JC2 Prelims P4 2024

Qns	Marking Instructions	Skill	Mark
1(a)(i)	l_0 = 2.1 cm (accept 1.9 cm to 2.2 cm) Recording of l_0 to the nearest 0.1 cm.	**MMO**	1
1(a)(ii)	l_1 = 14.1 cm ($l_1 - l_0$) = 12.0 cm Calculation of ($l_1 - l_0$)to the nearest 0.1 cm	**MMO**	1
1(a)(iii)	k = (0.300)(9.81) / 0.120 = 24.5 N m^{-1} or kg s^{-2} k calculated correctly with correct units	**PDO**	1
1(b)(i)	x = 40.0 cm number of oscillations N = 55 t_1 = 21.36 s t_2 = 21.41 s t_{avg} = 21.39 s $T = t_{avg}$ / N = 21.385 / 55 = 0.3888 s Total timing > 20 s Show evidence of repeat	**PDO**	1
1(b)(ii)	$\Delta t \approx$ 0.2 to 0.5 s percentage uncertainty of $T = \Delta T / T = \Delta t / t$ = 0.3 / 21.39 = 1.4% (1sf or 2sf only)	**PDO**	1
1(b)(iii)	2 marks for 6 sets of data without assistance and x > 35 cm 1 mark for column headings correctly labelled 1 mark for raw values to appropriate dp • x to the nearest 0.1 cm • t to the nearest 0.01 s 1 mark for calculated values to appropriate sf	**PDO**	5
1(b)(iv)	For graph plotting • 1 mark for axes labelled and appropriate scale used • 1 mark for points plotted correctly • 1 mark for line of best fit For calculation of C and D • 1 mark for linearisation statement • 1 mark for gradient triangle drawn, coordinates recorded to the nearest half square and D calculated with correct units (s^2 m^{-2} or s^2 cm^{-2}) • 1 mark for y-intercept calculated and C determined with correct units (s^2)	**ACE**	6

<table>
<tr><td>1(c)</td><td><u>difficult to count</u> the number of oscillations when the <u>frequency is too high</u> / <u>period is too short</u>.</td><td>MMO</td><td>1</td></tr>
<tr><td>1(d)</td><td>Line W with steeper gradient and not crossing the original line, because it is supposed to have the same y-intercept.</td><td>ACE</td><td>1</td></tr>
<tr><td>1(e)</td><td>• 1 mark for table heading correct and displaying 2 sets of data for number of springs and period. x and m must be kept constant.

Since k is inversely proportional to T, proportionality constant is kT. If k is indeed inversely proportional to T, then kT should remain relatively constant. Its variation should only be caused by uncertainties in k and T.

○ Example of table:
<table>
<tr><td>k/Nm^{-1}</td><td>n</td><td>nT$_1$/s</td><td>nT$_2$/s</td><td>T/s</td><td>kT/ Nsm^{-1}</td></tr>
<tr><td>24.5</td><td>45</td><td>22.95</td><td>23.10</td><td>0.5117</td><td>12.5</td></tr>
<tr><td>12.3</td><td>35</td><td>23.76</td><td>23.72</td><td>0.6783</td><td>8.34</td></tr>
</table>
• 1 mark for calculating the percentage difference of kT
• 1 mark for making comparison to percentage uncertainty in T and presenting valid conclusion</td><td>ACE</td><td>3</td></tr>
</table>

Total: 21 marks

Qns	Marking Instructions	Skill	Mark
2(a)(ii)	I = 65.3 mA Value of I in range of $50\text{ mA} \le I \le 80\text{ mA}$ AND to nearest 0.1 mA with unit.	**MMO**	1
2(b)(i)	L = 25.0 cm Value of L in range of $24.5\text{ cm} \le L \le 25.5\text{ cm}$ AND to nearest 0.1 cm with unit	**MMO**	1
	I = 62.4 mA Value of I in range of $50\text{ mA} \le I \le 80\text{ mA}$ AND to nearest 0.1 mA with unit.	**PDO**	
2(b)(ii)	Percentage uncertainty of $I = \frac{0.1}{62.4} \times 100 = 0.16\ \%$ Percentage uncertainty between 0.13% and 0.20%.	**PDO**	1

Qns	Marking Instructions	Skill	Mark
2(c)(i)	**MMO** • Award 1 mark if candidate has successfully collected 8 or more sets of data *(t, I)* without assistance/intervention. • Award zero mark if candidate has successfully collected 7 or fewer sets of data (*t, I)* without assistance/intervention. • Deduct 1 mark if candidate requires some assistance/intervention but has been able to do most of the work independently. **PDO** Layout: column headings (raw data I and *t).* Each column heading must contain a quantity and unit. **PDO** All values of *L*, I and 1/I to the correct precision. (1 d.p. for *L* in cm, 1 d.p. for I in mA and 3 s.f. for 1/I).	**MMO** **PDO** **PDO**	1 1 1
2(c)(ii)	All points in table plotted to half-square accuracy. Correct trendline.	**ACE**	1
	Judge by balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	**ACE**	1
2(d)	Values for *a* (–3.60 $m^{-2}A^{-1}$) and *b* (15.5 A^{-1}) correctly calculated to 3 s.f. with consistent units **(1 mark for *a* and 1 mark for *b*)**	**ACE**	2
2(e)(ii)	Point M correctly plotted and labelled with a marking different from those used in plotting data points	**ACE**	
2(e)(iii)	Percentage difference in the value of $\frac{1}{I}$ corresponding to the point M and the point on the best-fit curve at L = 50.0 cm (to 2 s.f.).	**PDO**	1
	Percentage uncertainty from **(b)(ii)** to 2 s.f.	**PDO**	
	Valid comparison (max 1 mark if comparison missing/incorrect)	**MMO**	1

Total: 12 marks

Qns	Marking Instructions	Skill	Mark
3(a)	Value of *h* to nearest 0.01 mm with unit. Repeated readings shown. AND $4.11\ \text{mm} \le h \le 5.88\ \text{mm}$	**MMO**	1
3(b)	Value of *W* to nearest 0.1 N with unit. AND $1.8\ \text{N} \le W \le 2.2\ \text{N}$	**MMO**	1
3(c)(i)	Clear demonstration of **diameter** measurement for *r.* Repeated readings shown. $3.68\ \text{cm} \le d \le 3.80\ \text{cm}$ $1.84\ \text{cm} \le r \le 1.90\ \text{cm}$	**MMO**	1
3(c)(ii)	Correct calculation of α with working.	**PDO**	1
3(c)(iii)	2 or 3 depending on justification based on s.f. in r and h or ($r - h$). s.f or r ,h and ($r - h$) must be referenced in the answer.	**PDO**	
3(d)	Repeated readings of *F* with unit.	**MMO**	
3(e)	Correct values of *W*, *r* and α. Repeated readings for W, D, r, F are to be shown. $0.8\ \text{N} \le W \le 1.2\ \text{N}$ $1.55\ \text{cm} \le r \le 1.60\ \text{cm}$ $38.6° \le \alpha \le 47.4°$ $3.10\ \text{cm} \le d \le 3.14\ \text{cm}$	**MMO**	1
	2nd *F* smaller than first		
3(f)	Method to measure *F* e.g. replace newton meter with force sensor connected to data logger (accept if analogue newton meter is re-used)		1
	Method to measure normal contact force e.g. support weight of masses with platform force sensor / strain gauge sensor connected to same data logger. (accept digital mass balance)		1

Qns	Marking Instructions	Skill	Mark
	Procedure: record both *F* and normal contact force (N) at intervals until roll e.g. Start data logger to log both sensors simultaneously. Slowly and steadily increase the pull on the force sensor until the platform newton meter reads zero.		1
	Keep *h* constant by using same board, *W* and *r* constant using same slotted mass - No marks awarded if more masses are used.		1
	If relationship is true, plot of normal contact force against *F* is a straight line passing through origin - Mark can only be awarded if procedure to record F and N at intervals is correct.		1

Total: 10 marks

Qns	Marking Instructions	Skill	Mark
	Comments: This question was generally quite well done. Students are to take note not to have floating equipment, retort stands are to be used if relevant and to label the diagram clearly including the bench/table top. They are also encouraged to write symbols clearly in both their diagram and procedure for the required quantities. There were a number of students who included replacing the sample with a fresh one, seemingly not understanding that the decay will still take place even regardless of whether or not it was used for the experiment.		
4	**Equipment**		
	Labelled diagram of workable equipment on bench including • Radioactive sample placed directly in front of GM tube's front plate.		A1
	• Distance *d* labelled and shown		B1
	Use metre rule / measuring tape to measure *d*		C1
	Use micrometer screw gauge / vernier calipers to measure *t*		D1
	Use GM tube and ratemeter to measure C		
	Variables		
	While keeping *d* constant, *t* is the independent variable and *C* is the dependent variable or vary *t* and measure *C*.		E1
	While keeping *t* constant, *d* is the independent variable and *C* is the dependent variable or vary *d* and measure *C*.		
	Keep the amount of strontium-90 the same		F1
	Procedure		
	Comments: Students are reminded to write their procedure in point form and to state clearly what steps to repeat and how to vary certain quantities instead of assuming that it is immediately clear.		
	1. Set up apparatus as shown in the diagram.		
	2. Conduct preliminary readings to determine the range of distances *d* and thicknesses *t* of front plates that will give a measurable difference in the count rate *C*.		
	3. Set radioactive sample at distance *d* away from front plate of GM tube. Measure distance *d* with metre rule or measuring tape.		
	4. Measure the thickness *t* of front plate with vernier caliper or micrometer screw gauge.		
	5. Measure the corresponding count rate on GM tube via ratemeter.		
	6. While keeping thickness *t* constant, repeat step 3-5 for <u>at least 6 distances *d*</u> by moving sample away perpendicularly from front plate and measure the corresponding value of *C*.		

Qns	Marking Instructions	Skill	Mark
	7. Plot a graph of ln *C* against ln *d, M* is the gradient. ($lnC = M\,lnd + lnkt^N$)		G1
	8. While keeping distance *d* constant, repeat step 3-5 by using at least 6 different front plates of different thickness *t* and measure the corresponding value of *C*.		H1 Only award if both step 6 and 8 were included
	9. Plot a graph of ln *C* against ln *t, N* is the gradient. ($lnC = N\,lnt + lnkd^M$)		J1
	Safety and Accuracy		Max: 3
	Comments: For safety procedures, students are reminded not to exaggerate their response and to keep to standard laboratory safety practices. For repeating of certain procedures, they should give ample details to make clear how they are done.		
	S1: Precaution linked to radioactive samples., e.g. handle radioactive material with tongs and wear gloves to prevent contact with radioactive sample / ensure hands are thoroughly washed to remove residual.		
	A2: Preliminary Results: Determine the range of distances *d* and thicknesses *t* of front plates that will give a measurable difference/ range in the count rate.		
	A3: Check for background radiation and subtract from count rate		
	A4: Repeat the measurement for C at different angle from the sample and average / take readings of *C* at equal time intervals and find average		
	A5: Set the gain setting on rate meter to an appropriate range that gives sufficiently high counts.		
	A6: Repeat measurement for *t* at different positions.		
	A7: Means to check that sample is always perpendicular from front plate of GM tube. (e.g. a straight line drawn between sample and tube and use of set square.		
	A8. Ensure no unintended shielding or sources of interference (other radioactive materials)		

Total: 12 marks