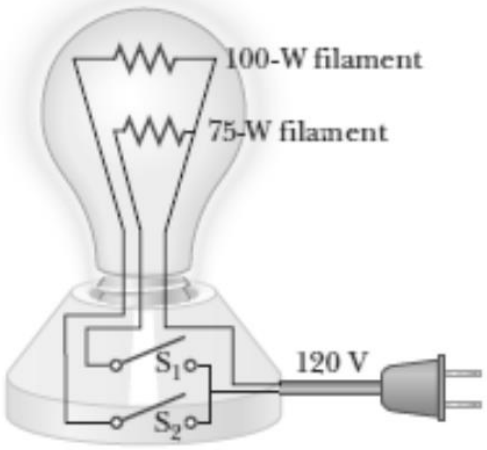
Q.No	Question	Marks
	Multiple Choice Question	
Q.39	A light bulb is rated at 44 W, 220 V, and a table fan is rated at 60 W, 110 V. Which statement is correct if each of the two devices is connected to a power supply of 220 V separately? A. The light bulb has a greater resistance and draws a greater current than the table fan. B. The light bulb has a greater resistance and draws a smaller current than the table fan. C. The light bulb has a smaller resistance and draws a greater current than the table fan. D. The light bulb has a smaller resistance and draws a smaller current than the table fan.	1
Q.40	Given below are four different electrical circuits with identical voltage sources. All the bulbs in each circuit are of the same voltage and power ratings.  Identify the brightest bulb in each circuit.	1

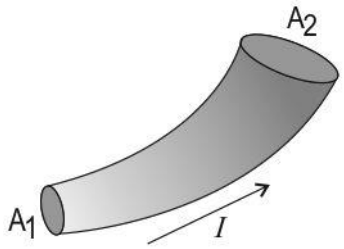
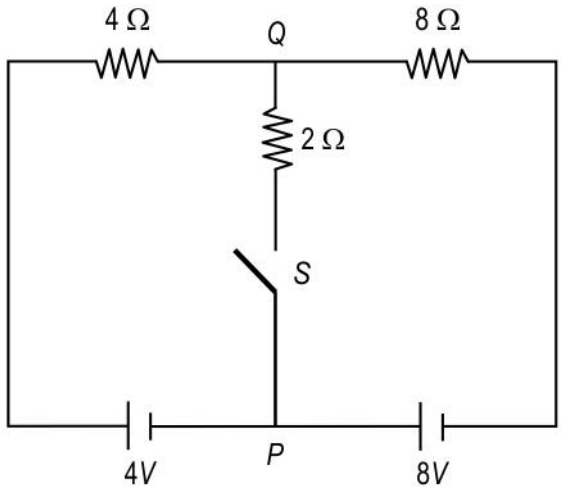
	A. Bulb A in all circuits B. Bulb B in all circuits C. Bulb A in circuits I & II and bulb B in circuits III & IV D. Bulb A in circuits I & II and bulb D in circuits III & IV	
Q.41	There are n identical resistors, all of which can be connected either in a series or in a parallel network. The power dissipated in the series and parallel networks will be different for a given applied voltage V. By what factor must the power dissipated through the series combination be multiplied in order to get the power dissipated through the parallel combination? A. n B. n^2 C. 1/n D. $1/n^2$	1
Q.42	Two statements are given below. One is labelled Assertion (A) and the other is labelled Reason (R). Read the statements carefully and choose the option that correctly describes statements A and R. Assertion (A): The net current in an isolated conductor placed in a uniform electric field is zero. Reason (R): There is no motion of electrons inside an isolated conductor placed in a uniform electric field as all charges reside on the surface of the conductor. A. Both Assertion and Reason are true and Reason is the correct explanation of Assertion. B. Both Assertion and Reason are true but Reason is not the correct explanation of Assertion. C. Assertion is true but Reason is false. D. Both Assertion and Reason are false.	1
Q.43	Two statements are given below. One is labelled Assertion (A) and the other is labelled Reason (R). Read the statements carefully and choose the option that correctly describes statements A and R. Assertion (A): The resistivity of conductors increases with an increase in temperature. Reason (R): The drift speed of electrons decreases with an increase in temperature. A. Both assertion and reason are true and reason is the correct explanation for assertion. B. Both assertion and reason are true and reason is not the correct explanation for assertion.	1

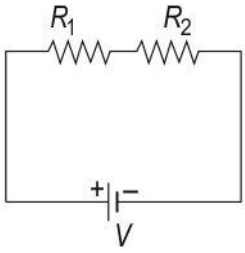
	C. Assertion is true but the reason is false. D. Assertion is false but reason is true.	
Q.44	What happens to the terminal voltage of a cell with an internal resistor as the current drawn from the cell increases? A. The terminal voltage remains constant. B. The terminal voltage decreases linearly. C. The terminal voltage increases linearly. D. The terminal voltage initially remains constant and then increases.	1
Q.45	Shown below is a closed electric circuit. Initially, the switch S is closed. If the switch S is now opened, what happens to the heat dissipated across R_1?  A. Increases B. Decreases C. There is no change D. Cannot be determined without actual values	1
Q.46	Assertion: In a current-carrying ohmic metal wire of decreasing diameter, both the electric current and the drift speed of the charge carriers is more at the thicker end and less at the thinner end of the wire. Reason: A variable drift speed of the charge carriers would result in accumulation of the charge carriers through a wire of decreasing thickness. Select the correct option. A. Both A and R are true and R is the correct explanation of A B. Both A and R are true but R is NOT the correct explanation of A C. A is true but R is false D. A is false and R is also false	1
Q.47	Assertion: Electrical power given as P = I ΔV, when transported over long distances is the same either at high currents and low potential differences or at low currents and high potential differences but it is preferred to be transported at lower currents and higher potential differences.	1

	Reason: It is cheaper to use high-resistance wires and the current I is kept as low as possible in order to reduce power losses I^2R through the transmission wires. Select the correct option: A. Both A and R are true and R is the correct explanation of A B. Both A and R are true but R is NOT the correct explanation of A C. A is true but R is false D. A is false and R is also false	
Q.48	Assertion: If the charges are placed on an isolated conductor, it results in a zero electric field inside the conductor. On the other hand, a conductor connected to a source of emf, results in a steady current due to a constant electric field inside the conductor. Reason: A conductor is always in an electrostatic equilibrium whether or not it is connected to a source of emf. Select the correct option. A. Both A and R are true and R is the correct explanation of A B. Both A and R are true and but R is NOT the correct explanation of A C. A is true but R is false D. A is false and R is also false	1
Free Response Questions/Subjective Questions		
Q.49	In the two electric circuits shown below, identical conducting rectangular blocks made of the same material are connected to identical voltage sources. Establish a relationship between the currents I_1 and I_2 in the two circuits.  **Figure A**  **Figure B**	3
Q.50	Two batteries B_1 and B_2 of the same emfs are used to light up a 10 ohm bulb independently. The bulb glows brighter when connected to battery B_2 than when connected to battery B_1. Internal resistances of B_1 and B_2 are 2 ohm and 1 ohm respectively. Determine the ratio of the power delivered to the bulb by B_1 to the power delivered by B_2.	2

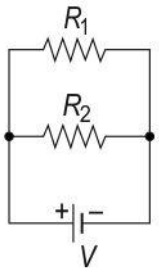
Q.51	In the circuit containing two cells of emfs 30 V and 10 V, determine which of the two points, P or Q is at higher potential.  	2
Q.52	A standard electric heater connected to 220 V power supply in a house uses 8 A of current in its normal heating mode of operation but only 2 A in the standby constant temperature maintain mode. For an hour of operation, how much more electrical energy is used in normal heating mode compared to standby mode? Express your answer in joules.	2
Q.53	In an electric circuit shown, a network of resistors is connected across a cell of emf 2V and internal resistance 0.5 ohm  (a) What is the total current drawn from the battery by the circuit? (b) What is the power consumed by the circuit from the battery?	3

Q.54	The image below shows two circuits (I and II) consisting of a battery, a bulb, and a switch.  circuit I circuit II (a) What is the difference in the working of the bulb in the two circuits when the switch is opened and closed? (b) Which circuit is preferred and why?	2
Q.55	Annie wants to check if a bulb rated 3 V, 6 W is working or not. But she only has a 12 V DC power source. She also has a few resistors with her. (a) How can she use the resistors with the light bulb to ensure that the bulb operates at its correct rating when connected to the 12 V supply? Give a reason for your answer. (b) What should be the resistance of the resistor that she uses with the bulb?	3
Q.56	The image below shows a three-way bulb that can glow at three different brightness. The bulb is rated to operate at 120 V power supply.  Determine how the bulb can have three different brightnesses. Determine the total current through the circuit which causes the bulb to glow in each of the three cases.	3
Q.57	For a current-carrying conductor of changing diameter as shown below, how does each of the following quantities vary along the two ends of conductors with area of cross sections A_1 and A_2 ? Give an explanation for each.	4

	 i. Current ii. Current density iii. Resistance iv. Potential drop	
Q.58	Find the change in power dissipated in the 4 Ω resistor after the switch S is closed. 	3
Q.59	a. Temperature coefficient of resistivity of a material can be positive, negative or zero. An electric heating device consists of a wire of material with an unknown temperature coefficient of resistivity and is connected to a constant voltage supply. Will the power delivered to the electrical device increase, decrease or remain constant with time as the temperature of the wire increases with usage? Give answers with explanations for all the three possible values of temperature coefficient of resistivity of the wire inside the device. b. The operating voltage of a water heater is 220V and that of a coffee whipper is 120V. With this information, can you say or not say, which of the two devices will draw lesser power? Give reason for your answer.	4
Q.60	Given two resistors R_1 and R_2 connected in series in circuit 1 and in parallel in circuit 2 across identical batteries of terminal voltage V with some internal resistance.	2



Circuit 1



Circuit 2

A third unknown resistor R_3 is added in series in circuit 1 and in parallel in circuit 2.

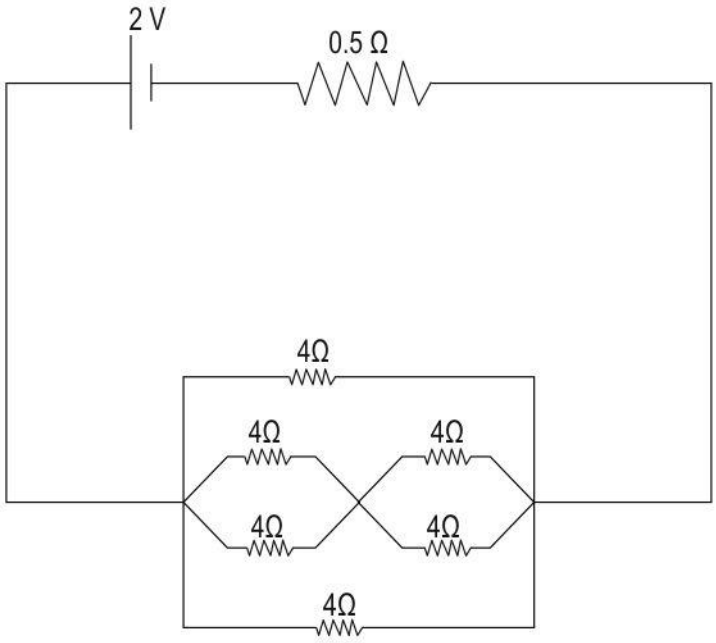
a. Does the current in the battery increase, decrease, or remain the same in each of the two circuits? Give a reason for your answer.

b. Does the terminal voltage of the battery increase, decrease, or remain the same in each of the two circuits? Give a reason for your answer.

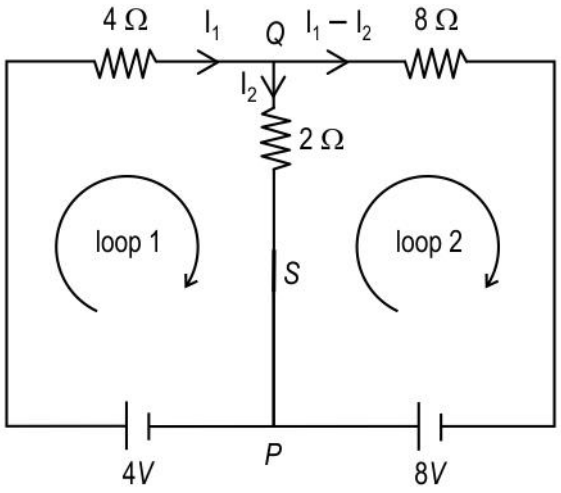
Answer key and Marking Scheme

Q.No	Answers	Marks
Q.39	B. The light bulb has a greater resistance and draws a smaller current than the table fan.	1
Q.40	C. Bulb A in circuits I & II and bulb B in circuits III & IV	1
Q.41	B. n^2	1
Q.42	C. Assertion is true but Reason is false.	1
Q.43	A. Both assertion and reason are true and reason is the correct explanation for assertion.	1
Q.44	B. The terminal voltage decreases linearly.	1
Q.45	B. decreases	1
Q.46	D. A is false and R is also false	1
Q.47	A. Both A and R are true and R is the correct explanation of A	1
Q.48	C. A is true but R is false	1
Q.49	Fig A: $\text{Resistance } R_1 = \frac{\rho L}{2L \times 3L} = \frac{\rho}{6L}$ $\text{Current } I_1 = V/R_1 = V \cdot \frac{6L}{\rho}$ [1 mark for the correct expression derived for current I_1] Fig B: $\text{Resistance } R_2 = \frac{\rho(2L)}{L \times 3L} = \frac{2\rho}{3L}$ $\text{Current } I_2 = V/R_2 = V \cdot \frac{3L}{2\rho}$ [1 mark for the correct expression derived for current I_2] So $I_1/I_2 = 4$ $I_1 = 4\ I_2$ [1 mark for the correct relationship between I_1 and I_2]	3
Q.50	The ratio :	2

	$\frac{P_1}{P_2} = \frac{I_1^2 R}{I_2^2 R}$ Here, R is the resistance of the bulb, I_1 and I_2 are the currents flowing through the bulb when connected to battery B_1 and B_2 respectively. (0.5 mark for the correct formula of the power) $I_1 = \frac{V}{R_1} = \frac{V}{R+r_1} = \frac{V}{10+2} = \frac{V}{12}$ $I_2 = \frac{V}{R_2} = \frac{V}{R+r_2} = \frac{V}{10+1} = \frac{V}{11}$ $\frac{P_1}{P_2} = \frac{I_1^2 R}{I_2^2 R} = \frac{11^2}{12^2} = \frac{121}{144}$ (0.5 mark for correct calculation of each current) (0.5 mark for the correct ratio of the powers)	
Q.51	Applying Kirchhoff's rule (in clockwise direction): 30 – 30I – 10 - 15I – 5I – 10I = 0, where I is the current through the loop. Calculating I, I = 1/3 A [*1 mark for the correct value of current through the circuit*] Across points P and Q: $V_P – V_Q$ = -30 +30 x 1/3 = -20 volt $V_Q = V_P + 20$ $V_Q > V_P$ [*1 mark for correct final relation between V_P and V_Q*]	2
Q.52	Energy consumed = P x t = VIt (0.5 mark) Energy consumed in the normal mode E_1 = 220 x 8 x 3600 Energy consumed in the normal mode E_2= 220 x 2 x 3600 (0.5 marks) Additional electrical energy drawn by the heater in normal mode in comparison to that in standby mode $E = E_1 - E_2$= 3600 x 220 (8 - 2)= 4.752 x 10^6 J (1 mark)	2

Q.53	(a) Equivalent network:  Applying the principle of resistors in parallel and series: R_{eq} = 4/3 ohm Current is drawn from the cell due to total Resistance = 4/3 ohm + 0.5 ohm in series = 11/6 ohm (1 mark) V = R I So current drawn from the cell I = 2 x 6/11 = 12/11 A ≈ 1.1 (1 mark) (b) Power consumed by the circuit = $I^2R = (12/11)^2 . (11/6) = 24/11 = 2.2$ W (1 mark)	3
Q.54	(a) Circuit I - the bulb glows when the switch is closed and does not glow when the switch is open. Circuit II - the bulb glows when the switch is open and does not glow when the switch is closed. (0.5 marks for each correct answer.)	2

	(b) Circuit I is preferred because current flows in circuit I only when the switch is closed. In circuit II, current flows both when the switch is opened and closed. This causes a wastage of energy. (OR) In circuit II, when the switch is closed, the battery might get damaged due to short-circuiting. (1 mark for writing the complete answer.)	
Q.55	(a) She can connect the resistors in series with the bulb. When the resistor is connected in series with the bulb, the supply voltage divides between the resistor and the light bulb. Hence, the voltage drop across the bulb can be reduced. (1 mark) (b) Resistance of bulb $R_{bulb} = V^2/P = 3 \times 3/6 = 1.5\ \Omega$ (0.5 marks) For the voltage drop to be 3 V across the bulb, the voltage drop across the resistor should be 9 V. (0.5 marks) Since the same current flows through the resistor and bulb, $V_{bulb}/R_{bulb} = V_{resistor}/R_{resistor}$ $3/1.5 = 9/R_{resistor}$ $R_{resistor} = 4.5\ \Omega$ (1 mark)	3
Q.56	Case (i) - when switch S_1 is closed, only the 75 W filament glows. (0.5 mark) Current through the circuit = P/V = 75/120 = 0.625 A (0.5 mark) Case (ii) - when switch S_2 is closed, only 100 W filament glows (0.5 mark) Current through the circuit = P/V = 100/120 = 0.833 A (0.5 mark) Case (iii) - when both switches are closed, both 75 W and 100 W filament glows. (0.5 mark) Current through the circuit = 0.625 + 0.833 = = 1.458 A (0.5 mark)	3
Q.57	i. Current : It remains the same along the length of the conductor. This is as per Kirchhoff's junction rule. Charge cannot collect at any point along the length of the conductor. [0.5 mark for the correct statement of variation] [0.5 mark for the correct explanation of the same]	4

	ii. Current density J varies inversely with area cross section of the conductor. As J = I/A , more the area cross section, less is the current density, for a constant current through the conductor. [0.5 mark for the correct statement of variation] [0.5 mark for the correct explanation of the same] iii. Resistance varies inversely with area cross section of the wire. R of the wire at broader parts will be lesser than along narrower part. [0.5 mark for the correct statement of variation] [0.5 mark for the correct explanation of the same] iv. Potential drop across two ends of the entire length of the conductor is as provided by the power source. The potential drop across different equal parts along the length of the wire varies in direct proportion to the resistance. Potential drop at narrower end will be more than at broader end (Resistance at narrower end is more than at broader end) [0.5 mark for the correct statement of variation] [0.5 mark for the correct explanation of the same]	
Q.58	When the switch is off, the current through the 4 Ω resistor is I = 12 V/12 Ω = 1 A (0.5 marks) Power dissipated = I^2R = 4 W (0.5 marks) Now, when the switch is closed, let the current in various branches of the circuit be as shown in the image.  Applying KVL in loop 1	3

	$4I_1+2I_2 = 4$ $I_2 = 2 - 2I_1$ ...(i) Applying KVL In loop 2 $-2I_2+8I_1-8I_2 = 8$ $-5I_2+4I_1 = 4$ .... (ii) (1 mark for getting two correct equations using Kirchhoff's laws.) from (i) and (ii) $10 - 10I_1 + 4I_1 = 4$ This gives, $I_1 = 1$ A (0.5 mark) The current through the 4 Ω resistor is the same even after the switch is closed, so there will be no change in power dissipated in the 4 Ω resistor. (0.5 mark)	
Q.59	a. Power delivered to a device, $P = V^2/R$ For positive temperature coefficient of resistivity of the material, with time, R will increase. So power delivered will decrease, for a constant voltage supply. For negative temperature coefficient of resistivity of the material, with time, R will decrease. So power delivered will increase, for a constant voltage supply. For a zero-temperature coefficient of resistivity of the material, with time, R will remain constant. So, power delivered will also stay constant, for a constant voltage supply. [1 mark for each case with correct explanation] b. Cannot say. For determining the power drawn by an electric device, the current flowing through the device or the resistance of device is a required. [0.5 mark for correct answer] [0.5 mark for correct explanation]	4
Q.60	a. In circuit 1 - adding another series resistor R_3 increases the total resistance of the circuit 1 and thus reduces the current in the battery. [0.5 mark for the correct explanation]	2

	In circuit 2 - If another resistor R_3 were connected in parallel, the total resistance of the circuit 2 would decrease, and the current in the battery would increase. [0.5 mark for the correct explanation] b. In circuit 1 - The terminal potential difference (V = E -Ir) across the battery terminals increases because the reduced current results in a smaller voltage drop across the internal resistance of the battery. [0.5 mark for the correct explanation] In circuit 2 - The terminal potential difference across the terminals would decrease because the increased current results in a greater voltage drop across the internal resistance of the battery. [0.5 mark for the correct explanation]	