1. (a) A 12 V 36 W lamp is lit to normal brightness using a 12 V car battery of negligible internal resistance. The lamp is switched on for one hour (3600 s). For the time of 1 hour, calculate

(i) the energy supplied by the battery

energy = ... J

[2]

(ii) the charge passing through the lamp

charge = ... unit ....

[3]

(iii) the total number of electrons passing through the lamp.

number of electrons = ...

[2]

(b) The wires connecting the 36 W lamp to the 12 V battery are made of copper. They have a cross-sectional area of 1.1×10^{-7} m^2. The current in the wire is 3.0 A. The number *n* of free electrons per m^3 for copper is 8.0×10^{28} m^{-3}.

(i) Describe what is meant by the term *mean drift velocity* of the electrons in the wire

....

....

....

[2]

(ii) Calculate the mean drift velocity v of the electrons in this wire.

v = ... m s^{-1}

[3]

[Total 12 marks]

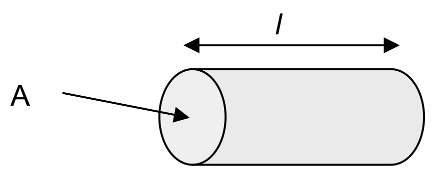
2. (a) Name the charge carriers responsible for electric current in a metal and in an electrolyte.

....

....

[2]

(b)



The diagram above shows a copper rod of length l = 0.080m, having a cross-sectional area $A = 3.0 \times 10^{-4}$ m^2.

The resistivity of copper is 1.7×10^{-8} Ω m.

The copper rod is used to transmit large currents. A charge of 650 C passes along the rod every 5.0 s. Calculate

1. the current in the rod

current = ... A

[2]

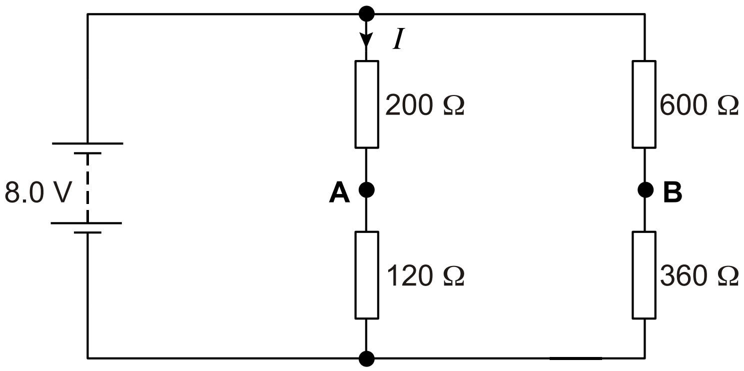
2. the total number of electrons passing any point in the rod per second.

number = ...

[2]

[Total 6 marks]

3. The diagram below shows an electrical circuit.



The battery has negligible internal resistance.

(a) Show that the current *I* is 25 mA.

[2]

(b) Calculate the potential difference (p.d.) across the resistor of resistance 120 Ω.

p.d. = ... V

[1]

(c) Explain why a voltmeter connected between points **A** and **B** will read 0 V.

....

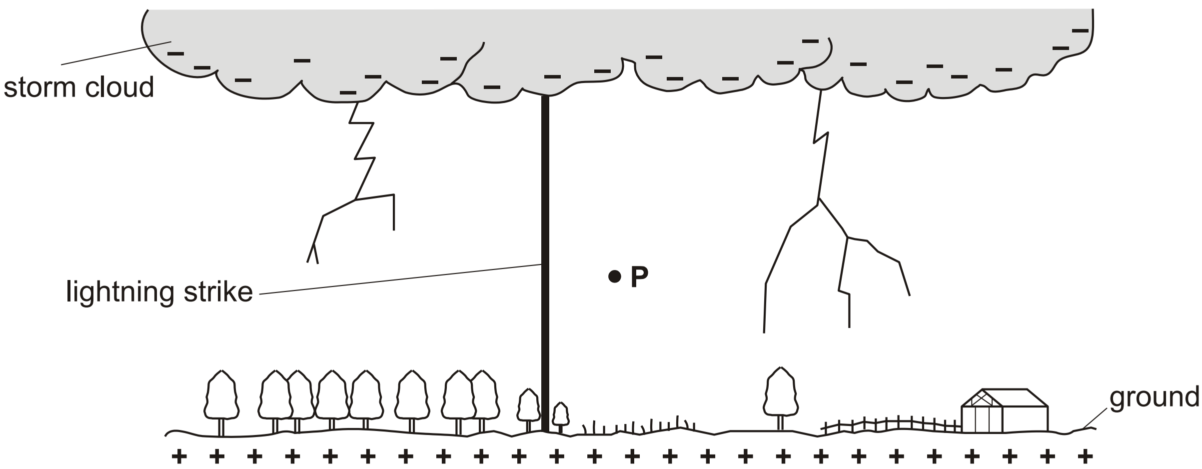
....

....

[2]

[Total 5 marks]

4. The diagram below shows a lightning strike between a storm cloud and the ground.



(a) State the direction of the magnetic field at point **P** due only to the lightning strike.

....

[1]

(b) The current in the lightning strike is 7800 A. The strike lasts for a time of 230 ms.

Calculate

1. the charge flowing between the cloud and the ground

charge = ... C

[3]

2. the number of electrons transferred to the ground.

number = ...

[2]

[Total 6 marks]

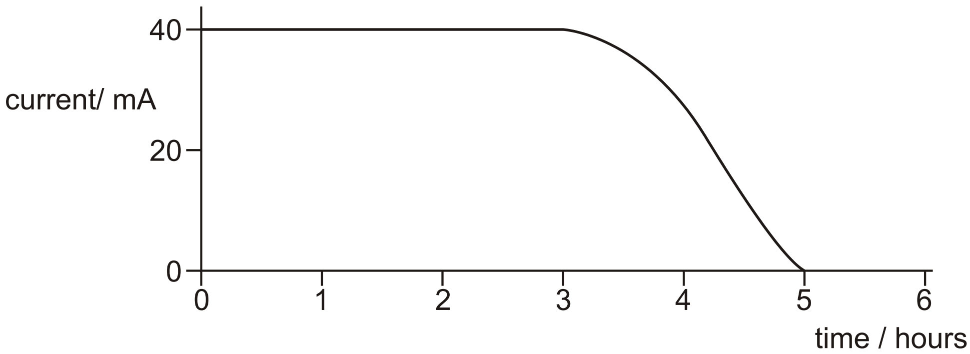
5. A small radio receiver uses a battery that is capable of delivering a constant current of 40 mA for a period of 5.0 hours.

(a) Calculate the total charge delivered by the battery.

charge = ... unit ....

[3]

(b) Below is the graph of current against time for a different battery.



Explain whether the charge delivered by this battery is the same as, greater than or less than your answer to **(a)**.

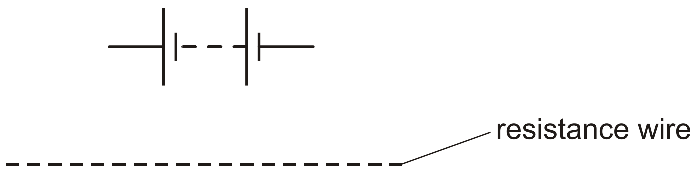
....

....

[1]

[Total 4 marks]

6. The figure below shows an incomplete circuit with a battery and a resistance wire made of a material of resistivity ρ.



(a) Complete the circuit of the figure and show how you would connect suitable meters to determine the current in the resistance wire and the potential difference across the resistance wire.

[2]

(b) In this question, two marks are available for the quality of written communication.

Use your answer to (a) to describe an experiment to determine the resistivity ρ of the material of the resistance wire. Your description should include

- the measurements taken
- the instruments used to take the measurements
- how the measurements are used to determine the resistivity of the material.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

[6]

Quality Of Written Communication [2]

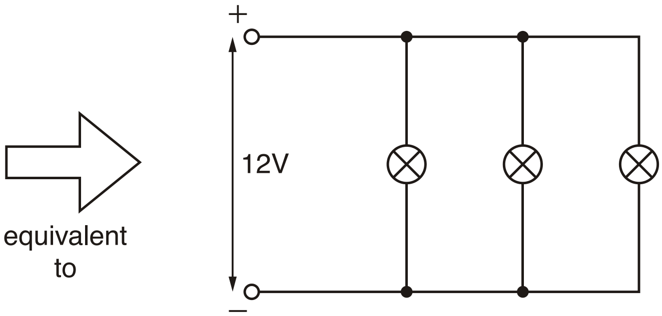
[Total 10 marks]

7. State the SI unit for electrical charge.

....

[Total 1 mark]

8. The figure below shows an arrangement of three – filament lamps used to illuminate a room.



(a) Name the arrangement in which the three lamps are connected.

....

[1]

(b) Each lamp has resistance 8.0 Ω when operating at 12 V.

Calculate

(i) the current drawn by **each** lamp

current = ... A

[2]

(ii) the power dissipated by **each** lamp

power = ... W

[3]

(iii) the **total** resistance of the lamps as connected in the picture above.

resistence = ... Ω

[3]

(iv) the **total** energy transformed by the three lamps in kilowatt hour when operated for 12 hours.

energy = ... kW h

[2]

(c) One of the lamps is replaced by another lamp that also operates at 12 V but has a smaller resistance than 8.0 Ω. State and explain how its brightness will compare with one of the other two remaining lamps.

....

....

....

....

[2]

[Total 13 marks]

9. State Kirchhoff's first law.

....

....

....

[Total 2 marks]

1. (a) (i) E = (Pt =) 36 × 3600

allow *I = 3 A and E = VIt, etc.* **C1**

= 1.3×10^5 (J)

accept *129600 (J)* **A1**

(ii) Q = E/V = $1.3 \times 10^5/12$ **or** Q = It =3 × 3600

ecf *(a)(i)* **C1**

= 1.1×10^4

accept *1.08×10^4* **A1**

unit: C

allow *A s* ***not*** *J V^{-1}* **B1**

(iii) Q/e = $1.1 \times 10^4/1.6 \times 10^{-19}$

ecf (a)(ii) **C1**

= 6.9×10^{22}

accept *6.75 or 6.8×10^{22} using 10800* **A1**

(b) (i) *no mark for quoting formula*

the average displacement/distance travelled of the electrons <u>along the wire</u> per second;

allow *in one second* **B1**

(over time/on average) they move slowly in one direction through the metal/Cu lattice (when there is a p.d. across the wire); **B1**

(because) they collide constantly/in a short distance with the lattice/AW

max 2 marks *from 3 marking points* **B1**

(ii) select I = nAev (= 3.0 A)
1 mark for correct formula **C1**

$v = 3.0/8.0 \times 10^{28} \times 1.1 \times 10^{-7} \times 1.6 \times 10^{-19}$
1 mark for correct substitutions into formula **C1**

$= 2.1 \times 10^{-3}$ ($m\ s^{-1}$)
1 mark for correct answer to 2 or more SF **A1**

[12]

2. (a) (i) Electrons in a metal B1

(ii) Ion in an electrolyte B1

(b) **1.** $I = Q/t$ / $I = 650/5$ C1
$I = 130$ (A) A1

2. $n = I/e = 130/1.6 \times 10^{-19}$ C1
$n = 8.1 \times 1020$ A1

[6]

3. (a) $R = R_1 + R_2$ / $R = 200 + 120$ / $R = 320$ C1

current = $\frac{8.0}{320}$ C1

current = 2.5×10^{-2} (A) 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 (Ω) resistor = p.d. across the 120 (Ω) 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 Ω resistor is shown to be 3.0 V /
The ratio of the resistances of the resistors is shown to be the same. B1

[5]

4. (a) Into the page B1

(b) $I = \frac{\Delta Q}{\Delta t}$ (Allow other subject, with or without Δ) C1 (charge =) 7800 × 0.23 C1

$1.794 \times 10^3 \approx 1.8 \times 10^3$ (C) (Ignore minus sign) A1

(1.8×10^6 (C) scores 2/3)

(c) (number =) $\frac{1.79 \times 10^3}{e}$ (Possible ecf) C1

(number =) $1.12 \times 10^{22} \approx 1.1 \times 10^{22}$ A1

[6]

5. (a) $Q = It$ (Allow any subject) C1

$Q = 0.040 \times 5.0 \times 60 \times 60$ \ $Q = 0.040 \times 1.8 \times 10^4$

charge = 720 A1

($40 \times 5 = 200$ or $0.040 \times 5 = 0.02$ or $40 \times 1.8 \times 10^4 = 7.2 \times 10^5$ scores 1/2)

coulomb \ C \ As B1

(b) It is less because the average current is less \ area (under graph) is less \ current 'drops' after 3 hours. B1

[4]

6. (a) Ammeter in series B1

Voltmeter in parallel (across the ends of the wire) B1

(b) $\rho = \frac{RA}{L}$ (Allow any subject) M1

R = resistance, L = length and A = (cross-sectional) area A1

(ρ = resistivity is given in the question)

Any **four** from:

Measure the length of the wire using a ruler B1

Measure the diameter of the wire B1

using a micrometer \ vernier (calliper) B1

Calculate the (cross-sectional) area using A = πr2 \ A = πd2/4 B1

Calculate the resistance (of the wire) using $R = \frac{V}{I}$ B1

Repeat experiment for different lengths \ current \ voltage \ diameter (to get an average) B1

Plot a graph of R against L. The gradient = ρ/A. B1

(Or Plot V against I. The gradient is ρL/A)

Structure and organisation. B1

Spelling and grammar. B1

[10]

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 B1

[1]

8. (a) Parallel B1

(b) (i) $I = \frac{12}{8.0}$ C1

current = 1.5 (A) A1

(ii) $P = \frac{V^2}{R}$ / $P = IV$ $P = I^2 R$ C1

$P = \frac{12^2}{8}$ / $P = 1.5 \times 12$ $P\ 1.5^2 \times 8.0$ (Possible ecf) C1

power = 18 (W) A1

(iii) $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + (\frac{1}{R_3})$ / $\frac{1}{R} = \frac{1}{8} + \frac{1}{8} + \frac{1}{8}$ C1

$\frac{1}{R} = 3 \times \frac{1}{8}$ C1

resistance = 2.67 ≈ 2.7 (Ω) (Allow answer expressed as 8/3) A1
(0.375 or 3/8 scores 2/3)

(iv) energy = 0.018 × 12 × 3 C1
energy = 0.648 ≈ 0.65 (kW h) (Possible ecf) A1
(0.22 (kW h) scores 1/2)
(648 (kW h) scores 1/2)
(2.3×10^6 (J) scores 1/2)

(c) It will be brighter B1
The current is larger / correct reference to: $P \propto 1 / R$ B1

[13]

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' B2
(–1 for the omission of 'sum' and -1 for omission of 'point'/ 'junction')
(Do not allow $I_1 + I_2 = I_3 + I_4$ unless fully explained)

[2]