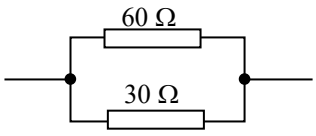
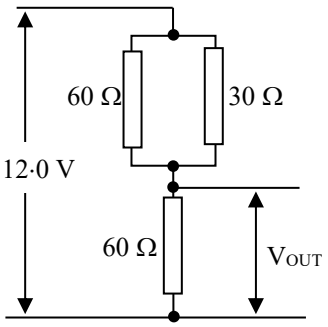
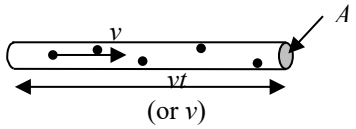
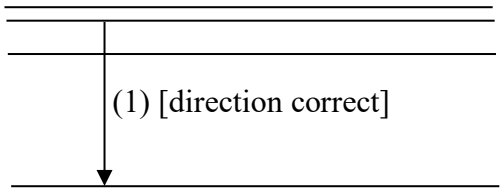
PH2 Mark Scheme – January 2007

Notes: This marking scheme, whilst reasonably complete does not give **all** the answers which were credited by the examiners. It is hoped that the scheme is self-explanatory, though it will need to be read alongside the question paper. The following clarifications may be of use:
Statements in brackets [ ] are exemplification, alternatives, indications of acceptable range of numerical answers (with ±), **or** statements which, whilst desirable in an answer were not required on this occasion for full marks.
The numbers in parentheses ( ) are the marks, usually 1, for each response.
e.c.f. stands for *error carried forward,* and indicates that the results of a previous (incorrect) calculation will be treated as correct for the current section. i.e. the mistake will only be penalised once.
The expression "or by implication" indicates that the mark is credited when subsequent credit-worthy working demonstrates that this idea/equation has been used.
Incorrect or absent units only attract a penalty when ((**unit**)) appears, otherwise they are there in the mark scheme for completeness.
Apart from in question 6 (c), no penalties for excessive significant figures are applied in this paper.
N.B. This Mark Scheme is not a set of Model Answers.

Question				
1	(a)		 Diagram: Configuration (1) Values (1) $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}$ or $R=\frac{R_1R_2}{R_1+R_2}$ (1) [or with values substituted]. Convincing working (1)	4
	(b)	(i)	$I=\frac{V_{IN}}{R_1+R_2}$ [accept R_{Tot} for R_1+R_2]	1
		(ii)	$V_{OUT}=IR_2$ [or equiv.]	1
	(c)	(i)	$R_1 = 120\,\Omega$ $R_2 = 30\,\Omega$ } (1) or by impl. $V_{OUT}=2\cdot4\,V$ (1)	2
		(ii)	 60 Ω in series with combination from part (a) (1) Correct [input and] output connection. (1)	2
				[10]

2	(a)	(i)	I. $E = 9{\cdot}5 - 10{\cdot}0$ V (1). Good line shown (1)	2
			II. Disconnect resistors [or equiv.]	1
		(ii)	I. Point shown at 1·2 A.	1
			II. 5·0 Ω [e.c.f.]	1
			III. to prevent short-circuiting the cell [or equiv.]	1
	(b)	(i)	$E = V + Ir$ (1) or $(E - V)$ worked out for a point or gradient attempted r = 3·0 Ω – 3·3 Ω (1) [e.c.f. on E]	2
		(ii)	Energy is converted [or dissipated, or wasted] in the internal resistance (1). Less current implies less energy wasted [or the converse argument] [or less current gives lower voltage loss across r](1).	2
				[10]
3	(a)	(i)	The number of <u>free</u> electrons per unit volume [accept per m^3]	1
		(ii)	 diagram with 2 or more labels (1) • free electrons in length vt (or v) will pass through A in time t (or in 1 second) ✓ • No. of electrons in length $vt = vAtn$ (or vAn) ✓ • Charge contained = $vAtne$ (or $vAne$) ✓ • Current $= \frac{\text{charge}}{\text{time}} = \frac{vAtne}{t}\left[\text{or}\ \frac{vAne}{1}\right]$ ✓ } any 3 × 1	4
	(b)	(i)	$A = \pi \times \left(\frac{0{\cdot}04\ \text{m}}{2}\right)^2$ (1) $v = \frac{I}{nAe}$ (1) [algebra] [N.B e.c.f. on factors of 4 due to diameter/radius slip.] $v = 4{\cdot}1 \times 10^{-5}\ \text{m s}^{-1}$ (1)	3
		(ii)	More energy converted to internal [accept "heat", "random" or "thermal"…] (1) in collisions between [free] electrons and ions (1) [per second]. **or** because I greater (1) and so I^2R greater (1)	2
				[10]

4	(a)	(i)	A	1
		(ii)	[A], B, E **or** A, B, C, D, E } 1 mark if only one correct point in (ii) and only one in (iii)	1
		(iii)	C, D }	1
	(b)	(i)	I. [impinging] electron	1
			II. energy of photon (1) with minimum wavelength (1)	2
		(ii)	$\lambda_{min} = 0{\cdot}03 \times 10^{-9}$ m (1) [or by impl.]	
			$V = 41$ kV (1)[e.c.f. on slips of 10^2]	2
	(c)	(i)	temperature raised [or equivalent]	1
		(ii)	X-rays ionise [i.r. waves don't]	1
				[10]
5	(a)		Electron orbits proton (1) [**or** orbits nucleus <u>and</u> nucleus is a proton] [N.B. Mar lost if neutron included]	
			Almost all mass of atom is in proton (1) [or equiv.]	
			Proton positively charged; electron negatively (1)	3
	(b)	(i)	Energy of excited state is greater	1
		(ii)	Electrons orbital radius is greater in excited state.	
			[N.B. Description in terms of orbitals credited]	1
	(c)	(i)		
			(1) [direction correct]	1
		(ii)	$\Delta E = \frac{hc}{\lambda}$ [or equiv. e.g. $c = f\lambda$ and $E = hf$](1)	
			$\Delta E = 19{\cdot}4 \times 10^{-19}$ J (1) (e.c.f.)	
			$\lambda = 1{\cdot}0 \times 10^{-7}$ m **((unit))** (1)	3
		(iii)	ultraviolet (e.c.f.)	1
				[10]

6	(a)		$P = \frac{V^2}{R}$ (1) $\left[\text{ or } P = VI \textbf{ and } R = \frac{V}{I}\right]$ Convincing working (1). Division by 2 because elements <u>in series</u>. (1)	3
	(b)		$R = \frac{\rho l}{A}$ (1)[or by impl.] $A = \frac{\rho l}{R}$ (1)[re-arrangement, or by impl.] $A = 8 \cdot 55 \times 10^{-8}\,\text{m}^2$ (1)[or by impl.] $t = 7 \cdot 1 \times 10^{-5}\,\text{m}$(1) (e.c.f.)	4
	(c)	(i)	resistance at 0°C ((**unit**))	1
		(ii)	$R_0 = \frac{R_\theta}{1 + \alpha\theta}$ (1)[transp. or by impl.] $= \frac{26 \cdot 1}{1 + 7 \cdot 5 \times 10^{-5} \times 20}$ (1)[figures inserted at any stage] $= 26 \cdot 06\,\Omega$ or $26 \cdot 05\,\Omega$ (1)	3
		(iii)	Data put into the equation are only to 2 or 3 s.f.	1
		(iv)	$\theta = \frac{R_\theta - R_0}{R_0 \alpha}$ (1)[transposition] $= \frac{27 \cdot 0 - 26 \cdot 1}{26 \cdot 1 \times 7 \cdot 5 \times 10^{-5}}$ (1)[accept $26 \cdot 0$ instead of $26 \cdot 1$] $= 460^\circ\text{C}$ [accept 510°C]; better 500°C (1) [Accept 480°C if 26·06 Ω used for R_0.]	3
			New current in each element is 2·13 A [**or** overall resistance is still 54 Ω or by impl.] (1) Element resistance = 108 Ω (1)	2
			I. Element ribbons thinner (1) More likely to break (1)	2
			II. You can still toast – one side at a time (1) [accept: heats up fast because wire is thinner]	1
				20

7	(a)	(i)	emission of electrons from a surface (1) [or metal or solid] when light [or u-v or e-m rad^{n}] falls on it. (1)	2
		(ii)	I. [Minimum] energy needed (1) to release an electron [from the surface]. (1)	2
			II. ▪ Light consists of packets of energy ▪ Energy of a photon is hf ▪ An electron can accept energy of 1 photon ▪ ϕ needed for electron to escape leaving $hf–\phi$ to be carried off as E_k. } any 3 × 1	3
		(iii)	I. Correct substitution of data into equation (1) $f = 8{\cdot}0 \times 10^{14}$ Hz ((**unit**)) (1)	2
			II. division of <u>an</u> energy by e (1) 0·94 V (1)	2
			III. $hf = \phi$ or equiv. (1) $f = 5{\cdot}8 \times 10^{14}$ Hz (1)	2
		(iv)	Points correctly plotted [e.c.f.] (1) Straight line drawn between the points. (1)	2
		(v)	Graph drawn with the same slope [by eye] (1) and intercept to the left of the previous line (1).	2
	(b)	(i)	[concentric, bright] circles	1
		(ii)	wave-like [or can diffract, show interference]	1
		(iii)	▪ graphite is crystalline ▪ crystals in graphite act as diffraction grating [accept graphite diffracts electrons if not credited in (ii)] ▪ electrons leave graphite at particular angles … ▪ … owing to constructive interference ▪ screen glows when hit by electrons ▪ spacing between atoms in graphite ~ $\lambda_{electrons}$ } any 2 × 1	2
				[20]