MCQ 50 marks

1. D. 5.67

Explanation: Let the current I be the same in series.

From $I = nAev_d$, $n_{Cu}A_{Cu}v_{Cu} = n_{Al}A_{Al}v_{Al}$

$\frac{v_{Al}}{v_{Cu}} = \frac{n_{Cu}}{n_{Al}} \times \left(\frac{d_{Cu}}{d_{Al}}\right)^2$

$= \frac{8.5}{6} \times 4$

Therefore, $\frac{v_{Al}}{v_{Cu}} = 5.67$

2. D. 12 C

Explanation: $Q = \int_0^2 I\,dt$

$= \int_0^2 (3t^2 + 2t)\,dt$

$= \left[t^3 + t^2\right]_0^2$

$= 8 + 4$

Therefore, Q = 12 C

3. A. 1.47×10^{-4} ms^{-1}

Explanation: $v_d = \frac{I}{nAe}$

Here, $A = 2 \times 10^{-6}$ m^2

$v_d = \frac{4}{8.5\times10^{28}\times2\times10^{-6}\times1.6\times10^{-19}}$

Therefore, $v_d = 1.47 \times 10^{-4}$ ms^{-1}

4. A. 4 Ω

Explanation: For constant volume, $R \propto l^2$

After stretching, $R' = 25 \times (1.2)^2 = 36\,\Omega$

Here, resistance of each piece $= \frac{36}{3} = 12\,\Omega$

Three pieces in parallel: $R_p = \frac{12}{3}$

Therefore, $R_p = 4\,\Omega$

5. B. 8 : 3

Explanation: $R = \frac{\rho l}{A} \Rightarrow R \propto \frac{l}{d^2}$

$\frac{R_1}{R_2} = \frac{l_1}{l_2} \times \left(\frac{d_2}{d_1}\right)^2$

$= \frac{2}{3} \times 4 = \frac{8}{3}$

Therefore, $R_1 : R_2 = 8 : 3$

6. D. 2.5×10^{-3} °C^{-1}

Explanation: $R_\theta = R_1(1 + \alpha_1\theta) + R_2(1 + \alpha_2\theta)$

$\alpha_{eq} = \frac{R_1\alpha_1 + R_2\alpha_2}{R_1 + R_2}$

$= \frac{10\times0.004 + 30\times0.002}{40} = \frac{0.1}{40}$

Therefore, $\alpha_{eq} = 2.5 \times 10^{-3}$ °C^{-1}

7. D. 12 V

Explanation: While discharging, $E - 2r = 11$

While charging, $E + 1 \times r = 12.5$

Subtracting, $3r = 1.5 \Rightarrow r = 0.5\,\Omega$

Therefore, $E = 11 + 2 \times 0.5 = 12$ V

8. A. 37

Explanation: Let the number of bulbs be n

Given, voltage across each bulb $\frac{220}{n} \leq 6$

$n \geq \frac{220}{6} = 36.67$

Therefore, the minimum n = 37

9. B. 10 Ω

Explanation: Let the number of resistors be n and the value of each be R

In series $nR = 50$ and in parallel $\frac{R}{n} = 2$

Dividing, $n^2 = \frac{50}{2} = 25 \Rightarrow n = 5$

Therefore, $R = \frac{50}{5} = 10\,\Omega$

10. C. 20 Ω

Explanation: For temperature independence,

$R_C\alpha_C + R_{Fe}\alpha_{Fe} = 0$

$-5 \times 10^{-4}R_C + 5 \times 10^{-3}R_{Fe} = 0 \Rightarrow R_C = 10R_{Fe}$

Again, $R_C + R_{Fe} = 22$

$11R_{Fe} = 22 \Rightarrow R_{Fe} = 2\,\Omega$

Therefore, $R_C = 20\,\Omega$

11. C. 5 Ω

Explanation: By symmetry, the equivalent resistance between the ends of the body diagonal is $\frac{R}{3} + \frac{R}{6} + \frac{R}{3}$

$= \frac{5R}{6}$

Here, $R = 6\,\Omega$

Therefore, $R_{eq} = \frac{5\times6}{6} = 5\,\Omega$

12. B. 2 A

Explanation: Condition for maximum power:

$r = R = 4\,\Omega$

From $P_{max} = \frac{E^2}{4r}$, $25 = \frac{E^2}{16} \Rightarrow E = 20$ V

Therefore, $I = \frac{20}{6+4} = 2$ A

13. C. $\frac{4}{3}$ A

Explanation: Resistance of the parallel part

$R_p = \frac{3\times6}{3+6} = 2\,\Omega$

Equivalent resistance $R_{eq} = 2 + 4 = 6\,\Omega$

Main current $I = \frac{12}{6} = 2$ A

Potential difference across the parallel part =

$2 \times 2 = 4$ V
Therefore, $I_3 = \frac{4}{3}$ A

14. **B.** 99 Ω
Explanation: Shunt $S = \frac{I_g G}{I - I_g} = \frac{0.001 \times 100}{0.1 - 0.001} = 1.0101\ \Omega$
Resistance of the ammeter $R_A = \frac{GS}{G+S} = \frac{100 \times 1.0101}{101.0101} = 1\ \Omega$
Full-scale current of the ammeter = 0.1 A
$R + R_A = \frac{10}{0.1} = 100\ \Omega$
Therefore, $R = 100 - 1 = 99\ \Omega$

15. **A.** 5 V
Explanation: $E = 1 \times (4 + r)$
$E = 0.5 \times (9 + r)$
Equating, $4 + r = 4.5 + 0.5r \Rightarrow r = 1\ \Omega$
Therefore, $E = 1 \times (4 + 1) = 5$ V

16. **D.** 12.5 W
Explanation: Condition for maximum power:
$R = r = 2\ \Omega$
$P_{max} = \frac{E^2}{4r}$
$= \frac{100}{8}$
Therefore, $P_{max} = 12.5$ W

17. **B.** 2 A
Explanation: Let there be n cells in each row and m rows; nm = 12
Condition for maximum current: $\frac{nr}{m} = R \Rightarrow \frac{n}{m} = 3$
$\frac{n}{m} \times nm = n^2 = 36 \Rightarrow n = 6,\ m = 2$
$I = \frac{nE}{R + \frac{nr}{m}} = \frac{12}{3+3}$
Therefore, I = 2 A

18. **D.** 30 Ω
Explanation: At balance, $\frac{P}{Q} = \frac{R}{S'}$
$S' = \frac{6 \times 8}{4} = 12\ \Omega$
Let the resistance connected in parallel be x
$\frac{20x}{20+x} = 12 \Rightarrow 20x = 240 + 12x$
Therefore, $x = 30\ \Omega$

19. **A.** 50 cm
Explanation: $\frac{6}{X} = \frac{40}{60} \Rightarrow X = 9\ \Omega$
After connecting in parallel, $X' = \frac{9 \times 18}{9+18} = 6\ \Omega$
Now $\frac{6}{X'} = \frac{l}{100-l} \Rightarrow \frac{l}{100-l} = 1$
Therefore, l = 50 cm

20. **B.** 5 Ω
Explanation: For the same current, $V \propto R$ and $V \propto l$
$\frac{R_1 + R_2}{R_1} = \frac{60}{40} = 1.5$
$R_2 = 0.5R_1$
Therefore, $R_2 = 5\ \Omega$

21. **A.** 1.18 m
Explanation: $R = \frac{\rho l}{A} \Rightarrow l = \frac{RA}{\rho}$
$= \frac{0.02 \times 10^{-6}}{1.7 \times 10^{-8}}$
Therefore, l = 1.18 m

22. **D.** 1 Ω
Explanation: $r = R\left(\frac{l_1 - l_2}{l_2}\right)$
$= 4 \times \frac{80-64}{64}$
$= 4 \times \frac{16}{64}$
Therefore, $r = 1\ \Omega$

23. **C.** 0.251 Ω
Explanation: $S = \frac{I_g G}{I - I_g}$
$= \frac{0.005 \times 50}{1 - 0.005}$
$= \frac{0.25}{0.995}$
Therefore, $S = 0.251\ \Omega$

24. **D.** 40 kΩ
Explanation: Resistance of the voltmeter
$R_V = 1000 \times 10 = 10\ k\Omega$
Full-scale current $I_g = \frac{10}{10^4} = 1$ mA
$R_V + R = \frac{50}{10^{-3}} = 50\ k\Omega$
Therefore, $R = 50 - 10 = 40\ k\Omega$

25. **C.** 0–10 A
Explanation: $I = I_a\left(1 + \frac{R_a}{S}\right)$
$= 1 \times \left(1 + \frac{0.9}{0.1}\right)$
Therefore, I = 10 A, i.e. the new range is 0–10 A

26. **D.** 5000 Ω
Explanation: Current in the circuit $I = \frac{20}{1000} = 0.02$ A
Potential difference across R = 120 − 20 = 100 V
Therefore, $R = \frac{100}{0.02} = 5000\ \Omega$

27. **B.** 10.5 min
Explanation: $H = ms\Delta\theta = 2 \times 4200 \times 75 = 630000$ J
$t = \frac{H}{P} = \frac{630000}{1000} = 630$ s
Therefore, t = 10.5 min

28. **A.** 26.7 W

Explanation: Resistance of each bulb $R = \frac{V^2}{P} = \frac{220^2}{60} = 806.7\,\Omega$

Equivalent resistance $= R + \frac{R}{2} = 1.5R = 1210\,\Omega$

$I = \frac{220}{1210} = 0.1818$ A

Therefore, $P_A = I^2R = 0.1818^2 \times 806.7 = 26.7$ W

29. **D. The** 60 W **bulb**

Explanation: From $R = \frac{V^2}{P}$, the 60 W bulb has the greater resistance

In series the current is the same, so $P = I^2R$

Therefore, the 60 W bulb dissipates more power, so it glows brighter

30. **C. 892.8 taka**

Explanation: Daily energy $= 5 \times 80 \times 10 + 4 \times 40 \times 6$

$= 4000 + 960 = 4960$ Wh $= 4.96$ kWh

In 30 days $= 4.96 \times 30 = 148.8$ kWh

Therefore, bill $= 148.8 \times 6 = 892.8$ taka

31. **B.** 1.09 A

Explanation: Let the potential of one junction be V and the other 0

Kirchhoff's current law: $\frac{6-V}{2} + \frac{3-V}{1} = \frac{V}{3}$

$6 = V\left(\frac{1}{2} + 1 + \frac{1}{3}\right) = \frac{11V}{6}$

$V = \frac{36}{11} = 3.27$ V

Therefore, $I_3 = \frac{3.27}{3} = 1.09$ A

32. **A.** $4 \times 10^{-8}\,\Omega$m

Explanation: Let the length of each wire be l and its cross-section A

$R = \frac{\rho_1 l}{A} + \frac{\rho_2 l}{A} = \frac{\rho_{eff}(2l)}{A}$

$\rho_{eff} = \frac{\rho_1+\rho_2}{2}$

Therefore, $\rho_{eff} = \frac{(2+6)\times10^{-8}}{2} = 4 \times 10^{-8}\,\Omega$m

33. **A.** $4.35 \times 10^{-3}\,°C^{-1}$

Explanation: $10 = R_0(1 + 20\alpha)$

$12 = R_0(1 + 70\alpha)$

Dividing, $\frac{12}{10} = \frac{1+70\alpha}{1+20\alpha}$

$12 + 240\alpha = 10 + 700\alpha$

Therefore, $\alpha = \frac{2}{460} = 4.35 \times 10^{-3}\,°C^{-1}$

34. **A.** 71.4°C

Explanation: Given, $4(1 + 0.004\theta) = 3.6(1 + 0.006\theta)$

$4 + 0.016\theta = 3.6 + 0.0216\theta$

$0.0056\theta = 0.4$

Therefore, $\theta = 71.4°C$

35. **A.** $T_1 > T_2$

Explanation: Slope of the V –I graph = R

The slope is greater at T_1, so the resistance is greater at T_1

The resistance of a metal increases with temperature

Therefore, $T_1 > T_2$

36. **B.** 10.29°C

Explanation: $W = VQ = 12 \times 50 \times 3600 = 2.16 \times 10^6$ J

From $W = ms\Delta\theta$, $\Delta\theta = \frac{W}{ms} = \frac{2.16\times10^6}{50\times4200}$

Therefore, $\Delta\theta = 10.29°C$

37. **B. 4 times**

Explanation: $v_d = \frac{I}{nAe} \Rightarrow v_d \propto \frac{1}{d^2}$

For $d' = \frac{d}{2}$, $v_d' = 4v_d$

Therefore, the drift velocity becomes 4 times

38. **D.** 3.24 Ω

Explanation: Let the equivalent resistance be R_{eq}

Adding one more section to an infinite network leaves the equivalent resistance unchanged

$R_{eq} = 2 + \frac{2R_{eq}}{2+R_{eq}}$

$R_{eq}^2 - 2R_{eq} - 4 = 0$

$R_{eq} = 1 + \sqrt{5}$

Therefore, $R_{eq} = 3.24\,\Omega$

39. **C.** 5 Ω

Explanation: Between two adjacent vertices, one path has 6 Ω and the other has $5 \times 6 = 30\,\Omega$, and the paths are in parallel

$R = \frac{6\times30}{6+30}$

Therefore, $R = 5\,\Omega$

40. **C.** 4.5 Ω

Explanation: Resistances of the two arcs: $\frac{24}{4} = 6\,\Omega$ and $\frac{3\times24}{4} = 18\,\Omega$

The arcs are in parallel

$R = \frac{6\times18}{6+18}$

Therefore, $R = 4.5\,\Omega$

41. **C.** 6 V

Explanation: Voltmeter and 4 kΩ resistor in parallel: $\frac{4\times4}{4+4} = 2$ kΩ

By potential division, $V = 12 \times \frac{2}{2+2}$
Therefore, $V = 6\,V$

42. **B.** $5.26\,\Omega$
Explanation: Current through the voltmeter $= \frac{10}{100} = 0.1\,A$
Current through the resistor $= 2 - 0.1 = 1.9\,A$
Therefore, $R = \frac{10}{1.9} = 5.26\,\Omega$

43. **A.** 11 V
Explanation: During charging, the current flows through the battery against its emf
$V = E + Ir = 10 + 2 \times 0.5$
Therefore, $V = 11\,V$

44. **C. 66.7%**
Explanation: $\eta = \frac{I^2R}{I^2(R+r)} = \frac{R}{R+r}$
$= \frac{2}{2+1} = \frac{2}{3}$
Therefore, $\eta = 66.7\%$

45. **D.** 6 min
Explanation: For the same V and the same heat, $t \propto R$
In parallel, $\frac{1}{t_p} = \frac{1}{t_1} + \frac{1}{t_2}$
$= \frac{1}{10} + \frac{1}{15} = \frac{1}{6}$
Therefore, $t_p = 6\,min$

46. **B.** 2200 W
Explanation: With half the length, $R' = \frac{R}{2}$
From $P = \frac{V^2}{R}$, $P' = 2P$
Therefore, $P' = 2200\,W$

47. **C.** 93.7 W
Explanation: $R_b = \frac{220^2}{100} = 484\,\Omega$
$I = \frac{220}{484+16} = 0.44\,A$
Therefore, $P = I^2R_b = 0.44^2 \times 484 = 93.7\,W$

48. **C.** 15.19 W
Explanation: Excluding R, the Thevenin voltage is $V_{th} = 9 \times \frac{3}{3+1} = 6.75\,V$
Thevenin resistance $R_{th} = \frac{3\times1}{3+1} = 0.75\,\Omega$
Condition for maximum power: $R = R_{th} = 0.75\,\Omega$
$P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{45.5625}{3}$
Therefore, $P_{max} = 15.19\,W$

49. **A.** −10 V
Explanation: $I = \frac{12}{2+4+6} = 1\,A$
Potential drop across the $4\,\Omega$ and $6\,\Omega$ resistors from ground to the negative terminal $= 1 \times (4 + 6) = 10\,V$
Potential falls along the direction of current
Therefore, potential of the negative terminal $= 0 - 10 = -10\,V$

50. **B.** $0.0216\,\Omega$
Explanation: $A = \pi(r_2^2 - r_1^2) = \pi(1.5^2 - 1^2) \times 10^{-6} = 3.93 \times 10^{-6}\,m^2$
$R = \frac{\rho l}{A} = \frac{1.7\times10^{-8}\times5}{3.93\times10^{-6}}$
Therefore, $R = 0.0216\,\Omega$