Measurement Techniques

Mark Scheme 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Measurement Techniques
Sub Topic	
Paper Type	Theory
Booklet	Mark Scheme 1

Time Allowed: **89 minutes**

Score: **/74**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1	**(a**	pressure = force / area (normal to the force) [clear ratio essential]	B1	[1]
	(b) (i)	$P = mg / A = (5.09 \times 9.81) / A$	C1	
		$A = (\pi d^2 / 4) = \pi \times (9.4 \times 10^{-2})^2 / 4$ (= 0.00694 m^2)	C1	
		$P = 49.93 / 0.00694$ = 7200 (7195) Pa (minimum of 2 s.f. required)	A1	[3]
	(ii)	$\Delta P / P = \Delta m / m + 2\Delta d / d$	C1	
		= 0.01 / 5.09 + (2 × 0.1) / 9.4 (= 0.0020 + 0.021 or 2.3%)	C1	
		ΔP = 170 (165 to 167) Pa		[3]
	(iii)	P = 7200 ± 200 Pa		[1]
2	**(a**	$\rho = m / V$ $V = (\pi d^2 / 4) \times t = 7.67 \times 10^{-7}\ m^3$ $\rho = (9.6 \times 10^{-3}) / [\pi(22.1/2 \times 10^{-3})^2 \times 2.00 \times 10^{-3}]$ $\rho = 12513\ kg\ m^{-3}$ (allow 2 or more s.f.)	C1 C A1	[3]
	(b) (i)	$\Delta\rho / \rho = \Delta m / m + \Delta t / t + 2\Delta d / d$	C1	
		= 5.21% + 0.50% + 0.905% [or correct fractional uncertainties]	C1	
		= 6.6% (6.61%)	A1	[3]
	(ii)	$\rho = 12\,500 \pm 800\ kg\ m^{-3}$	A1	[1]

3	**(a**	SI units for T: s, R: m and M: kg (or seen clearly in formula)	C1	
		$K = T^2 M / R^3$ units: s^2 kg m^{-3} (allow s^2 kg / m^3 or $\frac{s^2 kg}{m^3}$)	A1	[2]
	(b)	% uncertainty in K: 1% (for T) + 3% (for R) + 2% (for M) OR = 6%	C1	
		$K = [(86400)^2 \times 6 \times 10^{24}] / (4.23 \times 10^7)^3 = 5.918 \times 10^{11}$	C1	
		6% of $K = 0.355 \times 10^{11}$	C1	
		$K = (5.9 \pm 0.4) \times 10^{11}$ (SI units) correct power of ten required for both	A1	[4]
		[incorrect % value then max. 1]		
4	**(a**	resistance = potential difference / current	B1	[1]
	(b) (i)	metal wire in series with power supply and ammeter	B1	
		voltmeter in parallel with metal wire	B1	
		rheostat in series with power supply or potential divider arrangement or variable power supply	B1	[3]
	(ii)	**1.** intercept on graph	B1	[1]
		2. scatter of readings about the best fit line	B1	[1]
	(iii)	correction for zero error explained	B1	
		use of V and corrected I values from graph	C1	
		resistance = V/I = 22.(2)Ω [e.g. 4.0 / 0.18]	A1	[3]
	(c)	R = 6.8 / 0.64 = 10.625	C1	
		$\%R = \%V + \%I$		
		= (0.1 / 6.8) × 100 + (0.01 / 0.64) × 100	C1	
		= 1.47% + 1.56%		
		ΔR = 0.0303 × 10.625 = 0.32 Ω		
		R = 10.6 ± 0.3 Ω	A1	[3]

5 **(a)** $\frac{V}{t} = \frac{\pi P r^4}{8 C l}$

C = [π × 2.5 × 10^3 × (0.75 × 10^{-3})^4] / (8 × 1.2 × 10^{-6} × 0.25) C1

= 1.04 × 10^{-3} N s m^{-2} A1 [2]

(b) 4 × %r C1

%C = %P + 4 × %r + %V/t + %l

= 2% + 5.3% + 0.83% + 0.4% (= 8.6%) A1

ΔC = ± 0.089 × 10^{-3} N s m^{-2} A1 [3]

(c) C = (1.04 ± 0.09) × 10^{-3} N s m^{-2} A1 [1]

6 **(a (i)** metre rule / tape (*not 'rule'*) B [1]

(ii) micrometer (screw gauge) / digital caliper B1 [1]

(iii) ammeter and voltmeter / ohmmeter / multimeter on 'ohm' setting B1 [1]

(b) (i) resistivity = RA / L C1

= [7.5 × π × (0.38 × 10^{-3})^2 / 4] / 1.75 M1

= 4.86 × 10^{-7} Ω m A0 [2]

(ii) (uncertainty in R =) [0.2 / 7.5] × 100 = 2.7%

<u>and</u> (uncertainty in L =) [3 / 1750] × 100 = 0.17% C1

(uncertainty in A =) 2 × (0.01 / 0.38) × 100 = 5.3 % C1

total = 8.13% C1

uncertainty = 0.395 × 10^{-7} (Ω m) A1 [4]

(*missing 2 factor in uncertainty in A, then allow max 3/4*)

(c) resistivity = (4.9 × 10^{-7} ± 0.4 × 10^{-7}) Ω m A1 [1]

7	**(a**	2nd row random, 3rd row neither, 4th row systematic all correct two correct scores 1 only	B2	[2]
	(b) (i)	**1.** systematic error: the average / peak is not the true value / the readings are not centred around the true value	B1	[1]
		2. random error: readings have positive and negative values around the peak value / values are scattered / wide range	B1	[1]
	(ii)	**1.** accurate: peak / average value moves towards the true value	B1	[1]
		2. precise: lines are closer together / sharper peak	B1	[1]

8	connect microphone / (terminals of) loudspeaker to Y-plates of c.r.o.	B1	
	adjust c.r.o. to produce steady wave of 1 (or 2) cycles / wavelengths on screen	B1	
	measure length of cycle / wavelength λ and note time-base b	M1	
	frequency = $1 / \lambda b$	A1	[4]
	(*assume b is measured as s cm^{-1}, unless otherwise stated*)		
	(if statement is 'measure T, f = 1/T' then last two marks are lost)		

9	**(a)**	acceptable straight line drawn (touching every point)	B1	[1]
	(b)	the distance fallen is not d	C1	
		d is the distance fallen plus the diameter of the ball	A1	[2]
		('d is not measured to the bottom of the ball' scores 2/2)		
	(c) (i)	diameter: allow 1.5 ± 0.5 cm (accept one SF) no ecf from **(a)**	A1	[1]
	(ii)	gradient = 4.76, ± 0.1 with evidence that origin has not been used	C1	
		gradient = g / 2	C1	
		g = 9.5 m s^{-2}	A1	[3]

10	**(a)**		micrometer/screw gauge/digital callipers …….	B1	[1]
	(b)	**(i)**	look/check for zero error …….	B1	[1]
		(ii)	take several readings ……..	M1	
			around the circumference/along the wire …….	A1	[2]

11	**(a**	**(i)**	1% of ±2.05 is ±0.02	A1	[1]
		(ii)	max. value is 2.08 V	A1	[1]
	(b)		there may be a zero error/calibration error/systematic error	M1	
			which makes all readings either higher or lower than true value	A1	[2]