1

(a) Variable resistor \ rheostat — B1

(b) To change (allow 'control') current \ ammeter reading \ resistance (of the circuit) \ brightness (of lamp) \ p.d. (across) lamp \ **X** — B1

(c) Correct direction indicated (clockwise) — B1

(d) Electrical to heat \ light — B1

[Total 4]

2

(a)(i) Value within the range 5.0×10^{-9} to 4×10^{-7} (m) — B1

(a)(ii) Cause cancer (Allow other sensible suggestions) — B1

(b) Different wavelength \ frequency \ (photon) energy — B1
(Allow *'emitted from different sources' or 'different penetrations' - with some detail*)

[Total 3]

3

(a) resistance = p.d./current (Allow voltage instead of p.d.) — B2
(ratio of voltage to current scores 2/2)
(voltage per (unit) current scores 2/2)
(voltage per (unit) ampere scores 1/2)
($R = \frac{V}{I}$ scores 1/2 p.d. = current × resistance scores 1/2)

(b) $R = \frac{R_1 R_2}{R_1 + R_2}$ \ $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ — C1

$R = \frac{10 \times 15}{10 + 15} = 6.0\ (\Omega)$ — C1

resistance = 20 + 6 = 26 (Ω) (Possible ECF) — A1

(c)(i) $P = VI$ \ I^2R \ $\frac{V^2}{R}$ — C1

$P = 24 \times 0.028$ — C1

power = 0.672 ≈ 0.67 (W) (-1 for 10^n error ∴ 670 (W) scores 2/3) — A1

(c)(ii) (Thermistor's) temperature increases (due to electrical heating) [AW] — B1

Resistance of thermistor decreases — B1

[Total 10]

4

(a) $(\rho = \frac{RA}{L})$ $(\therefore \rho \rightarrow)$ $\Omega \times m^2/m$ M1

(Cancellation of m leading to) $\rho \rightarrow$ [Ω m] A0

(b)(i) $\rho = \frac{RA}{L}$ (Any subject for equation) (Possible credit from (a)) C1

$A = \pi r^2 = \pi \times (0.62 \times 10^{-3})^2$ $(= 1.208 \times 10^{-6}\ (m^2))$ C1

$R = \frac{6.8 \times 10^{-6} \times 0.32}{\pi \times (0.62 \times 10^{-3})^2}$ C1

$R = 1.8\ (\Omega)$ A0

(b)(ii) $V = \frac{R_2}{R_1 + R_2} \times V_0$ | $V = IR$ and $R_T = R_1 + R_2$ C1

$V = \frac{1.8}{2.8} \times 5.0$ | $I = 5.0 / 2.8 = 1.786 \approx 1.8$ (A) C1

$V \approx 3.2$ (V) | $V = 1.786 \times 1.8 \approx 3.2$ (V) A1

(1.8 (V) scores 2/3)

(Allow ECF from (b)(i) but –1 mark for not using given value of 1.8 Ω)

(b)(iii) The p.d. increases B1

because the resistance (of wire) increases (as it gets thinner \ longer) B1

[Total 9]

5 Any nine from:

1 kW h is the energy (transformed by) 1kW (device) in a time of 1 hour B1

Reference to '$E = Pt$' \ 1 kW h = 1000 ×3600 B1

1 kW h = 3.6×10^6 (J) B1

1 eV is the energy (transformed by an) electron travelling through a p.d. of 1V B1

Reference to '$E = VQ$' B1

1 eV = 1.6×10^{-19} (J) B1

Kilowatt hour is useful when dealing with large amounts of energy [AW] B1

Electronvolt is useful when dealing with small amounts of energy [AW] B1

'eV for photons \ in atomic physics \ in nuclear physics' B1

'kW h for domestic use \ electrical bills' B1

Energy of electron **or** lamp in joules (1.6×10^{-13} J and 4.3×10^6 J respectively) B1

(The above mark to be awarded only if $E=Pt$ or $E=VQ$ not credited)

Filament lamp: 1.2 kW h B1

Electron: 1.0 MeV B1

Two marks for QWC apply to this question. Spelling, punctuation and grammar, B2

Allow two mistakes for two marks.

Allow three/four mistakes for one mark.

More than four mistakes – zero marks.

[Total 11]

6

(a)(i) length = $2\pi r$ ($\times N$) M1
length = $2\pi \times 0.015 \times 250$ M1
length = 23.57 (m) $\approx$ 24 (m) (9.4×10^{-2} (m) scores 1/2) A0

(a)(ii) $F = BIL$ C1
$F = 3.6 \times 10^{-2} \times 48 \times 10^{-3} \times 24$ (-1 for 10^n error) C1
$F = 4.147.. \times 10^{-2} \approx 4.1 \times 10^{-2}$ (N) ($F \approx 4.1 \times 10^{-2}$ (N) if length 23.57 m is used) A1
(Allow ECF from (a)(i) but –1 mark for not using given value of 24 m)

(b) ampere \ amp \ A B1

[Total 6]

7

(a) Quantum of energy \ radiation \ Packet of energy B1

(b)(i)1. $\Delta Q = I\Delta t$ \ $1.2 \times 10^{-7} \times 5$ (Any subject and no need for Δ notation) C1
charge = 6.0×10^{-7} (C) (Allow 6×10^{-7} (C)) A1

(b)(i)2. number = $\frac{6.0\times10^{-7}}{1.6\times10^{-19}} = 3.75 \times 10^{12} \approx 3.8 \times 10^{12}$ (Possible ECF) B1

(b)(ii) $E = hf$ \ $E = 6.63 \times 10^{-34} \times 7.0 \times 10^{14} = 4.64 \times 10^{-19} \approx 4.6 \times 10^{-19}$ (J) C1

$hf = \phi + KE_{max}$ (Allow other subject for photoelectric equation) C1
$KE_{max} = (4.64 - 3.5) \times 10^{-19} = 1.14 \times 10^{-19} \approx 1.1 \times 10^{-19}$ (J) A1

(b)(iii)1. Energy of photon is the same B1
(b)(iii)2. KE of electron is the same B1
(b)(iii)3. The current doubled (as there are twice as many photons) B1

[Total 10]

8

(a) Electrons travel as waves [AW] B1

(b) $\lambda = \frac{h}{mv}$ C1
$mv = 6.63 \times 10^{-34} / 1.6 \times 10^{-15}$ C1
$mv = 4.14 \times 10^{-19} \approx 4.1 \times 10^{-19}$ A1
Unit: kg ms^{-1} \ N s B1

(c) $\lambda \approx 5.5 \times 10^{-34}$ (m) B1
Wavelength is (very) small compared with the width of the window [AW] B1

[Total 7]