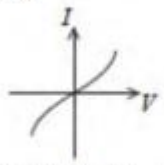
Question Number	Answer		Mark
1	The p.d. (across component) can be (reduced to) zero	(1)	1
	Use of $R = \rho l/A$	(1)	
	Use of $A = \pi r^2$	(1)	
	Diameter = 1.8×10^{-4} m	(1)	3
	Example of calculation		
	$24\ \Omega = 1.2 \times 10^{-6}\ \Omega$ m $\times$ 0.5 m $\div A$		
	$A = 2.5 \times 10^{-8}$ m^2		
	$r = \sqrt{(2.5 \times 10^{-8}\ \text{m}^2 \div \pi)} = 8.9 \times 10^{-5}$ m		
	$d = 1.78 \times 10^{-4}$ m		
	Use of ratio lengths:voltages		
	Or		
	Use of ratio lengths:resistances		
	Or		
	See $I = 0.24$ (A)	(1)	
	p.d. = 2.1 V	(1)	2
	Example of calculation		
	$V = 12.0$ V $\times$ 7.16 cm / 40.0 cm = 2.15 V		

Question Number	Answer		Mark
2	Use of e.m.f. = sum of p.d.s	(1)	
	Use of $V = IR$	(1)	3
	$r = 17\,000$ (Ω)	(1)	
	Example of calculation		
	1.79 V = 1.72 V + (4.20 μA × r)		
	$r = 16\,700$ (Ω)		
	Use of $P = IV$ with V=1.72 (V)	(1)	
	$P = 7.2 \times 10^{-6}$ W	(1)	
	Example of calculation		
	$P = 4.20\ \mu\text{A} \times 1.72$ V		2
	$P = 7.2 \times 10^{-6}$ W		
	Resistance of voltmeter very large **Or** $R >> r$ **Or** internal resistance much less than resistance of voltmeter	(1)	
	(So) I very small [accept $I = 0$]	(1)	
	(So) Ir very small **Or** lost volts ≈ 0 **Or** $Ir << \mathcal{E}$	(1)	
	(So) V (approximately) equal to e.m.f.	(1)	4

Question Number	Answer		Mark
3	Correct curve in the positive quadrant Symmetrical about origin e.g.  	(1) (1)	**2**
	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) (Increased p.d.) causes more energy transfer to lattice ions/atoms More charge carriers released/available $I=nAvq$, so relative increase in I Reference to $R=V/I$ to justify decrease in R	 (1) (1) (1)	**4**

Question Number	Answer		Mark
4	For low resistance the parallel arrangement has a higher current **Or** For high resistance the series arrangement has a higher current High resistance is equivalent to fresh water, so series is used for fresh water **Or** Low resistance is equivalent to salt water, so parallel is used for salt water	(1) (1)	**2**
	Use of e.m.f. = sum of p.d.s Use of $V = IR$ (accept use of $\mathcal{E} = V + Ir$ for MP1 & 2) $r = 0.48\ \Omega$ Example of calculation 6.9 V = 3.3 V + (1.5 A × r) $r = 2.4\ \Omega / 5 = 0.48\ \Omega$	(1) (1) (1)	**3**
	(if the ammeter has resistance) there will be a p.d. across it So the voltmeter will no longer be measuring terminal p.d. **Or** the voltmeter will be measuring a reduced value **Or** the voltmeter will measure terminal p.d. minus p.d. across ammeter (Accept converse arguments based on negligible resistance of ammeter)	(1) (1)	**2**

Question Number	Answer		Mark
5	To ensure a (very) small current **Or** to ensure zero current **Or** otherwise there would be a current So the lost volts = (nearly) zero **Or** so $Ir = 0$ **Or** because otherwise there would be lost volts **Or** $V = \mathcal{E}\, R_{Voltmeter} / (R_{Voltmeter} + r)$ (Accept $V = \mathcal{E}\, R / (R + r)$) If $R_{Voltmeter} >> r$, $V = \mathcal{E}$	**(1)** **(1)** **(1)** **(1)**	**2**