1

(a)	Voltmeter connected in parallel with **X**	B1
(b)	Same reading / no effect / no change	B1
(c)(i)	LDR / light-dependent resistor	B1
(c)(ii)	The resistance decreases (as the intensity of light increases)	B1
(c)(iii)	$3.5 – 4.0 \times 10^{-7}$ (m) (to) $6.5 – 7.5 \times 10^{-7}$ (m)	B1
(d)(i)	$R = \frac{V}{I}$ / $R = \frac{1.8}{4.8(\times 10^{-3})}$	C1
	resistance = 375 ≈ 380 (Ω)	A1
(d)(ii)1	$Q = It$ (Allow with or without the Δ notation)	C1
	$Q = 4.8 \times 10^{-3} \times 30$	C1
	charge = 0.144 ≈ 0.14 (C)	A1
(d)(ii)2	$W = VQ$ / $W = VIt$	C1
	$W = 1.8 \times 0.144$ / $W = 1.8 \times 4.8 \times 10^{-3} \times 30$	
	energy = 0.259 ≈ 0.26 (Possible ecf)	A1
	unit: joule / J / VC /VAs	B1
	(Allow 1/3 if power is 0.0086 (W))	
		[Total: 13]

2

(a)	Kirchhoff's <u>second</u>	B1
(b)	Ohm's	B1
(c)	Resistance	B1
(d)	Electronvolt (Allow eV)	B1
		[Total: 4]

3

(a)(i)	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ / $R = \frac{R_1 R_2}{R_1 + R_2}$	C1
	$\frac{1}{R} = \frac{1}{20} + \frac{1}{30}$ / $R = \frac{20 \times 30}{20 + 30}$	
	resistance = 12 (Ω)	A1
(a)(ii)	R = 10 + 12	
	resistance = 22 (Ω) (Possible ecf)	B1
(b)	R = 10 (Ω) / Resistance between B and C = 0	M1
	$I = \frac{5.0}{10}$	
	reading = 0.5 (A)	A1
		[Total: 5]

4

(a) Any two from: B1 × 2
1. Concentric circle(s). (Judge by eye)
2. Separation between successive circles increases with distance from wire
3. Correct direction of field (clockwise).

(b)(i) Three correct: 2/2 Two correct: 1/2 One correct 0/2 B2
first finger: (magnetic) field
second finger: (conventional) current
thumb: force / motion

(b)(ii) The field is parallel to the current / wire B1

(b)(iii) Out of (plane of) paper. (Do not allow 'up') B1

(b)(iv) **AB** and **CD** experience forces in opposite directions B1
(Allow reference to either torque or couple)

(b)(v) $F = BIL$ (Allow any subject) C1

$B = \dfrac{3.8\times10^{-2}}{5.2\times0.023}$ C1

magnetic flux density = 0.318 ≈ 0.32 (T) A1

[Total: 10]

5

Any four from: B1 × 4

1 (As temperature increases) the resistance of the thermistor / **T** decreases
2 The total resistance decreases (Possible ecf)
3 The current increases (in the circuit) (Possible ecf)
4 The (voltmeter) reading increases / voltage across **R** increases (Possible ecf)
5 The voltage across the thermistor / **T** decreases (Possible ecf)
6 Correct use of the potential divider equation / comment on the 'sharing' of voltage / correct use of $V = IR$

[Total: 4]

6

(a) $R = \dfrac{\rho L}{A}$ (Allow any subject) B1

(b) The resistance decreases M1
by a factor of four (because resistance is inversely proportional to radius^2) A1

(c)(i) $2200 = \dfrac{3.5\times10^{-5}\times1.3\times10^{-2}}{A}$ / $A = \dfrac{\rho L}{R}$ C1

$(A =)\dfrac{3.5\times10^{-5}\times1.3\times10^{-2}}{2200}$ C1

(A =) 2.07×10^{-10} (m^2) ≈ 2×10^{-10} (m^2) A0

(c)(ii) $P = I^2R$ / $P = VI$ and $V = IR$ C1

$0.50 = I^2 \times 2200$ C1

current = 0.015 (A) A1

(2.23×10^{-4} scores 2/3 – answer not square rooted)

[Total: 8]

7

(a) *Electromagnetic waves* **-** *Any <u>two</u> from:* *B1 × 2*

1. EM wave / light behave like 'particle'/ photon / quantum of energy
2. $E = hf$ / $E = hc/\lambda$
3. E is the energy of <u>photon</u> and f is the frequency (of EM waves) / λ is the wavelength

Moving electrons - Any <u>four</u> from: *B1 × 4*

4. Moving / travelling particle / electron behaves like a wave
5. Mention of the <u>de</u> <u>Broglie</u> (equation)
6. $\lambda = \frac{h}{mv}$
7. λ is the wavelength of <u>particle</u>/<u>electron</u>, m is the mass (of particle) and v is speed
8. Electrons can be diffracted (Can score on diagram)
9. Electrons travelling through matter /graphite (show diffraction effects) (Can score on diagram if not scored in 8 above)
10. Electrons diffract because their wavelength is comparable to the size of atoms /gap between atoms (Do not allow 'particles in place of atoms)

QWC Spelling, punctuation and grammar B1

Organisation B1

(b)(i) The <u>minimum</u> frequency needed to free an electron (from the surface of a metal) B1

(b)(ii)1 Line extended intersects (the f axis at) this value / At this frequency, $E_k = 0$ B1

(b)(ii)2 (ϕ =) $h \times 5.0 \times 10^{14}$ / (ϕ =) $6.63 \times 10^{-34} \times 5.0 \times 10^{14}$ C1

work function energy = 3.3×10^{-19} J A1

(b)(iii)1 The gradient / slope of the line is the same B1

The gradient is equal to h / independent of the metal B1

(b)(iii)2 The line is shifted to the right B1

The threshold frequency is greater (AW) B1

[Total: 16]