Rewarding Learning

ADVANCED
General Certificate of Education
January 2013

Physics

Assessment Unit A2 1

assessing

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

[AY211]

WEDNESDAY 16 JANUARY, AFTERNOON

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)	$\omega = 2\pi f = \theta/t = \frac{2\pi}{T}$	[1]		
			$= 160$ (rad s^{-1})	[1]	[2]	
		(ii)	0.039 (s) e.c.f. for ω		[1]	
		(iii)	$v = r\omega$	[1]		
			$= 6.4$ (m s^{-1}) e.c.f. for ω	[1]	[2]	
	(b)		$mg = mv^2/r$ [1] for either side, [1] for equating both	[2]		
			$v = (gr)^{0.5}$	[1]		
			$v = 34.9$ (m s^{-1})	[1]	[4]	9

2 (a) J kg^{-1} K^{-1} **or** m^2 s^{-2} K^{-1} allow °C
Amount of *energy* required to raise 1 kg of the *substance* by 1 K [2]

(b) Diagram includes container and insulation (lid), immersion heater, thermometer, water, stirrer, timer, circuit: Any three labelled points [1]
Procedure – switch on heater of known power (or include V and A) [1]
Time and temperature rise (of >15 °C) [1]
Mass of water [1]
(Use $c = Pt/m\Delta\theta$ or equivalent) correct equation [1] [5]

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]

(c) $160c(65 - 45) = mc(45 - 20)$ [1] for each side [2]
$m = 128$ (kg) [1] [3] — 12

						AVAILABLE MARKS
3	**(a)**	KE conserved (and momentum conserved)			[1]	
	(b)	**(i)** conservation of momentum equation: $400m = mV_m + 4mV_{4m}$		[1]		
		conservation of kinetic energy equation: e.g. $\frac{1}{2} \times m \times 400^2 = \frac{1}{2} mV_m^2 + 2mV_{4m}^2$		[1]	[2]	
		(ii) $V_m = -240$ (m s^{-1}), $V_{4m} = 160$ (m s^{-1})		[1]		
		Reasonable explanation, e.g. can't be other mathematically correct selection as it implies the objects pass through each other.		[1]	[2]	5
4	**(a)**	Acceleration proportional to distance from (fixed) point [1] and is towards point			[2]	
	(b)	**(i)**	**(1)** $a = -\omega^2 x$	[1]		
			$T = 1.80$ s **or** $\omega = 3.5$ rad s^{-1}	[1]		
			$f_0 = 0.56$ (Hz) e.c.f. ω **or** T	[1]	[3]	
			(2) $4 = A\cos 3.5(5.0)$ e.c.f. ω	[1]		
			A = 18 (cm)	[1]	[2]	
		(ii)	**(1)** Oscillate in water or equivalent		[1]	
			(2) Reduced natural frequency/oscillates for less time	[1]		
			Reduced amplitude	[1]	[2]	10
5	**(a)**	**(i)** Mass no. = 79		[1]		
		Radius of nucleon		[1]		
		Radius of nucleus ($= 1.2 \times 10^{-15}(79)^{\frac{1}{3}}$) $= 5.15 \times 10^{-15}$ m e.c.f. for "*A*"		[1]	[3]	
		(ii) $V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(5.15 \times 10^{-15})^3$ Eqn or subs		[1]		
		$V = 5.7 \times 10^{-43}$ e.c.f. for "*r*"		[1]	[2]	
		(iii) D = Am/V		[1]		
		$= 2(.35) \times 10^{17}$		[1]	[2]	
	(b)	$10^{15} - 10^{20}$			[1]	
		Close packing of particles within the nucleus/atom mostly empty space			[1]	9

						AVAILABLE MARKS
6	**(a)**	**(i)**	Time for activity to fall to half original value **or** equivalent		[1]	
		(ii)	Activity at time $t = t$ / Activity at time $t = 0$	[1]		
			Decay constant	[1]	[2]	
		(iii)	$\left(\text{Uses } \frac{1}{2}A_0 = A_0 e^{-\lambda t} \textbf{ or } A = \frac{A_0}{2} \textbf{ or } \ln 0.5 = -0.693 \text{ [1]}\right)$			
			Convincing proof, e.g.	[2]	[2]	
			$\frac{A_0}{2} = A_0 e^{-\lambda t}$			
			$\frac{1}{2} = e^{-\lambda t}$			
			$\ln \frac{1}{2} = -\lambda t$			
			$-0.693 = -\lambda t$			
			$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$			
	(b)	**(i)**	No. moles = $\frac{1.74 \times 10^{-9}}{0.131} = 1.3 \times 10^{-8}$	[1]		
			shows multiplication by 6.02×10^{23} or answer to $\geqslant$ 3 s.f.	[1]	[2]	
		(ii)	$\lambda = 0.087$ day	[1]		
			Subs into $N = N_0 e^{-\lambda t}$ or uses $A = A_0 e^{-\lambda t}$ and $A = \lambda N$ e.c.f. "λ"	[1]		
			1.3×10^{15}	[1]	[3]	
		(iii)	$\lambda = 1 \times 10^{-6} s^{-1}$	[1]		
			1.3×10^{9} (Bq)	[1]	[2]	12
7	**(a)**		Energy required to separate the nucleus into its individual nucleons or equivalent		[1]	
	(b)		$\Delta m = 0.1102u$ **or** 1.829×10^{-28} kg e.c.f. Δm	[1]		
			$E = mc^2$ **or** 1.646×10^{-11} J **or** uses 1u = 931 MeV **or** 932 MeV	[1]		
			E = 103 (MeV)	[1]	[3]	
	(c)	**(i)**	BE/nucleon C-14 = 103/14 = 7.4 MeV	[1]		
			BE/nucleon C-12 ~ 7.8 MeV (from graph)	[1]		
			C-12 more stable (since 7.8 > 7.4)	[1]	[3]	
		(ii)	Energy is released when the product(s) has(ve) greater BE/n (than the reactant(s)) or movement towards the peak	[1]		
			On LHS of peak fusion (of light nuclei to a heavier nucleus) satisfies criterion	[1]		
			On RHS of peak fission (of a heavy nucleus) satisfies the criterion	[1]	[3]	10

						AVAILABLE MARKS
8	(a)	(i)	Each neutron can cause a further fission/uncontrolled chain reaction/runaway	[1]		
			Use of (boron-steel) control rods to absorb neutrons	[1]	[2]	
		(ii)	The use of a moderator (graphite, heavy water)	[1]		
			to slow the neutron (to thermal energies)	[1]	[2]	
	(b)		Confinement	[1]		
			Gravitational qualified	[1]	[2]	
	(c)		12.9/6	[1]		
			= 2.2 MeV therefore smaller	[1]	[2]	8

9 (a) (i) $E^{\frac{1}{2}} = M^{\frac{1}{2}}Z - M^{\frac{1}{2}}$

$y = mx + c$ [1]

Eqn and mapping [1] [2]

(ii)

E/keV	$E^{\frac{1}{2}}$/keV$^{\frac{1}{2}}$
4.41	2.10
6.40	2.53
8.06	2.84
15.8	3.97
17.5	4.18

Values $E^{\frac{1}{2}}$, all to 3 sig fig [1]

(iii) Scale [1]
Plotting (±1 su square) [1]
Best fit line (their points) [1] [3]

(iv) (Determining) gradient use [1]
Value e.c.f. **(i)** [1]
Value^2 [1] [3]

(b) (i) (R = 1.09 × 10^7) Subs into $M = \frac{3hcR}{4 \times 10^{-3}e}$ [1]
consistent with M value [1] [2]

(ii) Using $\frac{\text{difference}}{R_{\text{theory}}} \times 100$ [1]
Consistent value [1] [2]

(iii) Using $E = hf$ and $c = f\lambda$ [1]
$Ry = 2.19 \times 10^{-18}$ (J) or consistent with M from **(i)** [1] [2] 15

Total **90**