ANSWER KEY & MARKING SCHEME · CBSE CLASS 12

Current Electricity

Physics · Chapter 3 · Use this with the Board Paper · Companion to Quick Drill

HOW TO USE

Attempt the Board Paper first (closed-book, full time). Then come here. For 2-mark+ questions, compare your answer to the model. For 3-4 mark questions, also consult the **Topper Templates** below — these show the exact step-by-step structure that scores full marks per CBSE marking-scheme conventions.

MODEL ANSWERS · BOARD PAPER

Section A — Very Short Answer (1 mark each)

Q1. Define drift velocity of electrons. **[1 mark]**

Ans: Average velocity acquired by free electrons of a conductor under the effect of an applied electric field; very small (~10^{-4} m/s).

Q2. State Ohm's law. **[1 mark]**

Ans: For an ohmic conductor at constant temperature, $V = IR$ — current is directly proportional to applied potential difference.

Q3. Write the SI unit of resistivity. **[1 mark]**

Ans: Ohm-metre (Ohm m).

Q4. Why is a potentiometer preferred over a voltmeter to measure EMF? **[1 mark]**

Ans: Because at null point no current flows through the cell, so its terminal voltage equals true EMF. A voltmeter always draws some current.

Q5. What is the principle on which Kirchhoff's loop rule is based? **[1 mark]**

Ans: Conservation of energy per unit charge around any closed loop.

Section B — Short Answer (2 marks each)

Q6. A cell of EMF 12 V and internal resistance 1 Ohm is connected to an external resistor of 5 Ohm. Find the current and terminal voltage. **[2 marks]**

Ans: $I = 12/(5+1) = 2$ A. $V_{terminal} = 12 - 2 \times 1 = 10$ V (or $V = IR = 2 \times 5 = 10$ V).

Q7. Two resistors of 4 Ohm and 12 Ohm are connected in parallel. Find the equivalent resistance. **[2 marks]**

Ans: $1/R = 1/4 + 1/12 = 3/12 + 1/12 = 4/12 = 1/3$. $R_{eq} = 3$ Ohm.

Q8. Distinguish between EMF and terminal voltage of a cell. **[2 marks]**

Ans: EMF (epsilon) is the potential difference across the cell when no current flows (open circuit). Terminal voltage $V = \varepsilon - Ir$ is the potential difference across its terminals when current I flows. $V < \varepsilon$ when $I > 0$.

Section C — Short-Long Answer (3 marks each)

Q9. Derive an expression for the drift velocity of free electrons in a conductor under an applied electric field E. Hence write the relation $I = neAv_d$. **[3 marks]**

Ans: Apply field E; force on electron $F = eE$. Acceleration $a = eE/m$. Average time between collisions = relaxation time τ. Drift velocity $v_d = a\tau = (eE/m)\tau$. Charge crossing area A per second: $I = neAv_d$.

Q10. Using Kirchhoff's laws, derive the balance condition of a Wheatstone bridge. Draw the labelled circuit. **[3 marks]**

Ans: Draw bridge ABCD with arms P (AB), Q (BC), R (AD), S (DC); cell across AC, galvanometer across BD. At balance $I_g = 0$; so current I_1 through P and Q, current I_2 through R and S. KVL ABDA: $I_1 P = I_2 R$. KVL BCDB: $I_1 Q = I_2 S$. Divide: $P/Q = R/S$.

Q11. **Two cells of EMFs epsilon_1, epsilon_2 and internal resistances r_1, r_2 are connected in parallel. Derive expressions for the equivalent EMF and internal resistance.** **[3 marks]**

> **Ans:** Let terminal voltage = V. Current from each: I_1 = (epsilon_1 - V)/r_1; I_2 = (epsilon_2 - V)/r_2. Total I = I_1 + I_2. Comparing with V = epsilon_eq - I r_eq: 1/r_eq = 1/r_1 + 1/r_2 and epsilon_eq/r_eq = epsilon_1/r_1 + epsilon_2/r_2.

Section D — Long Answer (5 marks; internal choice)

Q12. **(a) State Kirchhoff's junction and loop rules. (b) Three resistors 2 Ohm, 4 Ohm and 6 Ohm are connected in series across a 24 V battery with internal resistance 0 Ohm. Calculate (i) current, (ii) potential drop across each resistor, (iii) power dissipated in the 4 Ohm resistor.** **[5 marks]**

> **Ans:** (a) KCL: At any junction, sum of currents entering = sum leaving (charge conservation). KVL: Around any closed loop, algebraic sum of EMFs = algebraic sum of IR drops (energy conservation). (b) R_eq = 2+4+6 = 12 Ohm. (i) I = 24/12 = 2 A. (ii) V_2 = 2*2 = 4 V; V_4 = 2*4 = 8 V; V_6 = 2*6 = 12 V. (iii) P_4 = I^2 R = 4*4 = 16 W.

Q13. **OR (a) Explain the principle of a potentiometer. (b) Why is potentiometer preferred over a voltmeter for measuring EMF? (c) A potentiometer wire of length 10 m has a resistance of 20 Ohm. A 4 V battery of negligible internal resistance is connected across it. A cell of unknown EMF balances at 250 cm. Find the EMF.** **[5 marks]**

> **Ans:** (a) Principle: A potentiometer balances an unknown EMF against a known potential drop across a uniform wire. At balance length l, unknown EMF epsilon = k*l where k = V/L is the potential gradient. (b) At null point, no current flows through the test cell, so its terminal voltage = true EMF. A voltmeter always draws some current, so it reads V = epsilon - I r < epsilon. (c) Potential gradient k = 4/10 = 0.4 V/m. Balance length = 250 cm = 2.5 m. EMF = k * l = 0.4 * 2.5 = 1.0 V.

★ TOPPER ANSWER TEMPLATES

5 TEMPLATES · MEMORISE THE FORMAT

★ TOPPER TEMPLATE — Derive drift velocity expression (3 marks)

Appeared 6+ times in 2018-2024

Step 1 **[1 mark]**	**Setup + assumption**	Consider a conductor of length L, area A with n free electrons per unit volume. In absence of field, average thermal velocity sums to zero. Apply potential V across ends; this sets up electric field E = V/L throughout the conductor.
Step 2 **[1 mark]**	**Apply F = ma to single electron**	Force on each electron F = eE. Acceleration a = eE/m. Between successive collisions (relaxation time tau), electron gains velocity v = a*tau = eE*tau/m. This is the DRIFT VELOCITY v_d.
Step 3 **[1 mark]**	**Connect to current I = neAv_d**	Charge crossing area A in time dt: dQ = neA v_d dt. So I = dQ/dt = neA v_d = neA(eE*tau/m) = (ne^2 tau/m) AE. This gives Ohm's law I proportional to V.

COMMON LOSS OF MARKS:

- Forgetting to state that thermal velocity averages to zero (loses 0.5)
- Confusing drift velocity with thermal velocity in magnitude
- Not labelling tau as relaxation time (the AVERAGE time between collisions)

★ TOPPER TEMPLATE — Derive Wheatstone bridge balance condition (3 marks)

Appeared 5+ times in 2018-2024

Step 1 **[1 mark]**	**Diagram + label currents**	Draw the bridge: four resistors P (AB), Q (BC), R (AD), S (DC); cell across AC, galvanometer across BD. Let I1 flow through P and Q; I2 through R and S; Ig through galvanometer.
Step 2 **[1 mark]**	**Apply KVL with Ig = 0**	At BALANCE, Ig = 0, so I1 flows fully through P then Q, and I2 through R then S. KVL loop ABDA: I1*P = I2*R (no drop across galvanometer). KVL loop BCDB: I1*Q = I2*S.
Step 3 **[1 mark]**	**Divide and conclude**	Divide the two equations: (I1*P)/(I1*Q) = (I2*R)/(I2*S), giving P/Q = R/S. This is the WHEATSTONE balance condition. Used in metre bridge and resistance measurement.

COMMON LOSS OF MARKS:

- Not stating Ig = 0 BEFORE writing KVL (loses 1 mark)
- Wrong loop direction signs in KVL
- Forgetting to identify it as 'balance condition'

★ TOPPER TEMPLATE — Cells in series vs parallel — derive equivalent EMF and r (3 marks)

Appeared 4+ times in 2018-2023

Step 1 **[1 mark]**	**Series case**	Two cells (epsilon_1, r_1) and (epsilon_2, r_2) in series with same polarity: total EMF = epsilon_1 + epsilon_2; total internal resistance = r_1 + r_2. If opposing polarity: epsilon_eq = |epsilon_1 - epsilon_2|.
Step 2 **[1 mark]**	**Parallel case derivation**	For parallel cells, terminal voltage V is same. I = I_1 + I_2 where I_1 = (epsilon_1 - V)/r_1 and I_2 = (epsilon_2 - V)/r_2. Comparing with V = epsilon_eq - I r_eq gives: 1/r_eq = 1/r_1 + 1/r_2 and epsilon_eq/r_eq = epsilon_1/r_1 + epsilon_2/r_2.
Step 3 **[1 mark]**	**When to use which**	Series: when external R is LARGE — boosts driving EMF. Parallel: when external R is SMALL — minimises internal resistance and supplies more current. State both with one-line justification.

COMMON LOSS OF MARKS:

- Adding parallel EMFs directly (only valid if all EMFs equal)
- Mixing up the parallel formula structure
- Not commenting on practical choice (loses 0.5)

★ TOPPER TEMPLATE — Numerical — internal resistance from V-I data (2 marks)

Appeared 5+ times since 2018

Step 1 **[1 mark]**	**Set up V = epsilon - Ir**	Given two data points: when I = I_1, V = V_1; when I = I_2, V = V_2. Write: V_1 = epsilon - I_1 r AND V_2 = epsilon - I_2 r.
Step 1 **[1 mark]**	**Solve for r**	Subtract: V_1 - V_2 = (I_2 - I_1) r, so r = (V_1 - V_2)/(I_2 - I_1). Then epsilon = V_1 + I_1 r. Substitute numbers with units in Ohm and Volt; state final r in Ohm.

COMMON LOSS OF MARKS:

- Sign error in subtraction step
- Not finding epsilon when asked
- Missing unit in final answer

★ TOPPER TEMPLATE — Potentiometer — why preferred over voltmeter (3 marks)

Appeared 4+ times in 2019-2024

Step 1 **[1 mark]**	**Principle**	A potentiometer balances an unknown EMF against a known potential drop along a uniform resistance wire. Potential gradient k = V/L. At balance length l, unknown EMF epsilon = k*l.
Step 2 **[1 mark]**	**Null method**	At balance, NO current flows through the unknown cell — so the cell delivers zero current. Therefore terminal voltage of the cell equals its true EMF (V = epsilon - I*r becomes V = epsilon when I = 0).
Step 3 **[1 mark]**	**Contrast with voltmeter**	A voltmeter ALWAYS draws some current (its resistance is finite, not infinite). So it reads V = epsilon - I r, slightly LESS than the true EMF. Hence potentiometer gives the TRUE EMF; voltmeter only an approximation.

COMMON LOSS OF MARKS:

- Forgetting to state I = 0 at null point
- Confusing potential gradient k with EMF
- Not making the contrast explicit with voltmeter

MARKING SCHEME — GENERAL NOTES

- Section A: Award full mark for any correct one-line answer that mentions the key term. Half-marks not allowed in this section.
- Section B: For numericals — 1 mark for the correct formula/setup, 1 mark for the correct numerical answer with unit. Deduct 0.5 for missing unit.
- Section C: For derivations — 1 mark for diagram/setup, 1 mark for intermediate algebraic step, 1 mark for the final stated result. Diagrams without labels lose 0.5.
- Section D: 5 marks split typically 2 (theory) + 3 (numerical) OR 1+1+3. Marks distributed across sub-parts as indicated.
- Common deductions: missing units (-0.5), incorrect significant figures in numerical (-0.5), wrong sign in KVL (-1), forgetting Ig = 0 in Wheatstone derivation (-1).
- If a student solves an alternate but equivalent method (e.g., uses V = IR cross-check instead of V = epsilon - Ir), award full marks provided the working is correct.