1. (a) (i) \( E = (Pt =) 36 \times 3600 \)
   \( I = 3 \, A \) and \( E = VIt, \) etc.
   \[ E = 1.3 \times 10^5 \, (J) \]
   accept 129600 \((J)\)
   
   (ii) \( Q = E/V = 1.3 \times 10^5/12 \) or \( Q = It = 3 \times 3600 \)
   \( \text{ecf (a)(i)} \)
   \[ Q = 1.1 \times 10^4 \]
   accept \( 1.08 \times 10^4 \)
   unit: \( C \)
   allow \( A \) s not \( J \, V^{-1} \)

   (iii) \( Q/e = 1.1 \times 10^4/1.6 \times 10^{-19} \)
   \( \text{ecf (a)(ii)} \)
   \[ Q/e = 6.9 \times 10^{22} \]
   accept \( 6.75 \) or \( 6.8 \times 10^{22} \) using \( 10800 \)

(b) (i) no mark for quoting formula
the average displacement/distance travelled of the electrons along the wire per second;
   allow in one second
   (over time/on average) they move slowly in one direction through the metal/Cu lattice (when there is a p.d. across the wire);
   (because) they collide constantly/in a short distance with the lattice/\( \text{AW} \)
max 2 marks from 3 marking points
(ii) select \( I = nAev \) (= 3.0 A)

\[ v = \frac{3.0}{8.0} \times 10^{28} \times 1.1 \times 10^{-7} \times 1.6 \times 10^{-19} \]

1 mark for correct substitutions into formula

\[ = 2.1 \times 10^{-3} \text{ (m s}^{-1}) \]

1 mark for correct answer to 2 or more SF

A1

2. (a) (i) Electrons in a metal

(ii) Ion in an electrolyte

(b) \( I = \frac{Q}{t} / I = 650/5 \)

\( I = 130 \) (A) A1

\[ n = \frac{I}{e} = \frac{130}{1.6 \times 10^{-19}} \]

\[ n = 8.1 \times 10^{20} \]

C1

A1

[b] 3. (a) \( R = R_1 + R_2 / R = 200 + 120 / R = 320 \)

\( \text{current} = \frac{8.0}{320} \)

\( \text{current} = 2.5 \times 10^{-2} \) (A)

C1

C1

A0

(b) \( V = 25 \times 10^{-3} \times 120 / V = \frac{120}{120 + 200} \times 8.0 \)

\[ V = 3.0 \) (V) (Possible ecf) B1

(c) p.d. across the 360 (\( \Omega \)) resistor = p.d. across the 120 (\( \Omega \)) resistor / There is no current between A and B in the voltmeter

B1

(Allow ‘A & B have same voltage’ - BOD)

The p.d. calculated across 360 \( \Omega \) resistor is shown to be 3.0 V / The ratio of the resistances of the resistors is shown to be the same.

B1

[b] 4. (a) Into the page

(b) \[ I = \frac{\Delta Q}{\Delta t} \] (Allow other subject, with or without \( \Delta \)) C1
(charge =) $7800 \times 0.23$  
$1.794 \times 10^3 \approx 1.8 \times 10^3$ (C) (Ignore minus sign)  
$(1.8 \times 10^6$ (C) scores 2/3)  

(c) \( \text{(number \ = \)} \frac{1.79 \times 10^3}{e} \quad \text{(Possible ecf)} \)  
\( \text{(number \ = \)} 1.12 \times 10^{22} \approx 1.1 \times 10^{22} \)  

5. (a) \( Q = It \quad \text{(Allow any subject)} \)  
\[ Q = 0.040 \times 5.0 \times 60 \times 60 \quad \text{charge = 720} \]  
\[ Q = 0.040 \times 1.8 \times 10^4 \quad \text{coulomb \ C \ As} \]  
\[ (40 \times 5 = 200 \text{ or } 0.040 \times 5 = 0.2 \text{ or } 40 \times 1.8 \times 10^4 = 7.2 \times 10^5 \text{ scores 1/2}) \]  

(b) It is less because the average current is less \ area (under graph) is less \ current ‘drops’ after 3 hours.  

6. (a) Ammeter in series  
V oltmeter in parallel \ (across the ends of the wire)
(b) \[ \rho = \frac{RA}{L} \]  
(Allow any subject)  

\( R \) = resistance, \( L \) = length and \( A \) = (cross-sectional) area  

\( \rho \) = resistivity is given in the question  

Any **four** from:  

Measure the length of the wire using a ruler  
Measure the diameter of the wire  
using a micrometer \ vernier (calliper)  
Calculate the (cross-sectional) area using \( A = \pi r^2 \) \( A = \pi d^2/4 \)  

Calculate the resistance (of the wire) using \( R = \frac{V}{I} \)  

Repeat experiment for different lengths \ current \ voltage \ diameter  
(to get an average)  

Plot a graph of \( R \) against \( L \). The gradient = \( \rho/A \).  
(Or Plot \( V \) against \( I \). The gradient is \( \rho L/A \))  

Structure and organisation.  

Spelling and grammar.  

---  

**QWC**  
The answer must involve physics, which attempts to answer the question.  

**Structure and organisation**  
Award this mark if the whole answer is well structured.  

**Spelling and Grammar mark**  
More than two spelling mistakes or more than two grammatical errors means the SPAG mark is lost.  

7. Coulomb / C  

[1]
8. (a) Parallel

(b) (i) \[ I = \frac{12}{8.0} \]  
\[ \text{current} = 1.5 \text{ (A)} \]

(ii) \[ P = \frac{V^2}{R} \quad / \quad P = IV \quad P = I^2 R \]  
\[ P = \frac{12^2}{8} \quad / \quad P = 1.5 \times 12 \quad P = 1.5^2 \times 8.0 \]  
\[ \text{power} = 18 \text{ (W)} \]

(iii) \[ \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \left( \frac{1}{R_3} \right) \]  
\[ \frac{1}{R} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8} \]

\[ \frac{1}{R} = 3 \times \frac{1}{8} \]
\[ \text{resistance} = 2.67 \approx 2.7 \text{ (Ω)} \]  
\[ \text{(Allow answer expressed as 8/3) (0.375 or 3/8 scores 2/3)} \]

(iv) \[ \text{energy} = 0.018 \times 12 \times 3 \]  
\[ \text{energy} = 0.648 \approx 0.65 \text{ (kW h)} \]  
\[ \text{(Possible ecf) (0.22 (kW h) scores 1/2) (648 (kW h) scores 1/2) (2.3 \times 10^6 (J) scores 1/2)} \]

(c) It will be brighter
\[ \text{The current is larger / correct reference to: } P \propto \frac{1}{R} \]

9. The sum of the currents entering a point / junction is equal to the sum of the currents leaving (the same point) Or ‘Algebraic sum of currents at a point = 0’  
\[ \text{(-1 for the omission of ‘sum’ and -1 for omission of ‘point’/ ‘junction’)} \]
\[ \text{(Do not allow } I_1 + I_2 = I_3 + I_4 \text{ unless fully explained)} \]