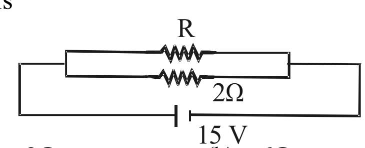
CHAPTER 17

Current Electricity

1. If an ammeter is to be used in place of a voltmeter, then we must connect with the ammeter a **[2002]**
   (a) low resistance in parallel
   (b) high resistance in parallel
   (c) high resistance in series
   (d) low resistance in series.

2. A wire when connected to 220 V mains supply has power dissipation P_1. Now the wire is cut into two equal pieces which are connected in parallel to the same supply. Power dissipation in this case is P_2. Then $P_2 : P_1$ is **[2002]**
   (a) 1 (b) 4
   (c) 2 (d) 3

3. If in the circuit, power dissipation is 150 W, then R is **[2002]**



   (a) 2Ω (b) 6Ω
   (c) 5Ω (d) 4Ω

4. The mass of product liberated on anode in an electrochemical cell depends on **[2002]**
   (a) $(It)^{1/2}$ (b) It
   (c) I/t (d) I^2t
   (where t is the time period for which the current is passed).

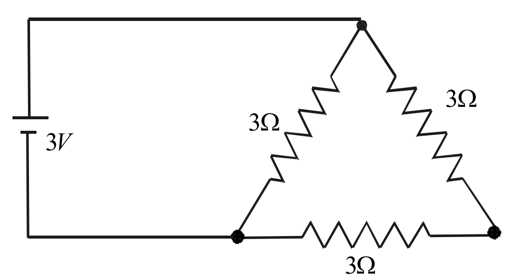
5. The length of a wire of a potentiometer is 100 cm, and the e. m.f. of its standard cell is E volt. It is employed to measure the e.m.f. of a battery whose internal resistance is 0.5Ω. If the balance point is obtained at $\ell = 30$ cm from the positive end, the e.m.f. of the battery is **[2003]**
   (a) $\frac{30E}{100.5}$ (b) $\frac{30E}{(100-0.5)}$
   (c) $\frac{30(E-0.5i)}{100}$ (d) $\frac{30E}{100}$
   where i is the current in the potentiometer wire.

6. The thermo e.m.f. of a thermo-couple is 25μV/°C at room temperature. A galvanometer of 40 ohm resistance, capable of detecting current as low as 10^{-5} A, is connected with the thermo couple. The smallest temperature difference that can be detected by this system is **[2003]**
   (a) 16°C (b) 12°C
   (c) 8°C 8° C (d) 20°C

7. The negative Zn pole of a Daniell cell, sending a constant current through a circuit, decreases in mass by 0.13g in 30 minutes. If the electeochemical equivalent of Zn and Cu are 32.5 and 31.5 respectively, the increase in the mass of the positive Cu pole in this time is **[2003]**
   (a) 0.180 g (b) 0.141g
   (c) 0.126 g (d) 0.242 g

8. An ammeter reads upto 1 ampere. Its internal resistance is 0.81ohm. To increase the range to 10 A the value of the required shunt is **[2003]**
   (a) 0.03 Ω (b) 0.3Ω
   (c) 0.9Ω (d) 0.09Ω

9. A 3 volt battery with negligible internal resistance is connected in a circuit as shown in the figure. The current I, in the circuit will be **[2003]**



   (a) 1 A (b) 1.5 A
   (c) 2 A (d) 1/3 A

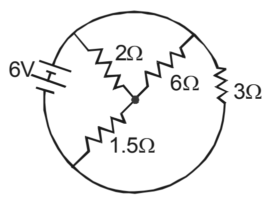
10. A 220 volt, 1000 watt bulb is connected across a 110 volt mains supply. The power consumed will be **[2003]**

(a) 750 watt (b) 500 watt
(c) 250 watt (d) 1000 watt

11. The length of a given cylindrical wire is increased by 100%. Due to the consequent decrease in diameter the change in the resistance of the wire will be **[2003]**

(a) 200% (b) 100%
(c) 50% (d) 300%

12. The total current supplied to the circuit by the battery is **[2004]**



(a) 4 A (b) 2 A
(c) 1 A (d) 6 A

13. The resistance of the series combination of two resistances is S. when they are joined in parallel the total resistance is P. If $S = nP$ then the minimum possible value of n is **[2004]**

(a) 2 (b) 3
(c) 4 (d) 1

14. An electric current is passed through a circuit containing two wires of the same material, connected in parallel. If the lengths and radii arein the ratio of $\frac{4}{3}$ and $\frac{2}{3}$, then the ratio of the current passing through the wires will be **[2004]**

(a) 8/9 (b) 1/3
(c) 3 (d) 2

15. In a meter bridge experiment null point is obtained at 20 cm. from one end of the wire when resistance X is balanced against another resistance Y. If $X < Y$, then where will be the new position of the null point from the same end, if one decides to balance a resistance of $4X$ against Y **[2004]**

(a) 40 cm (b) 80 cm
(c) 50 cm (d) 70 cm

16. The thermistors are usually made of **[2004]**

(a) metal oxides with high temperature coefficient of resistivity
(b) metals with high temperature coefficient of resistivity
(c) metals with low temperature coefficient of resistivity
(d) semiconducting materials having low temperature coefficient of resistivity

17. Time taken by a 836 W heater to heat one litre of water from 10°C to 40°C is **[2004]**

(a) 150 s (b) 100 s
(c) 50 s (d) 200 s

18. The thermo emf of a thermocouple varies with the temperature θ of the hot junction as $E = a\theta + b\theta^2$ in volts where the ratio a/b is 700°C. If the cold junction is kept at 0°C, then the neutral temperature is **[2004]**

(a) 1400°C
(b) 350°C
(c) 700°C
(d) No neutral temperature is possible for this termocouple.

19. The electrochemical equivalent of a metal is 3.35109^{-7} kg per Coulomb. The mass of the metal liberated at the cathode when a 3A current is passed for 2 seconds will be **[2004]**

(a) 6.6×10^{57}kg (b) 9.9×10^{-7} kg
(c) 19.8×10^{-7} kg (d) 1.1×10^{-7} kg

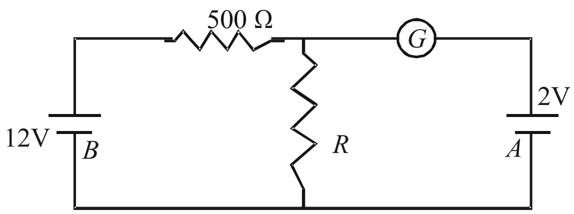
20. Two thin, long, parallel wires, separated by a distance 'd' carry a current of 'i' A in the same direction. They will **[2005]**

(a) repel each other with a force of $\mu_0 i^2/(2\pi d)$
(b) attract each other with a force of $\mu_0 i^2/(2\pi d)$
(c) repel each other with a force of $\mu_0 i^2/(2\pi d^2)$
(d) attract each other with a force of $\mu_0 i^2/(2\pi d^2)$

21. A heater coil is cut into two equal parts and only one part is now used in the heater. The heat generated will now be **[2005]**

(a) four times (b) doubled
(c) halved (d) one fourth

22. In the circuit , the galvanometer G shows zero deflection. If the batteries A and B have negligible internal resistance, the value of the resistor R will be - **[2005]**



(a) 100Ω (b) 200Ω
(c) 1000Ω (d) 500Ω

23. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10-divisions per milliampere and voltage sensitivity is 2 divisions per millivolt. In order that each division reads 1 volt, the resistance in ohms needed to be connected in series with the coil will be - **[2005]**

(a) 10^5 (b) 10^3
(c) 9995 (d) 99995

24. Two sources of equal emf are connected to an external resistance R. The internal resistance of the two sources are R_1 and R_2 $(R_1 > R_1)$. If the potential difference across the source having internal resistance R_2 is zero, then **[2005]**

(a) $R = R_2 - R_1$
(b) $R = R_2 \times (R_1 + R_2)/(R_2 - R_1)$
(c) $R = R_1 R_2 /(R_2 - R_1)$
(d) $R = R_1 R_2 /(R_1 - R_2)$

25. Two voltameters, one of copper and another of silver, are joined in parallel. When a total charge q flows through the voltameters, equal amount of metals are deposited. If the electrochemical equivalents of copper and silver are Z_1 and Z_2 respectively the charge which flows through the silver voltameter is **[2005]**

(a) $\dfrac{q}{1+\dfrac{Z_2}{Z_1}}$ (b) $\dfrac{q}{1+\dfrac{Z_1}{Z_2}}$

(c) $q\dfrac{Z_2}{Z_1}$ (d) $q\dfrac{Z_1}{Z_2}$

26. In a potentiometer experiment the balancing with a cell is at length 240 cm. On shunting the cell with a resistance of 2Ω, the balancing length becomes 120 cm. The internal resistance of the cell is **[2005]**

(a) 0.5Ω (b) 1Ω
(c) 2Ω (d) 4Ω

27. The resistance of hot tungsten filament is about 10 times the cold resistance. What will be the resistance of 100 W and 200 V lamp when not in use ? **[2005]**

(a) 20Ω (b) 40Ω
(c) 200Ω (d) 400Ω

28. An energy source will supply a constant current into the load if its internal resistance is **[2005]**

(a) very large as compared to the load resistance
(b) equal to the resistance of the load
(c) non-zero but less than the resistance of the load
(d) zero

29. The Kirchhoff's first law $(\Sigma i = 0)$ and second law $(\Sigma iR = \Sigma E)$, where the symbols have their usual meanings, are respectively based on **[2006]**

(a) conservation of charge, conservation of momentum
(b) conservation of energy, conservation of charge
(c) conservation of momentum, conservation of charge
(d) conservation of charge, conservatrion of energy

30. A material 'B' has twice the specific resistance of 'A'. A circular wire made of 'B' has twice the diameter of a wire made of 'A'. then for the two wires to have the same resistance, the ratio l_B/l_A of their respective lengths must be **[2006]**

(a) 1 (b) $\dfrac{1}{2}$

(c) $\dfrac{1}{4}$ (d) 2

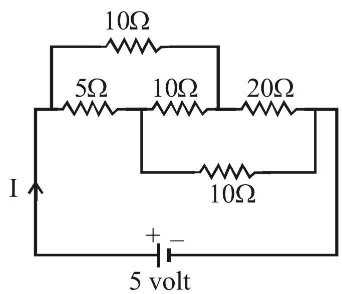
31. A thermocouple is made from two metals, Antimony and Bismuth. If one junction of the couple is kept hot and the other is kept cold, then, an electric current will **[2006]**

(a) flow from Antimony to Bismuth at the hot junction
(b) flow from Bismuth to Antimony at the cold junction

(c) now flow through the thermocouple

(d) flow from Antimony to Bismuth at the cold junction

32. The current I drawn from the 5 volt source will be **[2006]**



(a) 0.33 A (b) 0.5 A

(c) 0.67 A (d) 0.17 A

33. The resistance of a bulb filmanet is 100Ω at a temperature of 100°C. If its temperature coefficient of resistance be 0.005 per °C, its resistance will become 200 Ω at a temperature of **[2006]**

(a) 300°C (b) 400°C

(c) 500°C (d) 200°C

34. In a Wheatstone's bridge, three resistances P, Q and R connected in the three arms and the fourth arm is formed by two resistances S_1 and S_2 connected in parallel. The condition for the bridge to be balanced will be **[2006]**

(a) $\frac{P}{Q}=\frac{2R}{S_1+S_2}$ (b) $\frac{P}{Q}=\frac{R(S_1+S_2)}{S_1S_2}$

(c) $\frac{P}{Q}=\frac{R(S_1+S_2)}{2S_1S_2}$ (d) $\frac{P}{Q}=\frac{R}{S_1+S_2}$

35. An electric bulb is rated 220 volt - 100 watt. The power consumed by it when operated on 110 volt will be **[2006]**

(a) 75 watt (b) 40 watt

(c) 25 watt (d) 50 watt

36. A battery is used to charge a parallel plate capacitor till the potential difference between the plates becomes equal to the electromotive force of the battery. The ratio of the energy stored in the capacitor and the work done by the battery will be **[2007]**

(a) 1/2 (b) 1

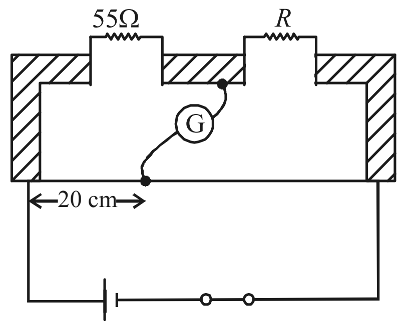
(c) 2 (d) 1/4

37. The resistance of a wire is 5 ohm at 50°C and 6 ohm at 100°C. The resistance of the wire at 0°C will be **[2007]**

(a) 3 ohm (b) 2 ohm

(c) 1 ohm (d) 4 ohm

38. Shown in the figure below is a meter-bridge set up with null deflection in the galvanometer.



The value of the unknown resistor R is **[2008]**

(a) 13.75 Ω (b) 220 Ω

(c) 110 Ω (d) 55 Ω

DIRECTIONS : Question No. 39 and 40 are based on the following paragraph.

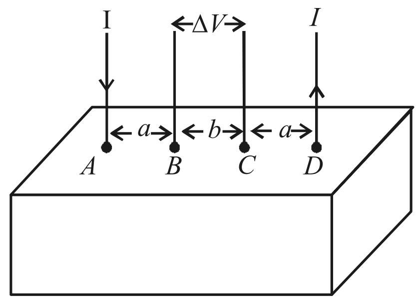
Consider a block of conducting material of resistivity 'ρ' shown in the figure. Current 'I' enters at 'A' and leaves from 'D'. We apply superposition principle to find voltage 'ΔV' developed between 'B' and 'C'. The calculation is done in the following steps:

(i) Take current 'I' entering from 'A' and assume it to spread over a hemispherical surface in the block.

(ii) Calculate field E(r) at distance 'r' from A by using Ohm's law E = ρ j, where j is the current per unit area at 'r'.

(iii) From the 'r' dependence of E(r), obtain the potential V(r) at r.

(iv) Repeat (i), (ii) and (iii) for current 'I' leaving 'D' and superpose results for 'A' and 'D'.



39. ΔV measured between B and C is **[2008]**

(a) $\frac{\rho I}{\pi a}-\frac{\rho I}{\pi(a+b)}$ (b) $\frac{\rho I}{a}-\frac{\rho I}{(a+b)}$

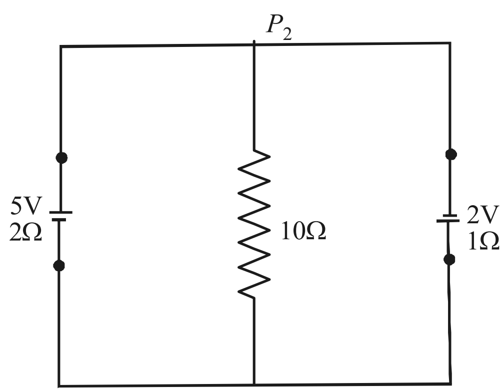
(c) $\frac{\rho I}{2\pi a}-\frac{\rho I}{2\pi(a+b)}$ (d) $\frac{\rho I}{2\pi(a-b)}$

40. For current entering at A, the electric field at a distance 'r' from A is **[2008]**

(a) $\frac{\rho I}{8\pi r^2}$ (b) $\frac{\rho I}{r^2}$

(c) $\frac{\rho I}{2\pi r^2}$ (d) $\frac{\rho I}{4\pi r^2}$

41. A 5V battery with internal resistance 2Ω and a 2V battery with internal resistance 1Ω are connected to a 10Ω resistor as shown in the figure. **[2008]**



The current in the 10Ω resistor is

(a) 0.27 A P_2 to P_1 (b) 0.03 A P_1 to P_2

(c) 0.03 A P_2 to P_1 (d) 0.27 A P_1 to P_2

42. Let C be the capacitance of a capacitor discharging through a resistor R. Suppose t_1 is the time taken for the energy stored in the capacitor to reduce to half its initial value and t_2 is the time taken for the charge to reduce to one-fourth its initial value. Then the ratio t_1/t_2 will be **[2010]**

(a) 1 (b) $\frac{1}{2}$

(c) $\frac{1}{4}$ (d) 2

43. Two conductors have the same resistance at 0°C but their temperature coefficients of resistance are α_1 and α_2. The respective temperature coefficients of their series and parallel combinations are nearly **[2010]**

(a) $\frac{\alpha_1+\alpha_2}{2}, \alpha_1+\alpha_2$

(b) $\alpha_1+\alpha_2, \frac{\alpha_1+\alpha_2}{2}$

(c) $\alpha_1+\alpha_2, \frac{\alpha_1\alpha_2}{\alpha_1+\alpha_2}$

(d) $\frac{\alpha_1+\alpha_2}{2}, \frac{\alpha_1+\alpha_2}{2}$

44. If a wire is stretched to make it 0.1% longer, its resistance will : **[2011]**

(a) increase by 0.2%

(b) decrease by 0.2%

(c) decrease by 0.05%

(d) increase by 0.05%

45. If 400 Ω of resistance is made by adding four 100 Ω resistances of tolerance 5%, then the tolerance of the combination is **[2011 RS]**

(a) 5% (b) 10%

(c) 15% (b) 20%

46. 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 **[2011 RS]**

(a) 1 V/m (b) 0.5 V/m

(c) 0.1 V/m (d) 0.2 V/m

47. Two electric bulbs rated 25W – 220 V and 100W – 220V are connected in series to a 440 V supply. Which of the bulbs will fuse? **[2012]**

(a) Both (b) 100 W

(c) 25 W (d) Neither

48. The supply voltage to room is 120V. The resistance of the lead wires is 6Ω. 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? **[2013]**

(a) zero (b) 2.9 Volt
(c) 13.3 Volt (d) 10.04 Volt

49. This questions has Statement I and Statement II. Of the four choices given after the Statements, choose the one that best describes into two Statements.

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. **[2013]**

(a) Statement-I is true, Statement-II is true, Statement-II is the correct explanation of Statement-I.
(b) Statement-I is true, Statement-II is true, Statement-II is not the correct explanation of Statement-I.
(c) Statement-I is true, Statement-II is false.
(d) Statement-I is false, Statement-II is true.

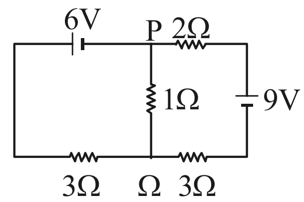
50. In a large building, there are 15 bulbs of 40 W, 5 bulbs of 100 W, 5 fans of 80 W and 1 heater of 1 kW. The voltage of electric mains is 220 V. The minimum capacity of the main fuse of the building will be: **[2014]**

(a) 8 A (b) 10 A
(c) 12 A (d) 14 A

51. 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 : **[2015]**

(a) 1.6×10^{-6} Ωm (b) 1.6×10^{-5} Ωm
(c) 1.6×10^{-8} Ωm (d) 1.6×10^{-7} Ωm

52. In the circuit shown, the current in the 1Ω resistor is : **[2015]**



(a) 0.13 A, from Q to P
(b) 0.13 A, from P to Q
(c) 1.3A from P to Q
(d) 0A

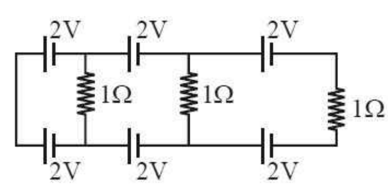
53. The temperature dependence of resistances of Cu and undoped Si in the temperature range 300-400 K, is best described by : **[2016]**

(a) Linear increase for Cu, exponential decrease of Si.
(b) Linear decrease for Cu, linear decrease for Si.
(c) Linear increase for Cu, linear increase for Si.
(d) Linear increase for Cu, exponential increase for Si.

54. Which of the following statements is false ? **[2017]**

(a) A rheostat can be used as a potential divider
(b) Kirchhoff's second law represents energy conservation
(c) Wheatstone bridge is the most sensitive when all the four resistances are of the same order of magnitude
(d) In a balanced wheatstone bridge if the cell and the galvanometer are exchanged, the null point is disturbed.

55. **[2017]**



In the above circuit the current in each resistance is

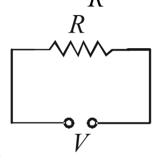
(a) 0.5A (b) 0 A
(c) 1 A (d) 0.25 A

Answer Key														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(c)	(b)	(b)	(b)	(d)	(a)	(c)	(d)	(b)	(c)	(d)	(a)	(c)	(b)	(c)
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
(a)	(a)	(d)	(c)	(b)	(b)	(a)	(c)	(a)	(a)	(c)	(b)	(d)	(d)	(d)
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
(d)	(b)	(b)	(b)	(c)	(a)	(d)	(b)	(a)	(c)	(c)	(c)	(d)	(a)	(a)
46	47	48	49	50	51	52	53	54	55					
(c)	(c)	(d)	(d)	(c)	(b)	(a)	(a)	(d)	(b)					

SOLUTIONS

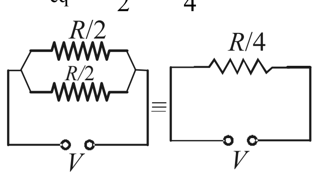
1. **(c)** To convert a galvanometer into a voltmeter we connect a high resistance in series with the galvanometer.
The same procedure needs to be done if ammeter is to be used as a voltmeter.

2. **(b)** **Case 1** $P_1 = \frac{V^2}{R}$



Case 2
The wire is cut into two equal pieces. Therefore, the resistance of the individual wire is $\frac{R}{2}$. These are connected in parallel

$$\therefore R_{eq} = \frac{R/2}{2} = \frac{R}{4}$$



$$\therefore \quad P_2 = \frac{V^2}{R/4} = 4\left(\frac{V^2}{R}\right) = 4P_1$$

3. **(b)** The equivalent resistance is $R_{eq} = \frac{2 \times R}{2+R}$

$$\therefore \text{ Power dissipation } P = \frac{V^2}{R_{eq}}$$

$$\therefore 150 = \frac{15 \times 15}{R_{eq}}$$

$$\therefore R_{eq} = \frac{15}{10} = \frac{3}{2}$$

$$\Rightarrow \frac{2R}{2+R} = \frac{3}{2} \Rightarrow 4R = 6 + 3R \Rightarrow R = 6\Omega$$

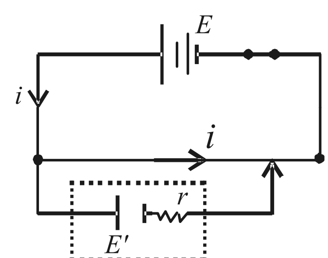
4. **(b)** According to Faraday's first law of electrolysis
$m = ZIt \Rightarrow m \propto It$

5. **(d)** From the principle of potentiometer, $V \propto l$

$$\Rightarrow \frac{V}{E} = \frac{l}{L}; \text{ where}$$

V = emf of battery, E = emf of standard cell.
L = length of potentiometer wire

$$V = \frac{El}{L} = \frac{30E}{100}$$



NOTE In this arrangement, the internal resistance of the battery E does not play any role as current is not passing through the battery.

6. **(a)** Let θ be the smallest temperature difference that can be detected by the thermocouple, then

$I \times R = (25 \times 10^{-6})\ \theta$

where I is the smallest current which can be detected by the galvanometer of resistance R.

Here $I = 10^{-5} A, \quad R = 40\ \Omega$

$\therefore\ 10^{-5} \times 40 = 25 \times 10^{-6} \times \theta$

$\therefore\ \theta = 16°C.$

7. **(c)** According to Faraday's first law of electrolysis

$m = Z \times q$

For same q, $m \propto Z$

$$\therefore\ \frac{m_{Cu}}{m_{Zn}} = \frac{Z_{Cu}}{Z_{Zn}}$$

$$\Rightarrow m_{Cu} = \frac{Z_{Cu}}{Z_{Zn}} \times m_{Zn}$$

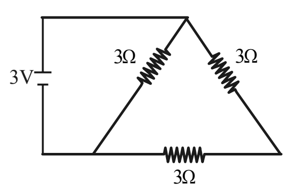
$$= \frac{31.5}{32.5} \times 0.13 = 0.126\ g$$

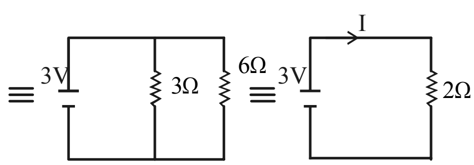
8. **(d)** $i_g \times G = (i - i_g)\, S$

$$\therefore\ S = \frac{i_g \times G}{i - i_g} = \frac{1 \times 0.81}{10 - 1} = 0.09\Omega$$

9. **(b)** $R_p = \dfrac{3 \times 6}{3 + 6} = \dfrac{18}{9} = 2\Omega$

$$\therefore\ V = IR \quad \Rightarrow I = \frac{V}{R} = \frac{3}{2} = 1.5A$$





10. **(c)** We know that $R = \dfrac{V_{rated}^2}{P_{rated}} = \dfrac{(220)^2}{1000}$

When this bulb is connected to 110 volt mains supply we get

$$P = \frac{V^2}{R} = \frac{(110)^2 \times 1000}{(220)^2} = \frac{1000}{4} = 250W$$

11. **(d)** The total volume remains the same before and after stretching.

Therefore $A \times \ell = A' \times \ell'$

Here $\ell' = 2\ell$

$$\therefore\ A' = \frac{A \times \ell}{\ell'} = \frac{A \times \ell}{2\ell} = \frac{A}{2}$$

Percentage change in resistance

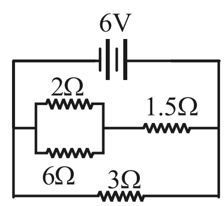
$$= \frac{R_f - R_i}{R_i} \times 100 = \frac{\rho\dfrac{\ell'}{A'} - \dfrac{\ell}{A}}{\rho\dfrac{\ell}{A}} \times 100$$

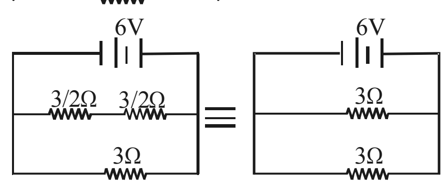
$$= \left[\left(\frac{\ell'}{A'} \times \frac{A}{\ell}\right) - 1\right] \times 100$$

$$= \left[\left(\frac{2\ell}{A/2} \times \frac{A}{\ell}\right) - 1\right] \times 100$$

$= 300\%$

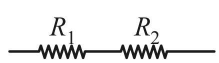
12. **(a)**





hence $R_{eq} = 3/2;$ $\quad \therefore I = \dfrac{6}{3/2} = 4A$

13. **(c)**



Resistance of the series combination,

$S = R_1 + R_2$

Resistance of the parallel combination,

$$P = \frac{R_1 R_2}{R_1 + R_2}$$

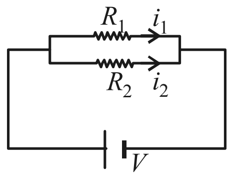
$$S = nP \Rightarrow R_1 + R_2 = \frac{n(R_1 R_2)}{(R_1 + R_2)}$$

$$\Rightarrow (R_1 + R_2)^2 = nR_1R_2$$

Minimum value of n is 4 for that

$$(R_1 + R_2)^2 = 4R_1R_2 \ \Rightarrow (R_1 - R_2)^2 = 0$$

14. (b)



$R_1 = \dfrac{\rho \ell_1}{\pi r_1^2}$; $R_2 = \dfrac{\rho \ell_2}{\pi r_2^2}$

$i_1 R_1 = i_2 R_2$ (same potential difference)

$$\therefore \frac{i_1}{i_2} = \frac{R_2}{R_1} = \frac{\ell_2}{\ell_1} \times \frac{r_1^2}{r_2^2} = \frac{3}{4} \times \frac{4}{9} = \frac{1}{3}$$

15. (c) $\dfrac{R_1}{R_2} = \dfrac{\ell_1}{\ell_2}$ where $\ell_2 = 100 - \ell_1$

In the first case $\dfrac{X}{Y} = \dfrac{20}{80}$

In the second case

$$\frac{4X}{Y} = \frac{\ell}{100-\ell} \Rightarrow \ell = 50$$

16. (a) Thermistors are usually made of metaloxides with high temperature coefficient of resistivity.

17. (a) $\Delta Q = mC_p \times \Delta T$

$= 1 \times 4180 \times (40 - 10) = 4180 \times 30$

($\therefore \Delta Q$ = heat supplied in time t for heating 1L water from 10°C to 40°C)

also $\Delta Q = 836 \times t \Rightarrow t = \dfrac{4180 \times 30}{836} = 150\text{s}$

18. (d) Neutral temperature is the temperature of a hot junction at which E is maximum.

$$\Rightarrow \frac{dE}{d\theta} = 0 \text{ or } a + 2b\theta = 0$$

$$\Rightarrow \theta = \frac{-a}{2b} = -350$$

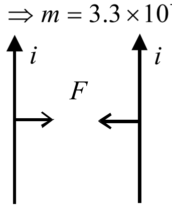
$$\Rightarrow \frac{d^2E}{d\theta^2} = 2b$$

hence no θ is possible for E to be maximum no neutral temperature is possible.

19. (c) The mass liberated m and electrochemical equivalent of a metal Z, are related as $m = Zit$

$$\Rightarrow m = 3.3 \times 10^{-7} \times 3 \times 2 = 19.8 \times 10^{-7} \text{ kg}$$

20. (b)



$$\frac{F}{\ell} = \frac{\mu_0 i_1 i_2}{2\pi d} = \frac{\mu_0 i^2}{2\pi d}$$

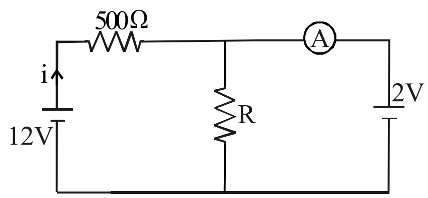
(attractive as current is in the same direction)

21. (b) $H = \dfrac{V^2 t}{R}$

Resistance of half the coil $= \dfrac{R}{2}$

$\therefore$ As R reduces to half, 'H' will be doubled.

22. (a)



$$12 - 2 = (500\Omega)i \Rightarrow i = \frac{10}{500} = \frac{1}{50}$$

Again, $i = \dfrac{12}{500 + R} = \dfrac{1}{50}$

$\Rightarrow 500 + R = 600$

$\Rightarrow R = 100\,\Omega$

23. (c) Resistance of Galvanometer,

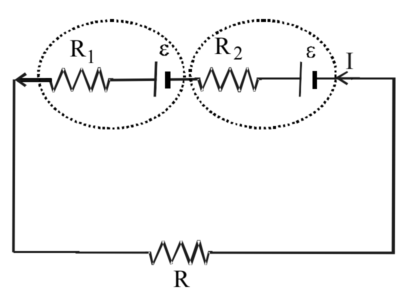
$$G = \frac{\text{Current sensitivity}}{\text{Voltage sensitivity}} \Rightarrow G = \frac{10}{2} = 5\Omega$$

Here i_g = Full scale deflection current $= \dfrac{150}{10} = 15\text{ mA}$

V = voltage to be measured = 150 volts (such that each division reads 1 volt)

$$\Rightarrow R = \frac{150}{15 \times 10^{-3}} - 5 = 9995\Omega$$

24. (a)



$$I = \frac{2\varepsilon}{R + R_1 + R_2}$$

Potential difference across second cell

$= V = \varepsilon - iR_2 = 0$

$$\varepsilon - \frac{2\varepsilon}{R + R_1 + R_2} . R_2 = 0$$

$R + R_1 + R_2 - 2R_2 = 0$

$R + R_1 - R_2 = 0$

$\therefore R = R_2 - R_1$

25. (a) Mass deposited

$m = Zq$

$$\Rightarrow Z \propto \frac{1}{q} \Rightarrow \frac{Z_1}{Z_2} = \frac{q_2}{q_1} \quad \text{.... (i)}$$

Also $q = q_1 + q_2$ .... (ii)

$$\Rightarrow \frac{q}{q_2} = \frac{q_1}{q_2} + 1$$

(Dividing (ii) by q_2)

$$\Rightarrow q_2 = \frac{q}{1 + \frac{q_1}{q_2}} \quad \text{.... (iii)}$$

From equation (i) and (iii),

$$q_2 = \frac{q}{1 + \frac{Z_2}{Z_1}}$$

26. (c) The internal resistance of the cell,

$$r = \left(\frac{\ell_1 - \ell_2}{\ell_2}\right) \times R = \frac{240 - 120}{120} \times 2 = 2\Omega$$

27. (b) $P = Vi = \dfrac{V^2}{R}$

$$R_{\text{hot}} = \frac{V^2}{P} = \frac{200 \times 200}{100} = 400\Omega$$

$$R_{\text{cold}} = \frac{400}{10} = 40\Omega$$

28. (d) $I = \dfrac{E}{R + r}$, Internal resistance (r) is zero, $I = \dfrac{E}{R} =$ constant.

29. (d) **NOTE** Kirchhoff's first law is based on conservation of charge and Kirchhoff's second law is based on conservation of energy.

30. (d) $\rho_B = 2\rho_A$

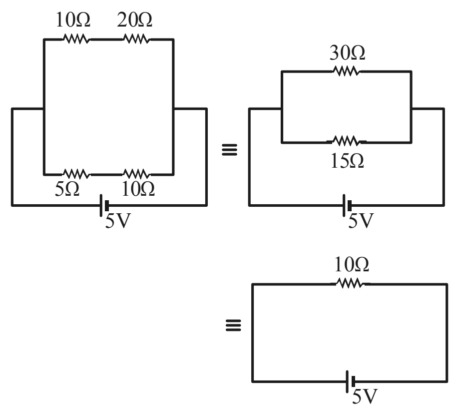
$d_B = 2d_A$

$$R_B = R_A \Rightarrow \frac{\rho_B \ell_B}{A_B} = \frac{\rho_A \ell_A}{A_A}$$

$$\therefore \frac{\ell_B}{\ell_A} = \frac{\rho_A}{\rho_B} \times \frac{d_B^2}{d_A^2} = \frac{\rho_A}{2\rho_A} \times \frac{4d_A^2}{d_A^2} = 2$$

31. (d) At cold junction, current flows from Antimony to Bismuth (because current flows from metal occurring later in the series to metal occurring earlier in the thermoelectric series).

32. (b) The network of resistors is a balanced wheatstone bridge. The equivalent circuit is



$$R_{eq} = \frac{15 \times 30}{15 + 30} = 10\ \Omega$$

$$\Rightarrow \quad I = \frac{V}{R} = \frac{5}{10} = 0.5\ \text{A}$$

33. (b) $R_1 = R_0[1 + \alpha \times 100] = 100$ ....(1)

$R_2 = R_0[1 + \alpha \times T] = 200$ ....(2)

On dividing we get

$$\frac{200}{100} = \frac{1 + \alpha T}{1 + 100\alpha} \Rightarrow 2 = \frac{1 + 0.005T}{1 + 100 \times 0.005}$$

$\Rightarrow T = 400°\text{C}$

NOTE We may use this expression as an approximation because the difference in the answers is appreciable. For accurate results one should use $R = R_0 e^{\alpha \Delta T}$

34. (b) $\dfrac{P}{Q} = \dfrac{R}{S}$ where $S = \dfrac{S_1 S_2}{S_1 + S_2}$

35. (c) The resistance of the bulb is

$$R = \frac{V^2}{P} = \frac{(220)^2}{100}$$

The power consumed when operated at 110 V is

$$P=\frac{(110)^2}{(220)^2/100}=\frac{100}{4}=25\ \text{W}$$

36. (a) Required ratio

$$=\frac{\text{Energy stored in capacitor}}{\text{Workdone by the battery}}=\frac{\frac{1}{2}CV^2}{Ce^2}$$

where C = Capacitance of capacitor
V = Potential difference,
e = emf of battery

$$=\frac{\frac{1}{2}Ce^2}{Ce^2}=\frac{1}{2} \qquad (\because V=e)$$

37. (d) We know that
$R_t=R_0(1+\alpha t)$,
where R_t is the resistance of the wire at t °C,
R_0 is the resistance of the wire at 0°C
and α is the temperature coefficient of resistance.

$\Rightarrow R_{50}=R_0(1+50\alpha)$ ... (i)
$R_{100}=R_0(1+100\alpha)$ ... (ii)
From (i), $R_{50}-R_0=50\,\alpha R_0$ ... (iii)
From (ii), $R_{100}-R_0=100\,\alpha R_0$ ... (iv)
Dividing (iii) by (iv), we get

$$\frac{R_{50}-R_0}{R_{100}-R_0}=\frac{1}{2}$$

Here, $R_{50}=5\Omega$ and $R_{100}=6\Omega$

$$\therefore \frac{5-R_0}{6-R_0}=\frac{1}{2}$$

or, $6-R_0=10-2R_0$ or, $R_0=4\Omega$.

38. (b) According to the condition of balancing

$$\frac{55}{20}=\frac{R}{80}\Rightarrow R=220\Omega$$

39. (a) Let j be the current density.

Then $j\times 2\pi r^2=I\Rightarrow j=\dfrac{I}{2\pi r^2}$

$$\therefore E=\rho j=\frac{\rho I}{2\pi r^2}$$

Now, $\Delta V'_{BC}=-\int_{a+b}^{a}\vec{E}.\vec{dr}=-\int_{a+b}^{a}\frac{\rho I}{2\pi r^2}dr$

$$=-\frac{\rho I}{2\pi}\left[-\frac{1}{r}\right]_{a+b}^{a}=\frac{\rho I}{2\pi a}-\frac{\rho I}{2\pi(a+b)}$$

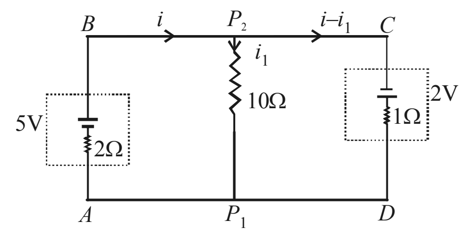
On applying superposition as mentioned we get

$$\Delta V_{BC}=2\times\Delta V'_{BC}=\frac{\rho I}{\pi a}-\frac{\rho I}{\pi(a+b)}$$

40. (c) As shown in Answer (a) $E=\dfrac{\rho I}{2\pi r^2}$

41. (c) Applying Kirchoff's loop law in ABP_2P_1A, we get

$-2i+5-10\,i_1=0$ .....(i)



Again applying Kirchoff's loop law in $P_2CDP_1P_2$ we get, $10\,i_1+2-i+i_1=0$ ...(ii)

From (i) and (ii) $11\,i_1+2-\left[\dfrac{5-10i_1}{2}\right]=0$

$\Rightarrow i_1=\dfrac{1}{32}$ A from P_2 to P_1

42. (c) Initial energy of capacitor, $E_1=\dfrac{q_1^2}{2C}$

Final energy of capacitor,

$$E_2=\frac{1}{2}E_1=\frac{q_1^2}{4C}=\frac{\left(\frac{q_1}{\sqrt{2}}\right)^2}{2C}$$

$\therefore t_1$ = time for the charge to reduce to $\dfrac{1}{\sqrt{2}}$ of its initial value

and t_2 = time for the charge to reduce to $\dfrac{1}{4}$ of its initial value

We have, $q_2=q_1e^{-t/CR}$

$$\Rightarrow \ln\left(\frac{q_2}{q_1}\right)=-\frac{t}{CR}$$

$$\therefore \ln\left(\frac{1}{\sqrt{2}}\right)=\frac{-t_1}{CR} \qquad ...(1)$$

and $\ln\left(\frac{1}{4}\right)=\frac{-t_2}{CR}$ ...(2)

By (1) and (2), $\frac{t_1}{t_2}=\frac{\ln\left(\frac{1}{\sqrt{2}}\right)}{\ln\left(\frac{1}{4}\right)}$

$$=\frac{1}{2}\frac{\ln\left(\frac{1}{2}\right)}{2\ln\left(\frac{1}{2}\right)}=\frac{1}{4}$$

43. **(d)** $R_1=R_0[1+\alpha_1\Delta t]$;

$R_2=R_0[1+\alpha_2\Delta t]$

In Series, $R=R_1+R_2$

$=R_0[2+(\alpha_1+\alpha_2)\Delta t]$

$=2R_0\left[1+\left(\frac{\alpha_1+\alpha_2}{2}\right)\Delta t\right]$

$\therefore\ \alpha_{eq}=\frac{\alpha_1+\alpha_2}{2}$

In Parallel, $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}$

$=\frac{1}{R_0[1+\alpha_1\Delta t]}+\frac{1}{R_0[1+\alpha_2\Delta t]}$

$\Rightarrow \frac{1}{\frac{R_0}{2}(1+\alpha_{eq}\Delta t)}$

$=\frac{1}{R_0(1+\alpha_1\Delta t)}+\frac{1}{R_0(1+\alpha_2\Delta t)}$

$2(1-\alpha_{eq}\Delta t)=(1-\alpha_1\Delta t)(1-\alpha_2\Delta t)$

$\therefore\ \alpha_{eq}=\frac{\alpha_1+\alpha_2}{2}$

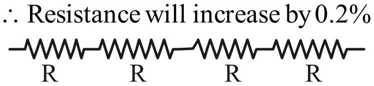
44. **(a)** Resistance of wire

$R=\frac{\rho l}{A}=\frac{\rho l^2}{C}$ (where $Al=C$)

$\therefore$ Fractional change in resistance

$$\frac{\Delta R}{R}=2\frac{\Delta l}{l}$$

$\therefore$ Resistance will increase by 0.2%

45. **(a)** 

R = 100 ± 5

$\Rightarrow$ 4R = 400 ± 20

Thus, tolerance of combination is also 5%.

46. **(c)** Potential gradient

$x=\frac{V}{\ell}=\frac{IR}{\ell}=\frac{I}{\ell}\left(\frac{\rho\ell}{A}\right)=\frac{I\rho}{A}$

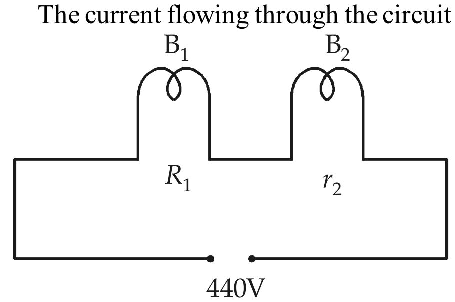
$x=\frac{0.2\times4\times10^{-7}}{8\times10^{-7}}=\frac{0.8}{8}=0.1$ V/m

47. **(c)** The current upto which bulb rated 25W – 220V, will not fuse

$I_1=\frac{W_1}{V_1}=\frac{25}{220}$ Amp

Similarly, $I_2=\frac{W_2}{V_2}=\frac{100}{220}$ Amp

The current flowing through the circuit



$I=\frac{440}{R_{eff}}$

$R_{eff}=R_1+R_2$

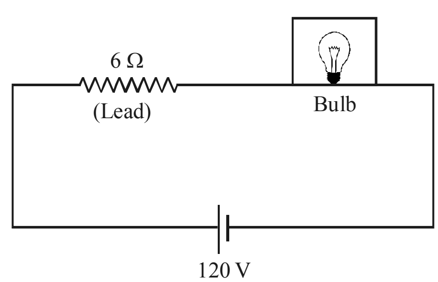
$R_1=\frac{V_1^2}{P_1}=\frac{(220)^2}{25}$; $R_2=\frac{V_2^2}{P}=\frac{(220)^2}{100}$

$I=\frac{440}{\frac{(220)^2}{25}+\frac{(220)^2}{100}}$

$=\frac{440}{(220)^2\left[\frac{1}{25}+\frac{1}{100}\right]}$; $I=\frac{40}{220}$ Amp

$\because I_1\left(=\frac{25}{220}A\right)<I\left(=\frac{40}{220}A\right)<I_2\left(=\frac{100}{200}A\right)$

Thus the bulb rated 25 W – 220 will fuse.

48. **(d)** 

Power of bulb = 60 W (given)

Resistance of bulb $= \dfrac{120\times120}{60} = 240\Omega$

$\left[\because\ P = \dfrac{V^2}{R}\right]$

Power of heater = 240W (given)

Resistance of heater $= \dfrac{120\times120}{240} = 60\Omega$

Voltage across bulb before heater is switched on,

$V_1 = \dfrac{240}{246}\times120 = 117.73$ volt

Voltage across bulb after heater is switched on,

$V_2 = \dfrac{48}{54}\times120 = 106.66$ volt

Hence decrease in voltage

$V_1 - V_2 = 117.073 - 106.66 = 10.04$ Volt (approximately)

49. **(d)** Statements I is false and Statement II is true

For ammeter, shunt resistance, $S = \dfrac{IgG}{I - Ig}$

Therefore for I to increase, S should decrease, So additional S can be connected across it.

50. **(c)** Total power consumed by electrical appliances in the building, $P_{total} = 2500W$

Watt = Volt × ampere

$\Rightarrow\ 2500 = V \times I \Rightarrow 2500 = 220\,I$

$\Rightarrow\ I = \dfrac{2500}{220} = 11.36 \approx 12A$

(Minimum capacity of main fuse)

51. **(b)** $V = IR = (neAv_d)\rho\dfrac{\ell}{A}$

$\therefore\ \rho = \dfrac{V}{V_d l n e}$

Here V = potential difference

l = length of wire

n = no. of electrons per unit volume of conductor.

e = no. of electrons

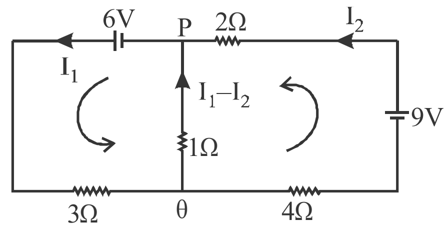
Placing the value of above parameters we get resistivity

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

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

52. **(a)** From KVL

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



$6 = 3I_1 + I_1 - I_2;\ 4I_1 - I_2 = 6$ ...(1)

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

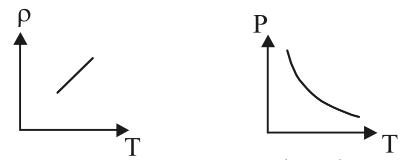
$-I_1 + 6I_2 = 9$ ...(2)

On solving (1) and (2)

$I_1 = 0.13A$

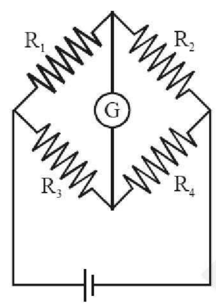
Direction Q to P, since $I_1 > I_2$.

53. **(a)**



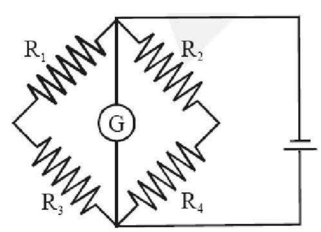
Metal (for limited range of temperature) Semiconductor $\rho = \rho_o e^{\frac{-Eg}{K_B T}}$

54. **(d)** There is no change in null point, if the cell and the galvanometer are exchanged in a balanced wheatstone bridge.



On balancing condition $\dfrac{R_1}{R_3} = \dfrac{R_2}{R_4}$

After exchange



On balancing condition $\dfrac{R_1}{R_2} = \dfrac{R_3}{R}$,

55. **(b)** The potential difference in each loop is zero.

$\therefore$ No current will flow or current in each resistance is Zero.