



Attempt all questions before checking the answer key. Use $e = 1.6 \times 10^{-19}$ C. Draw circuit diagrams and mark assumed current directions.

A. Very short answers - 1 mark each

1. Distinguish drift speed from the random thermal speed of electrons.
2. Define mobility and give its SI unit.
3. Why does a cell's terminal voltage differ from its emf when delivering current?
4. What physical quantity is represented by the slope of a V-versus-I graph for an ohmic conductor?
5. State the physical conservation law underlying Kirchhoff's junction rule.

B. Short answers / practice - 2 marks each

6. A $10\ \Omega$ wire is stretched to twice its length at constant volume. Find its new resistance.
7. A cell of emf 2 V and internal resistance $0.5\ \Omega$ supplies a $3.5\ \Omega$ resistor. Find current and terminal voltage.
8. Explain why alloys are preferred for standard resistors.
9. A wire carries 2 A for 5 min. Find the charge transferred and number of electrons crossing a section.
10. A conductor has resistance $20\ \Omega$ at $0\ ^\circ\text{C}$ and temperature coefficient $0.004\ ^\circ\text{C}^{-1}$. Find resistance at $50\ ^\circ\text{C}$.
11. Can terminal voltage exceed emf? Explain for a charging cell.
12. Find resistivity if $R = 5\ \Omega$, length = 2 m and area = $0.4\ \text{mm}^2$.
13. A wire has electron drift speed v . What happens to v when current doubles at fixed area?
14. Why should an ammeter have low resistance and a voltmeter high resistance?
15. Find equivalent resistance of $4\ \Omega$ and $12\ \Omega$ in parallel.
16. Calculate energy supplied by a 6 V battery carrying 2 A for 10 s.
17. Does a junction accumulate charge in steady current?
18. A cell has emf 1.5 V and $r = 0.25\ \Omega$. Find its short-circuit current in the ideal model.
19. Two identical cells of emf E and resistance r are in parallel. State equivalent values.
20. Sketch an ohmic I-V graph and explain how its slope gives resistance.

C. Short answers - 3 marks each

21. A wire of area $1\ \text{mm}^2$ carries 1.6 A. If free-electron density is $8 \times 10^{28}\ \text{m}^{-3}$, find drift speed.
22. Three resistors $2\ \Omega$, $3\ \Omega$ and $6\ \Omega$ are in parallel across 6 V. Find branch currents, total current and power supplied.
23. Two cells of emfs 2 V and 1.5 V and internal resistances $0.5\ \Omega$ each are connected in series opposition to $4\ \Omega$. Find current and terminal voltage of each cell.
24. A 12 V source feeds $2\ \Omega$ in series with a parallel combination of $3\ \Omega$ and $6\ \Omega$. Find total current and power in the $6\ \Omega$ resistor.
25. In a Wheatstone bridge, arms AB, BC, AD and DC are $2\ \Omega$, $3\ \Omega$, $4\ \Omega$ and R . A source is across AC and a galvanometer across BD. Find R for balance and explain why galvanometer resistance is irrelevant then.

D. Long answers - 5 marks each

26. Derive $I = neAv_d$ and relate drift speed to relaxation time. Hence obtain conductivity in the free-electron model and discuss temperature dependence qualitatively.
27. Derive equivalent emf and internal resistance for two cells in parallel with like terminals joined. State when circulating current can occur.
28. State Kirchhoff's rules. Between nodes A and B are three branches: a 6 V cell (positive at A) with $2\ \Omega$, a 3 V cell (positive at A) with $1\ \Omega$, and a $3\ \Omega$ resistor. Find all branch currents.
29. Derive the Wheatstone bridge balance condition with a labelled circuit. Explain how it can determine an unknown resistance.
30. A cell gives 0.5 A through $5\ \Omega$ and 1 A through $2\ \Omega$. Determine emf and internal resistance, then find current, terminal voltage and external power for a $3\ \Omega$ load.

ANSWER KEY - Numerical / short answers

- 6) 40 Ω . 7) 0.50 A; 1.75 V. 9) 600 C; 3.75×10^{21} electrons. 10) 24 Ω . 11) Yes; $V = E + Ir$ during charging. 12) $1.0 \times 10^{-6}\ \Omega\ \text{m}$. 13) It doubles. 15) 3 Ω . 16) 120 J. 17) No; incoming and outgoing currents balance. 18) 6 A. 19) E and $r/2$. 21) 1.25×10^{-4} m/s. 22) 3 A, 2 A, 1 A; total 6 A; power 36 W. 23) 0.10 A; 2 V cell: 1.95 V; 1.5 V cell being charged: 1.55 V. 24) 3 A; 6 W. 25) 6 Ω . 28) $V_A - V_B = 36/11$ V; 6 V branch: $15/11$ A $B \rightarrow A$; 3 V branch: $3/11$ A $A \rightarrow B$; resistor: $12/11$ A $A \rightarrow B$. 30) Emf 3 V; $r = 1\ \Omega$; $I = 0.75$ A; terminal $V = 2.25$ V; load power = 1.6875 W.