Rewarding Learning

ADVANCED
General Certificate of Education
2014

Physics

Assessment Unit A2 1

assessing

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

[AY211]

TUESDAY 20 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)**		$p = 1.06 \times 10^{-22}$		[1]	
	(b)		p(Pb) + p(α) = 0 or some statement of momentum conservation	[1]		
			mass of Pb = 51.5(mass α) or 206(1.66×10^{-27}) etc.	[1]		
			v = –305 to –311 (m s^{-1}) magnitude [1] and direction [1] accept "–"	[2]	[4]	
	(c)		Inelastic	[1]		
			KE not conserved	[1]	[2]	7
			(Elastic → [0]/[2])			
2	**(a)**	**(i)**	Diagram with labels to show:			
			the fixed mass of gas	[1]		
			the means of measuring and varying pressure	[1]		
			the means of measuring volume/length	[1]	[3]	
		(ii)	Temperature or volume should be constant	[1]		
			Either increase pressure slowly			
			or wait for a length of time before taking readings	[1]	[2]	
	(b)	**(i)**	Boyle's Law or pV = const. or pl = const.		[1]	
		(ii)	pV = nRT or Theoretical gradient = nRT/A = 97.1T	[1]		
			Actual gradient = 230/0.08 = 2875 kPa cm = 28 750 Pa m	[1]		
			T = 296 K ± 5 K	[1]	[3]	9
			(or stated correctly in °C)			
			S.E. Use of $\frac{1}{l}$ [–1]			
3			Q = 0.5 × 4190 × 6.9 = 14 455.5 J — subs or ans	[1]		
			Q/t = 14 455.5/(20 × 60) = 12.0 J s^{-1} — ecf Q	[1]		
			12.0 × 30 × 60 = 0.35 × 4190 × $\Delta\theta$ — sub	[1]		
			$\Delta\theta$ = 14.7 K — ecf Q/t	[1]		
			Temperature = 22 – 14.7 = 7.3°C — Ans	[1]	[5]	5
			S.E. → 12.1°C [3]/[5]			
4	**(a)**		$\omega = \theta/t = 100\pi/(36.3 \times 60)$ — eqn or subs	[1]		
			ω = 0.14 (rad s^{-1})	[1]	[2]	
	(b)		$r = 1.61 \times 10^3/(2\pi) = 256$ m — eqn or subs	[1]		
			$F = m\omega^2 r = 450(0.14)^2(256)$ — eqn or subs ecf (ω)	[1]		
			F = 2.3 kN — ans	[1]	[3]	5
			Penalise circumference/radius confusion once only in **(a)** and **(b)**			
5	**(a)**		The object executes simple harmonic motion	[1]		
			acceleration is proportional to displacement	[1]		
			acceleration acts in the opposite direction to the displacement	[1]	[3]	
	(b)	**(i)**	Fig. 5.1 T = 0.025 s	[1]		
			Fig. 5.2 grad = 20 000/0.32 or $a = -\omega^2 x$	[1]		
			ω = 250 rad s^{-1}	[1]		
			$T = 2\pi/250 = 0.025$ s ecf (ω)	[1]	[4]	
		(ii)	The amplitude (0.16 m) is the same on both graphs		[1]	8

						AVAILABLE MARKS
6	**(a)**	**(i)**	This is to determine the impact of the glass supporting plate on the results	[1]		
			Corrected effect = with foil – without foil	[1]	[2]	
		(ii)	Too many scintillations to count per minute		[1]	
		(iii)	The alpha source is radioactive	[1]		
			Results have to be adjusted up to compensate	[1]	[2]	
	(b)		Most α particles pass straight through or small number significantly deflected means most of atom is empty space/nucleus is small or massive	[1]		
			Backscattering	[1]		
			positive	[1]	[3]	8
7	**(a)**	**(i)**	It is not possible to know when a particular nucleus will decay Or similar		[1]	
		(ii)	It reduces at a rate proportional to its value/by a fixed fraction per unit time etc.		[1]	
	(b)	**(i)**	Generator of a random event, e.g. dice, random number generator, coin, burette and water, voltage across a capacitor	[1]		
			A large number ($\geqslant$ 100) events generated for first cycle	[1]		
			A particular outcome(s) designated as a decay Number of events generated (cycle 2) = number in cycle 1 – number of decays	[1]		
			Repeat for a number of cycles	[1]	[4]	
		(ii)	Graph (must have y-intercept) number of events against cycle number	[1]		
			Determine the time to fall by a certain fraction	[1]		
			Repeat (two more times) and the same time should be obtained if exponential	[1]		
			or			
			Calculate ln(number of events)	[1]		
			Graph ln(number of events) against cycle number	[1]		
			If exponential get a linear graph of negative slope	[1]	[3]	
	(c)		$\lambda = 0.693/51(\times 24 \times 3600) = 0.0136\ \text{day}^{-1} = (1.57 \times 10^{-7}\ \text{s}^{-1})$	[1]		
			$A_0 = 1.57 \times 10^{-7} \times N = 9.40 \times 10^{18}$ Bq subs or ans	[1]		
			$A = 9.27 \times 10^{18}$ (Bq)	[1]	[3]	12
8	**(a)**		Mass defect = 0.213 u	[1]		
			Mass defect = 3.54×10^{-28} kg ecf Δm in u	[1]		
			$E = \Delta mc^2 = 3.54 \times 10^{-28} \times (3.00 \times 10^8)^2$ eqn or subs	[1]		
			$E = 3.19 \times 10^{-11}$ (J)	[1]	[4]	
	(b)		1.00 kg = $1/(235.044 \times 1.66 \times 10^{-27}) = 2.56 \times 10^{24}$ nuclei subs or ans	[1]		
			$E = 8.18 \times 10^{13}$ ecf number nuclei and **(a)**	[1]	[2]	6

AVAILABLE MARKS

9 **(a)** Function: to absorb neutrons [1]
Movement: to sustain criticality and safety shutdown [1] [2]

(b) Fuel rods individually are subcritical mass/size
or Single mass would be supercritical mass/size [1]

(c) **(i)** To slow neutrons [1]
so U-235 absorb neutrons [1]

(ii) Coolant [$\frac{1}{2}$]
to remove thermal energy from reactor [$\frac{1}{2}$]
Round down [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 always 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] 8

10 **(a)** **(i)** Nuclei must be confined within a finite volume to increase the chance of collision [1]
with sufficient energy to overcome the electrostatic repulsion [1] [2]

(ii) (Gravitational confinement:) large mass (to confine and heat the fuel) [1]
(Inertial confinement:) fuel pellet bombarded by laser (ion) beam [1]
(Magnetic confinement:) magnetic bottle (tokamak) (heated electrically) [1] [3]

(b) $4.48 \times 10^{-14} = \frac{3}{2} \times 1.38 \times 10^{-23} \times T$ subs [1]
$T = 2.16 \times 10^{9}$ K [1] [2] 7

AVAILABLE MARKS

11 (a) Energy 6.77 MeV = 1.08×10^{-12} J   MeV →J   [1]

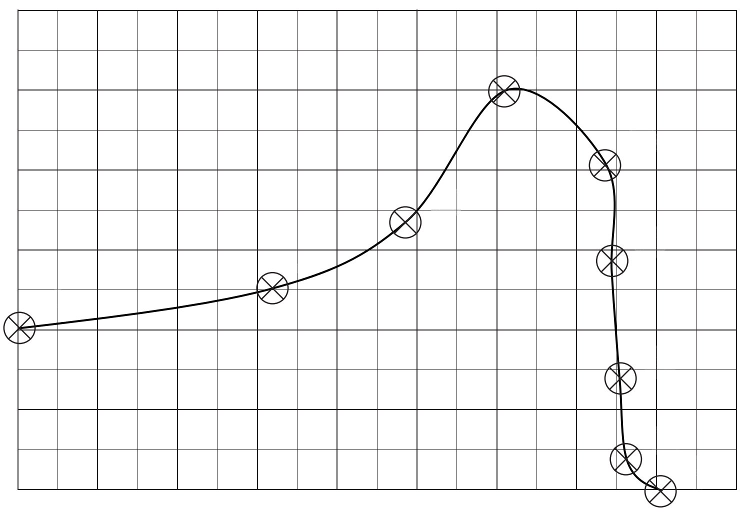
use of KE = $\frac{1}{2}mv^2$ [1]

$v = 1.81 \times 10^{7}$ (m s^{-1})   ecf energy   [1]

$a = R/v^3 = 56.8 \times 10^{-3}/(1.81 \times 10^{7})^3 = 9.64 \times 10^{-24}$ ecf v [1]   [4]

Penalty [–1] for using wrong isotope

(b) (i)



[1]

Penalty for drawing point-to-point with straight lines [–1]

(ii) 37.5 mm < Range < 39 mm   [1]

(iii) Ionisation efficiency increases as the alpha particle's velocity decreases to a certain value (after which it falls rapidly to zero)   [1]

(c) (i) mapping to y = mx + c   [1]

grad = 10 – (–3)/(39 – 30)
grad ~ 1.4   ans   } [1]

intercept calculated using their gradient and a point from the best-fit line   [1]

intercept ~ –45   ans   [1]   [4]

(ii) $\log 1.41 \times 10^{17} = 17.1$ ans   [1]

$-45 + 1.4(90/(4.27)^{\frac{1}{2}}) = 16.5$ subs   [1]

stating 17.2 ~ 16.0 therefore consistent   [1]

$\frac{17.1 - 16.5}{17.1} \times \frac{100}{1} = 3.5\%$ [1]   [4]   15

or

Z = 90   (92 – 2)

$\frac{\sqrt{4.27}}{1.4}(\log(1.4 \times 10^{17}) + 45) = 91.5$

stating 91.5 ~ 90

$\frac{91.5 - 90}{90} \times \frac{100}{1} = 1.7\%$

Using Z = 92   penalty [–1] only

Other alternatives are acceptable

Total   **90**