

The maximum mark for this paper is **60**.

SPECIMEN

Section A		
Question Number	Answer	Max Mark
1	$C s^{-1} \checkmark$; $V A^{-1} \checkmark$; $J C^{-1} \checkmark$	[3]
2(a)	B \checkmark	[1]
(b)	$(1.6-0.4) / 80 = 0.015$; $V \text{ } ^\circ C^{-1}$ ($15 \text{ mV } ^\circ C^{-1}$) \checkmark evaluation ; \checkmark unit	[2]
3(a)	410 ± 20 (m pixel ⁻¹) \checkmark	[3]
(b)	21 ± 2 (km) \checkmark	
(c)	Allow any response which suggests any reasonable impact of global warming or Antarctic ice-shelf loss on people, which could be environmental, demographics or academic /scientific. \checkmark e.g. evidence of global warming / sea levels rising / flooding lowlands / population movements / refugees .	
4(a)(i)	50 ± 1 (μs) \checkmark	[1]
(ii)	$\{20 \pm 0.4\} \times 10^3$ (Hz) ecf consistent with (i) \checkmark	[1]
(b)	Identifying no of bits /sample = 3 & samples /s = 10^6 \checkmark 3×10^6 \checkmark	[2]
5	$\log_2(3.0/0.5) = 2.58$ so 2 is the maximum number \checkmark Allow reverse argument & trial and error using $2^n = 3.0/0.5$	[1]
6	strength \checkmark ; hardness \checkmark	[2]
7	Combines $P=IV$ & $R=V/I$ or recalls $P=V^2/R$ \checkmark $V = \sqrt{P R}$ / $= \sqrt{0.5 \times 470}$; $= 15.3$ (V) \checkmark	[2]
8	Accept 12.3 (mean) with no calculation shown. If 12.5 given, either justification for choice of mode should be present or calculation of median; \checkmark \pm in range 1 to 2 (N) ; \checkmark 3 rd mark for 3 s.f. in estimate and 1 S.F in uncertainty. \checkmark .	[3]
Total section A :		[21]
9(a)(i)	F where rays parallel to principal axis meet \checkmark	[1]
(ii)	F would be image position if lamp were at very distant/ object fairly close to lens so image outside focal length owtte \checkmark QWC: spelling, punctuation & grammar \checkmark	[2]
(b)(i)	1 line through points and 2 through uncertainty bars \checkmark	[1]
(ii)	intercept best estimate 0.10 m by eye \checkmark range 0.095 to 0.105 m \checkmark lower limit should be > 0.090 , < 0.10 ; upper limit should be > 0.10 , < 0.11 If graphs drawn inaccurately, allow values consistent with actual lines providing the lines are actually straight.	[2]
(c)(i)	it is the closest to the lens a real image can be formed / object at ∞ needed for $1/v = 1/f$ / to give incoming waves zero curvature AW \checkmark NOT $h = 0$ NOT $v = f$ unless explained clearly, e.g. when image is a point when the object is at infinity.	[1]

Section B		
Question Number	Answer	Max Mark
(ii)	$P = 1/f \quad \checkmark = 1/0.1 = 10.0 \text{ D} \quad \checkmark$ uncertainty method using $\pm 5\%$ or least or most intercept \checkmark uncertainty evaluation $\pm 0.5 \text{ D} \quad \checkmark$ Allow calculation of P for extreme values of horizontal intercept and subtraction to give uncertainty provided that it is 1S.F.	[4]
	Total	[11]
10(a)	R decreases / falls / drops as T increases \checkmark Mathematical description of the change \checkmark , e.g. change in resistance per degree gets less and less as T increases, or increase in temperature needed for R to half gets smaller, or quantitative comparisons to the same effect, e.g. R drops by 100Ω in 5° to start with but by the end it's dropping by only about 10Ω in 5°C . Sensitivity is the change in the measured variable owtte per unit change in the independent variable owtte; is greater at low temperatures \checkmark for the mark it is essential that both the idea of sensitivity as gradient of the graph and the decrease in sensitivity with T are described.	[4]
(bi)	connections in parallel with fixed resistor \checkmark	[1]
(ii)	$R_{\text{Thermistor}} = 100 \pm 5 \Omega \quad \checkmark$ (evidence from graph) $R_{\text{Total}} = 200 + R_{\text{Thermistor}} (\Omega) = 300 \Omega$; ecf \checkmark $I = (V/R_{\text{Total}}) = 6 / R_{\text{Total}} = 0.02 \text{ A} \quad \checkmark$ (conversion to mA not required)	[3]
(c)(i)	X \checkmark	[1]
(ii)	advantage (near) constant sensitivity / linear (output) \checkmark NOT "just" straight line disadvantage less sensitive (over most of range) / range of voltages is small / battery lasts for less time \checkmark allow AW or other sensible quality physics	[2]
	Total	[11]
11(a)(i)	student choice sets appropriate context – no marks (0)	
(ii)	long so resistance large enough / conductance small enough to measure \checkmark thin <u>so smaller cross sectional area</u> and therefore resistance is larger/ conductance is smaller \checkmark OR reasonable current at low p.d. in each case, but both must be justified separately.	[2]
(iii)	correct circuit diagram (circuit with A and V meters (accept Ω meter) \checkmark Clear method to include measurement of L and d of wire \checkmark Description of calculation of resistivity / conductivity \checkmark	[3]

Section B		
Question Number	Answer	Max Mark
(b)	identify systematic error / source of greatest random uncertainty ✓ suggest reasonable solution ✓ e.g. small resistance for good conductor needing thin long wire with difficulty in measuring diameter ✓ ,use of micrometer / Vernier caliper [accept repeated readings and averaging] ✓ e.g. contact resistance at wire ends results in voltage drops (inside voltmeter loop) ✓ solder connections/ make firmer voltmeter contacts ✓ QWC: appropriate form and style ✓	[3]
(c)	p.d. <u>and</u> current ✓ (allow resistance if Ω meter used in (a)(iii))	[1]
	Total	9
12(a)	$20 \text{ (nm)} / 14 = 1.4 \times 10^{-9} \text{ m}$ accept 1 nm Method ✓ ; evaluation ✓ Allow count of molecules 13 or 15, giving $d = 1.5 \text{ nm}$ and 1.3 nm respectively. If a bald '1nm' is given with no working, give one mark only. Correct answer with 4 or more S.F. gets one mark only	[2]
(b)(i)	$V = 4 \pi (0.50 / 2)^3 / 3 ; = 0.065 \text{ mm}^3 \approx 0.07 \text{ mm}^3$ substitution ✓; evaluation ✓ Calculating $4 \pi (0.50)^3 / 3 = 0.52 \text{ mm}^3$ gets evaluation ✓ only. Correct expression followed by 0.07 mm^3 without clear evaluation of V (i.e. to at least 2 SF) gets substitution ✓ only	[2]
(ii)	$(300 + 280 + 280 + 260) / 4 = (1120) / 4 = 280 \text{ mm}$ accept bare answer	[1]
(iii)	$A = \pi (280 / 2)^2 ; = 6.2 \times 10^4 \text{ mm}^2$ ✓ ecf on (ii) $h = V/A = 0.065 / (6.2 \times 10^4) \text{ mm}$ substitution ✓ $= 1.0 \times 10^{-6} \text{ mm} = 1.0 \times 10^{-9} \text{ m}$ evaluation ✓ Accept answers in e.g. mm if correct, and correct prefix is put before m on answer line.	[3]
	Total	8
	Total Section B	[39]
	Paper Total	[60]