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Physics

Assessment Unit A2 1

assessing

Deformation of Solids, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

[APH11]

MONDAY 20 MAY, AFTERNOON

MARK SCHEME

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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.

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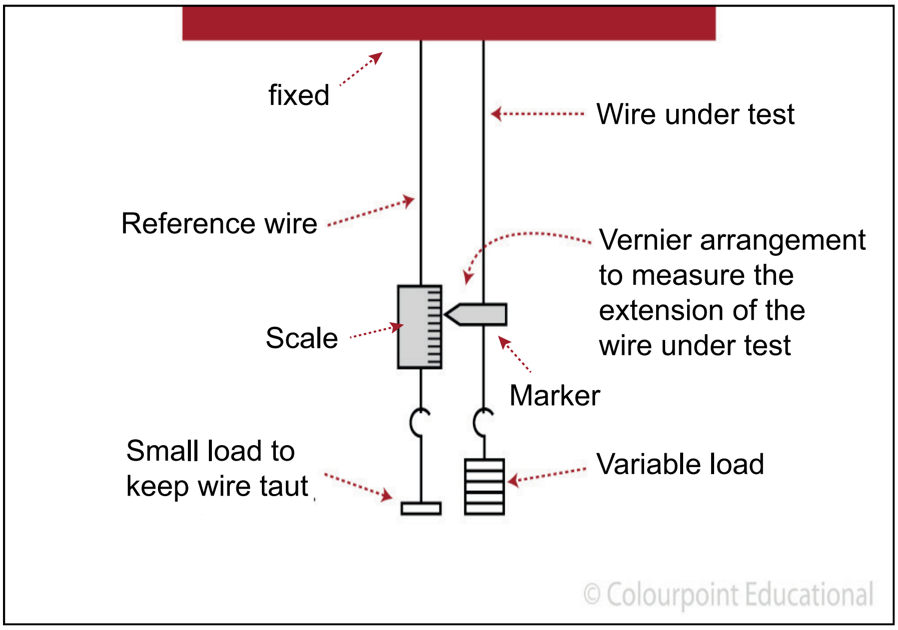
AVAILABLE MARKS

1 (a) (i) The extension is proportional to the applied load/force [1]
provided the limit of proportionality is not exceeded. [1] [2]

(ii) $k = F/x$ or 1/gradient [1]
$= 13/1.1$ [1]
$= 11.8\ \text{N mm}^{-1}$ (± 0.2) [1] [3]

(iii)



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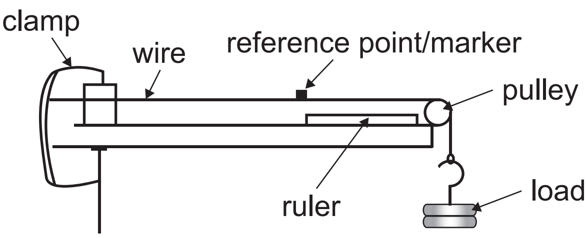
or



Any five out of six labels [5]

(b) (i) $E = FL_0/Ax$ or $k\ L_0/A$ [1]
$= A = \frac{\pi d^2}{4} = 1.26 \times 10^{-7}\ \text{m}^2$ [1]
$= [4 \times (11.8 \times 10^3) \times 2.0]/\pi \times (0.4 \times 10^{-3})^2$ [1]
$= 1.88 \times 10^{11}\ \text{N m}^{-2}$ [1] [4]
ecf from (a)(ii)

(ii) $R = \rho L/A$ [1]
Length increases [1]
C.S.A decreases when wire stretched [1]
Electrical resistance increases [1] [4] 18

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					AVAILABLE MARKS
2	**(a)** **(i)**	$\omega = \theta/t$ or			
		$T = 2\pi/2.4$	[1]		
		$= 2.6\,s$	[1]	[2]	
	(ii)	$v = \omega r$	[1]		
		$= 2.4 \times 0.80$	[1]		
		$= 1.9\ m\ s^{-1}$	[1]	[3]	
	(iii)	$a = v^2/r$ or $a = r\omega^2$	[1]		
		$= 1.9^2/0.80$	[1]		
		$= 4.5\ m\ s^{-2}$ (4.6 using $\omega = 2.4$)	[1]	[3]	
		ecf from (a)(ii)			
	(b)	$W = mg = 1.47\,N$	[1]		
		$Fc = ma = 0.68\,N$	[1]		
		$Fc^2 + W^2 = T^2$	[1]		
		$T = 1.6\,N$	[1]	[4]	12
		alternative			
		$T\ Sin\theta = 1.47$ or 0.69 [1]			
		$T\ Cos\theta = 0.69$ or 1.47 [1]			
		$\theta = 65°$ or $25°$ [1]			
		$T = 1.6\,N$ [1]			
3	**(a)** **(i)**	$T = 2.0$	[1]		
		$(\omega = 2\pi/T)$			
		$= 3.14\ rad\ s^{-1}$ ecf T	[1]	[2]	
	(ii)	Tangent drawn at max slope	[1]		
		Gradient calculated from their tangent	[1]		
		$0.16\ m\ s^{-1}$ (quality between 0.150–0.170)	[1]	[3]	
		(accept by calculation)			
	(b) **(i)**	Sin graph with same period	[1]		
		negative max at 0.5s	[1]	[2]	
	(ii)	All positive	[1]		
		Graph touches time axes at t = 0, 1.0, 2.0, 3.0 seconds and max at 0.5, 1.5, 2.5....	[1]	[2]	9
4	**(a)**	Resonance		[1]	
	(b)	Correct shape of curve with max		[1]	
	(c)	Smaller amplitude of oscillation.	[1]		
		Less defined peak	[1]		
		Graph displaced to lower f_0 at resonance	[1]	[3]	5

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AVAILABLE MARKS

5 **(a)** $E = P \times t$ [1]
$= 28 \times 12 \times 60$ correct subs [1]
$= 20160$ J [1]
$\Delta m = E/c^2$ [1]
$= 20160/(3 \times 10^8)^2$ [1]
$= 2.24 \times 10^{-13}$ kg [1] [6]
Apply ecf * throughout
SE: 3.73×10^{-15} [5]/[6]

(b) Mass increases [1] 7

6 **(a)** **(i)** Ions and electrons (accept ionised gas/matter) [1]

(ii) ${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$
minimum required: D + T → *He* + *n* [1]

(iii) Provide shielding from (high-energy) neutrons/absorption of neutrons/ transfer k.e. of neutrons to heat/prevent neutrons escaping [1]

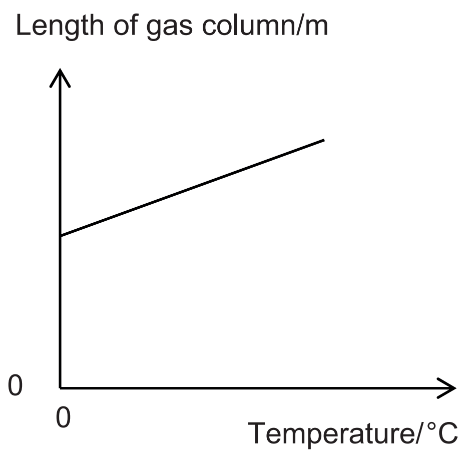
(iv) Different specific frequencies for different types of ion/electron [1]
(Each one) matched to the natural frequency/resonant frequency [1] [2]

(b) $E_k = 3/2\ kT$
$= 3/2 \times 1.38 \times 10^{-23} \times (150 \times 10^6)$ [1]
$= 3.11 \times 10^{-15}$ J [1] [2] 7

7 **(a)** **(i)** Fixed mass of gas/no. of moles, molecules, amount of gas [1]
Constant pressure [1] [2]
([–1] each incorrect statement)

(ii) Volume = C.S.A (of capillary tube) × Length
or L proportional to V [1]
C.S.A remains constant/diameter constant [1] [2]

(iii)



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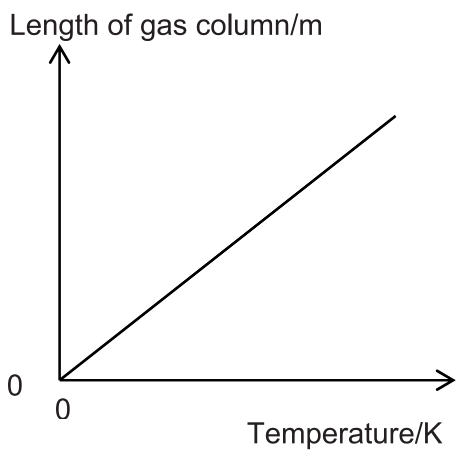

Correctly labelled including unit [1]
Correct shape of graph [1] [2]

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					AVAILABLE MARKS
(b)	**(i)**	Use of $pV = \frac{1}{3}Nm\langle c^2\rangle$ rearranged to p = by dividing by V total mass = Nm and $\rho = \frac{Nm}{V}$ sub	[1]	[2]	
	(ii)	subs into $p = \frac{1}{3}\rho\langle c^2\rangle$ 1.8×10^6 m^2 s^{-2}	[1] [1]	 [2]	
	(iii)	subs into $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$ 6.6×10^{-27} kg ecf from **(ii)** SE: T in °C, 2.76×10^{-28} [1]/[2]	[1] [1]	 [2]	12
8	**(a)** **(i)**	r_0 = radius of 1 nucleon/radius of a proton/neutron A = mass number/number of nucleons	[1] [1]	 [2]	
	(ii)	1. $\log_{10}(r) = 1/3\log_{10}(A) + \log_{10}(r_0)$ $r_0 = 10^c$ 2. Gradient = 1/3	[1] [1] [1]	 [3]	
	(b)	$r = r_0A^{1/3} = 1.2 \times 10^{-15} \times 14^{1/3} = 2.89 \times 10^{-15}$ m $V = 4/3 \times \pi \times r^3 = 1.01 \times 10^{-43}$ m^3 $m_{nucleus} = 14 \times 1.66 \times 10^{-27} = 2.32 \times 10^{-26}$ kg $\rho = 2.30 \times 10^{17}$ kg m^{-3} **Apply ecf*** SE: 1.64×10^{16} [3]/[4], 3.2×10^{18} [3]/[4] [or in terms of $\frac{3m}{4\pi r_0^3}$ where m = mass of 1 nucleon]	[1] [1] [1] [1]	 [4]	9

9 **(a)** Indicative content

- An α-particle is a helium nucleus/two protons and two neutrons.
- It is positively charged or a mass of 4u.
- α-particles move slowly (approximately 5% of the speed of light).
- Lose energy by ionisation.
- They are highly ionising (producing about 10^5 ion-pairs per centimetre of air through which they pass).
- α-particles (thus have poor powers of penetration and) can be stopped by a few centimetres of air or a sheet of paper.

Response	**Marks**
Candidates identify clearly **5 or 6** of the points above relating to the nature and properties of alpha particles. There is widespread and accurate use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are excellent. They use the most appropriate form and style of writing. Relevant material is organised with clarity and coherence.	[5]–[6]
Candidates identify clearly **3 or 4** of the points above relating to the nature and properties of alpha particles. Presentation, spelling, punctuation and grammar are sufficiently competent to make meaning clear. They use appropriate form and style of writing. There is good reference to scientific terminology.	[3]–[4]
Candidates identify clearly **1 or 2** of the points above relating to the nature and properties of alpha particles. There may be some errors in their spelling, punctuation and grammar but form and style are of a satisfactory standard. They have made some reference to specialist terms.	[1]–[2]
Response is not worthy of credit	[0]

[6]

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				AVAILABLE MARKS
(b) **(i)**	$^{170}_{69}Tm \rightarrow \, ^{170}_{70}Yb + \, ^{0}_{-1}\beta$			
	Correct A values for Yb and β	[1]		
	Correct Z values	[1]	[2]	
(ii)	$\lambda = \ln 2/(128 \times 24 \times 3600) = 6.27 \times 10^{-8}\ s^{-1}$	[1]		
	time conversion correct	[1]	[2]	
	SE: 5.4×10^{-3}, 2.26×10^{-4}, 3.76×10^{-6} [1]/[2]			
(iii)	2 half lives	[1]		
	$N = 1.60 \times 10^{20}/(2 \times 2) = 0.4 \times 10^{20}$	[1]	[2]	
(iv)	$A = \lambda N = 6.27 \times 10^{-8} \times 0.4 \times 10^{20} = 2.51 \times 10^{12}$ Bq		[1]	
(c) **(i)**	Number of disintegrations $= 1.20 \times 10^{20}$ ecf **(b)(iii)**	[1]		
	Energy released $= 1.20 \times 10^{20} \times 1.41 \times 10^{-13} = 1.69 \times 10^{7}$ J	[1]	[2]	
(ii)	$0.084\ MeV = 1.344 \times 10^{-14}$ J	[1]		
	$E = hc/\lambda$ or $E = hf$ and $c = f\lambda$ or $f = 2.03 \times 10^{19}$ Hz	[1]		
	$\lambda = (6.63 \times 10^{-34} \times 3 \times 10^{8})/1.344 \times 10^{-14}$	[1]		
	$= 1.48 \times 10^{-11}$ m	[1]	[4]	
	SE: 2.4×10^{-24} [2]/[4], 2.4×10^{-30} [3]/[4]			
(iii)	$\lambda = h/m_e v$			
	$= 6.63 \times 10^{-34}/(9.11 \times 10^{-31} \times 2.85 \times 10^{6})$ subs	[1]		
	$= 2.55 \times 10^{-10}$ m	[1]	[2]	21
			Total	**100**