MCQ 50 marks

1. **C.** 1152 J

Explanation: $I = \frac{Ne}{t} = \frac{3\times10^{20}\times1.6\times10^{-19}}{60} = 0.8\ A$

$H = I^2Rt$

$= 0.8^2 \times 15 \times 120$

Therefore, $H = 1152\ J$

2. **B.** 22 C

Explanation: Q = area under the I–t graph

First part: $\frac{1}{2} \times 5 \times 4 = 10\ C$

Second part: $4 \times 3 = 12\ C$

Therefore, $Q = 10 + 12 = 22\ C$

3. **D.** 4 : 1

Explanation: In series the current I is the same

$v_d = \frac{I}{nAe} \Rightarrow v_d \propto \frac{1}{r^2}$

$\frac{v_1}{v_2} = \left(\frac{r_2}{r_1}\right)^2 = \left(\frac{2}{1}\right)^2$

Therefore, $v_1 : v_2 = 4 : 1$

4. **B.** 1.87 h

Explanation: $v_d = \frac{I}{nAe} = \frac{3}{8.4\times10^{28}\times1.5\times10^{-6}\times1.6\times10^{-19}}$

$v_d = 1.488 \times 10^{-4}\ ms^{-1}$

$t = \frac{l}{v_d} = \frac{1}{1.488\times10^{-4}} = 6720\ s$

Therefore, $t = 1.87\ h$

5. **B.** 48 Ω

Explanation: Volume is constant: $r' = \frac{r}{2} \Rightarrow A' = \frac{A}{4},\ l' = 4l$

$R \propto \frac{l}{A} \Rightarrow R' = R \times 4 \times 4 = 16R$

Therefore, $R' = 16 \times 3 = 48\ \Omega$

6. **B.** 3 Ω

Explanation: Resistance of each side = $\frac{16}{4} = 4\ \Omega$

Between two adjacent corners, one path has 4 Ω and the other has $3 \times 4 = 12\ \Omega$, in parallel

$R = \frac{4\times12}{4+12}$

Therefore, $R = 3\ \Omega$

7. **D.** 256.4°C

Explanation: $R_\theta = R_0(1 + \alpha\theta) = 2R_0$

$\alpha\theta = 1$

Therefore, $\theta = \frac{1}{0.0039} = 256.4°C$

8. **C.** 1 : 4

Explanation: Equal mass and the same material mean equal volume

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

Therefore, $\frac{R_1}{R_2} = \left(\frac{1}{2}\right)^2 = 1 : 4$

9. **D.** $1.01 \times 10^{-6}\ \Omega m$

Explanation: $A = \pi(0.2 \times 10^{-3})^2 = 1.257 \times 10^{-7}\ m^2$

$\rho = \frac{RA}{l}$

$= \frac{4\times1.257\times10^{-7}}{0.5}$

Therefore, $\rho = 1.01 \times 10^{-6}\ \Omega m$

10. **B.** 5.33 W

Explanation: $R_1 = \frac{6\times3}{6+3} = 2\ \Omega,\ R_2 = \frac{4}{2} = 2\ \Omega$

$R_{eq} = 2 + 2 = 4\ \Omega$

$I = \frac{8}{4} = 2\ A$

Potential difference across the 6 Ω–3 Ω part = $2 \times 2 = 4\ V$

Therefore, $P_3 = \frac{V^2}{R} = \frac{4^2}{3} = 5.33\ W$

11. **A.** 1 Ω

Explanation: Possible combinations using all three 2 Ω resistors: all in series gives 6 Ω

All in parallel gives $\frac{2}{3}\ \Omega$

Two in parallel plus one in series gives $1 + 2 = 3\ \Omega$

Two in series with one in parallel gives $\frac{4\times2}{4+2} = \frac{4}{3}\ \Omega$

Only two resistors in parallel are needed to get 1 Ω; adding the third changes the value

Therefore, 1 Ω cannot be obtained using all three resistors

12. **B.** 6 V

Explanation: $I_1 = \frac{4}{2} = 2\ A,\ I_2 = \frac{5}{5} = 1\ A$

$E = 4 + 2r$ and $E = 5 + r$

Equating, $4 + 2r = 5 + r \Rightarrow r = 1\ \Omega$

Therefore, $E = 5 + 1 = 6\ V$

13. **C.** 2 Ω

Explanation: Fraction wasted internally = $\frac{I^2r}{I^2(R+r)} = \frac{r}{R+r} = 0.2$

$R + r = 5r$

$R = 4r$
Therefore, $R = 4 \times 0.5 = 2\,\Omega$

14. **D.** 1 A
Explanation: Since the cells oppose each other, $E_{net} = 6 - 2 = 4$ V
Total resistance = $1 + 1 + 2 = 4\,\Omega$
Therefore, $I = \frac{4}{4} = 1$ A

15. **C.** 0.643 A
Explanation: Both cells have the same emf, so $E_{eq} = 1.5$ V
$r_{eq} = \frac{0.5\times1}{0.5+1} = 0.333\,\Omega$
Therefore, $I = \frac{1.5}{2+0.333} = 0.643$ A

16. **C.** $R = r$
Explanation: In series $I_s = \frac{nE}{R+nr}$ and in parallel $I_p = \frac{E}{R+\frac{r}{n}} = \frac{nE}{nR+r}$
For $I_s = I_p$, $R + nr = nR + r$
$(n - 1)r = (n - 1)R$, where $n > 1$
Therefore, $R = r$

17. **B.** 2 A
Explanation: From $V = E - Ir$, the intercept on the V axis is $E = 12$ V
Intercept on the I axis $\frac{E}{r} = 6$ A $\Rightarrow r = 2\,\Omega$
Therefore, $I = \frac{12}{4+2} = 2$ A

18. **D.** 48.3 cm
Explanation: At 0°C, $X_0 = 15 \times \frac{40}{60} = 10\,\Omega$
At 100°C, $X = 10(1 + 0.004 \times 100) = 14\,\Omega$
$\frac{14}{15} = \frac{l}{100-l}$
$14(100 - l) = 15l \Rightarrow 1400 = 29l$
Therefore, $l = 48.3$ cm

19. **A.** 0.45 A
Explanation: $V = kl = 0.02 \times 45 = 0.9$ V
$I = \frac{V}{R} = \frac{0.9}{2}$
Therefore, $I = 0.45$ A

20. **B.** 2 Ω
Explanation: Potential difference across the wire = $\frac{1}{60} \times 100 = 1.667$ V
$I = \frac{1.667}{10} = 0.1667$ A
Total resistance = $\frac{2}{0.1667} = 12\,\Omega$
Therefore, $R = 12 - 10 = 2\,\Omega$

21. **A. the bridge will still remain balanced**
Explanation: $\frac{P}{Q} = \frac{5}{10} = \frac{1}{2}$ and $\frac{R}{S} = \frac{15}{30} = \frac{1}{2}$, so the bridge is balanced
After interchanging, the balance condition becomes $\frac{P}{R} = \frac{Q}{S}$, which is equivalent to $\frac{P}{Q} = \frac{R}{S}$
Therefore, the bridge still remains balanced

22. **B.** 60 cm
Explanation: $I = \frac{4}{30+10} = 0.1$ A
Potential difference across the wire = $0.1 \times 10 = 1$ V
Potential gradient $k = 1\ Vm^{-1}$
Therefore, $l = \frac{0.6}{1} = 0.6$ m = 60 cm

23. **C. 10%**
Explanation: $I_g = I \times \frac{S}{G+S}$
For $S = \frac{G}{9}$, $I_g = I \times \frac{\frac{G}{9}}{G+\frac{G}{9}} = I \times \frac{1}{10}$
Therefore, $I_g = \frac{I}{10}$, i.e. 10%

24. **D.** 50 Ω
Explanation: $I_g(G + 1950) = 2$ and $I_g(G + 4950) = 5$
Subtracting, $3000I_g = 3 \Rightarrow I_g = 1$ mA
Therefore, $G = \frac{2}{0.001} - 1950 = 50\,\Omega$

25. **A. 231 taka**
Explanation: Daily energy = $1 \times 0.5 + 0.12 \times 5 = 1.1$ kWh
In 30 days = $1.1 \times 30 = 33$ kWh
Therefore, bill = $33 \times 7 = 231$ taka

26. **C. 16.7%**
Explanation: Actual current without the ammeter = $\frac{12}{10} = 1.2$ A
Reading with the ammeter = $\frac{12}{10+2} = 1$ A
Percentage error = $\frac{1.2-1}{1.2} \times 100\%$
Therefore, error = 16.7%

27. **B.** 5.85 A
Explanation: Ammeter and 10 Ω resistor in parallel: $\frac{0.5\times10}{0.5+10} = 0.476\,\Omega$
Main current $I = \frac{6}{0.5+0.476} = 6.15$ A
Current through the ammeter = $6.15 \times \frac{10}{10+0.5}$
Therefore, ammeter reading = 5.85 A

28. **A.** 2 : 1
Explanation: If the current in the 3 Ω resistor is I, the current in each 6 Ω resistor is $\frac{I}{2}$
From $H = I^2Rt$, $\frac{H_3}{H_6} = \frac{I^2\times3}{(\frac{I}{2})^2\times6}$
$= \frac{3}{1.5}$
Therefore, $H_3 : H_6 = 2 : 1$

29. **A.** 20 min

Explanation: For constant resistance, $P = \frac{V^2}{R} \Rightarrow P \propto V^2$

$P' = \left(\frac{110}{220}\right)^2 P = \frac{P}{4}$

For the same heat, $t \propto \frac{1}{P}$

Therefore, $t' = 4 \times 5 = 20$ min

30. **C.** 82.6 W

Explanation: $P' = P\left(\frac{V'}{V}\right)^2$

$= 100 \times \left(\frac{200}{220}\right)^2$

Therefore, $P' = 82.6$ W

31. **A.** −1 V

Explanation: Add up the changes in potential from a to b

Potential drop across 2 Ω: −2 V

Across the battery from negative to positive terminal: +6 V

Potential drop across 3 Ω: −3 V

$V_b = V_a - 2 + 6 - 3 = V_a + 1$

Therefore, $V_a - V_b = -1$ V

32. **C.** 16 : 1

Explanation: $R_s = 4R,\ R_p = \frac{R}{4}$

For the same V , $P = \frac{V^2}{R} \Rightarrow P \propto \frac{1}{R}$

Therefore, $\frac{P_p}{P_s} = \frac{R_s}{R_p} = 16 : 1$

33. **D.** 87.5°C

Explanation: $R_{20} = \frac{12}{2} = 6\,\Omega,\ R_\theta = \frac{12}{1.6} = 7.5\,\Omega$

$\frac{1+0.004\theta}{1+0.004\times20} = \frac{7.5}{6} = 1.25$

$1 + 0.004\theta = 1.35$

Therefore, $\theta = 87.5°C$

34. **D.** 2200°C

Explanation: $\frac{R_\theta}{R_{20}} = \frac{1+\alpha\theta}{1+20\alpha} = 10$

$1 + 0.0045\theta = 10 \times 1.09 = 10.9$

Therefore, $\theta = \frac{9.9}{0.0045} = 2200°C$

35. **D.** 1 : 3

Explanation: Slope of the V –I graph R = tan θ

$\frac{R_1}{R_2} = \frac{\tan 30°}{\tan 60°} = \frac{\frac{1}{\sqrt{3}}}{\sqrt{3}}$

Therefore, $R_1 : R_2 = 1 : 3$

36. **A.** 2 : 1

Explanation: $R = \frac{\rho l}{A} \Rightarrow A = \frac{\rho l}{R}$

Mass $m = DAl = \frac{D\rho l^2}{R} \Rightarrow m \propto D\rho$

$\frac{m_{Cu}}{m_{Al}} = \frac{8900\times1.7}{2700\times2.8}$

Therefore, $m_{Cu} : m_{Al} \approx 2 : 1$

37. **B. will be halved**

Explanation: $I = \frac{V}{R} = \frac{VA}{\rho l}$

$v_d = \frac{I}{nAe} = \frac{V}{ne\rho l} \Rightarrow v_d \propto \frac{1}{l}$

Therefore, when the length is doubled, v_d is halved

38. **C.** 3 Ω

Explanation: Equivalent resistance along a face diagonal of a cube = $\frac{3R}{4}$

Here, R = 4 Ω

Therefore, $R_{eq} = \frac{3\times4}{4} = 3\,\Omega$

39. **D.** 4 Ω

Explanation: $P = \frac{E^2R}{(R+r)^2}$

Given, $\frac{E^2\times2}{(2+r)^2} = \frac{E^2\times8}{(8+r)^2}$

$\frac{8+r}{2+r} = 2$

$8 + r = 4 + 2r$

Therefore, r = 4 Ω

40. **A.** 0.4 Ω

Explanation: Given, $15 - 12 = 5(R + 0.2)$

$R + 0.2 = 0.6$

Therefore, R = 0.4 Ω

41. **D.** 6.67 V

Explanation: Voltmeter and resistor in parallel: $\frac{10\times10}{10+10} = 5$ kΩ

By potential division, $V = 20 \times \frac{5}{10+5}$

Therefore, V = 6.67 V

42. **D. 1.99 times**

Explanation: Range $I = I_g\left(1 + \frac{G}{S}\right)$

For S = 1 Ω, $I_1 = I_g(1 + 99) = 100I_g$

For S = 0.5 Ω, $I_2 = I_g(1 + 198) = 199I_g$

Therefore, $\frac{I_2}{I_1} = 1.99$

43. **B.** 3 A

Explanation: $E_{eq} = 4 \times 1.5 = 6$ V

$r_{eq} = \frac{4\times0.4}{2} = 0.8\,\Omega$

Therefore, $I = \frac{6}{1.2+0.8} = 3$ A

44. **A.** 10 h

Explanation: Charge effectively stored per hour = 0.8 × 5 = 4 Ah

Therefore, $t = \frac{40}{4} = 10$ h

45. **A.** 3 min

Explanation: Resistance of each piece is $\frac{R}{2}$; in parallel $R' = \frac{R}{4}$
For the same V , $t \propto R$
Therefore, $t' = \frac{12}{4} = 3$ min

46. **C.** $8\,\Omega$
Explanation: From the condition for maximum power, $r = 2\,\Omega$
$\eta = \frac{R}{R+r} = 0.8$
$R = 0.8R + 1.6$
Therefore, $R = 8\,\Omega$

47. **C.** 24 W
Explanation: From $R = \frac{V^2}{P}$, $R_s = V^2\left(\frac{1}{40} + \frac{1}{60}\right)$
$P = \frac{V^2}{R_s} = \frac{1}{\frac{1}{40}+\frac{1}{60}}$
Therefore, $P = \frac{40\times60}{40+60} = 24$ W

48. **B.** 1.47 A
Explanation: Let the potential across the external resistor be V
Kirchhoff's current law: $\frac{10-V}{1} + \frac{5-V}{2} = \frac{V}{5}$
$12.5 = V\,(1 + 0.5 + 0.2) = 1.7V$
$V = 7.353$ V
Therefore, $I = \frac{7.353}{5} = 1.47$ A

49. **A.** 1 : 3
Explanation: In parallel V is the same, $P \propto \frac{1}{R}$
$P_1 = 3P_2 \Rightarrow R_2 = 3R_1$
In series I is the same, $P \propto R$
Therefore, $P_1 : P_2 = R_1 : R_2 = 1 : 3$

50. **A.** 600 J
Explanation: Total energy converted in the cell = $EIt = 1.5 \times 2 \times 300 = 900$ J
Internal loss = $I^2rt = 2^2 \times 0.25 \times 300 = 300$ J
Therefore, energy delivered to the external circuit = $900 - 300 = 600$ J