Current Electricity — CBSE Pattern Test 1

Class 12 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 1 — CBSE Pattern (90 minutes, 40 marks)

Class 12 Physics · Current Electricity · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A (1 × 10), Section B (2 × 4), Section C (3 × 4) and Section D (5 × 2) — total 40 marks. Time allowed: 90 minutes.
(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.
(3) For MCQ questions choose the single correct option; for VSA answers write a single line.
(4) Take g = 10 m/s^2. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA (10 × 1 = 10 marks)

1. The ratio of the maximum to the minimum effective resistance obtainable with n identical resistors of resistance R is
   (A) n^2
   (B) n
   (C) 1/n
   (D) n^3
2. A current of 5 A flows through a wire for 2 minutes. The charge that crosses any section of the wire is
   (A) 600 C
   (B) 10 C
   (C) 0.04 C
   (D) 300 C
3. Ohm's law asserts that
   (A) for a conductor at constant temperature the plot of I versus V is linear, i.e. R is independent of V
   (B) R = V/I for every device at every instant
   (C) R is always constant for any material
   (D) I is directly proportional to R
4. The equivalent resistance of 1 Ω, 2 Ω and 3 Ω connected in parallel is
   (A) 6/11 Ω
   (B) 6 Ω
   (C) 11/6 Ω
   (D) 1/6 Ω
5. Kirchhoff's junction rule is based on the conservation of
   (A) charge
   (B) energy
   (C) linear momentum
   (D) magnetic flux
6. For a metallic conductor, the temperature coefficient of resistance is typically
   (A) positive
   (B) negative
   (C) zero
   (D) infinite
7. State Ohm's law for a metallic conductor.
8. Define current density and write its SI unit.

9. State Kirchhoff's loop rule for a closed circuit.

10. Write the relation between the drift velocity v_d of free electrons, the current I, the area of cross-section A and the free-electron number density n of a wire.

Section B — Short Answer I (4 × 2 = 8 marks)

11. A copper wire of area of cross-section 2.0×10^{-6} m^2 carries a steady current of 3.0 A. If the free-electron number density is 8.5×10^{28} m^{-3}, find the drift velocity of the free electrons.

12. At room temperature (27.0 °C) the resistance of a heating element is 100 Ω. What is the temperature of the element if its resistance is found to be 117 Ω? The temperature coefficient of resistance of the material is 1.70×10^{-4} °C^{-1}.

13. Three resistors 2 Ω, 4 Ω and 5 Ω are combined in parallel and connected to a battery of emf 20 V and negligible internal resistance. Determine the current through each resistor and the total current drawn from the battery.

14. At a junction of a network, currents of 3 A and 4 A enter the node while a current of 2 A leaves it along one branch. Find the current leaving the node along the remaining branch, stating the rule you use.

Section C — Short Answer II (4 × 3 = 12 marks)

15. Derive the relation I = n A e v_d for the current in a conductor in terms of free-electron density n, drift velocity v_d and area A.

16. Given three resistors 1 Ω, 2 Ω and 3 Ω, how would you combine them to obtain an equivalent resistance of (i) 11/3 Ω and (ii) 11/5 Ω?

17. A cell of emf 4 V and internal resistance 2 Ω is connected in parallel with a cell of emf 2 V and internal resistance 2 Ω, with like terminals joined through a 6 Ω resistor. Using Kirchhoff's laws, find the current in the 6 Ω resistor.

18. A battery of emf 10 V and internal resistance 3 Ω is connected to a resistor; the current in the circuit is 0.5 A. Find the resistance of the resistor and the terminal voltage of the battery when the circuit is closed.

Section D — Long Answers (2 × 5 = 10 marks)

19. (a) State Kirchhoff's junction rule and loop rule, and name the conservation principle underlying each. (b) Derive the balance condition P/Q = R/S of a Wheatstone bridge using Kirchhoff's laws.

20. (a) Show that the effective resistance of two resistors R_1 and R_2 connected in parallel is smaller than the smaller of the two. (b) A wire of resistance 12 Ω is bent into the form of a closed square. Find the resistance between two diagonally opposite corners of the square.

Answer Key (Marking Scheme)

Q1 – (A) n^2 (series nR, parallel R/n). Q2 – (A) 600 C (Q = 5 × 120). Q3 – (A). Q4 – (A) 6/11 Ω (1/(1+1/2+1/3)). Q5 – (A) charge. Q6 – (A) positive (metals).

Q7 – V I at constant temperature (R = V/I constant). Q8 – j = I/A, SI unit A/m^2. Q9 – In any closed loop, the algebraic sum of the emfs and potential drops is zero (Σε − ΣIR = 0). Q10 – I = n A e v_d.

Q11 – v_d = I/(nAe) = $3.0/(8.5\times10^{28}\times2.0\times10^{-6}\times1.6\times10^{-19})\approx1.1\times10^{-4}$ m/s. Q12 – $R/R_0 = 1+\alpha\Delta t$ ⇒ $\Delta t = (17/100)/(1.70\times10^{-4}) = 1000$ °C ⇒ T = 1027 °C.

Q13 – R_eq = 20/19 Ω; currents 10 A (2 Ω), 5 A (4 Ω), 4 A (5 Ω); total 19 A. Q14 – Junction rule (charge conservation): I = 3 + 4 − 2 = 5 A.

Q15 – In time dt charge nA v_d e dt crosses a section ⇒ I = nA e v_d (full micro derivation accepted). Q16 – (i) (1 Ω ∥ 2 Ω) + 3 Ω: 2/3 + 3 = 11/3 Ω; (ii) (2 Ω ∥ 3 Ω) + 1 Ω: 6/5 + 1 = 11/5 Ω.

Q17 – Branch equations $4 - 2I_1 = 2 - 2I_2$ and $4 - 2I_1 = 6(I_1 + I_2)$ give $I_1 = 5/7$ A, $I_2 = -2/7$ A. $I_{6\Omega} = 3/7 \approx 0.43$ A. Q18 – $R + r = \varepsilon/I = 20\ \Omega \Rightarrow R = 17\ \Omega$; $V = \varepsilon - Ir = 10 - 1.5 = 8.5$ V.

Q19 – (a) Junction rule ↔ conservation of charge; loop rule ↔ conservation of energy. (b) At balance $I_G = 0$: $P/Q = R/S$ (standard derivation). Q20 – (a) $1/R_{eq} = 1/R_1 + 1/R_2 \Rightarrow R_{eq} = R_1R_2/(R_1+R_2) < \min(R_1, R_2)$. (b) Each side 3 Ω; between opposite corners $(3+3) \parallel (3+3) = 6 \parallel 6 = 3\ \Omega$.