Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
9	*(a)*		Force on charge carriers/electrons in mag field [1] [Force right] so left face becomes +ve [1] Electric field/voltage linked to charge movement [1] Electric force balances magnetic force / $V_H \propto B$ also constant I [1]	4			4		
	(b)		Correct application/substitution into equation $I = nAve$ [1] Answer = 0.204 [m s^{-1}] [1]		2		2	2	
	(c)		$eE = Bev$ used or equivalent e.g. $V = Bvd$ or $V = \frac{BI}{nte}$ [1] Correct comparison to get k e.g. $k = vd$ or $\frac{I}{nte}$ etc. [1] Correct answer = 6.13×10^{-4} V T^{-1} or m^2 s^{-1} or A m^2 C^{-1} **unit mark, ecf on** v [1]		3		3	3	
			Question 9 total	**4**	**5**	**0**	**9**	**5**	**0**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*		Rate of flow of electric charge/electrons (1)	1			1		
	(b)	(i)	During $t = 0$ to $t = 0.8$ s current (or I) = 0 (1) Then there is a sudden increase at 0.8 s (1) Value of current = $\frac{1.5}{0.2}$ = 7.5 A (1) Current = 0 from t = 1.0 to 2.5 s (1)		4		4		
		(ii)	Tangent drawn to the graph at t = 3.0 s (1) Gradient calculated correctly (ignore negative sign) (1) Current in the range 1.0 ± 0.1 A (1)			3	3	3	
			Question 4 total	**1**	**4**	**3**	**8**	**3**	**0**

#3

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
(a)			**Before pd applied**: [Free] electrons move randomly/no overall velocity/mean velocity zero/vector average velocity zero [1] **After pd applied:** [Free] electrons accelerated by pd/drift velocity/overall velocity due to pd [1] **Reference to speed either before or after pd applied:** [1] **e.g. either** • [Free] electrons move very quickly/magnitude approx. 10^6 m s^{-1} before pd is applied **or** • Drift velocity is small/magnitude approx. 10^{-3} or 10^{-4} m s^{-1} after pd is applied.	3			3		
(b)	(i)		Volume = vtA or lA [1] can be obtained from diagram No of free electrons = $vtAn$ or lAn [1] Total charge = $vtAne$ or $lAne$ [1] Current = $\frac{vtAne}{t}$ or $\frac{lAne}{t}$ [1]	4			4	1	
	(ii)		$I_P = I_Q$ seen or implied- e.g. $n_PA_Pv_P = n_QA_Qv_Q$ [1] Substitution e.g. $6.4 \times A \times v_P = 2.0 \times 4A \times v_Q$ [1] Algebra to show $\frac{v_Q}{v_P} = \frac{6.4}{8}$ (or $\frac{4}{5}$ or 0.8) [1]	1	1 1		3	3	
			Question total	**8**	**2**	**0**	**10**	**4**	**0**

#4

<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="4">Marks available</th><th rowspan="2">Maths</th><th rowspan="2">Prac</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th></tr>
<tr><td></td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th></th><th>Advantage</th><th>Disadvantage</th></tr>
<tr><td>Ben (ruler)</td><td>Easy to use/convenient / quicker</td><td>Inaccurate [only to ± 1 mm] / reference to parallax errors / difficulty in supporting ruler / may touch spheres</td></tr>
<tr><td>Sarah (rod)</td><td>Diameter measured accurately / greater accuracy</td><td>Diameter/radius of spheres need to be known beforehand / difficult to judge one complete rotation / difficult to measure angle [of rotation] / difficult to set-up / thread overlapping</td></tr>
</table>
4 × 1 mark - one response required from each cell.</td><td></td><td>4</td><td></td><td>4</td><td></td><td>4</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Any ×(1) from:
• Pins/markers on ruler
• Marker on cylinder
• Measure diameter of spheres
• Mark point at centre of each sphere and use a travelling microscope to measure the separation
• Fix the ruler close to spheres
• Smaller diameter rod
• Use of Vernier calipers (for Ben)
Don't accept repeat readings</td><td></td><td></td><td>1</td><td>1</td><td></td><td>1</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>$F = 9.81 \times 10^{-5}$ N (1)
Use of $F = \frac{9 \times 10^9 Q_1Q_2}{r^2}$ (1)
$Q_1Q_2 = 4.36 \times 10^{-18}$ [C^2] (1)</td><td>1</td><td>1
1</td><td></td><td>3</td><td>3</td><td>3</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>$Q = (4.36 \times 10^{-18})^{1/2}$ determined (or use of 4.4×10^{-18}) = 2.09×10^{-9} C (1)
Area under graph calculated: $3.2 \times 10^{-6} \times 0.65 \times 10^{-3}$ = 2.08×10^{-9} C (1)
Alternative:
Area, $Q = 2.08 \times 10^{-9}$ (1)
So $QQ = (2.08 \times 10^{-9})^2 = 4.3 \times 10^{-18}$ C^2 (1)</td><td></td><td></td><td>2</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>$n = \frac{2.09 \times 10^{-9}}{1.6 \times 10^{-19}} = 1.31 \times 10^{10}$ electrons ecf on Q</td><td></td><td>1</td><td></td><td>1</td><td>1</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td>Question total</td><td>1</td><td>7</td><td>3</td><td>11</td><td>6</td><td>11</td></tr>
</table>

#5

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
	(a)		Using $I = nAve$ (1) Area calculated correctly = 1.96×10^{-7} m^2 (1) $n = 18 \times 10^{28}$ [m^{-3}] (1) Drift velocity v = 0.000496 or 0.0005[0] m s^{-1} **unit mark** (1)	1	1 1 1		4	4	
	(b)		Current remains the same as do n and e (1) [Cross-sectional] area less in thinner portion (1) Correct conclusion needs to be qualified - drift velocity is <u>greater</u> in thinner portion (1)			3	3		
	(c)	(i)	Superconductor is when R = 0 accept negligible	1			1		
		(ii)	**Advantage** No power / energy loss [in the power lines] (1) power lines needs to be referenced if referring to 100% efficient As R = 0 [and $P = I^2R$] / no heat (1) **Or** Use in MRI scanners / particle accelerators (1) High currents / large magnetic fields (1) **Disadvantage** Operates at very low temperature (1) Extra energy/apparatus required to cool the wires (1) **Or** Due to cooling [the materials] (1) Cost is high (needs to be qualified) (1)		4		4		
			Question total	**2**	**7**	**3**	**12**	**4**	**0**

#6

<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="4">Marks available</th><th></th><th></th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td></td><td>(a)</td><td>(i)</td><td>For Left Hand Combination:
$\frac{1}{R_{\text{parallel}}} = \frac{1}{2R} + \frac{1}{R} + \frac{1}{2R}$ (RHS seen in any correct form e.g. $\frac{4}{2R}$)(1)
$= \frac{R}{2}$ (1)
Total $R = \frac{R}{2} + R$ or $\frac{3R}{2}$ seen (1)
Alternative solutions possible e.g.
Sum of top and bottom branch = R (1)
Then parallel branch = $\frac{R}{2}$ (1)
Total $R = \frac{R}{2} + R$ (1)</td><td></td><td>3</td><td></td><td>3</td><td>3</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Right hand resistor circled (1)
Greatest current / greatest voltage (1)</td><td></td><td>2</td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td>Correct substitution into $l = \frac{RA}{\rho}$
i.e. $\frac{2.0 \times 10^{3} \times 250 \times 10^{-9} \times 0.25 \times 10^{-3}}{1.20 \times 10^{-6}}$ (1)
l = 0.10 [m] (1) (ecf on slip in powers of 10)</td><td>1</td><td>1</td><td></td><td>2</td><td>2</td><td></td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>n- free electron density. Accept- number of free electrons per unit volume or per m^3 (or equivalent)</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td><table><tr><th>Ratio</th><th>Value</th><th>Explanation</th></tr><tr><td>$\frac{n_X}{n_Y}$</td><td>1</td><td>Wires made of the same material</td></tr><tr><td>$\frac{I_X}{I_Y}$</td><td>1</td><td>Wires in series</td></tr><tr><td>$\frac{v_X}{v_Y}$</td><td>0.25</td><td>Correct explanation based on $A_x v_x = A_y v_y$
e.g $(d)^2 v_x = \left(\frac{d}{2}\right)^2 v_y$</td></tr></table>
Award 1 mark for each correct row</td><td>1
1</td><td>1</td><td></td><td>3</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td>$R = \frac{\rho l}{A}$ substituted into $P = I^2 R$ i.e. $P = \frac{I^2 \rho l}{A}$ (1)
$P_x = \frac{I^2 \rho_x l_x}{A_x}$ and $P_z = \frac{I^2 \rho_z l_z}{A_z}$ (or equivalent) - can award 1st mark from one of these expressions
$A_x = 4A_z$ and $l_x = \frac{l_z}{2}$ and $\rho_x = 2\rho_z$ to show: (1)
$\frac{P_z}{P_x} = 4$ (1)</td><td></td><td>3</td><td></td><td>3</td><td>3</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Question total</td><td>4</td><td>10</td><td>0</td><td>14</td><td>8</td><td>0</td></tr>
</table>

#7

Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
2	(a)	(i)	Rate of charge flow Accept $I = \frac{\Delta Q}{\Delta t}$ only if ΔQ and Δt defined [accept Q and t]	1			1		
		(ii)	J C^{-1} and C s^{-1} as units of V and I respectively clearly shown (1) Correct division seen i.e. $\frac{\text{JC}^{-1}}{\text{Cs}^{-1}}$ seen (1) Or from alternative correct expression, e.g. $R = \frac{V^2}{P}$ etc. Or equivalent in terms of quantities.	1	1		2	1	
	(b)	(i)	I through R_P = 1.2 A and I through R_T = 0.8 A (1) $\frac{V_P}{V_T} = \frac{1.2R_P}{0.8R_T}$ (=1.5) seen (1) Or Parallel combination calculated as $\frac{2}{3}R$ (1) Potential divider: $\frac{R}{R+\frac{2}{3}R} \times 9 = 1.5$ (1)		2		2	1	
		(ii)	$2.5V_T = 9.0$ or $\frac{5V_P}{3} = 9.0$ (1) V_T = 3.6 V or V_P = 5.4 V (1) Award 2 marks for either V_P or V_T calculated correctly. $R_T = \frac{3.6}{0.8} = 4.5\ \Omega$ or $R_P = \frac{5.4}{1.2} = 4.5\ \Omega$ or $\frac{1.8}{0.4} = 4.5\ \Omega$(1) **Alternative:** Total circuit $R = \frac{9.0}{1.2} = 7.5\ \Omega$ (1) Parallel and series combination shown to be = $\frac{5R}{3}$ (1) $\frac{5R}{3} = 7.5$ and $R = 4.5\ \Omega$ (1) **Alternative:** Understanding that $V_P + V_T = 9$ (1) $1.2R_P + 0.8R_T = 9$ (1) (award 2 marks for this only) $R_P = R_T = R$ and $R = \frac{9}{2} = 4.5\ \Omega$ clearly shown (1) Accept reverse argument.		3		3	3	
	(c)		P (circuit) = 10.8 W (1) (either $\frac{81}{7.5}$ or $(1.2)^2 \times 7.5$ or 1.2×9) P in $R_Q = (0.4)^2 \times 4.5 = 0.72$ W (1) $\frac{10.8}{0.72} = 15$ seen (1) **Alternative:** $P_s = P_Q$ since $I_s = I_Q$ $P_T = 4 \times P_Q$ since $I_T = 2 \times I_Q$ $P_P = 9 \times P_Q$ since $I_P = 3 \times I_Q$ Hence total circuit power = $P_Q + P_Q + 4P_Q + 9P_Q$ $= 15P_Q$ Award (1) for correct individual power analysis Award (1) for correct reason linked to currents Award (1) for showing correct total P		3		3	2	
	(d)		Circuit resistance increases, leading to total current decreasing. Power dissipated in circuit decreases (1) V across R_Q has increased (from 1.8 V to 3.0 V), so P_Q increases / I through R_Q has increased (from 0.4 A to 0.67 A) so P_Q increases (1) Hence ratio decreases (1) [only award from correct explanation] Accept numerical explanation: e.g. Circuit resistance is now 13.5 Ω and circuit current = 0.67 A (1) circuit power shown to be 6 W and P_Q shown to be 2 W (1) Hence ratio decreases or is now 3 (1) **Alternative:** With T removed, I through all remaining resistors is the same or V across each is the same (1) Use of VI or I^2R or V^2/R or power / energy dissipated in all three resistors equal (1) So total $P = 3 \times P_Q$ or which is less than $15P_Q$ (1)		3		3		
			Question 2 total	2	12	0	14	7	0