Rewarding Learning

ADVANCED
General Certificate of Education
2015

Physics

Assessment Unit A2 1

assessing

Momentum, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

[AY211]

TUESDAY 19 MAY, MORNING

MARK SCHEME

Subject-specific Instructions

In numerical problems, the marks for the intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the final correct answer. A correct answer and unit, if obtained from a valid starting-point, gets full credit, even if all the intermediate steps are not shown. It is not necessary to quote correct units for intermediate numerical quantities.

Note that this "correct answer" rule does not apply for formal proofs and derivations, which must be valid in all stages to obtain full credit.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, **in a physically incorrect equation**. However, answers to subsequent stages of questions that are consistent with an earlier incorrect numerical answer, and are based on physically correct equation, must gain full credit. Designate this by writing **ECF** (Error Carried Forward) by your text marks.

The normal penalty for an arithmetical and/or unit error is to lose the mark(s) for the answer/unit line. Substitution errors lose both the substitution and answer marks, but 10^n errors (e.g. writing 550 nm as 550×10^{-6} m) count only as arithmetical slips and lose the answer mark.

						AVAILABLE MARKS
1	**(a)**	**(i)**	Finds ave t = 29.4 s (or finds correct ave of 3 angular velocities)	[1]		
			Uses $\omega = \frac{\theta}{t}$ Eqn or subs	[1]		
			1.07 rad s^{-1}	[1]	[3]	
		(ii)	Subs into v = rω	[1]		
			2.68 m s^{-1}	[1]	[2]	
			ecf: their **(i)** × 2.5			
	(b)		Ball already has velocity (at a tangent to the circle) when it is thrown	[1]		
			Resultant of the two velocities will cause the ball to move at an angle	[1]	[2]	
	(c)	**(i)**	In an isolated system/provided no external forces act	[1]		
			Total momentum before collision = total momentum after	[1]	[2]	
		(ii)	Calculates resultant velocity of ball = 6.75	[1]		
			ecf: $\sqrt{6.2^2 + (\text{their } \mathbf{(a)(ii)})^2}$			
			Uses principle of conservation of momentum	[1]		
			Subs: 1.1 × 6.75 = 26.1 v	[1]		
			v = 0.28 m s^{-1}	[1]	[4]	
			SE 1: using velocity of 6.2 for ball gives 0.26 scores [3]/[4]			
			SE 2: using mass of 25 after gives 0.30 scores [3]/[4]			
			SE 3: making both mistakes with v and m gives 0.27 scores [2]/[4]			
			SE 4: using velocity of 2.68 for ball gives 0.11 scores [2]/[4]			13
2	**(a)**		pV = nRT or pV = NkT			
			$\left[\frac{pV}{T}\right.$ = constant, with terms explained [1]/[3]$\left.\right]$	[1]		
			Identifies all terms correctly ([–1] each omission, apply twice only)	[2]		
			V, n and (R) are constant	[1]		
			As T increases P increases	[1]	[5]	
	(b)	**(i)**	V = π $(0.025)^2$ × 0.15	[1]		
			V of can = 2.94 × 10^{-4} m^3 (any unit)	[1]		
			0.0131 moles (e.c.f. from their volume)	[1]	[3]	
			S.E. n = 0.053 [2]/[3]			
		(ii)	Subs into pV = nRT	[1]		
			1083 K	[1]		
			807 °C – Independent conversion e.c.f. T	[1]	[3]	
			(e.c.f. from V and n values)			
		(iii)	Number of molecules = N_A × n = 7.88 × 10^{21}	[1]		
			(ecf from n)			
			KE of each molecule = 2.22 × 10^{-20}	[1]		
			(e.c.f. from T but must be in K)			
			175 J	[1]	[3]	14
			or use of $KE_{(total)} = \frac{3}{2}$ pV			

AVAILABLE MARKS

3 (a) **Weight** and tension [1]
Magnitude is maximum at A and B; Magnitude zero at equilibrium [1]
Direction at A is downwards, direction at B is upwards or towards equilibrium position [1] [3]

Quality of written communication

2 marks
The candidate expresses ideas clearly and fluently, through well-linked sentences and paragraphs. Arguments are generally relevant and well-structured. There are few errors of grammar, punctuation and spelling.

1 mark
the candidate expresses ideas clearly, if not fluently. There are some errors in grammar, punctuation and spelling, but not such as to suggest weakness in these areas.

0 marks
The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage. [2]

(b) $a = -\omega^2 x$ [1]
$\omega = 1.57$ or $f = 0.25$ [1]
T = 4 s   e.c.f. ω – don't credit negative answers [1]

Subs into $x = A \cos \omega t$ [1]
A = 0.5 m (e.c.f. from their ω)   S.E. = 0.3 [1]/[2] for A [1]

Graph: Starting at max and at least 2 cycles shown [1]
Correct A and T (e.c.f. from their values) [1] [7]

(c) Both return to equilibrium position without oscillating/both lose energy [1]
Critically damped does so in quickest time possible. (Overdamped takes longer) [1] [2] 14

4 (a) Most alpha particles passed through (undeflected) [1]
Some were backscattered (through large angles) [1] [2]

(b) Activity required = 93 × 76 = 7068 kBq (or works out A_0 and × 76 at end) [1]
$\lambda = 0.693/11.4 = 0.0608$ day^{-1} (0.0025 hr^{-1}, 4.2×10^{-5} min^{-1}, 7×10^{-7} s^{-1}) [1]
Uses $A = A_0 e^{-\lambda t}$ – subs [1]
A_0 = 7398 kBq [1] [4]
(both gives 94 400 kBq → [2]/[4])
SE, use of 93 kBq as A gives 97 kBq scores [3]/[4]
SE uses 6 hours gives 7200 kBq scores [3]/[4]

(c) **(i)** Major grid lines going up in 10s [1]
(negative identified once only)

(ii) Plot ln A against t [1]
Gradient related to λ [1]
Half-life = –0.693/gradient [1] [3] 10

						AVAILABLE MARKS
5	(a)		Splitting up of a heavy/large nucleus into lighter/smaller nuclei	[1]		
			With the release of energy	[1]	[2]	
	(b)	(i)	144	[1]		
			92	[1]	[2]	
		(ii)	Mass diff = 0.1818 u	[1]		
			Conversion to kg = 3.01788×10^{-28} kg e.c.f. * for u	[1]		
			$E = mc^2$	[1]		
			2.716×10^{-11} J e.c.f. * for m	[1]		
			Conversion to eV = 1.7×10^8 eV e.c.f.* for E	[1]	[5]	
		(iii)	$478 \times 10^6 \div$ E in joules e.c.f. E	[1]		
			1.76×10^{19}	[1]	[2]	
	(c)	(i)	Heavy water (has a higher SHC so) can absorb more heat energy for the same temp rise/temp won't increase as much for same amount of heat energy added		[1]	
		(ii)	Subs: their Q in J from **(b)(ii)** = $1 \times 4228 \times \Delta\theta$	[1]		
			6.4×10^{-15} K (e.c.f. from their Q)	[1]	[2]	14
6	(a)	(i)	No long-lived radioactive waste More energy yield per kg Raw materials readily available Any **two**, [1] each		[2]	
		(ii)	Potential because fusion hasn't yet been achieved on a big enough scale to be viable	[1]		
			Achieving high enough temperature (for long enough time)	[1]	[2]	
	(b)	(i)	Charged		[1]	
		(ii)	Toroidal/doughnut shaped/Tokamak		[1]	
	(c)	(i)	Mass required would be much too large		[1]	
		(ii)	Inertial	[1]		
			Laser used (or ion beam)	[1]		
			Compresses or heats fuel pellet/plasma	[1]	[3]	10

						AVAILABLE MARKS
7	**(a)**	**(i)**	Draws tangent at θ = 40 °C	[1]		
			Calculates any gradient correctly or $d\theta/dt$	[1]		
			Quality = 0.43–0.53	[1]	[3]	
			Do not credit any answer without working out.			
		(ii)	Φ = constant ×	[1]		
			(Temp of body – temp of external environment)	[1]	[2]	
		(iii)	Axis labelled with units	[1]		
			Scale	[1]		
			Points correct [–1] each incorrect point	[2]		
			Best fit line	[1]	[5]	
		(iv)	Conclusion consistent with graph			
			Yes, straight line through origin		[1]	
	(b)		Straight line with negative gradient	[1]		
			$\ln \theta = \ln 90 - 0.012t$	[1]		
			y-axis cuts at 4.5 (ln 90)	[1]		
			x-axis cuts at 375 (ln 90/0.012)	[1]	[4]	15
			(Can assume 2nd mark if values correct)			
					Total	**90**