# 2822: Electrons and photons

**1**

| | | | |
|---|---|---|---|
| (a) | Flow / movement of charge / charged particles | AW | B1 |
| | (Allow current = rate of flow of charge / current = rate of change of charge) | | |
| (b) | The charge (flowing past a point) in 1 s when current is 1 A | | B1 |
| | (Allow 1C = 1A × 1s) | | |
| (c)(i) | $I = \frac{\Delta Q}{\Delta t}$  $I = \frac{340}{50}$ | (Allow any subject - with or without Δ) | C1 |
| | 6.8 (A) | | A1 |
| (c)(ii) | 1 There is magnetic field (around the current-carrying strips) and hence a force | AW | B1 |
| | 2 (Fleming's) left-hand rule | | B1 |
| | 3 Towards A / To the left | (Allow direction given on Fig 1.1) | B1 |
| | | | **[Total : 7]** |

**2**

| | | | |
|---|---|---|---|
| (a) | current ∝ voltage / p.d. (for a metal conductor) [Allow $I$ ∝ $V$ because of (b)] | | M1 |
| | as long as temperature remains constant / all physical conditions remain the same | | A1 |
| | ($V = IR$ and $R$ = constant scores 1/2) | | |
| | ($V = IR$ scores 0/2) | | |
| (b)(i) | (Semiconductor) diode | | B1 |
| (b)(ii) | Any five from: | | B1 × 5 |
| | Resistance is given by $R = V/I$ (Allow the use of $R$ for resistance in this question) | | |
| | The resistance is not constant / Diode is a non-ohmic (component) | | |
| | For <u>negative</u> value(s) (of $V$) resistance is infinite / (very) large (Allow a calculation) | | |
| | For $V$ value(s) less than 0.6 (V) the resistance is infinite / (very) large (Accept 0.62 V) | | |
| | For $V$ value(s) greater than 0.6 (V) the resistance is small / less | | |
| | For $V$ value(s) greater than 0.6 (V) the resistance decreases (as $V$ increases) (Also scores mark above) | | |
| | Resistance correctly calculated at one point (Assume values are in ohms if unit is not given) | | |
| | Resistance correctly calculated at another point | | |
| | (Allow '*voltage increases the resistance decreases*' if there is no reference to 0.6 V and the second mark above is not scored) | | |
| | QWC - 'Spelling and grammar' | | B1 |
| | | | **[Total : 9]** |

**3**

| | | | |
|---|---|---|---|
| (a) | sum of current(s) into a point / junction = sum of current(s) out (from the point / junction) | | B2 |
| | (-1 for omission of 'point' or 'sum' in the statement of the law) | | |
| | (Algebraic sum of current(s) at a point = 0 scores 2/2) | | |
| (b)(i) | Thermistor | | B1 |
| (b)(ii) | $I$ = 51 (mA) | | B1 |
| | $I$ = 9 (mA) | | B1 |
| | $I$ = 29 (mA) | | B1 |
| | | | **[Total : 6]** |

**4**

(a) $R = R_1 + R_2$ ; $R = 200 + 120$ ; $R = 320$ C1

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

current $= 2.5 \times 10^{-2}$ (A) A0

(b) $V = 2.5 \times 10^{-2} \times 120$ or $V = \frac{120}{120 + 200} \times 8.0$

$V = 3.0$ (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

**[Total : 5]**

**5**

(a) Correct field direction B1
Correct field pattern (minimum of three lines) B1

(b)(i) length $= 2\pi \times 2.8 \times 10^{-2} \times 20$ length $= 2\pi \times 2.8 \times 20$ M1
length $= 3.52$ (m) $\approx 3.5$ (m) length $\approx 350$ (cm) A0

(b)(ii) $R = \frac{\rho L}{A}$ (Allow any subject) C1

$R = \frac{4.9 \times 10^{-7} \times 3.5}{8.4 \times 10^{-7}}$ C1

$R = 2.04 \approx 2.0$ (Ω) ($R = 2.05 \approx 2.1$ Ω if 3.52 m is used) A1

(c)(i) $V = 6.0 \times 2.04$ (Possible ecf) (Allow initial current 5.7 A to 6.0 A) C1
$V = 12.2 \approx 12$ (V) (Allow $V = 2.0 \times 2.04 \approx 4.1$ (V) – 1 mark) A1

(c)(ii) $P = VI$ (Allow $P = I^2R$ or $P = V^2/R$) C1
$P = 12 \times 6.0$ (Possible ecf)
$P = 72$ A1
watt / W / J s$^{-1}$ / VA B1

(c)(iii) Any four from B1 × 4
The temperature of the coil increases / the coil gets 'hotter' (Allow 'coil heats up')
The resistance / resistivity of coil increases (as its temperature increases)
The decrease in current is linked to $I = V/R$
More / frequent collisions of electrons and (vibrating) atoms / ions (as temperature / resistance increases)
The coil (eventually) reaches steady temperature / constant (higher) resistance

QWC – Organisation B1

**[Total : 16]**

6

(a) particle-like / particulate (nature) / photon (behaviour) B1

(b)(i) A 'packet' of energy / radiation / A quantum of (EM) radiation / energy / light B1
(Do not allow '*particle of light*')

(b)(ii) The minimum frequency (of the EM radiation) for emission of electrons / photoelectric effect B1

(c)(i) Visible (light) B1

(c)(ii) work function = $1.9 \times 1.6 \times 10^{-19}$ M1
work function = $3.04 \times 10^{-19}$ (J) $\approx 3.0 \times 10^{-19}$ (J) A0

(c)(iii) $E = hf$ / $E = \frac{hc}{\lambda}$ C1

$E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{5.1 \times 10^{-7}}$

$E = 3.9 \times 10^{-19}$ (J) A1

2. $hf = \phi + KE_{max}$ / $hf = \phi + \frac{1}{2}mv^2$ (Allow $E = \phi + \frac{1}{2}mv^2$ if $E$ is qualified in (c)(iii)) C1
$3.9 \times 10^{-19} = 3.0 \times 10^{-19} + KE_{max}$ / $3.9 \times 10^{-19} = 3.04 \times 10^{-19} + KE_{max}$ C1
$KE = 9.0 \times 10^{-20}$ (J) / $KE = 8.6 \times 10^{-20}$ (J) {Possible ecf} A1

(c)(iv) No change (to maximum KE of electron) B1
Each photon has same energy (but there are fewer photons) B1

(c)(v) number of photons = $\frac{80 \times 10^{-3}}{3.9 \times 10^{-19}}$ (= $2.05 \times 10^{17}$) {Possible ecf} C1

number of electrons = $0.07 \times \frac{80 \times 10^{-3}}{3.9 \times 10^{-19}}$

number of electrons = $1.44 \times 10^{16}$ ($s^{-1}$) $\approx 1.4 \times 10^{16}$ ($s^{-1}$) A1

(d) $\lambda = \frac{h}{mv}$ (Allow any subject) C1

$5.1 \times 10^{-7} = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times v}$ C1

$v = 1.43 \times 10^{3} \approx 1.4 \times 10^{3}$ ($m s^{-1}$) A1

**[Total : 17]**