Rewarding Learning

ADVANCED
General Certificate of Education
2017

Physics

Assessment Unit A2 1

assessing

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

[AY211]

WEDNESDAY 21 JUNE, 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)** For a fixed mass of gas at constant volume	[1]		
	the pressure is (directly) proportional to the kelvin temperature/ absolute T/thermodynamic T	[1]	[2]	
	(b) **(i)** –273 °C		[1]	
	(ii) Absolute zero	[1]		
	Molecules would be at rest/stationary/not moving	[1]	[2]	
	(c) $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$	eqn [1]		
	Temp conversion to K → 276, 285	[1]		
	V_2 = 4.13V	[1]		
	% increase = 313%	[1]	[4]	9

SE : Using °C : 1500% → 3/4
1600% → 2/4

Swapping P's : –74% → 3/4
74% or 26% → 2/4

Swapping T's : 287% → 3/4

AVAILABLE MARKS

2 (a) **900 J** of energy is required to raise the temperature of **1 kg** of **aluminium** by **1 K or 1°C** [1]

(b) (i) **Procedure**
Measure **mass m** of aluminium block (using balance)
(Switch on power supply and) **record V and I**
Heat for **a temperature rise** $\Delta\theta$ (of at least 15 °C)
Record time t for temperature rise of $\Delta\theta$ 4 × [$\frac{1}{2}$] round down [2]

Determination of c
$c = VIt/m\Delta\theta$ or $E = VIt$ and $E = mc\Delta\theta$ [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 always fluently. Arguments may sometimes stray from the point. There are some errors in grammar, punctuation and spelling, but not such as to suggest a 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]

(ii) Result would be higher due to heat loss (to the surroundings) [1]
more energy must be supplied (to cause temperature change recorded) or change in temperature will be less [1] [2]

(c) (i) 120 × 0.900 (   ) = (–) 250 × 4.190 (   ) [1]
Idea of common temperature [1]
T = 66.6 °C [1] [3]

(ii) $C_{mug} < C_{coffee}$ [1]
$mass_{coffee} > mass_{mug}$ [1] [2]

13

				AVAILABLE MARKS
3 **(a)**	Acceleration is (defined as the rate of) change of velocity	[1]		
	Direction continually changes, therefore velocity changes (and object accelerates)	[1]	[2]	
(b) **(i)**	(Lcos60° = W)			
	L = 825g/cos60°	subs [1]		
	L = 16187 N (ecf from m = 735 $\rightarrow$ 14421)	[1]	[2]	
(ii)	Horizontal cpt of L acting towards centre of circle = Lsin60 = 14018 N ecf L	[1]		
	a = F/m = 14018/825	eqn or subs [1]		
	= 17.0 ms^{-2}	[1]	[3]	
	SE : Use of L without component 2/3			
	ecf from b(i)			
(iii)	a = v^2/R			
	R = $(56)^2$/17.0 (ecf **(ii)**)	eqn or subs [1]		
	= 185 m	[1]	[2]	9
	ecf: [19.6 in **(ii)** $\rightarrow$ 160 2/2; 5.66 in **(ii)** $\rightarrow$ 554 2/2]			
	ecf from b(ii)			
4 **(a)**	Motion where the acceleration of an object is directly proportional to its displacement from a fixed point	[1]		
	and always directed towards that fixed point/in opposite direction to displacement	[1]	[2]	
(b)	T = 12 hours	[1]		
	A = (15 – 6)/2 = 4.5 m	[1]		
	x = 0.5 m	[1]		
	$\omega = 2\pi/T$	[1]		
	$\omega = \pi/6$ or 0.52 radians or ecf T	[1]		
	t = 2.79 hours (ecf from their A, x and ω) or 3.21 hours	[1]		
	Latest time = 12.47pm (ecf their t) 7.13pm	[1]	[7]	9
	SE If x = 4.0 m, t = 0.9 hours; latest time = 10.55 am	award [6/7]		

AVAILABLE MARKS

5 (a) $v_{alpha} = (2E_k/m)^{1/2} = 1.98 \times 10^7$ [1]

$p_{before} = p_{after}$ [1]

$0 = (206 \times 1.66 \times 10^{-27})v + (4 \times 1.66 \times 10^{-27})1.98 \times 10^7$ subs [1]

$v = 3.84 \times 10^5\ m\,s^{-1}$ [1] [4]

SE If $m_{nucleus} = 210$ after emission, $v = 3.77 \times 10^5\ m\,s^{-1}$ award [3/4]

SE no kg conversion : $1.57 \times 10^{-8}\ m\,s^{-1}$ 3/4. Both **SE** : 1.54×10^{-8} 2/4

(b) (i) 1. Radioactive/Alpha source/lead shielding
2. Gold foil
3. Zinc sulfide screen/fluorescent screen
4. Microscope $4 \times [\frac{1}{2}]$ round down [2]

(ii) Conclusion – existence of a **small** or **dense**/mostly empty space/mass concentrated [1] positive core [1] [2] 8

6 (a) (i) The (random spontaneous) disintegration/breakdown of an (unstable) nucleus (to become more stable) [1]
with the emission of α, β, γ radiation

(ii)

Symbol	Quantity	S. I. Unit
A	Activity	Bq
λ	Decay constant	s^{-1}
N	Number of un-decayed nuclei	No unit

Each line correct [3]

(iii) Exponential decay
Cuts A axis; asymptotic to t axis [1]

(b) $\lambda = 0.693/5700 = 1.22 \times 10^{-4}$ years^{-1}

$(3.85 \times 10^{-12}\ s^{-1}, 1.39 \times 10^{-8}\ hr^{-1})$ [1]

Activity of 1 kg wood = $136/(2.15 \times 10^{-3} \times 3600) = 17.6\ s^{-1}$ [1]

$17.6 = 250\ e^{-\lambda t}$ ecf A, λ subs [1]

$t = 2.2 \times 10^4$ years [1] [4] 9

Or

$\lambda = 0.693/5700 = 1.22 \times 10^{-4}$ years^{-1} [1]

$\mathbf{A_0} = 250 \times 2.15 \times 10^{-3} \times 60 \times 60$ counts per hour for a mass of 2.15 g = **1935** h^{-1}, $0.5375\ s^{-1}$ [1]

$136 = 1935\ e^{-\lambda t}$ ecf λ, A_0 [1]

$t = 2.2 \times 10^4$ years [1]

AVAILABLE MARKS

7 (a) (i) Mass defect - difference between mass of separated nucleons and the combined mass of the nucleus [1]

(ii) Binding energy of nucleus - energy required to separate a nucleus into its constituent nucleons (neutrons and protons) [1]

(iii) $\Delta m = (2m_p + 2m_n) - m_{He}$
$= [(2 \times 1.00728u) + (2 \times 1.00867u)] - 4.00150u$
$= 0.03040u$ subs or value [1]
$= 5.0464 \times 10^{-29}$ kg ecf u [1]

$\Delta E = \Delta mc^2 = 5.0464 \times 10^{-29} \times (3 \times 10^8)^2$ ecf m
$= 4.54176 \times 10^{-12}$ J [1]
$= 28.4$ MeV [1] [4]

or use of $(0.03040 \times 931\text{MeV})$

apply ecf *

(b) (i) The joining of 2 light nuclei to form a heavier one (with the release of energy). [1]

Confinement of plasma must occur for long enough
Particle density must be high
Temperatures greater than 10^8 K required [2] [3]
Any **two** points

(ii) $\Delta E = (0.65/100) \times 1.99 \times 10^{30} \times (3 \times 10^8)^2$
$= 1.16 \times 10^{45}$ J [1]
Time for ΔE to occur $= 1.16 \times 10^{45}/3.75 \times 10^{26}$
$= 3.09 \times 10^{18}$ s [1]
$= 9.78 \times 10^{10}$ years [1] [3]

(iii) $\frac{1}{2}m\langle c^2\rangle = 3/2\,kT$
$\langle c^2\rangle = (3 \times 1.38 \times 10^{-23} \times 5780)/(1.67 \times 10^{-27})$ subs [1]
$\sqrt{\langle c^2\rangle} = 11970\ \text{m s}^{-1}$ [1] [2] 14

	AVAILABLE MARKS

8 (a) $(m_2g - T) = m_2a$ w_2 ok [1]
$(T - m_1g) = m_1a$ w_1 ok [1]
Add equations to give $(m_2 - m_1)g = (m_2 + m_1)a$ [1]
Thus equation 8.1
Comparison to show Q = acceleration due to gravity, g, 9.81 [1] [4]

(b) (i) $\frac{2h}{t^2} = \frac{(m_2 - m_1)Q}{(m_1 + m_2)}$

Rearrange mapping exercise to show [1]
c = 0 and $m = Q/(m_1 + m_2)$ [1] [2]

(ii)

t_{av}	t^2/s^2	$2h/t^2/m\,s^{-2}$
1.12	1.25	2.40
1.22	1.49	2.01
1.37	1.88	1.60
1.57	2.46	1.22
1.97	3.88	0.773
3.00	9.00	0.333

Each column [1] mark [3]
Each correct unit [1] mark [2] [5]
[–1] incorrect significant figures (once only).

(iii) Axes scaled correctly [1]
Points plotted correctly [1]
Best fit [1] [3]

(iv) Gradient (correct for their graph) [1]
Q = 500 × gradient [1]
Unit $m\,s^{-2}$ [1] [3]

(v) Graph would be **steeper**.
(Correct reasoning. Gradient = $Q/(m_1 + m_2)$) Since **$(m_1 + m_2)$ has decreased**, (gradient has increased). [1]

(vi) As $(m_2 - m_1)$ increases, **t becomes smaller**, therefore:-
(more difficult to measure time accurately/% error in measuring time increases/% error in time is doubled) [1] 19

Total **90**