

CBSE CLASS 10 ELECTRICITY: SOLUTIONS & MARKING SCHEME

Comprehensive Step-by-Step Evaluated Answers with CBSE Step-Marking Scheme

Answer Key &
Solutions
Evaluator Standard

PART I: CONCEPTUAL THEORY QUESTIONS (SOLUTIONS)

Q1 TO Q10

Q1. Definition of One Ampere & Electron Count

[1 Mark Total]

One ampere is defined as the flow of one coulomb of electric charge across a given cross-section per second ($1 \text{ A} = 1 \text{ C/s}$).

[½ M]

Since $Q = ne$, $1 \text{ C} = n \times (1.6 \times 10^{-19} \text{ C}) \Rightarrow n = 6.25 \times 10^{18}$ electrons passing per second. [½ M]

Q2. One Volt Definition & Voltmeter Polarity

[1 Mark Total]

The potential difference between two points is 1 Volt when 1 Joule of work is done in moving an electric charge of 1 Coulomb from one point to another ($1 \text{ V} = 1 \text{ J} / 1 \text{ C}$). [½ M]

It is measured using a **voltmeter** connected in **parallel** across the points, with its positive terminal connected toward the higher potential. [½ M]

Q3. Ohm's Law & Temperature V-I Characteristics

[3 Marks Total]

(a) **Ohm's Law:** At constant temperature and physical dimensions, the electric current (I) flowing through a metallic conductor is directly proportional to the potential difference (V) applied across its terminals ($V \propto I \Rightarrow V = IR$). [1 M]

(b) In a V-I graph with V along the y-axis and I along the x-axis, the slope represents Resistance ($R = V/I$). For metals, resistance increases with temperature. Since $T_1 > T_2$, $R(T_1) > R(T_2)$. Thus, the straight line corresponding to T_1 has a greater slope (steeper) than the line for T_2 . [2 M]

Q4. Resistance vs. Resistivity & Stretching Analysis

[3 Marks Total]

(a) **Resistance (R)** is the opposition offered to electric current, depending on length (L), area (A), material, and temperature (Unit: Ω). **Resistivity (ρ)** is the characteristic material property equal to resistance of unit length and unit cross-section; it depends strictly on material and temperature, independent of geometry (Unit: $\Omega \cdot \text{m}$). [1 M]

(b) Initial: $R = \rho L/A$. When length is stretched to $L' = 2L$, volume remains constant ($V = AL = A'L'$). Thus, $A' = A/2$. [1 M]

New Resistance: $R' = \rho(2L) / (A/2) = 4(\rho L/A) = 4R$ (Quadrupled). **New $R = 4R$** . Resistivity remains **unchanged ($\rho' = \rho$)**. [1 M]

Q5. Scientific Reasons for Electrical Components

[3 Marks Total]

(i) **Heating Elements:** Alloys have significantly higher electrical resistivity than pure metals and do not oxidize (burn) easily even at high operational temperatures ($\sim 800^\circ\text{C}$ – 1000°C). [1 M]

(ii) **Electric Fuse:** An alloy of lead and tin has a low melting point and appropriate resistivity, melting quickly when current exceeds the safe limit. [1 M]

(iii) **Lamp Filament:** Tungsten possesses an exceptionally high melting point (3422°C) and high mechanical strength at white-hot incandescence. [1 M]

Q6. Disadvantages of Series Combination in Homes

[3 Marks Total]

1. If one electrical appliance fails or is switched off, the circuit is broken and all other appliances stop operating. [1 M]
2. All appliances are forced to operate at the same current, despite having vastly differing current requirements (e.g., bulb: 0.5 A vs. heater: 10 A). [1 M]
3. The total supply voltage is divided across appliances, resulting in reduced voltage across each component and sub-optimal operation. [1 M]

Q7. Joule's Law of Heating & Mathematical Derivation

[3 Marks Total]

Statement: The heat produced in a resistor is directly proportional to: (i) square of current (I^2), (ii) resistance (R), and (iii) time (t) for which current flows: **$H = I^2 R t$** . [1 M]

Derivation: Work done $W = V \times Q$. By definition, $Q = I \times t$. Hence, $W = V \times I \times t$. [1 M]

From Ohm's Law, $V = IR$. Substituting V : $W = (IR) \times I \times t = I^2 R t$. Assuming all electrical work transforms into heat energy: **$H = I^2 R t$** . [1 M]

Q8. Operating Principle & Rating of Electric Fuse

[2 Marks Total]

A fuse operates on the **Joule heating effect**. It contains a wire of high resistance and low melting point connected in series with the live wire. If current exceeds rated capacity, excessive heat melts the fuse, breaking the circuit. [1 M]

Lighting circuits require lower power ($\sim$ few hundred watts; current $< 5 \text{ A}$), so a 5 A fuse is suitable. Heavy appliances (geysers, ACs) consume 1.5 – 3 kW , drawing 7 – 14 A , thus requiring a 15 A fuse. [1 M]

Q11. Parallel Equivalent Resistance Derivation**[3 Marks Total]**

Let three resistors R_1, R_2, R_3 be connected in parallel across voltage V . The potential difference across each is V . The main current I divides: $I = I_1 + I_2 + I_3$. **[1 M]**

By Ohm's Law: $I_1 = V/R_1, I_2 = V/R_2, I_3 = V/R_3$, and $I = V/R_p$. **[1 M]**

Substituting: $V/R_p = V/R_1 + V/R_2 + V/R_3 \Rightarrow$ Dividing by V : $1/R_p = 1/R_1 + 1/R_2 + 1/R_3$. **[1 M]**

Q12. Five Wire Segments in Parallel**[2 Marks Total]**

When a wire of resistance R is cut into 5 equal parts, each piece has resistance $r = R/5$. **[½ M]**

When connected in parallel: $1/R' = 1/r + 1/r + 1/r + 1/r + 1/r = 5/r = 5/(R/5) = 25/R \Rightarrow R' = R/25$. **[1 M]**

Therefore, the ratio is: $R / R' = 25$ (or $25 : 1$). **[½ M]**

Q13. Heater Cord vs. Element & Alloy Temperature Behavior**[3 Marks Total]**

(a) The heating element is made of high-resistivity alloy (Nichrome), having very high resistance. Since $H = I^2 R t$ and both cord and element carry the same series current, heat dissipated in the element is very large, causing it to glow red hot. The connecting cord (copper) has negligible resistance, dissipating minimal heat. **[2 M]**

(b) Alloys exhibit a very small temperature coefficient of resistance compared to pure metals; their resistivity changes negligibly with temperature. **[1 M]**

Q14. Assertion-Reasoning Evaluation**[2 Marks Total]**

(i) **Correct Answer: Both (A) and (R) are true, and (R) is the correct explanation of (A).**

Explanation: Resistance $R = V^2/P$. For 60 W: $R_{60} = 220^2/60 = 806.7 \Omega$; for 100 W: $R_{100} = 220^2/100 = 484 \Omega$. In series, I is identical, so $P_{\text{dissipated}} = I^2 R$. The 60 W bulb dissipates more power and glows brighter. **[1 M]**

(ii) **Correct Answer: (A) is False, but (R) is True.** Bending a wire without stretching or changing its cross-sectional area or length does not alter its resistance ($R = \rho L/A$). **[1 M]**

Q15. Experimental Verification of Parallel Circuits**[5 Marks Total]**

(a) Connect two resistors R_1 and R_2 in parallel with a battery, key, and ammeter in the main line. Place a voltmeter across the parallel combination: it reads potential difference V . Connect the voltmeter across R_1 and R_2 individually; the reading remains V , proving voltage is uniform. Connect ammeters in each branch: branch currents measure I_1 and I_2 , verifying $I = I_1 + I_2$. **[3 M]**

(b) Adding an identical resistor in parallel reduces equivalent resistance from R_{eq} to $R_{\text{new}} = R_{\text{eq}} \cdot R / (R_{\text{eq}} + R)$. Hence: main line ammeter reading **increases**; voltmeter reading remains **constant** (equal to battery terminal voltage). **[2 M]**

Q16. Case Study: Geyser Heating Element Configurations**[5 Marks Total]**

Resistances: $R_1 = V^2/P_1 = 220^2/1000 = 48.4 \Omega$; $R_2 = V^2/P_2 = 220^2/2000 = 24.2 \Omega$.

1. **Individual Operation:** Either 1000 W (low heat) or 2000 W (medium heat). **[1 M]**

2. **Parallel Combination:** $P_{\text{total}} = P_1 + P_2 = 1000 + 2000 = 3000 \text{ W (3 kW)}$ (Maximum heating mode). **[2 M]**

3. **Series Combination:** $R_s = 48.4 + 24.2 = 72.6 \Omega$. Total power $P_s = V^2/R_s = 220^2 / 72.6 = 666.7 \text{ W}$ (Minimum heating mode).

Four distinct operational heating rates are achieved. **[2 M]**

Q17. Calculation of Current from Electron Count**[2 Marks Total]**

Total charge $Q = n \cdot e = (3.75 \times 10^{19}) \times (1.6 \times 10^{-19} \text{ C}) = 6.0 \text{ C}$. **[1 M]**

Current $I = Q / t = 6.0 \text{ C} / 5 \text{ s} = 1.2 \text{ A}$. **[1 M]**

Q18. Work Done and Electric Power**[2 Marks Total]**

Work done $W = Q \cdot V = 4 \text{ C} \times 12 \text{ V} = 48 \text{ Joules}$. **[1 M]**

Power $P = W / t = 48 \text{ J} / 2 \text{ s} = 24 \text{ Watts}$. **[1 M]**

Q19. Conductor Length and Diameter Doubling**[3 Marks Total]**

Diameter $d = 0.5 \text{ mm} = 0.5 \times 10^{-3} \text{ m} \Rightarrow$ Radius $r = 0.25 \times 10^{-3} \text{ m}$. Area $A = \pi r^2 = (22/7) \times (2.5 \times 10^{-4})^2 = 1.964 \times 10^{-7} \text{ m}^2$.

Using $R = \rho L / A \Rightarrow L = (R \cdot A) / \rho = (10 \times 1.964 \times 10^{-7}) / (1.6 \times 10^{-8}) = 122.7 \text{ m}$. **[2 M]**

Since $R \propto 1/d^2$, doubling diameter makes new resistance $R' = R / 2^2 = 10 / 4 = 2.5 \Omega$ (decreases by a factor of 4). **[1 M]**

Q20. Resistivity and Conductivity Determination**[3 Marks Total]**

Q21. Percentage Increase in Resistance on Stretching**[3 Marks Total]**Initial length = L ; New length $L' = L + 0.25L = 1.25L = (5/4)L$. **[½ M]**Since volume is constant ($A \cdot L = A' \cdot L'$), $A' = A \cdot (L / L') = (4/5)A$. **[1 M]**New resistance $R' = \rho \cdot L' / A' = \rho \cdot [(5/4)L] / [(4/5)A] = (25/16) \cdot (\rho L / A) = 1.5625 R$. **[1 M]**Fractional change = $(R' - R) / R = 0.5625 \Rightarrow$ Percentage increase = **56.25%**. **[½ M]****Q22. Parallel Combination Analysis****[3 Marks Total]**(a) $1/R_p = 1/5 + 1/10 + 1/30 = (6 + 3 + 1) / 30 = 10/30 = 1/3 \Rightarrow R_p = 3 \Omega$. **[1 M]**(b) Branch currents: $I_1 = V/R_1 = 12/5 = 2.4 \text{ A}$; $I_2 = 12/10 = 1.2 \text{ A}$; $I_3 = 12/30 = 0.4 \text{ A}$. **[1 M]**(c) Total current $I = I_1 + I_2 + I_3 = 2.4 + 1.2 + 0.4 = 4.0 \text{ A}$ (or $I = V / R_p = 12 / 3 = 4.0 \text{ A}$). **[1 M]****Q23. Mixed Series-Parallel Network****[3 Marks Total]**Parallel pair: $R_p = (8 \times 12) / (8 + 12) = 96 / 20 = 4.8 \Omega$. **[1 M]**(a) Total circuit resistance $R_{eq} = 6 \Omega + 4.8 \Omega = 10.8 \Omega$. **[1 M]**(b) Total line current $I = V / R_{eq} = 16 \text{ V} / 10.8 \Omega = 1.48 \text{ A}$ (or $40/27 \text{ A}$). **[½ M]**(c) Potential difference across 6Ω : $V_{6\Omega} = I \times 6 = (40/27) \times 6 = 80/9 = 8.89 \text{ V}$. **[½ M]****Q24. Number of Resistors in Parallel****[3 Marks Total]**Required equivalent resistance of network: $R_{eq} = V / I = 220 \text{ V} / 5 \text{ A} = 44 \Omega$. **[1 M]**For n identical resistors of 176Ω in parallel: $R_{eq} = R / n \Rightarrow 44 = 176 / n$. **[1 M]** $n = 176 / 44 = 4$ resistors. **[1 M]****Q25. Heat Developed in Joules and Calories****[2 Marks Total]**Heat generated $H = I^2 R t = (5)^2 \times 20 \times 30 = 25 \times 20 \times 30 = 15,000 \text{ Joules (15 kJ)}$. **[1 M]**In calories: $H (\text{cal}) = 15000 / 4.18 = 3,588.5 \text{ calories (3.59 kcal)}$. **[1 M]****Q26. Lamps in Parallel****[3 Marks Total]**(a) Current drawn: $I_1 = P_1 / V = 100 \text{ W} / 220 \text{ V} = 0.455 \text{ A}$ ($5/11 \text{ A}$); $I_2 = P_2 / V = 60 \text{ W} / 220 \text{ V} = 0.273 \text{ A}$ ($3/11 \text{ A}$). **[2 M]**(b) Total power consumed = $P_1 + P_2 = 100 \text{ W} + 60 \text{ W} = 160 \text{ Watts (0.16 kW)}$. **[1 M]****Q27. Commercial Electricity Cost Calculation****[4 Marks Total]**Energy consumed daily by refrigerator = $400 \text{ W} \times 8 \text{ h} = 3200 \text{ Wh} = 3.2 \text{ kWh}$. **[1 M]**Energy consumed daily by TV = $100 \text{ W} \times 6 \text{ h} = 600 \text{ Wh} = 0.6 \text{ kWh}$. **[1 M]**Total daily energy = $3.2 + 0.6 = 3.8 \text{ kWh}$. Total energy in 30 days = $3.8 \times 30 = 114 \text{ kWh (Units)}$. **[1 M]**Total Cost = $114 \text{ kWh} \times ₹ 4.50 = ₹ 513.00$. **[1 M]**

Q28. Dual-Coil Boiling Time in Series and Parallel**[5 Marks Total]**

Let required heat to boil water be H . Power $P = V^2/R$. Heat $H = (V^2/R) \cdot t \Rightarrow R = (V^2 \cdot t) / H$. Thus, resistance is directly proportional to boiling time ($R \propto t$): $R_1 = k \cdot t_1 = 6k$, $R_2 = k \cdot t_2 = 8k$. **[1.5 M]**

(a) **In Series:** $R_s = R_1 + R_2 = 6k + 8k = 14k \Rightarrow t_s = t_1 + t_2 = 6 + 8 = \mathbf{14 \text{ minutes}}$. **[1.5 M]**

(b) **In Parallel:** $1/R_p = 1/R_1 + 1/R_2 \Rightarrow 1/t_p = 1/t_1 + 1/t_2 = 1/6 + 1/8 = 7/24 \Rightarrow t_p = 24/7 = \mathbf{3.43 \text{ minutes (3 min 26 s)}}$. **[2 M]**

Q29. Bulb Operated at Reduced Voltage**[2 Marks Total]**

Filament resistance $R = V^2 / P = 220^2 / 100 = 48400 / 100 = 484 \Omega$. **[1 M]**

Actual power consumed at 110 V: $P' = (V')^2 / R = 110^2 / 484 = 12100 / 484 = \mathbf{25 \text{ Watts}}$. (When voltage is halved, power becomes one-fourth). **[1 M]**

Q30. Bridge Network Circuit Analysis**[5 Marks Total]**

Group 1: $R_1 (10 \Omega) \parallel R_2 (40 \Omega) \Rightarrow R_{p1} = (10 \times 40) / (10 + 40) = 400 / 50 = 8 \Omega$. **[1 M]**

Group 2: $R_3 (30 \Omega) \parallel R_4 (20 \Omega) \Rightarrow R_{p2} = (30 \times 20) / (30 + 20) = 600 / 50 = 12 \Omega$. **[1 M]**

(a) Total equivalent resistance $R_{eq} = R_{p1} + R_{p2} = 8 \Omega + 12 \Omega = \mathbf{20 \Omega}$. **[1 M]**

(b) Total line current $I = V / R_{eq} = 12 \text{ V} / 20 \Omega = \mathbf{0.6 \text{ A}}$. **[1 M]**

(c) Voltage across Group 1 $= I \times R_{p1} = 0.6 \text{ A} \times 8 \Omega = 4.8 \text{ V}$. Current through R_2 : $I_2 = 4.8 \text{ V} / 40 \Omega = \mathbf{0.12 \text{ A}}$. **[1 M]**

Q31. Electric Heater Multi-Parameter Calculation**[4 Marks Total]**

(a) Current $I = V / R = 220 \text{ V} / 440 \Omega = \mathbf{0.5 \text{ A}}$. **[1 M]**

(b) Power $P = V \times I = 220 \times 0.5 = 110 \text{ W} = 0.11 \text{ kW}$. Time $t = 10 \text{ min} = (10/60) \text{ h} = 1/6 \text{ h}$.

Electrical energy $= 0.11 \text{ kW} \times (1/6) \text{ h} = \mathbf{0.0183 \text{ kWh}}$. **[1.5 M]**

(c) Heat energy $H = P \times t \text{ (seconds)} = 110 \text{ W} \times (10 \times 60 \text{ s}) = 110 \times 600 = \mathbf{66,000 \text{ Joules (66 kJ)}}$. **[1.5 M]**

Q32. Power Comparison in 2 Ω Resistor**[4 Marks Total]**

(i) **Series Circuit:** Total $R = 1 + 2 = 3 \Omega$. Circuit current $I = 6 \text{ V} / 3 \Omega = 2 \text{ A}$.

Power consumed in 2Ω resistor: $P_1 = I^2 \cdot R = (2)^2 \times 2 = \mathbf{8 \text{ Watts}}$. **[2 M]**

(ii) **Parallel Circuit:** Voltage across 2Ω resistor is directly 4 V .

Power consumed in 2Ω resistor: $P_2 = V^2 / R = 4^2 / 2 = 16 / 2 = \mathbf{8 \text{ Watts}}$. **[1.5 M]**

Conclusion: In both circuits, the power consumed by the 2Ω resistor is identical ($8 \text{ W} : 8 \text{ W} = 1 : 1$). **[½ M]**

Q33. Electric Motor Energy Consumption**[4 Marks Total]**

Power of motor $P = V \times I = 220 \text{ V} \times 5 \text{ A} = \mathbf{1100 \text{ Watts (1.1 kW)}}$. **[1 M]**

Time $t = 2 \text{ hours} = 2 \times 3600 \text{ seconds} = 7200 \text{ s}$. **[½ M]**

Energy in Joules: $E = P \times t = 1100 \text{ W} \times 7200 \text{ s} = \mathbf{7.92 \times 10^6 \text{ Joules}}$. **[1.5 M]**

Energy in Megajoules: Since $1 \text{ MJ} = 10^6 \text{ J}$, $E = \mathbf{7.92 \text{ MJ}}$ (or 2.2 kWh). **[1 M]**