1(a)(i)	Ammeter		B1
(ii)	Voltmeter		B1
(b)	I: current		B1
	Δt: time (interval / duration)		B1
(c)(i)	$I = 7.5 \times 10^3 / 1500$		C1
	$I = 5.0$ (A)		A1
(ii)	$V = P / I$	(allow other variants)	C1
	$V = 1.2 \times 10^3 / 5.0$	(possible e.c.f)	C1
	$V = 240$ (V)	(-1 for missing k or 10^3 factor)	A1
(iii)	$E = 1.2 \times 10^3 \times 1500$		C1
	$E = 1.80 \times 10^6$ (J)	(-1 for missing k or 10^3 factor) penalise once only in (ii) & (iii)	A1
(iv)	units = 1500/3600 x 1.2 = 0.5	units = $1.8 \times 10^6 / 3.6 \times 10^6 = 0.5$	C1
	cost = 0.5 x 6.4 = 3.2 (p)	(possible (e.c.f if (iii) used)	A1
2(a)	$R = V / I$		C1
	symbols defined: R = resistance, V = p.d. / voltage and I = current		A1
	($V = IR$ with all symbols defined scores 1/ 2)		
	(R = p.d. / voltage per unit current scores 2/2)		
	(R = p.d. / voltage per unit amp / A scores 1/ 2)		
(b)	Resistance decreases as temperature increases.		B1
	Correct curve with R decreasing as temperature increases.		B1
(c)(i)	Resistance increases (as V increases)		B1
	Temperature increases / atoms vibrate more / more electron collisions (with atoms)		B1
(ii)	**1.** $P = 24 \times 2$		C1
	$P = 48$ (W)		A1
	2. $V = 12$ (V) when current is 2.0 (A)	(Allow $V = 11.0$ V from graph)	C1
	$R = 12 / 2.0 = 6.0$ (Ω)		A1
	3. $R_T = 6.0 + 5.0 = 11.0$ (Ω)	(possible e.c.f)	B1
	4. $V_L = 11.0 \times 2.0 = 22$ (V)	$R_{circuit} = 48 / 2.0^2 = 12$ (Ω)	C1
	$r = (24-22) / 2.0 = 1.0$ (Ω)	$r = 12.0 - 11.0 = 1.0$ (Ω)	A1
3(a)	$\rho = RA / L$		M1
	Symbols defined: ρ = resistivity, A = cross-sectional area, R = resistance and L = length		A1
	($R = \rho L/A$ with all symbols defined scores 1/ 2)		
(b)(i)	$A = \rho L / R$		C1
	$A = 4.3 \times 10\text{-}6 \times 1.2 \times 10^{-2} / 5.0$	(-1 for using L as 2.0 mm)	C1
	$A = 1.0(3) \times 10^{-8}$ (m^2)		A1
(ii)	$t = 1.0(3) \times 10^{-8} / 2.0 \times 10^{-3}$		
	$t = 5.1(6) \times 10^{-6}$ (m)	(possible e.c.f)	B1

4(a)	Sum of currents = zero (at junction) / sum of currents in = sum of currents out (at junction)	B1
	Charge is conserved.	B1
(b)(i)	$V = V_0 \times R_2 / (R_1 + R_2)$ / $R = V/I$ and $R = R_1 + R_2$	C1
	$V = 6.0 \times 400 / (1200 + 400)$ / $I = 6.0 / 1600 = 3.75 \times 10^{-3}$ (A)	
	$V = 3.75 \times 10^{-3} \times 400$	C1
	$V = 1.5$(V) / $V = 1.5$(V)	A0
	(Answer of 4.5 (V) scores 1/ 2)	
(ii)	**1.** $R_D = 1.5 / 0.1 = 15$ (Ω)	C1
	$R = R_1R_2 / (R_1 + R_2)$ / $1/R_T = \sum 1/R_1$	C1
	$R = 400 \times 15 / (400 + 15) = 14.5 = 15$ (Ω) (possible e.c.f)	A1
	2. $V \approx 6.0 \times 15 / (1200 + 15)$ / $I \approx 6.0 / 1200 + 15 \approx 4.98 \times 10^{-3}$ (A)	C1
	$V \approx 0.07$ (V) / $V \approx 4.98 \times 10^{-3} \times 15 = 0.07$ (V)	A1
	(Answer of 5.93 (V) scores 1/ 2)	
	3. Resistance of device is small(er) / current in device is small(er) / p.d. across device is small(er)	B1
5(a)	Fig. 5.1: (long straight) wire / conductor	B1
	Fig. 5.2: (single) coil / two (parallel) wires	B1
(b)(i)	Zero	B1
(ii)	**1.** $F = BIL$	C1
	$F = 1.2 \times 10^{-2} \times 0.30 \times 1.5 \times 10^{-2}$	C1
	$F = 5.4 \times 10^{-5}$ (-1 for L = '1.5')	A1
	Unit: newton / N (do not allow **n**)	B1
	2.(Fleming's) L.H.R	B1
6(a)	(Moving) electrons behave like a wave	B1
(b)(i)	$\lambda = h / p$ / $\lambda = h / mv$	M1
	λ = wavelength, p = momentum / λ = wavelength, m = mass and v = velocity / speed	A1
(ii)	**1.** $E = 0.01 \times 10^6 \times 1.6 \times 10^{-19}$	
	10^6 factor in answer	M1
	use of **1eV = 1.6×10^{-19}** (J) in answer	M1
	$E = 1.6 \times 10^{-15}$ (J)	A0
	2. $E_k = \frac{1}{2} m v^2$	C1
	$1.6 \times 10^{-15} = 0.5 \times 9.1 \times 10^{-31} \times v^2$	C1
	$v = 5.9(3) \times 10^7$ (ms^{-1})	A1
	3. $\lambda = 6.63 \times 10^{-34} / 9.1 \times 10^{-31} \times 5.9(3) \times 10^7$	C1
	$\lambda = 1.2(3) \times 10^{-11}$ (m) (possible e.c.f)	A1
(c)	Shorter wavelength	B1
	Mass of proton is larger (than an electron's).	B1

7(a)	Any five from:	B1 x 5

- Photons are involved / $E = hf$
- Surface electrons are involved.
- One-to-one exchange of energy between photon and electron
- Electrons carry negative charge, therefore removal means reduction in (negative) charge (of plate).
- Electron released when photon energy > workfunction (energy).
- Electron emission related to threshold frequency.
- Energy conserved in the interaction (between photon and electron).
- Einstein's equation mentioned ($hf = \frac{1}{2} mv^2 + \phi$).

Any two from:
More photons (in a given time).
More electrons are removed (in a given time)
The plate loses charge quicker. B1 x 2

(b)(i)	**1.** $f = 3.0 \times 10^8 / 6.3 \times 10^{-7}$	C1
	$f = 4.7(6) \times 10^{14}$	A1
	unit: hertz / Hz	B1
	2. $E = h f$	C1
	$E = 6.63 \times 10^{-34} \times 4.76 \times 10^{14} = 3.1(6) \times 10^{-19}$ (J) (possible e.c.f)	A1
(ii)	$N = 1 \times 10^{-3} / 3.16 \times 10^{-19}$ (possible e.c.f)	C1
	$N = 3.1(7) \times 10^{15}$ (s^{-1})	A1
(iii)	Energy of photon is greater/ blue light has shorter wavelength.	B1
	Reduced (rate) of photons / fewer photons (in a given time)	B1

8	Any two from:	B1 x 2

- Travel at the speed of light / 3×10^8 (ms^{-1})(in vacuum).
- Travel in vacuum / space.
- Transverse waves.
- Oscillating electric and magnetic fields.
- Can be reflected / diffracted / refracted / polarized etc.

Principal radiation named. B1 x 3
Correct wavelength. (see guide below) B1 x 3

Guide:		
	γ-rays	$10^{-16} - 10^{-12}$ m
	X-rays	$10^{-11} - 10^{-9}$ m
	u.v	$\sim 10^{-8}$ m
	visible	$\sim 10^{-7}$ m
	i.r	$\sim 10^{-6}$ m
	microwaves	$10^{-4} - 10^{-2}$ m
	radio waves	$> 10^{-1}$ m

(If unit for wavelength not given, then penalty of –1)

QWC applied to Q7 & Q8 Maximum of 4 marks