Rewarding Learning

ADVANCED
General Certificate of Education
2016

Physics

Assessment Unit A2 1

assessing

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

[AY211]

TUESDAY 24 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)**		Mass × velocity			[1]	
	(b)	**(i)**	$28.8\,\text{km}\,\text{h}^{-1} = 8.0\,\text{m}\,\text{s}^{-1}$		[1]		
			Momentum = 120 × 8.0 = 960 ecf v		[1]	[2]	
		(ii)	960 – (100 × 2.0) = 220 v ecf **(b)(i)** [1] [1]		[2]		
			v = 3.45 m s^{-1}		[1]		
			SE v > 5.27 m s^{-1} → [1]/[3]				
			Direction = same as first player		[1]	[4]	
		(iii)	They will still travel in the same direction after tackle	No ecf **(ii)**	[1]		
			(Combined) velocity will be reduced		[1]	[2]	9
2	**(a)**	**(i)**	Volume-calibrated tube (containing gas) (confined by e.g. oil)		[1]		
			Means of applying pressure/Pressure Gauge		[1]		
			Take several different readings of V (allow l) and P		[1]	[3]	
		(ii)	Make changes slowly or allow time (to come to equilibrium)			[1]	
			Quality of written communication			[2]	
	(b)	**(i)**	$P_1/T_1 = P_2/T_2$ or P/T = const.	eqn	[1]		
			$P_2 = 292 \times (302/281) =$	subs	[1]		
			314	ans	[1]	[3]	
			SE.1: 7.4% (1.074) → [2]/[3] (from pressure or temp)				
			SE.2: 90% (1.9) → [2]/[3]				
		(ii)	mean square speed or KE proportional to T/calculating KE		[1]		
			$[\langle c^2 \rangle_{302} / \langle c^2 \rangle_{281}]^{\frac{1}{2}} = (302/281)^{\frac{1}{2}} (= 1.037)$		[1]		
			Percentage increase = 3.7%		[1]	[3]	12
			N.B. T not in K penalised in **(i) and (ii)**				

							AVAILABLE MARKS
3	**(a)**	$V = r\omega$				[1]	
	(b)	**(i)** Point C (Wrong point may get 2nd mark)			[1]		
		(Resultant) force is greatest			[1]		
		$(mr\omega^2 + mg)$			[1]	[3]	
		(ii) **(1)** Point A (wrong point may get 3rd mark)			[1]		
		$mg = mr\omega^2$			[1]		
		Thus bar under **no** tension (**zero** force)			[1]	[3]	
		(2) $\omega = \sqrt{\frac{g}{r}}$ allow $m\omega^2 r = mg$			[1]		
		$= 2.33 \text{ rad s}^{-1}$			[1]	[2]	9
4	**(a)**	**(i)** **(1)** $a = \omega^2 A = 0.68\,(4\pi^2)/4.1^2$ or $\omega = 1.53\ (\text{rad s}^{-1})$		eqn & subs	[1]		
		$a = 1.6 \text{ m s}^{-2}$		ans	[1]	[2]	
		(2) acceleration = 0				[1]	
		(ii) **(1)** kinetic energy = 0				[1]	
		(2) at maximum displacement				[1]	
	(b)	**(i)** Amplitude slowly decreases				[1]	
		(ii) Air resistance/friction				[1]	
		(iii) **TRUE** energy of oscillating pendulum decreases because pendulum does work against air resistance, air molecules moved etc., or energy loss to the surroundings				[1]	8
5	**(a)**	Most of α particles passed straight through Few (1 in approximately 8000) α particles were back scattered. Some α particles scattered appreciably		any **two**		[2]	
	(b)	Concentration of charge			[1]		
		Large electrostatic repulsion/positive			[1]		
		Concentration of mass			[1]	[3]	
	(c)	$D = M/V = \frac{Am}{\frac{4}{3}\pi r_0^3 A} = \frac{3m}{4\pi r_0^3} = \frac{3 \times 1.66 \times 10^{-27}}{4\pi (1.2 \times 10^{-15})^3} = 2.29 \times 10^{17}$ [1] [1] [1] [1]				[4]	9
		SE.1: $4.51 \times 10^{19} \rightarrow$ [2]/[4]					
		SE.2: $1.16 \times 10^{15} \rightarrow$ [2]/[4]					

				AVAILABLE MARKS
6 **(a)** Number of protons = 75	[1]			
Number of neutrons = 89	[1]	[2]		
(b) **(i)** The time it takes for half the undecayed atoms to decay or equivalent		[1]		
(ii) Take count rate* (measure background count rate) Timing until activity halves – allow full marks if repeated and safety considerations included	[1]			
Every e.g. minute/over a period of time/repeatedly	[1]			
Either plot (corrected) count rate against time find the time it takes the count rate to halve repeat and average **Or** plot log (corrected) count rate against time and (–) gradient = λ $t_{\frac{1}{2}} = 0.693/\lambda$ use of equation appreciated	[3]			
Safety: Shielding, distance, duration (any **one**)	[1]	[6]		9
*Accept count, ionisation current				
7 **(a)** $E = mc^2$ where E is energy, m is mass and c is the speed of light		[1]		
(b) **(i)** Mass of protons = 2.01456				
Mass of neutrons = 2.01734				
Mass of electrons = $\frac{0.00110}{4.03300}$	[1]			
Mass defect = 4.03300 – 4.00260 = 0.0304 u ecf	[1]			
$= 0.0304 \times 1.66 \times 10^{-27} = 5.0464 \times 10^{-29}$ kg	[1]	[3]		
SE: $4.8638 \times 10^{-29} \rightarrow$ [2]/[3]				
(ii) $5.0464 \times 10^{-29} \times (3 \times 10^8)^2$	[1]			
$= 4.54176 \times 10^{-12}$ J				
= 28.4 MeV (ECF: SE. 27.4 MeV) conversion mark independent	[1]	[2]		
Alternative method: 1 u = 931 MeV ∴ 28.3 MeV				
(iii) Energy required to split a nucleus / atom up into its component nucleons / particles		[1]		
(c) $\frac{1}{2}mv^2 = 4.54176 \times 10^{-12}$	[1]			
$v = 7.37 \times 10^7$ m s^{-1} (ECF: SE. 7.26×10^7)	[1]	[2]		9

						AVAILABLE MARKS
8	**(a)**	The joining of two light nuclei to form a single heavier/more stable nucleus.			[1]	
	(b) (i)	$^{2}_{1}D + ^{3}_{1}T \rightarrow ^{4}_{2}He + ^{1}_{0}n$ ignore energy			[1]	
	(ii)	Any **two** from: Ample supply of fuel Temperature required relatively low/Plasma less difficult to control Energy yield good Single stage reaction No long term radioactive waste			[2]	
	(c) (i)	So that nuclei can have enough k.e.		[1]		
		to overcome electrostatic repulsion		[1]	[2]	
	(ii)	Using toroidal/coils		[1]		
		Magnetic field is generated		[1]		
		Exerts controlling force on charged particles		[1]	[3]	9

AVAILABLE MARKS

9 (a) The graph is not a straight line/through origin [1]

(b) log D = *p* log n + log a   allow ln [1]

p = slope [1]

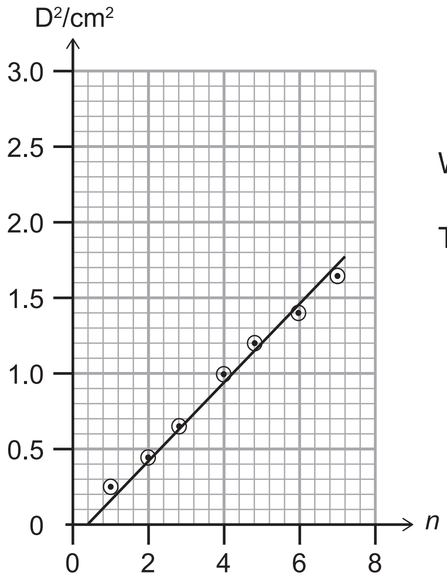
a = anti-log intercept [1] [3]

(c) (i)

D/cm	0.52	0.68	0.80	1.00	1.08	1.20	1.26
D^2/cm^2	0.27	0.46	0.64	1.00	1.17	1.44	1.59
n	1	2	3	4	5	6	7

[2] all values correct [2]
Penalty: [–1] **not** given to 2 d.p.

(ii)



Wrong plot – max [3]/[5]

Transposed axes – max [4]/[5]

[1] axes, [1] scales, [2] for points ([–1] each error), [1] for straight line [5]

(iii) Large triangle + values [1]
c = gradient = 0.25 – 0.22 [1] [2]

(iv) Evidence of max gradient [1]
% uncertainty in c determined from gradient difference [1]
Independent → % uncertainty in a = $\frac{1}{2}$% uncertainty in c [1] [3] 16

Total **90**