PH2 Mark Scheme – January 2008

Question			Marking details	Marks Available
1	*(a)*	(i)	$Q = It$ (1) [or by impl] = 2.9×10^5 C ((**unit**)) (1)	2
		(ii)	Energy = VIt [or equiv. or by impl.] (1) Energy = 3.5 MJ (1) [e.c.f. on Q]	2
	(b)	(i)	I = 20 A (1) [or by impl, **or** ΣI] time = 4 hours (1)	2
		(ii)	I. $V = E - Ir$ (1) [or equiv. **or** ‘lost volts’ = 0.40 V] V = 11.6 V (1)	2
			II. Greater ‘lost volts’ **or** 3 V extra ‘lost’ (1) Smaller terminal p.d. (1) [**or** terminal p.d. now 8.6 V]	2
				[10]
2.	*(a)*		$I = \dfrac{\Delta Q}{\Delta t}$ [or equiv.](1) **or** No of e’s = $\dfrac{\Delta Q}{e}$ or flow rate = $\dfrac{I}{e}$ No passing through per second = 1.9×10^{21} s^{-1} (1)	2
	(b)		$I = nAve$ (1) [or by impl.] $n = 18 \times 10^{28}$ m^{-3} (1) [or by impl.] v = 0.052 m s^{-1} (1) [e.c.f. on factor of 3]	3
	(c)		any 2 × (1): • v is a vector, mean speed a scalar [accept: v directed along wire; mean speed not directed] • v<< mean speed • mean speed [almost entirely] due to randon [thermal] motion	2
	(d)	(i)	the same	1
		(ii)	n is [also] the same (1) [throughout wire]. v is greater in the thinner portion – at least partial justification (1)	2
				[10]

Question			Marking details	Marks Available
3	*(a)*	(i)	$R = \dfrac{\rho l}{A}$ (1) [or by impl.] $A = \pi\left(\dfrac{0.12\times10^{-3}}{2}\right)^2$ (1)$\left[=1.14\times10^{-8}\,\text{m}^2\right]$ R = 22.5 Ω (1) [e.c.f. on slips of factor of 2 in radius]	3
		(ii)	$\dfrac{1}{R} = \sum_1^7 \dfrac{1}{R_i}$ [or equiv or by impl.] (1) or $R_{\text{Tot}} = \dfrac{R_{\text{strand}}}{7}$ [or by impl.] R_{Tot} = 3.2 Ω (1) [e.c.f. on R_{strand}]	2
		(iii)	Treat as one conductor with 7 times the c.s.a. [or accept calculation]	1
	(b)	(i)	$P = I^2R$ (1) [**or** $P = IV$ **and** $V = IR$] So $P = I^2\dfrac{\rho l}{A}$ (1) [use of ρ formula must be clear].	2
		(ii)	$\left(\dfrac{P}{l}\right)_X = \dfrac{\rho I^2}{\pi(d/2)^2}$; $\left(\dfrac{P}{l}\right)_Y = \dfrac{\rho(2I)^2}{\pi(2d/2)^2}$ [or equiv.] (1) Same $\dfrac{P}{l}$ for X and Y (1) [Awarded only if recognisable attempt at correct reasoning]	2 **[10]**
4.	*(a)*	(i)	80, 120, 80	1
		(ii)	Protons and neutrons in nucleus [accept centre of atom] **and** electrons outside nucleus / in orbitals / orbiting	1
		(iii)	202 in top box (1); and 80 in bottom box(1)	2
	(b)	(i)	I. $E = \dfrac{hc}{\lambda}$ (1) or $E = hf$ **and** $f = \dfrac{c}{\lambda}$; $E = \dfrac{6.6\times10^{-34}\times3\times10^8}{254\times10^{-9}}$ (1)	2
			II. Output power = 13 W (1) [**or** Power emitted = Energy emitted per second.] ∴ 1.7×10^{19} photons s^{-1}. (1)[e.c.f. on power]	2
		(ii)	Downward arrow shown between −8.8 and -16.6×10^{-19} J levels.	1
		(iii)	254 is in the ultraviolet. [Accept λ too small **or** λ not between 400 and 700 nm]	1 **[10]**

Question			Marking details	Marks Available
5	*(a)*		Target [accept metal] hit by electrons (1). Target [**or** decelerating electron(s)] emits X-rays (1)	2
	(b)	(i)	34×10^{-12} m or 38×10^{-12} m [accept 39×10^{-12} m]	1
		(ii)	$\lambda_{min} = 15.5\ [\pm 0.5] \times 10^{-12}$ m (1) V = 80 kV (1) [e.c.f. on <u>slips</u> in λ_{min}]	2
		(iii)	I. Continuous spectrum labelled 'background' II. Decelerating electrons [or equiv] emit e-m rad^{n}.	1 1
	(c)		• X-rays penetrate matter. • Denser matter [e.g. bone] not penetrated as much [or absorbs more]. • X-rays affect photographic plate [so image can be formed] • Sharp shadows cast because of short λ. any 3 × (1)	3
				[10]

Question			Marking details	Marks Available
6	*(a)*		N.B. The diagram requirement could be satisfied by either a photo-emissive cell in a circuit or a negatively charged gold-leaf electroscope with a suitable metal surface (e.g. a zinc plate) Emissive surface shown on a diagram (1) Suitably placed detector shown on diagram (1) Light or u-v illuminating surface either shown on diagram or stated in words. (1) Potentials correct (1) [i.e. cell correct way round or no cell, or negative p.d. or negatively charged electroscope] What is observed (1) [i.e. current registered or leaf falls].	5
	(b)	(i)	I. [emitted] electron II. [incident] photon	1 1
		(ii)	1 electron takes energy from 1 photon [or equiv. or by impl.] (1) ϕ is the [minimum] energy electron needs to escape surface. (1) So electron's ['left over'] energy is less than photon's [by ϕ]. (1)	3
	(c)	(i)	Vertical axis labelled $\frac{1}{2}mv_{\text{max}}^2\ /10^{-19}\ \text{J}$ [or equiv.] with scale (1) Points correctly plotted (1)	2
		(ii)	Graph line (1). 4.5×10^{14} Hz or 4.6×10^{14} Hz. (1)	2
		(iii)	$3.0\ [\pm 0.4] \times 10^{-19}$ J	1
		(iv)	h = slope of graph [or by impl.] (1) $h = \frac{(1.21 - 0.13)\times 10^{-19}}{(6.38 - 4.74)\times 10^{14}}$ Js[or equiv.][N.B. Method mark](1) $= 6.6 \times 10^{-34}$ Js((**unit**))(1) [e.c.f. on slips in 10^n]	3
		(v)	Intensity [at a given frequency] doesn't affect individual photon energies. (1) Intensities <u>don't</u> have to be the same [because Einstein's equn involves individual photon energies] (1).	2 **[20]**

Question			Marking details	Marks Available
7	*(a)*	(i)	$\frac{V_R}{V_{Tot}} = \frac{R}{R_{Tot}}$ [or equiv] **or** $I = 20$ mA (1) So $\frac{V_{CD}}{6} = \frac{50}{300}$ **or** V_{CD}=0.02 × 50 V (1)	2
		(ii)	2.0 / A & B; 3.0 / B & C; 4.0 / B & D; 5.0 / A & C ½ for each correct box, rounded down.	2
	(b)		Any arrangement which drives current through coil (1). Meters correctly placed (1). Potential divider used correctly (2) [Potential divider used as rheostat → (1)]	4
	(c)	(i)	3.3 [±0.3] V [if justified by drawn graph]	1
		(ii)	I. 12.5 ±0.5 Ω II. 16 – 17 Ω	1 1
		(iii)	Graph drawn with horizontal line starting from V = 0 (1) bends upwards [> ~ 3 V] from 'earlier' straight line. (1)	2
		(iv)	I. [Free] electrons collide with ions (1) [accept atoms / lattice] raising random energy (1) of ions and free electrons [or making ions vibrate more vigorously, or equiv.] II. mean drift velocity reduced **or** [free] electrons collide more often with ions.	2 1
		(v)	I. R_{25} = 12.5 Ω (1) [e.c.f. from *(c)*(ii)I.] $R_0 = \frac{R_\theta}{1+\alpha\theta}$ [correct re-arrangement at any stage] [=11.26 Ω] (1) [Accept starting with R_θ, R_0 and θ and finishing with α. 2nd mark only awarded if comment made about consistency] II. R_0 = 11.3 Ω, R_θ = 16.7 Ω [e.c.f. from *(c)*(ii)I.] (1) θ = 109 [±5] °C (1)	2 2
				[20]