Question	Answer	Marks
1	C	1
2	B	1
3	B	1
4	$I = \frac{\Delta Q}{\Delta t} \Rightarrow \Delta Q = I\Delta t = 350 \times 10^{-3}\ \text{A} \times 1\ \text{s} = 0.35\ \text{C}$ $Ne = \Delta Q \Rightarrow N = \frac{\Delta Q}{e} = \frac{0.35\ \text{C}}{1.6 \times 10^{-19}} = 2.1875 \times 10^{18} = 2.2 \times 10^{18}\ (2\ \text{s.f.})$	1 1
5	p.d. across 5.0 Ω resistor = p.d. across terminals = 8.6 V $R = \frac{V}{I} \Rightarrow I = \frac{V}{R} = \frac{8.6\ \text{V}}{1.72\ \text{A}} = 1.72\ \text{A}$ p.d. across internal resistance r ('lost volts') V_r = 9.0 V – 8.6 V = 0.4 V $r = \frac{V_R}{I} = \frac{0.4\ \text{V}}{1.72\ \text{A}} = 0.2326\ \Omega = 0.23\ \Omega\ (2\ \text{s.f.})$	1 1 1
6	$G = \frac{I}{V} = \frac{0.16\ \text{A}}{1.2\ \text{V}} = 0.1333\ \text{S}$ $G = \sigma\frac{A}{L} \Rightarrow \sigma = \frac{GL}{A}$ Where L = 0.85 m and $A = \pi \times (0.05 \times 10^{-3}\ \text{m})^2 = 7.854 \times 10^{-9}\ \text{m}^2$ $\sigma = \frac{GL}{A} = \frac{0.1333\ \text{S} \times 0.85\ \text{m}}{7.854 \times 10^{-9}\ \text{m}^2} = 1.443 \times 10^7\ \text{S m}^{-1}$ (2 s.f.)	1 1 1 1
7 a	$V_{out} = \frac{R_2}{R_1 + R_2} \times V_{in}$, where R_2 is the LDR, R_1 is the thermistor and V_{in} = 4.5 V R_1 = 10 kΩ and R_2 = 1000 kΩ under the conditions stated $V_{out} = \frac{1000\ \text{k}\Omega}{(100\ \text{k}\Omega + 1000\ \text{k}\Omega\Omega} \times 4.5\ \text{V} = \frac{1000\ \text{k}\Omega}{1100\ \text{k}\Omega} \times 4.5\ \text{V} = 4.091\ \text{V} = 4.1\ \text{V}$ (2 s.f.)	1 1 1
7 b	R_2 will rise immediately while R_1 will be unchanged (it may rise a little, slowly) R_2 will now be a larger fraction of $(R_1 + R_2)$ So V_{out} will rise	1 1 1
8 a i	$P = IV$ = 10 A × 120 V = 1200 W	1
8 a ii	$R = \frac{V}{I} = \frac{120\ \text{V}}{10\ \text{A}} = 12\ \Omega$	1
8 b	$P = \frac{E}{\Delta t} \Rightarrow \Delta t = \frac{E}{P} = \frac{370 \times 10^3\ \text{J}}{1200\ \text{W}}$ = 308.3 s = 310 s (2 s.f.)	1
8 c	Assumption: resistance is the same Justification: temperature is kept the same by the water in the kettle $R = \frac{V}{I} \Rightarrow I = \frac{V}{R} = \frac{230\ \text{V}}{12\ \Omega}$ = 19.17 A $P = IV$ = 19.17 A × 230 V = 4408 W $\Delta t = \frac{E}{P} = \frac{370 \times 10^3\ \text{J}}{4408\ \text{W}}$ = 83.93 s = 84 s (2.s.f.)	1 1 1 1 1
8 d	Current drawn by the kettle > 13 A The kettle would blow a fuse/overheat and cause a fire.	1 1

9 a	Circuit should have: Battery of e.m.f. in range 1–20 V in series with thermistor and fixed resistor. Fixed resistor should be of value between 33 kΩ at 0 °C and 680 Ω. V_{out} measured across ends of fixed resistor.	 1 1 1
9 b	Immerse thermistor and a thermometer in a water bath. Take regular readings of V_{out} over the range 0 °C (ice/water mix) to 100 °C (boiling). Plot calibration graph of V_{out} against temperature.	1 1 1
9 c	Calculate V_{out}, using the chosen value of fixed resistor and e.m.f., at 0 °C, 20 °C, 80 °C and 100 °C (all correct = 2 marks: at least one correct = 1 mark) (typical values, for R_{fixed} = 10 kΩ, are 1.0 V, 2.0 V, 4.0 V and 4.2 V respectively) Compare changes in V_{out} between 0 °C and 20 °C and between 80 °C and 100 °C. Recognise that sensitivity (change in p.d. per °C) is greater at lower temperatures.	 2 1 1