

Solutions

These allocations are for the original questions on this sheet. B1 = one standalone point, M1 = one method point, A1 = one accuracy point.

2.1 $Q = It = 0.25 \times 40 = 10 \text{ C}$. $W = VQ = 6.0 \times 10 = 60 \text{ J}$. $P = VI = 6.0 \times 0.25 = 1.5 \text{ W}$.

2.2 Parallel branches share p.d. V . Charge conservation gives $I = I_1 + I_2$. Substitute $I = V/R$ to get $1/R = 1/R_1 + 1/R_2$. Added branch conductance increases total current at fixed voltage, so resistance is smaller.

2.3 Use $I = nqvA$ for directed carrier flow. $v = I/(nqA)$. $v = 1.6/(8.0 \times 10^{28} \times 1.60 \times 10^{-19} \times 1.0 \times 10^{-6}) = 1.25 \times 10^{-4} \text{ m s}^{-1}$.

3.1 $R_p = (1/6 + 1/3)^{-1} = 2.0 \text{ } \Omega$. $I = V/(R_p + 4) = 12/6 = 2.0 \text{ A}$. $V_p = IR_p = 4.0 \text{ V}$. $P_3 = V_p^2/R_3 = 16/3 = 5.33 \text{ W}$. The branch has only 4.0 V, because the series resistor takes the remaining 8.0 V.

3.2 Measure V, I across several measured contact separations, then $R = V/I$. Use a small current/switch off between readings to limit heating. Measure diameter repeatedly with a zero-checked micrometer. $A = \pi d^2/4 = 7.07 \times 10^{-8} \text{ m}^2$. $\rho = A \times \text{gradient} = 3.53 \times 10^{-7} \text{ } \Omega \text{ m}$. Fixed contact/lead resistance can cause the intercept; it should not be included in the gradient-based wire resistivity.

3.3 Ohmic: straight line through the origin, at constant temperature and other physical conditions. Lamp: symmetric curve flattening as voltage magnitude rises due to heating. Diode: little reverse current before breakdown and steep forward rise after its knee. V/I is the operating-point resistance using the line from the origin; a tangent describes a small change in current divided by a small change in voltage, which need not equal I/V .