1. (a) resistors in series add to 20 Ω and current is 0.60 A
   accept potential divider stated or formula
   so p.d. across XY is 0.60 × 12 (= 7.2 V)
   gives \((12/20) \times 12 V = 7.2 \ V\)

   (b) (i) the resistance of the LDR decreases

   (so total resistance in circuit decreases) and current increases

   (ii) resistance of LDR and 12 Ω (in parallel)/across XY decreases

   so has smaller share of supply p.d. (and p.d. across XY falls)
   alternative I increases so p.d. across 8.0 Ω increases; so p.d. across XY falls

2. (a) Line crosses ‘y-axis’ at 1.4 (V) / \( V = E \) or 1.4(V) when \( I = 0 \)

   \( V = E - Ir; \) since \( I = 0 \) (Hence \( V = E \) or 1.4(V))

   (b) (i) (Graph extrapolated to give) current = 2.0 (A)

   (Allow tolerance ± 0.1A)

   (ii) \( E = I_{(max)} r \) gradient = \( r \) (Ignore sign)

   \( (r = \frac{1.4}{2.0}) \) (Attempt made to find gradient)

   \( r = 0.7(0) (\Omega) \) (Possible ecf)

   (iii) (excessive) heating of cell / energy wasted internally /

   cell might ‘explode’ / cell goes ‘flat’ (quickly)
3. (a) No current (in circuit) / ‘open’ circuit / p.d. between X and Y is 5.0 V B1

(b) \[ V = \frac{R_2}{R_1 + R_2} \times V_0 \]  
\[ V_1 = \frac{R_1}{R_2} \times V \]  
\[ I = \frac{3.4}{168} \times 10^{-2} \text{ mA} \] C1

\[ R = \frac{168}{168 + R} \times 5.0 \]  
\[ R = \frac{168}{3.4} \]  
\[ R = \frac{1.6}{2.02 \times 10^{-2}} \] C1

Resistance \approx 79 \text{ (k}\Omega) \quad \text{(Total resistance of 250 k}\Omega \text{ scores 2/3)} A1

4. (a) Energy (transformed by a device working) at 1 kW for 1 hour B1

(b) \[ E = Pt / 5.8 = 0.12 \times \text{time} / (\text{time} = 48.3 \text{ (hr)}) \]  
\[ (\text{time} = 1.74 \times 10^5 \approx 1.7 \times 10^5 \text{ (s)}) \] C1 A1

5. (a) (i) Correctly selected and re-arranged: \[ \rho = \frac{RA}{L} \]; M1

symbols defined: \( A = \) cross-sectional area, \( R = \) resistance, \( L = \) length A1

(ii) \( \rho \) is independent of dimensions of the specimen of the material/AW B1

(b) \[ R = 1.7 \times 10^{-8} \times 0.08/3.0 \times 10^{-4} \] C1

\[ R = 4.5(3) \times 10^{-6} \text{ (}\Omega) \] A1

6. (a) (i) \[ Q = It \text{ with knowledge of what the symbols mean (1)} \]
\[ = 0.050 \times 4.0 \times 3600 \] (1)
\[ = 720 \text{ (C)} \] (1) 3

(ii) \[ E = QV \text{ with knowledge of what the symbols mean (1)} \]
\[ = 720 \times 6.0 = 4320 \text{ (J)} \] (1) 2

(b) chemical (potential) (energy) (1) 1

(c) (i) \[ I = 4.0/48 = 0.5/r \text{ (ie by proportion or by finding current) (1)} \]
\[ r = 24/4 = 6 \text{ (}\Omega) \] (1) 2

(ii) \[ E = V2t/R \text{ with knowledge of what the symbols mean (1)} \]
\[ = 4.02 \times 2700 / 48 \] (1)
\[ = 900 \text{ (J)} \] (1) 3
(iii) $900/4320 = 5/24 = (0.208)$ \( \text{(1)} \)

(d) because the p.d. across it \((4.5 - 4.0)\) is known only to 1 sig.fig. \( \text{1} \)

7. (i) \( \text{M} \) marked at the end of the graph \( \text{B1} \)

(ii) current is 5 (A) and p.d is 6 (V) \( \text{C1} \)

\[
P = VT \quad p = 6.0 \times 5.0
\]

(Allow \( p = I^2 R \) or \( p = V^2/R \)) \( \text{C1} \)

\[\text{power} = 30 \text{ (W)} \]

(iii) \( \text{1.} \)

\[
\begin{align*}
V_L &= 1.0 \text{ (V)} \quad \text{(From the } I/V \text{ graph)} \\
R_L &= 1.0/2.0 \text{ or } 0.5 \text{ (Ω)} \\
V &= 1.0 \times 2.0 \quad \text{or} \quad V = 1.7 \times 2.0 \\
\text{voltmeter reading} &= 3.4 \text{ (V)} \\
\end{align*}
\]

\( \text{M1} \)

\(\text{A1} \)

2. \( V_r = 4.5 - 3.4 (= 1.1 \text{ V}) \quad 4.5 = 2.0r + 3.4 \text{ (Possible ecf)} \)

\[
r = \frac{1.1}{2.0}
\]

\( r = 0.55 \text{ (Ω)} \)

\( (1.05 \text{ Ω scores } 0/2 \text{ since the lamp is ignored}) \)

8. (i) p.d.: energy transferred per unit charge from electrical form (into other forms, e.g. light/heat) \( \text{B1} \)

e.m.f.: energy transferred per unit charge into electrical form (from other forms, e.g. chemical/mechanical) \( \text{B1} \)

(ii) \( JC^{-1} \)

\( \text{B1} \)

9. (a) (i) resistance decreases/falls/drops (with increase in temperature) \( \text{B1} \)

(ii) \( 100 \pm 10 \text{ Ω} \)

(iii) for low temps \( \Delta R \) is large for \( \Delta \theta \) and at high temps \( \Delta R \) is small for same \( \Delta \theta \); so sensitivity decreases (continuously) from low to high temperatures \( \text{B1} \)
(b)  
(i)  correct circuit symbol  
(ii) connections in parallel with fixed resistor  
(iii) $R_{th} = 100$ to $105 \ \Omega$  
     $R_{tot} = 200 + R_{th}$  
     $I = V/R_{tot} = 6/R_{tot} = 0.02 \ \text{A}$  
(iv)  $V = IR = 0.02 \times 200 = 4.0 \ \text{V}$

10. Current is (directly) proportional to potential difference (for a metal conductor) provided the temperature \ (all) physical condition(s) remains constant