CAMBRIDGE INTERNATIONAL AS & A LEVEL • PHYSICS 9702

Topical Questions

Units 9 & 10: Electricity

Past Papers 2021 – 2025

MARK SCHEME 40 Questions

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Question 1 — Mark Scheme

Question	Answer	Marks
5(a)	sum of current(s) in = sum of current(s) out **or** (algebraic) sum of current(s) is zero	**M1**
	at a junction (in a circuit)	**A1**
5(b)(i)	(current in R_4 or R_1 =) 0.30 + 0.30 (= 0.60 A)	**B1**
	(R =) 2.4 / 0.60 = 4.0 (Ω)	**A1**
	or	
	(p.d. across R_3 or R_2 =) 2.4 / 2 (= 1.2 V)	**(B1)**
	(R =) 1.2 / 0.30 = 4.0 (Ω)	**(A1)**
5(b)(ii)	E = 2.4 + 2.4 + 1.2	**C1**
	= 6.0 V	**A1**
	or	
	total resistance = 10 (Ω)	**(C1)**
	E = 10 × 0.60 = 6.0 V	**(A1)**
5(c)	total resistance increases	**B1**
	current decreases (in battery) so total power decreases	**B1**

Question	Answer	Marks
5(d)	resistivity = RA / L	C1
	$= 4.0 \times \pi \times (240 \times 10^{-6})^2 / 0.67$	C1
	$= 1.1 \times 10^{-6}\ \Omega$ m	A1

Question 2 — Mark Scheme

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Question	Answer	Marks
6(a)	$Q = It$	C1
	$= 0.80 \times 7.5 \times 60$ $= 360$ C	A1
6(b)	$P = EI$ **or** $P = VI$ **or** $P = I^2R$ **or** $P = V^2 / R$	C1
	$0.80^2 \times 0.40$ (= 0.256 W) **or** 0.48×0.80 (= 0.384 W)	C1
	efficiency = $(0.256 / 0.384) \times 100$ $= 67\%$	A1
6(c)(i)	$n = 3.2 \times 10^{22} / (1.3 \times 10^{-7} \times 3.0)$ $= 8.2 \times 10^{28}$ m^{-3}	A1
6(c)(ii)	$I = Anvq$ $v = 0.80 / (1.3 \times 10^{-7} \times 8.2 \times 10^{28} \times 1.60 \times 10^{-19})$	C1
	$= 4.7 \times 10^{-4}$ m s^{-1}	A1
6(d)	(wire Y has) larger resistance / resistance increases	M1
	(wire Y has) smaller current / current decreases	M1
	(average drift) speed is less (in wire Y)	A1

Question 3 — Mark Scheme

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Question	Answer	Marks
6(a)	$R = \rho L / A$	C1
	$(R =)\ 5(.0) \times 10^{-7} \times 2(.0) / 3.3 \times 10^{-7} = 3.0\ \Omega$	A1
6(b)(i)	$I = 1.2 / 3.0$ $= 0.40$ A	A1
6(b)(ii)	$r = (1.50 - 1.20) / 0.40$ **or** $1.50 / 0.40 - 3.0$	C1
	$= 0.75\ \Omega$	A1
6(c)	$E / 1.20 = 1.4 / 2.0$	C1
	$E = 0.84$ V	A1
	or	
	$R_{XP} = (1.4 / 2.0) \times 3.0\ (= 2.1\ \Omega)$ $E = 2.1 \times 0.40$	(C1)
	$E = 0.84$ V	(A1)
6(d)	(second wire has) larger resistance/resistance increases	M1
	p.d. across XY is larger/increases (for second wire) **or** p.d. across the (second) wire is larger/increases	M1
	(so) length XP (for second wire) is shorter	A1

Question 4 — Mark Scheme

Question	Answer	Mark
5(a)	sum of e.m.f.(s) = sum of p.d.(s) **or** (algebraic) sum of e.m.f.(s) and p.d.(s) is zero	**M1**
	around a loop/around a closed circuit	**A1**
5(b)(i)	$I = 1.8 / 0.90$ $= 2.0$ A	**A1**
5(b)(ii)	$Q = It$	**C1**
	number = $(2.0 \times 45) / 1.60 \times 10^{-19}$ $= 5.6 \times 10^{20}$	**A1**
5(b)(iii)	$4.0 = 1.8 + [2.0 \times (0.35 + R)]$ **or** $4.0 = 2.0 \times (0.90 + 0.35 + R)$	**C1**
	$R = 0.75\ \Omega$	**A1**
5(c)(i)	$1.2 / 1.8 = 0.30 / L$	**C1**
	$L = 0.45$ m	**A1**
5(c)(ii)	p.d. across XY decreases/p.d. across XP decreases	**B1**
	(so) P is moved towards Y/away from X/to the right	**B1**

Question 5 — Mark Scheme

Question	Answer	Marks
5(a)	volt / ampere	**B1**
5(b)	$R = \rho L / A$	**B1**
	$(A = V / L)$ (so) $R = \rho L^2 / V$ (with ρ and V constant so $R \propto L^2$)	**B1**
5(c)(i)	$E = 2.4$ V	**A1**
5(c)(ii)	$P = VI$ **or** I^2R **or** V^2 / R	**C1**
	$= 1.3 \times 5.0$ **or** $5.0^2 \times 0.26$ **or** $1.3^2 / 0.26$	**C1**
	= 6.5 W	**A1**
5(c)(iii)	(–) internal resistance **or** (–) r	**B1**

Question 6 — Mark Scheme

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Question	Answer	Marks
5(a)	energy per unit charge	**B1**
	energy transferred by source driving charge around the complete circuit **or** energy transferred from other forms to electrical energy	**B1**
5(b)	there is a p.d. across the internal resistance/*r*	**B1**
	change in current/*I* results in a change in p.d. across the internal resistance	**B1**
	V = *E* – p.d. across internal resistance **or** change in p.d. across *r* causes a change in *V* (as e.m.f. is constant)	**B1**
5(c)(i)	*E* = 7.4 V	**A1**
5(c)(ii)	maximum current = 0.92 A	**A1**
5(c)(iii)	$r = E / I_{MAX}$ **or** (–)gradient	**C1**
	e.g. $r = 7.4 / 0.92$ $= 8.0\ \Omega$	**A1**
5(d)	straight line with negative gradient that is smaller in magnitude than the original line	**B1**
	line which would have intercept on *V*-axis below the original line	**B1**

Question 7 — Mark Scheme

Question	Answer	Mark
6(a)	sum of current(s) into junction = sum of current(s) out of junction or (algebraic) sum of current(s) at a junction is zero	**B1**
6(b)(i)	$I = 3.6 - 2.1$ $= 1.5$	**C1**
	$V = 4.4$	**C1**
	$R = 4.4 / 1.5$ $= 2.9\ \Omega$	**A1**
6(b)(ii)	$12.0 = 4.4 + 3.6r$ or $12.0 = 3.6\ (1.2 + r)$	**C1**
	$r = 2.1\ \Omega$	**A1**
6(b)(iii)	$t = (470 \times 10^3 - 240 \times 10^3) / (12 \times 3.6)$	**C1**
	$= 5300$ s	**A1**
6(b)(iv)	$I = Anvq$ ratio $= (360A / A) \times (2.5n / n)$ or 360×2.5	**C1**
	$= 900$	**A1**

Question 8 — Mark Scheme

Question	Answer	Marks
6(a)(i)	$P = VI$	C1
	$I = 36 / 8.0$ $= 4.5$ A	A1
6(a)(ii)	charge $= 4.5 \times 50$ $= 225$	C1
	number $= 225 / 1.6 \times 10^{-19}$ $= 1.4 \times 10^{21}$	A1
6(a)(iii)	$R = V^2 / P$ or $R = V / I$ or $R = P / I^2$ $= 8.0^2 / 36$ or $= 8.0 / 4.5$ or $= 36 / 4.5^2$	C1
	$= 1.8\ \Omega$	A1

Question	Answer	Marks
6(b)	$R = \rho L / A$	C1
	$L = (1.8 \times 0.25 \times 10^{-6}) / 1.4 \times 10^{-6}$ $= 0.32$ m	A1
6(c)	(larger cross-sectional area, same length, same resistivity and so) less resistance	M1
	(same p.d. and more current so) more power (dissipated)	A1
6(d)	current (in wire) is the same	M1
	(same p.d. across wire so) power stays the same	A1

Question 9 — Mark Scheme

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Question	Answer	Marks
6(a)	sum of current(s) into junction = sum of current(s) out of junction **or** (algebraic) sum of current(s) at a junction is zero	**B1**
6(b)(i)	same potential difference (across X and Y as in parallel)	**B1**
	power = V^2 / R (and $R_X > R_Y$) **or** power = VI **and** $I_X < I_Y$	**M1**
	(so) Y (dissipates more power)	**A1**
6(b)(ii)	$R = \rho L / A$ (and $R_X > R_Y$)	**M1**
	(so) Y (has the larger (cross-sectional) area)	**A1**
6(c)(i)	current = 5.4 / 1800 $= 3.0 \times 10^{-3}$ A	**A1**
6(c)(ii)	5.4 / 9.0 = 1800 / (1800 + R_L) **or** $R_L = (9.0 – 5.4) / 3.0 \times 10^{-3}$	**C1**
	R_L = 1200 Ω	**A1**
6(c)(iii)	resistance of LDR / R_L decreases	**B1**
	current (in the circuit) increases (so) voltmeter reading increases	**B1**

Question 10 — Mark Scheme

Question	Answer	Marks
6(a)	$V = V_1 + V_2 + V_3$	B1
	$IR = IR_1 + IR_2 + IR_3$ **or** $(V / I) = (V_1 / I) + (V_2 / I) + (V_3 / I)$ **and** $R = R_1 + R_2 + R_3$	B1
6(b)(i)	$V / 8.0 = 6.0 \times 10^3 / (4.0 \times 10^3 + 6.0 \times 10^3)$ **or** $I = 8.0 / (4.0 \times 10^3 + 6.0 \times 10^3) = 8.0 \times 10^{-4}$ $V = 8.0 \times 10^{-4} \times 6.0 \times 10^3$	C1
	$V = 4.8$ V	A1
6(b)(ii)	total resistance in parallel = 3.0×10^3 (Ω) **or** 3.0 (kΩ)	C1
	current = $8.0 / (3.0 \times 10^3 + 6.0 \times 10^3)$ $= 8.9 \times 10^{-4}$ A	A1
6(c)	thermistor resistance increases	B1
	(thermistor resistance increases so total resistance increases so) current decreases (in battery)	M1
	($P = EI$ and E constant so) power decreases	A1

Question 11 — Mark Scheme

Question	Answer	Marks
6(a)(i)	line passes through (0,0) and is in first and third quadrants only	**M1**
	gradient of line becoming less steep in both quadrants and roughly symmetrical	**A1**
6(a)(ii)	(as I increases) the temperature (of the filament wire/lamp) increases	**B1**
	(as I / temperature / V increases) the resistance (of wire/lamp) increases	**B1**
	(as I / temperature / V increases the graph curves because) ratio V / I increases or ratio I / V decreases	**B1**
6(b)	$R = \rho L / A$	**C1**
	$= (5.6 \times 10^{-8} \times 5.8) / 3.4 \times 10^{-8}$ $= 9.6\ \Omega$	**A1**

Question	Answer	Marks
6(c)		**B4**

position of switches		ammeter readings		
S_1	S_2	X / A	Y / A	Z / A
open	open	0	0	0
open	closed	1.0	**0**	**1.0**
closed	open	**2.0**	**2.0**	**0**
closed	closed	**3.0**	**2.0**	**1.0**

second row: both values correct (B1)

third row: all three values correct (B1)

fourth row: $X = Y + Z$ (any values) (B1)

all three values correct (B1)

Question 12 — Mark Scheme

Question	Answer	Marks
5(a)	current (through a conductor is directly) proportional to potential difference (across the conductor)	**M1**
	(provided that) temperature (of conductor remains) constant	**A1**
5(b)(i)	(ratio of) V / I increases (as p.d. increases)	**B1**
5(b)(ii)	(as p.d. increases, current increases so) temperature increases	**B1**
5(c)(i)	$I = 1.55$ A	**A1**
5(c)(ii)	$P = VI$ **or** $P = I^2R$ **or** $P = V^2 / R$	**C1**
	$= 6.0 \times 1.55 \times 2$ **or** $1.55^2 \times 3.87 \times 2$ **or** $(6.0^2 / 3.87) \times 2$ $= 19$ W	**A1**
5(c)(iii)	$I = 1.78 - 1.55$ $(= 0.23$ A)	**C1**
	$R = 12.0 / 0.23$ $= 52\ \Omega$	**A1**
5(d)	lamp P: p.d. across lamp decreases to zero so goes 'out'	**B1**
	lamp Q: p.d. across lamp increases to 12 V so gets brighter	**B1**

Question 13 — Mark Scheme

Question	Answer	Marks
6(a)	energy transferred per (unit) charge (from electrical to other forms)	**B1**
6(b)	same/equal current (in X and Y)	**B1**
	$P = I^2R$ (and $R_X > R_Y$) **or** $P = VI$ **and** $V_X > V_Y$	**M1**
	(so) X (dissipates more power)	**A1**
6(c)(i)	$I = Q / t$	**C1**
	$= 650 / 540$ $= 1.2$ A	**A1**
6(c)(ii)	$V = W / Q$ **or** W / It	**C1**
	$= 4800 / 650$ **or** $4800 / (1.2 \times 540)$ $= 7.4$ V	**A1**
	or	
	$V = P / I$ **and** $P = W / t$	**(C1)**
	$= 8.9 / 1.2$ $= 7.4$ V	**(A1)**
6(c)(iii)	$I = 4.5 + 1.2$ (= 5.7 A)	**C1**
	$9.0 = 7.4 + 5.7r$ **or** $9.0 = 5.7\ (1.3 + r)$ $r = 0.28\ \Omega$	**A1**

Question 14 — Mark Scheme

Question	Answer	Marks
5(a)	sum of e.m.f.(s) = sum of p.d.(s) **or** (algebraic) sum of e.m.f.(s) and p.d.(s) is zero	**M1**
	around a loop / around a closed circuit	**A1**
5(b)(i)	$1 / r_{(T)} = 1 / 0.59 + 1 / 0.59 + 1 / 0.59$	**B1**
	$(r_{(T)} =) 0.197\ (\Omega)$ $(R =) 2.2 - 0.197 = 2.0\ \Omega$	**A1**
	or	
	$I = 1.5 / 2.2$ (= 0.68 A) **and** $i = 0.68 / 3$ (where I is the circuit current and i is the current from each cell)	**(B1)**
	$(E = IR + ir =) 1.5 = 0.68R + (0.68 / 3) \times 0.59$ **and** $R = 2.0\ \Omega$	**(A1)**

Question	Answer	Marks
5(b)(ii)	current = 1.5 / 2.2	C1
	= 0.68 A	A1
	or	
	p.d. across cell = p.d. across conductor 1.5 – 0.59I = 3I × 2.0 so I = 0.228 A (where I is current in cell) current = 3 × 0.228	(C1)
	= 0.68 A	(A1)
	or	
	current in conductor = 3 × current in cell V / 2.0 = 3 × (1.5 – V) / 0.59 (where V is p.d. across conductor) V = 1.37 V current = 1.37 / 2.0	(C1)
	= 0.68 A	(A1)
5(c)(i)	$R = \rho L / A$	C1
	$R = 4\rho L / \pi d^2$ (ρ and L are the same so) $R_A / R_B = 7.6^2 / 4.3^2$	C1
	= 3.1	A1

Question 15 — Mark Scheme

Question	Answer	Marks
6(a)	energy (transferred from electrical to other forms) per unit charge	**B1**
6(b)(i)	(resistance is) infinite / very high	**B1**
6(b)(ii)	(resistance) decreases (as V increases)	**B1**
6(c)(i)	current = 2.7 – 1.5 = 1.2 A	**A1**
6(c)(ii)	$12 = (1.5 \times 5.0) + (1.5 \times R)$ **or** $R = (12/1.5) - 5.0$	**C1**
	$R = 3.0\ \Omega$	**A1**
6(c)(iii)	$V_{(XZ)} = (1.6 / 2.0) \times 12$ (= 9.6 V)	**C1**
	$V_{(XW)} = 1.5 \times 5.0$ (= 7.5 V)	**C1**
	potential difference = 9.6 – 7.5 = 2.1 V	**A1**
	or	
	$V_{(ZY)} = (0.4 / 2.0) \times 12$ (= 2.4 V)	**(C1)**
	$V_{(WY)} = 1.5 \times 3.0$ (= 4.5 V)	**(C1)**
	potential difference = 4.5 – 2.4 = 2.1 V	**(A1)**

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Question	Answer	Marks
6(c)(iv)	current in (fixed / variable) resistor decreases	**B1**
	current in (resistance) wire is unchanged	**B1**
	(so) current in battery decreases, (same e.m.f. so) power decreases	**B1**

Question 16 — Mark Scheme

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Question	Answer	Marks
6(a)	(number density =) $2.3 \times 10^{23} / (1.5 \times 10^{-6} \times 1.8) = 8.5 \times 10^{28}$ (m^{-3})	**A1**
6(b)	$I = Q / t$ **or** $I = 172 / 2.5 \times 60$ **or** $I = 1.1(5)$	**C1**
	$I = nAvq$ $172 / (2.5 \times 60) = 1.5 \times 10^{-6} \times 8.5 \times 10^{28} \times v \times 1.6 \times 10^{-19}$	**C1**
	$v = 5.6 \times 10^{-5}$ m s^{-1}	**A1**

Question 17 — Mark Scheme

Question	Answer	Marks
7(a)	$9.6 = 6.0 + (I \times 5800)$ **or** $3.6 = I \times 5800$	**C1**
	$I = 6.2 \times 10^{-4}$ A	**A1**
7(b)	$9.6 = 6.2 \times 10^{-4} \times (3400 + 5800 + R)$ **or** $6.0 = 6.2 \times 10^{-4} \times (3400 + R)$	**C1**
	$R = 6.3 \times 10^{3}\ \Omega$	**A1**
7(c)	$(\Delta E =)\ 9.6 \times 330\ (= 3170$ J)	**C1**
	final stored energy $= 2.6 \times 10^{4} - 3170$ $= 2.3 \times 10^{4}$ J	**A1**
7(d)(i)	decrease	**B1**
7(d)(ii)	decrease	**B1**
7(d)(iii)	increase	**B1**

Question 18 — Mark Scheme

Question	Answer	Marks
6(a)	temperature decreases (so) resistance decreases	**B1**
6(b)(i)	current = V / R	**A1**
6(b)(ii)	$I = Anvq$ $n = N / V$ **or** $n = N / AL$	**C1**
	$v = (V / R) / [(V / L) (N / V) e]$ **or** $(V / R) / [A (N / AL) e]$ $= VL / RNe$	**A1**
	or	
	$v = L / t$ $= L / (Q / I)$	**(C1)**
	$= LI / Q$ $= L(V / R) / Ne$ $= VL / RNe$	**(A1)**
6(b)(iii)	time = distance / speed **or** Q / I $= L / (VL / RNe)$ **or** $Ne / (V / R)$ time = RNe / V	**A1**

Question 19 — Mark Scheme

Question	Answer	Marks
7(a)	$V / 9.0 = 1800 / (1800 + 1200)$	C1
	$V = 5.4$ V	A1
	or	
	$I = 9.0 / (1800 + 1200) = 3.0 \times 10^{-3}$ (A) $V = 3.0 \times 10^{-3} \times 1800$	(C1)
	$= 5.4$ V	(A1)
7(b)(i)	$L / 1.2 = 5.4 / 9.0$ **or** XZ / 1.2 = 5.4 / 9.0	C1
	$L = 0.72$ m	A1
	or	
	$L / 1.2 = 1800 / (1800 + 1200)$ **or** XZ / 1.2 = 1.8 / (1.8 + 1.2)	(C1)
	$L = 0.72$ m	(A1)
7(b)(ii)	• (intensity) increase	B1
	• (power) increase	B1
	• (length XZ) decrease	B1

Question 20 — Mark Scheme

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Question	Answer	Marks
5(a)	correct symbol for the heater **or** for the LDR	**M1**
	all correct symbols in series (ignore voltmeter) and no extra symbols	**A1**
	correct symbol for voltmeter and in parallel with the heater	**B1**
5(b)(i)	$R = \rho L / A$	**C1**
	$= (1.1 \times 10^{-6} \times 2.0) / 3.8 \times 10^{-7}$ $= 5.8\,\Omega$	**A1**
5(b)(ii)	$I = 4.8 / 5.8$ $= 0.83$ A	**A1**
5(c)(i)	A larger (for new wire) **or** $A \propto d^2$ (and d larger for new wire) **or** $R \propto 1 / d^2$ (and d larger for new wire)	**M1**
	so R is less (than that of first wire)	**A1**
5(c)(ii)	(heater / total resistance decreases so) current (in circuit) increases (so p.d. across LDR increases) **or** heater resistance decreases so it has a smaller share/proportion/fraction of the (total) voltage / e.m.f.	**M1**
	(so voltmeter) reading is less (than 4.8 V)	**A1**

Question 21 — Mark Scheme

Question	Answer	Mark
6(a)(i)	(I =) 16 / 320 = 0.050 (A)	**A1**
6(a)(ii)	R = (25 – 16) / 0.050 **or** R = (9 / 16) × 320 **or** R = (25 / 0.050) – 320	**C1**
	R = 180 (Ω)	**C1**
	$R_{(LDR)}$ = [(1 / 180) – (1 / 240)]$^{-1}$ = 720 Ω	**A1**
	or	
	I = (25 – 16) / 240 (= 0.0375 A)	**(C1)**
	$I_{(LDR)}$ = 0.050 – 0.0375 (= 0.0125 A)	**(C1)**
	$R_{(LDR)}$ = 9.0 / 0.0125 = 720 Ω	**(A1)**

Question	Answer	Mark
6(a)(iii)	$P = V^2 / R$ **or** $P = VI$ **or** $P = I^2R$	**C1**
	ratio = $(9^2 / 720) / (9^2 / 240)$ **or** ratio = $(9 \times 0.0125) / (9 \times 0.0375)$ **or** ratio = $(0.0125^2 \times 720) / (0.0375^2 \times 240)$ ratio = 0.1125 / 0.3375 = 0.33	**A1**
6(b)	resistance of LDR decreases	**B1**
	resistance of parallel combination decreases **or** total resistance (of circuit) decreases **or** current in resistor of resistance 320 Ω increases **or** potential difference across parallel combination / LDR / 240 Ω resistor decreases	**M1**
	voltmeter reading increases	**A1**

Question 22 — Mark Scheme

Question	Answer	Marks
6(a)	$R = \rho L / A$	C1
	$\rho = 0.92 \times 5.3 \times 10^{-7}$ $= 4.9 \times 10^{-7}\ \Omega\,m$	A1
6(b)(i)	(current =) $6.4 / 1600 = 4.0 \times 10^{-3}$ (A)	A1
6(b)(ii)	charge = $4.0 \times 10^{-3} \times 3.2 \times 60$ (= 0.768 C)	C1
	number = $0.768 / 1.6 \times 10^{-19}$ $= 4.8 \times 10^{18}$	A1
6(b)(iii)	$6.4 / E = 1600 / (1400 + 1600)$ **or** $E = 6.4 + (4.0 \times 10^{-3} \times 1400)$ **or** $E = 4.0 \times 10^{-3}\,(1600 + 1400)$	C1
	$E = 12$ V	A1
6(b)(iv)	$P = I^2R$ **or** $P = VI$ **or** $P = V^2 / R$	C1
	ratio = $(6.4^2 / 1600) / [(4.0 \times 10^{-3})^2 \times 1400]$ $= 1.1$	A1
6(c)(i)	increase	B1
6(c)(ii)	increase	B1
6(c)(iii)	decrease	B1

Question 23 — Mark Scheme

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Question	Answer	Marks
7(a)	current (through a conductor is directly) proportional to potential difference (across the conductor) or vice versa	M1
	(provided that) temperature (of conductor remains) constant	A1
7(b)(i)	$R = \rho L / A$	C1
	$\rho = (18 \times 7.2 \times 10^{-8}) / 0.94$ $= 1.4 \times 10^{-6}\ \Omega\,m$	A1
7(b)(ii)	voltmeter reading = 3.1 V	A1
7(b)(iii)	current in the battery: increase	B1
	voltmeter reading: decrease	B1
7(b)(iv)	cross marked on the resistance wire to right of the arrowhead of S, but not touching the right-hand end of the resistance wire	B1
7(c)(i)	$I = Anvq$ $q = 0.93 / [(7.2 \times 10^{-8}) \times (9.0 \times 10^{28}) \times (1.3 \times 10^{-3})]$	C1
	$q = 1.1 \times 10^{-19}$ C	A1
7(c)(ii)	charge / q (value) is below 1.6×10^{-19} (C) **or** charge cannot be below 1.6×10^{-19} (C) **or** (the charge carriers / q) should have a charge of 1.6×10^{-19} (C)	B1

Question 24 — Mark Scheme

Question	Answer	Marks
7(a)	energy (transferred) per (unit) charge	**B1**
7(b)	$V = 0.25 \times 6$ $= 1.5$	**C1**
	$Ir = E - IR$ $Ir = 1.8 - 1.5$ $= 0.3$	**C1**
	$r = 0.3 / 0.25$ $= 1.2\ \Omega$	**A1**
	or (Total) $R = 1.8 / 0.25$ $= 7.2$ $E / I = (R + r)$	**(C1)**
	$1.8/0.25 = 6 + r$	**(C1)**
	$r = 7.2 - 6$ $= 1.2\ \Omega$	**(A1)**
7(c)(i)	The same	**B1**
7(c)(ii)	Any 3 from: • before t_1 / when current constant, the (total) resistance is constant • at t_1 / when current increases, the (total) resistance decreases (due to decrease of external resistance) • (after t_1) temperature (of lamp) increases (so the resistance of the lamp increases) • (after t_1) resistance **of lamp** increases (so total resistance increases so the current in the ammeter decreases)	**B3**

Question 25 — Mark Scheme

Question	Answer	Marks
6(a)	sum of current(s) entering a junction = sum of current(s) leaving (the same junction) **or** (algebraic) sum of current (s) at a junction is zero	**B1**
6(b)	(by Kirchhoff's second law) $V = V_1 + V_2$	**B1**
	so $IR_T = IR_1 + IR_2$ (and cancelling I gives) $R_T = R_1 + R_2$ **or** $V / I = V_1 / I + V_2 / I$ (and substituting R gives) $R_T = R_1 + R_2$	**B1**
6(c)	current in circuit = 1.35 / (10 + 15) (= 0.054 A)	**C1**
	$r = (E – V) / I$	**C1**
	$= (1.5 – 1.35) / 0.054$ $= 2.8\ \Omega$	**A1**
	or	
	by potential divider principle $\frac{0.15}{1.35} = \frac{r}{25}$	**(C2)**
	$r = 2.8\ \Omega$	**(A1)**
	or	
	I = 1.35 / (10 + 15) (= 0.054 A)	**(C1)**
	total resistance = 1.50 / 0.054 (= 27.8 Ω) $r = 27.8 – 25$	**(C1)**
	$r = 2.8\ \Omega$	**(A1)**

Question	Answer	Marks
6(d)(i)	the (total) resistance (of the circuit) has decreased (and e.m.f. is unchanged)	**M1**
	(the current (in the cell) will) increase	**A1**
6(d)(ii)	(as the current is greater and so there is a) larger p.d. across the internal resistance	**M1**
	(terminal p.d. will) decrease	**A1**

Question 26 — Mark Scheme

Question	Answer	Marks
5(a)	sum of electromotive force(s) = sum of potential difference(s) around a (closed) loop.	**B1**
5(b)(i)	$R = V / I$	**C1**
	$= (9.0 - 4.0) / 1.1 \times 10^{-2}$ $= 450\,\Omega$	**A1**
5(b)(ii)	resistance (of thermistor) = 25 (Ω) (from graph)	**C1**
	$V = E \times R_Y / (R_Y + R_X)$ $= 9 \times 25 / (25 + 450)$ **or** $I = E / R_{Total} = 9 / (25 + 450) = 1.89 \times 10^{-2}$ A $V = IR = 1.89 \times 10^{-2} \times 25$ **or** $V_{(X)} = 9 \times 450 / (25 + 450) = 8.53$ V $V = 9 - 8.53$	**C1**
	$V = 0.47$ V	**A1**
5(b)(iii)	(resistance of X increases so) the total resistance increases	**B1**
	current decreases	**B1**
	potential difference (across thermistor / Y) decreases	**B1**

Question 27 — Mark Scheme

Question	Answer	Marks
5(a)(i)	sum of electromotive force(s) = sum of potential difference(s) around a (closed) loop **or** the (algebraic) sum of the p.d.(s) and e.m.f.(s) is zero around a (closed) loop	**B1**
5(a)(ii)	(law of conservation of) energy	**B1**
5(b)(i)	(by Kirchhoff's first law) $I = I_1 + I_2$	**B1**
	$V / R_T = V / R_1 + V / R_2$ therefore $1 / R_T = 1 / R_1 + 1 / R_2$	**B1**
5(b)(ii)	resistance of parallel combination $= (15 \times 10) / (15 + 10)$ $(= 6.0\ \Omega)$	**C1**
	$r = (E - V) / I$	**C1**
	$I = 1.38 / 6.0 = 0.23$ A $r = (1.50 - 1.38) / 0.23$ $= 0.52\ \Omega$	**A1**
	or	
	(by potential divider principle) $r / R_T = Ir / V$	**(C1)**
	$r / 6.0 = 0.12 / 1.38$ $r = 0.52\ \Omega$	**(A1)**
	or	
	(by potential divider equation) $V = E \times R_T / (R_T + r)$	**(C1)**
	$1.38 = 1.5 \times 6.0 / (6.0 + r)$ $r = 0.52\ \Omega$	**(A1)**

Question	Answer	Marks
5(c)(i)	as the (total) resistance has decreased (and e.m.f. is unchanged)	**M1**
	current will (in the cell) increase	**A1**
5(c)(ii)	(as greater current means a) bigger drop in p.d. across the internal resistance	**M1**
	p.d. (on voltmeter) will decrease	**A1**

Question 28 — Mark Scheme

Question	Answer	Marks
7(a)(i)	(V =) 1.50 – 1.36 (= 0.14 V)	**B1**
	current = V / R = 0.14 / 0.28 = 0.50 A	**A1**
7(a)(ii)	resistance = V / I	**C1**
	= 1.36 / 0.50 = 2.7 Ω	**A1**
7(a)(iii)	R = 2.7 – 1.0 = 1.7 Ω	**A1**
7(b)(i)	two resistors correctly shown in parallel with cell and no other components	**B1**
7(b)(ii)	(external) resistance is now smaller **and** (so) current (in cell) is greater / (external) resistance smaller fraction of total resistance / internal resistance larger fraction of total resistance	**B1**
	(greater p.d. across internal resistance so) terminal p.d. is less	**B1**

Question 29 — Mark Scheme

Question	Answer	Marks
5(a)	energy transferred per unit charge (from electrical to other forms)	**B1**
5(b)(i)	heater	**A1**
5(b)(ii)	(V =) 7.0 × 0.86 = 6.0 (V)	**A1**
5(b)(iii)	I = (230 – 6.0) / 170 (= 1.3 A)	**C1**
	I_1 = 7.0 – 1.3 = 5.7 A	**A1**
5(b)(iv)	V = 230 – 6.0 – (5.7 × 2.4)	**C1**
	= 210 V	**A1**
	or	
	R = ((230 – 6.0) / 5.7) – 2.4 (= 36.9 Ω)	**(C1)**
	V = 5.7 × 36.9 = 210 V	**(A1)**

Question	Answer	Marks
5(b)(v)	$P = IV$ **or** $P = I^2R$ **or** $P = V^2 / R$	**C1**
	$P = 5.7 \times 210$ **or** $P = 5.7^2 \times (210 / 5.7)$ **or** $P = 210^2 / (210 / 5.7)$ $P = 1200$ W	**A1**
5(b)(vi)	% efficiency = <u>useful</u> power out / (total) power in ($\times$ 100)	**C1**
	= 1200 / (230 $\times$ 7.0) ($\times$100) = 0.75 ($\times$ 100) = 75% or 74% (using 3 s.f. value from **(v)** gives 74%)	**A1**
5(b)(vii)	(current) decreases	**A1**

Question 30 — Mark Scheme

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Question	Answer	Marks
6(a)	potential difference per unit current	B1
6(b)(i)	$\rho = RA / L$	C1
	$= (0.33 \times 8.0 \times 10^{-6}) / 2.4$ $= 1.1 \times 10^{-6}\ \Omega\,\text{m}$	A1
6(b)(ii)	$Q = It$	C1
	$= 4.7 \times 5.0 \times 60$ $= 1400\ \text{C}$	A1
6(b)(iii)	$I = nAvq$ $n = 4.7 / (8.0 \times 10^{-6} \times 0.16 \times 10^{-3} \times 1.60 \times 10^{-19})$	C1
	$= 2.3 \times 10^{28}\ \text{m}^{-3}$	A1
6(c)(i)	correct symbols for resistor and thermistor, shown correctly connected in series with the battery	B1
6(c)(ii)	(as temperature increases) resistance of thermistor decreases	M1
	(total resistance decreases so) greater current (in circuit/wire) so power (dissipated in the wire) increases **or** (total resistance decreases so) greater (share of) p.d. across wire so power (dissipated in the wire) increases	A1

Question 31 — Mark Scheme

Question	Answer	Marks
6(a)	$V = IR$ $= 0.85 \times 3.3 \times 10^{-3}$	C1
	$= 2.8 \times 10^{-3}$ V	A1
6(b)(i)	$(A =) \rho L / R$	C1
	$= 1.8 \times 10^{-8} \times 0.24 / 3.3 \times 10^{-3} = 1.3 \times 10^{-6}$ (m^2)	A1
6(b)(ii)	$(n =) 2.6 \times 10^{22} / (1.3 \times 10^{-6} \times 0.24) = 8.3 \times 10^{28}$ (m^{-3})	A1

Question	Answer	Marks
6(b)(iii)	$v = I / nAq$ $= 0.85 / (8.3 \times 10^{28} \times 1.3 \times 10^{-6} \times 1.6 \times 10^{-19})$	C1
	$= 4.9 \times 10^{-5}\ \text{m s}^{-1}$	A1
	OR $v = IL / Nq$ $= 0.85 \times 0.24 / (2.6 \times 10^{22} \times 1.6 \times 10^{-19})$	(C1)
	$= 4.9 \times 10^{-5}\ \text{m s}^{-1}$	(A1)
6(c)(i)	Length (of Q) is greater (than P)	B1
	(Average cross-sectional) area (of Q) is less (than P)	B1
	Resistance is proportional to length / (cross-sectional) area	M1
	(so) the resistance (of Q) is greater (than P)	A1
6(c)(ii)	A line starting from a non-zero value of drift speed at distance = 0	B1
	A line with an increasing positive gradient	B1

Question 32 — Mark Scheme

Question	Answer	Marks
6(a)(i)	I = 1.3 / 1.1 = 1.2 A	A1
6(a)(ii)	$v = I / nqA$ = 1.2 / (8.5 × 10^{28} × 1.60 × 10^{-19} × 4.7 × 10^{-7})	C1
	= 1.9 × 10^{-4} m s^{-1}	A1
6(a)(iii)	$\rho = RA / L$	C1
	= (1.1 × 4.7 × 10^{-7}) / 0.45	C1
	= 1.1 × 10^{-6} Ω m	A1
6(b)(i)	(Total) resistance decreases (and the potential difference stays the same)	M1
	(so the reading on the ammeter) increases	A1
6(b)(ii)	(The average drift speed will be) the same because the current is the same (in X).	B1

Question 33 — Mark Scheme

Question	Answer	Marks
6(a)	energy transferred (to the component) per (unit) charge	B1
6(b)(i)	$Q = It$ $= 0.030 \times 4.0 \times 60$	C1
	$= 7.2$ C	A1
6(b)(ii)	$I = V / R$ $I_1 = 8.0 / (430+240)$	C1
	$= 0.012$ A	A1
6(b)(iii)	$I_2 = 0.030 - I_1$ $= 0.030 - 0.012$ $= 0.018$ A	A1

Question	Answer	Marks
6(b)(iv)	$R = V / I_2$ $= (8.0 - (0.018 \times 210)) / 0.018$	**C1**
	$= 230\ \Omega$	**A1**
	OR resistance of top branch = 8.0 / 0.018 R = 8.0 / 0.018 – 210	**(C1)**
	$= 230\ \Omega$	**(A1)**
	OR total circuit resistance = 8.0 / 0.030 = 267 1 / 267 = 1 / (210 + R) + 1 / (430 + 240) 1 / 267 – 1 / 670 = 1 / (210 + R) 210 + R = 443	**(C1)**
	$R = 230\ \Omega$	**(A1)**
6(c)	(When) the galvanometer reads 0 (A)	**M1**
	The ratio of the resistances in the top branch will equal the ratio of the resistances in the bottom branch (so the resistance of X can be determined)	**A1**
	OR The ratio of the left pair of resistances will equal the ratio of the right pair of resistances	**(A1)**

Question 34 — Mark Scheme

Question	Answer	Marks
7(a)	$R = \rho L / A$	C1
	$= (1.12 \times 10^{-6} \times 1.5) / 2.45 \times 10^{-7}$	C1
	$= 6.86\ \Omega$	A1
7(b)(i)	(A method where the) reading (on the galvanometer) is zero.	B1

Question	Answer	Marks
7(b)(ii)	e.m.f. / 1.2 = 64 / 150	C1
	e.m.f. = (64 / 150) × 1.2 = 0.51 V	A1
7(b)(iii)	(the internal resistance will cause a) drop in p.d. across the wire / the terminal p.d. is lower	B1
	So the null point will move to the right	B1

Question 35 — Mark Scheme

Question	Answer	Marks
5(a)(i)	temperature decreases, resistance decreases	**B1**
5(a)(ii)	line from origin with decreasing gradient drawn in first quadrant or line from origin with decreasing gradient drawn in third quadrant	**M1**
	line drawn in the third or first quadrant of similar composition (straight line from origin followed by correct curve) and similar size as compared by eye to the first line	**A1**
5(b)(i)	$E = P / I$ $= 18 / 1.5$	**C1**
	$= 12$ V	**A1**
5(b)(ii)	$I = 3.3 - 1.5$ $= 1.8$	**C1**
	$I = Anvq$ $1.8 = 1.4 \times 10^{-9} \times 3.4 \times 10^{28} \times v \times 1.6 \times 10^{-19}$	**C1**
	$v = 0.24$ m s^{-1}	**A1**

Question 36 — Mark Scheme

Question	Answer	Marks
6(a)	$2.4 / 6.0 = 8 / (R + 8)$	C1
	$R = 12\ \Omega$	A1
	or $I = 2.4 / 8$ $= 0.30$ $R = (6 - 2.4) / 0.3$ or $R = (6 / 0.3) - 8$	(C1)
	$R = 12\ \Omega$	(A1)
6(b)	$V = I(\rho L / A)$ **or** $V = IR$ **and** $R = (\rho L / A)$	M1
	I, ρ, A are constant (so $V \propto L$)	A1
6(c)(i)	$V_{XP} / V_{XY} = L_{XP} / L_{XY}$ $E / 2.4 = 1.24 / 2.00$	C1
	$E = 1.5$ V	A1
6(c)(ii)	p.d. across XY / wire increases / p.d. across XP increases	M1
	so P moved towards X / away from Y / to the left	A1

Question 37 — Mark Scheme

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Question	Answer	Marks
5(a)	sum of current(s) into junction = sum of current(s) out junction **or** (algebraic) sum of current(s) at a junction is zero	**B1**
5(b)(i)	line with negative gradient	**C1**
	line from 0 °C to 100 °C, starting at (0, R_0) with negative gradient throughout and never reaching $R = 0$	**A1**
5(b)(ii)	(resistance of T decreases so) total resistance (of circuit) decreases	**B1**
	current in cell increases (so p.d. across internal resistance increases)	**B1**
	terminal p.d. decreases (and resistance of R is constant) so current in R decreases	**B1**
5(c)(i)	p.d. across r $= 1.50 - (6.00 \times 0.200)$ $(= 0.30\ \text{V})$	**C1**
	current in cell $= 0.30 / 0.12$ $= 2.5\ \text{A}$	**A1**
5(c)(ii)	current in thermistor $= 2.5 - 0.200$ $(= 2.3\ \text{A})$	**C1**
	resistance of T $= (6.00 \times 0.200) / 2.3$ $= 0.52\ \Omega$	**A1**

Question 38 — Mark Scheme

Question	Answer	Marks
5(a)	sum of current(s) into junction = sum of current(s) out junction **or** (algebraic) sum of current(s) at a junction is zero	**B1**
5(b)(i)	$(V=)\ E - Ir$	**C1**
	$(V=)\ 5.0 - (38 \times 10^{-3} \times 4.7) = 4.8$ (V)	**A1**
5(b)(ii)	$R_{(Z)} = 120\ \Omega$	**C1**
	$I_2 = 38 \times 10^{-3} - (4.8 / (100 + 120))$	**C1**
	$I_2 = 0.016$ A	**A1**
	or	
	$R_{(Z)} = 120\ \Omega$	**(C1)**
	$R_{(EXT)} = 4.8 / 38 \times 10^{-3}$ $(= 126\ \Omega)$ $1 / R_{(Y)} = 1 / 126 - 1 / (120 + 100)$ $(R_{(Y)} = 297\ \Omega)$ $I_2 = 4.8 / 297$	**(C1)**
	$I_2 = 0.016$ A	**(A1)**

Question	Answer	Marks
5(b)(iii)	$P = IV$ **or** $P = I^2R$ **or** $P = V^2 / R$	**C1**
	$P = 0.016 \times 4.8$ **or** $P = 0.016^2 \times (4.8 / 0.016)$ **or** $P = 4.8^2 / (4.8 / 0.016)$ $P = 0.077$ W	**A1**
5(b)(iv)	resistance of the LDR / Z increases (as light intensity decreases)	**B1**
	total resistance (of the circuit) increases **or** current in the battery decreases	**M1**
	(potential difference across the internal resistor decreases so) the terminal potential difference increases	**A1**

Question 39 — Mark Scheme

Question	Answer	Marks
5(a)	sum of current(s) into junction = sum of current(s) out junction **or** (algebraic) sum of current(s) at a junction is zero	**B1**
5(b)(i)	line with negative gradient	**C1**
	line from 0 °C to 100 °C, starting at (0, R_0) with negative gradient throughout and never reaching $R = 0$	**A1**
5(b)(ii)	(resistance of T decreases so) total resistance (of circuit) decreases	**B1**
	current in cell increases (so p.d. across internal resistance increases)	**B1**
	terminal p.d. decreases (and resistance of R is constant) so current in R decreases	**B1**
5(c)(i)	p.d. across r $= 1.50 - (6.00 \times 0.200)$ $(= 0.30\ V)$	**C1**
	current in cell $= 0.30 / 0.12$ $= 2.5\ A$	**A1**
5(c)(ii)	current in thermistor $= 2.5 - 0.200$ $(= 2.3\ A)$	**C1**
	resistance of T $= (6.00 \times 0.200) / 2.3$ $= 0.52\ \Omega$	**A1**

Question 40 — Mark Scheme

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Question	Answer	Marks
5(a)(i)	potential difference per unit current	B1
5(a)(ii)	resistor connected to cell in a closed loop **and** correct circuit symbols used for all components	B1
	ammeter connected in series with resistor **and** voltmeter connected in parallel with resistor	B1
5(b)(i)	(resistance) = 1.38 / 0.276 = 5.00 (Ω)	A1
5(b)(ii)	$\rho = RA / L$	C1
	$\rho = 5.00 \times \pi \times (0.496 \times 10^{-3})^2 / (4 \times 0.864)$	C1
	$= 1.12 \times 10^{-6}\ \Omega\,m$	A1
5(b)(iii)	calculation of a fractional or percentage uncertainty in one quantity 0.001 / 0.864 **or** 0.002 / 0.496 **or** 0.02 / 1.38 **or** 0.001 / 0.276	C1
	percentage uncertainty = [(0.001 / 0.864) + (2 × 0.002 / 0.496) + (0.02 / 1.38) + (0.001 / 0.276)] × 100 = 2.7%	A1
5(b)(iv)	$\Delta\rho = 0.03 \times 1.12 \times 10^{-6}$ $= 3 \times 10^{-8}\ \Omega\,m$	A1

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