

A-Level Physics – Electricity

A-Level Physics (Edexcel / AQA / OCR) · Total marks: 40 · Answers on the last page

This worksheet covers current, resistance, potential dividers, EMF and internal resistance, and capacitors. A calculator is required throughout.

Section A – Current and Resistance (Skills)

1. Define electric current in terms of charge flow, giving the appropriate equation and units. [2]
2. A charge of 24 C flows past a point in a circuit in 6 s . Calculate the current. [2]
3. Two resistors of $6\ \Omega$ and $12\ \Omega$ are connected:
(a) in series
(b) in parallel.
Calculate the combined resistance in each case. [4]
4. A resistor of resistance $15\ \Omega$ has a potential difference of 6 V across it. Calculate the current through it and the power dissipated. [3]

Section B – EMF, Internal Resistance and Potential Dividers (Exam-style)

5. A battery of EMF 9.0 V and internal resistance $0.5\ \Omega$ is connected to an external resistor of $4.0\ \Omega$.
(a) Calculate the current in the circuit.
(b) Calculate the terminal potential difference across the battery. [5]
6. Explain why the terminal potential difference of a battery decreases as the current drawn from it increases. [2]
7. A potential divider consists of two resistors, $2.0\text{ k}\Omega$ and $8.0\text{ k}\Omega$, connected in series across a 12 V supply. Calculate the potential difference across the $8.0\text{ k}\Omega$ resistor. [3]
8. A light-dependent resistor (LDR) is used with a fixed resistor of $5.0\text{ k}\Omega$ in a potential divider across a 6.0 V supply, with the output voltage taken across the fixed resistor. In darkness the LDR resistance is $200\text{ k}\Omega$; in bright light it is $1.0\text{ k}\Omega$. Calculate the output voltage in:
(a) darkness
(b) bright light. [4]

Section C – Capacitors and Extended Problems

9. A capacitor of capacitance $470\ \mu\text{F}$ is charged to a potential difference of 12 V .
(a) Calculate the charge stored.
(b) Calculate the energy stored in the capacitor. [4]
10. A capacitor of capacitance $220\ \mu\text{F}$ discharges through a resistor of $100\text{ k}\Omega$.
(a) Calculate the time constant of the circuit.
(b) State what is meant by the "time constant" of a capacitor discharge circuit. [4]
11. Two resistors, $3.0\ \Omega$ and $6.0\ \Omega$, are connected in parallel, and this combination is connected in series with a $2.0\ \Omega$ resistor and a battery of EMF 12 V with negligible internal resistance. Calculate the

current supplied by the battery. [4]

12. A student sets up a circuit to determine the internal resistance of a cell by measuring terminal p.d. for several values of current. Explain how a graph of terminal p.d. (y-axis) against current (x-axis) can be used to find both the EMF and the internal resistance of the cell. [3]

Answers

Check your working against these. If an answer does not match, try the question again before looking for the method.

- Current is the rate of flow of charge: $I = \frac{\Delta Q}{\Delta t}$, where I is in amperes (A), Q is charge in coulombs (C) and t is time in seconds (s).
- $I = \frac{Q}{t} = \frac{24}{6} = 4 \text{ A}$.
- (a) $R = 6 + 12 = 18 \Omega$.
(b) $\frac{1}{R} = \frac{1}{6} + \frac{1}{12} = \frac{1}{4}$, so $R = 4 \Omega$.
- $I = \frac{V}{R} = \frac{6}{15} = 0.4 \text{ A}$. $P = VI = 6 \times 0.4 = 2.4 \text{ W}$.
- (a) $I = \frac{\varepsilon}{R+r} = \frac{9.0}{4.0+0.5} = 2.0 \text{ A}$.
(b) Terminal p.d. $= \varepsilon - Ir = 9.0 - (2.0 \times 0.5) = 8.0 \text{ V}$ (equivalently $V = IR = 2.0 \times 4.0 = 8.0 \text{ V}$).
- Since $V = \varepsilon - Ir$, some of the EMF is used to drive current through the battery's own internal resistance (the "lost volts", Ir); as I increases, Ir increases, so the terminal p.d. available to the external circuit decreases.
- $V_{\text{out}} = V_{\text{in}} \times \frac{R_2}{R_1 + R_2} = 12 \times \frac{8.0}{2.0 + 8.0} = 9.6 \text{ V}$.
- (a) $V_{\text{out}} = 6.0 \times \frac{5.0}{5.0 + 200} = 0.146 \text{ V}$ (3 s.f.).
(b) $V_{\text{out}} = 6.0 \times \frac{5.0}{5.0 + 1.0} = 5.0 \text{ V}$.
- (a) $Q = CV = 470 \times 10^{-6} \times 12 = 5.64 \times 10^{-3} \text{ C}$.
(b) $E = \frac{1}{2}CV^2 = \frac{1}{2} \times 470 \times 10^{-6} \times 12^2 = 3.38 \times 10^{-2} \text{ J}$ (3 s.f.).
- (a) $\tau = RC = 100\,000 \times 220 \times 10^{-6} = 22 \text{ s}$.
(b) The time constant is the time taken for the charge (or p.d., or current) on a discharging capacitor to fall to $1/e$ (about 37%) of its initial value.
- Parallel combination: $\frac{1}{R_p} = \frac{1}{3.0} + \frac{1}{6.0} = \frac{1}{2.0}$, so $R_p = 2.0 \Omega$. Total resistance $= 2.0 + 2.0 = 4.0 \Omega$.
 $I = \frac{\varepsilon}{R} = \frac{12}{4.0} = 3.0 \text{ A}$.
- Since $V = \varepsilon - Ir$, a graph of V against I is a straight line with y -intercept equal to the EMF ε (the p.d. when $I = 0$) and gradient equal to $-r$, so the magnitude of the gradient gives the internal resistance r .

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