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QUESTION WORKBOOK

Current, charge and the direction problem

Electricity · Year 12

AQA 3.5.1.1 · CIE 9.1.1, 9.1.2, 9.1.3, 9.1.4, 9.2.1, 9.2.2, 9.3.1, 9.3.2
OCR A 4.1.1(a), 4.1.1(b), 4.1.1(c), 4.1.1(d), 4.1.1(e), 4.1.1(f), 4.1.2(a), 4.1.2(b), 4.1.2(c), 4.2.2(a), 4.2.2(d), 4.2.2(e), 4.2.3(a)

20 questions · 58 marks

NAVY SCREEN EDITION

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SECTION A · Warm-up

A1 A charge of 30 C flows past a point in 10 s. Calculate the current. [2]

A2 Define the coulomb. [2]

A3 12 J of work is done moving a charge of 4.0 C between two points. Calculate the potential difference. [2]

A4 A camera flash produces a current of 0.75 A that lasts for 2.4 ms. Calculate the charge that flows through the flash lamp. [2]

A5 A phone battery is rated at 3200 mA h, meaning it can supply a current of 3200 mA for one hour. Calculate the charge the battery stores. [2]

A6 An electron moving between two electrodes in a vacuum tube gains 8.0×10^{-19} J of energy. Calculate the potential difference between the electrodes ($e = 1.60 \times 10^{-19}$ C). [2]

SECTION B · Standard

B1 A current of 0.50 A flows for 2.0 minutes. Calculate (a) the charge that passes and (b) the number of electrons this represents ($e = 1.60 \times 10^{-19}$ C). [3]

B2 A component has a potential difference of 6.0 V across it and carries a current of 0.25 A. Calculate its resistance. [2]

B3 A charge of 8.0 C passes through a resistor with a potential difference of 12 V across it. Calculate the energy transferred in the resistor. [2]

B4 A steady current of 2.0 A flows in a lamp filament for 5.0 minutes. Calculate the charge that passes through the filament. [2]

B5 The flexible lead to a kettle contains copper wire of diameter 1.2 mm carrying a current of 13 A. Copper has 8.5×10^{28} free electrons per cubic metre ($e = 1.60 \times 10^{-19}$ C). Calculate (a) the cross-sectional area of the wire and (b) the drift velocity of the electrons. [4]

B6 A wire in a circuit tapers so that its cross-sectional area halves. State what happens to the drift velocity of the electrons where the wire narrows, and explain your answer using $I = nAvq$. [3]

B7 A cyclist's rear lamp is powered by a 3.0 V battery and draws a current of 0.20 A. Calculate the energy transferred by the lamp during a 10 minute ride. [3]

SECTION C · Stretch

C1 A device draws a current of 3.0 A from a 230 V supply for 1.0 hour. Calculate (a) the charge that flows, (b) the energy transferred and (c) the number of electrons that pass ($e = 1.60 \times 10^{-19}$ C). [4]

C2 Explain what is meant by conventional current and how it relates to the actual direction electrons move in a metal wire. [4]

C3 Explain why the convention for current direction was not changed once electrons were discovered to be the charge carriers in metals. [3]

C4 An electric bicycle battery needs at least 2.0×10^{5} C of charge to charge fully. It is connected for 8.0 hours overnight to a charger that supplies a steady current of 6.5 A. Deduce whether the battery charges fully. [3]

C5 A copper track (8.5×10^{28} free electrons per m^{3}) and a semiconductor channel (5.0×10^{19} charge carriers per m^{3}) in a sensor have the same cross-sectional area and carry the same current. Determine the ratio of the drift velocity in the semiconductor to that in the copper. [3]

C6 In a metal wire the electrons drift at less than a millimetre per second, yet a lamp lights the instant the switch is closed and the current can be several amperes. Explain fully how both observations are consistent with the drift of electrons. [6]

C7 A 9.0 V battery for a smoke alarm stores 1.9×10^4 C of charge. (a) Show that the energy stored is about 1.7×10^5 J. (b) In standby the alarm draws a steady current of 60 µA. The manufacturer claims a 10 year standby life. Determine whether the claim is justified (1 year = 3.15×10^7 s). [4]