Rewarding Learning

**ADVANCED**
**General Certificate of Education**
**2013**

# Physics

## Assessment Unit A2 1

*assessing*

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

**[AY211]**

**MONDAY 20 MAY, 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 later stages 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 $550 \times 10^{-6}$ m) count only as arithmetical slips and lose the answer mark.

| | | | | | | AVAILABLE MARKS |
|---|---|---|---|---|---|---|
| **1** | **(a)** | | mom before = mom after | | | |
| | | | $0.75 \times 0.7 = (0.75 + 0.5)\,v$ | [1] | | |
| | | | $v = 0.42\ (\mathrm{m\,s^{-1}})$ | [1] | [2] | |
| | **(b)** | | k.e. before = $0.5 \times 0.75 \times 0.7^2 = 0.18$ (J) ecf **(a)** for m and v | [1] | | |
| | | | k.e. after = 0.11 (J) | [1] | | |
| | | | loss of k.e. = 39 (%) (40%) | [1] | [3] | 5 |
| **2** | **(a)** | | For a fixed mass of gas at constant temperature | [1] | | |
| | | | pressure is inversely proportional to its volume | [1] | [2] | |
| | **(b)** | **(i)** | Diagram with labels: P gauge, trapped mass of air, means of changing P | | [1] | |
| | | **(ii)** | Method: **Increase** P, allow **equilibrium** to be established, | [1] | | |
| | | | read **V or l**, **repeat** | [1] | [2] | |
| | | | $4 \times [\frac{1}{2}]$ and round down | | | |
| | | **(iii)** | Results: axes labelled correctly, | [1] | | |
| | | | straight line from (0,0) | [1] | [2] | |
| | **(c)** | | Volume = A × l, $A = \frac{\pi d^2}{4}$ or is constant | [1] | | |
| | | | Constant d means $V \propto l$ | [1] | [2] | |
| | **(d)** | | $\frac{1}{2} mv^2 = mc\Delta t$ | [1] | | |
| | | | $\frac{1}{2} \times 640 \times 83.3^2 = 4 \times 1.5 \times c \times (970)$ | | | |
| | | | $2.22 \times 10^6 = 6 \times c \times 970$ | [1] | | |
| | | | $c = 382\ (\mathrm{J\,kg^{-1}\,^\circ C^{-1}})$ | [1] | [3] | |
| | | | Penalty [–1] for using the wrong mass for the car | | | |
| | | | S.E. 1530 $(\mathrm{J\,kg^{-1}\,^\circ C^{-1}}) \rightarrow$ [2] | | | 12 |
| **3** | **(a)** | **(i)** | $\omega = \frac{2\pi}{T} \left(= \frac{2\pi}{0.64}\right)$ | [1] | | |
| | | | $= 9.82\ (\mathrm{rad\,s^{-1}})$ | [2] | [2] | |
| | | **(ii)** | $F = m\,\omega^2 r$ [1] $= 0.024 \times (9.82)^2 \times 15 \times 10^{-2}$ [1] | | | |
| | | | = 0.35 (N) [1] | | [3] | |
| | | **(iii)** | **Horizontal component of tension** in the string | | [1] | |
| | **(b)** | **(i)** | T = 0.64 (s) | | [1] | |
| | | **(ii)** | $x = A \cos \omega t$ | | | |
| | | | $= 15 \times 10^{-2} \cos (9.82 \times 0.40)$ | [1] | | |
| | | | $= -0.1059$ ecf + 0.15 m → cm | [1] | | |
| | | | $d = 25.5$ (cm) | [1] | [3] | 10 |

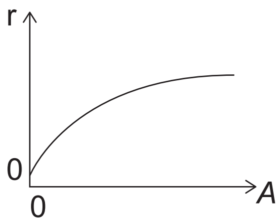
AVAILABLE MARKS

**4 (a) (i)** Most $\alpha$ particles passed straight through/few backscattered [1]
Both $\alpha$ and nucleus are charged
$\alpha$ not near any (charged) particles [1] [2]

**(ii)** (Only 1 in 8000) alpha backscattered [1]
Nucleus (must be very small with concentrated) +ve charge [1] [2]
Alpha has a positive charge and is repelled

**(iii)** No backscattering [1]
Some slightly deflected/most undeflected [1] [2]

**(b) (i)** Correct curve upwards i.e. [1]




Curve with correct sense [1]

Curve shape varying $r \approx A^{\frac{1}{3}}$ [1] [2]
(Penalty [–1] for curve developing a negative gradient)

**(ii)** $r = 1.2 \times 10^{-15} \times (27)^{\frac{1}{3}}$ [1]
$= 3.6 \times 10^{-15}$ (m) [1] [2] 10

| | | | | AVAILABLE MARKS |
|---|---|---|---|---|
| **5** **(a)** **(i)** | Sample + named detector + stopwatch | | [1] | |
| **(ii)** | Determine initial reading and start timer | [1] | | |
| | Record readings after suitable time intervals | [1] | [2] | |
| **(iii)** | 50s $\leqslant T_{\frac{1}{2}} \leqslant$ 6 hours – short half life | | [1] | |
| | Quality of written communication | | [2] | |

**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.

| | | | | |
|---|---|---|---|---|
| **(b)** **(i)** | Halves activity, e.g. 8600 – 4300 Bq | [1] | | |
| | $T_{\frac{1}{2}}$ = 0.75 h = 45 min    0.7–0.8 hr (42–48 min) | [1] | | |
| | Repeats process and averages | [1] | [3] | |
| **(ii)** | $\lambda$ = (–) grad | [1] | | |
| | $\lambda \approx$ 0.93 ($h^{-1}$) or 0.0155 ($min^{-1}$) | [1] | | |
| | $T_{\frac{1}{2}} = \frac{0.693}{\lambda}$ = 45 (minutes) | [1] | [3] | |
| **(c)** | keV conversion to J   ($2.24 \times 10^{-14}$ J) | [1] | | |
| | Calculation of $A$   ($4.46 \times 10^{7}$ Bq) | [1] | | |
| | Appreciating $A_0$ = 800 ($\times 10^{6}$ Bq) | [1] | | |
| | Consistent answer + unit using candidate's values for $A$ and $A_0$ in $A = A_0 e^{-\lambda t}$ | [1] | [4] | 16 |

AVAILABLE MARKS

6 (a)

| Symbol | Quantity | Unit |
| --- | --- | --- |
| E | Energy | joule/J |
| $\Delta$m | Mass difference | kg |
| c | Speed of light | m $s^{-1}$ |

Quantities identified [1]
SI units identified [1] [2]

(b) Mass defect = 0.20183 u
= $3.35 \times 10^{-28}$ kg
Binding energy = $3.02 \times 10^{-11}$
BE/n = 7.85 (MeV) e.c.f. for B.E. [1] [4] 6

} use of [1]
1u = 931 MeV [1]
(J) = 188 (MeV) [1]

7 (a) (i) Lowering of (boron) control rods [1]
Neutrons absorbed (and reaction stopped) [1] [2]

(ii) k.e. of fission fragments [1]

(iii) Amount of uranium greater than critical value [1]
No control over neutrons possible [1] [2]

(iv) Blanket of concrete would absorb radioactive emissions [1]

(b) (i) Joining (two) light nuclei [1]
to form one (heavier) more stable nucleus/release energy [1] [2]

(ii) Increase particle density [1]
Increased time for reaction [1] [2]

(c) (i) ${}^{2}_{1}D + {}^{3}_{1}T \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$ (+ Q) [1]

(ii) Deuterium in abundance, tritium obtained from lithium reaction, one stage reaction, large yield,relatively low temperature required, greater probability of collision
Any **two** [2] 13

AVAILABLE MARKS

**8** **(a)** log $T = n \log l + \log A$
Y = mx + c [1]
Grad = $n$ intercept = log $A$ [1] [2]

**(b)** **(i)** Timings too short, rapid oscillations [1]

**(ii)** Increase number of oscillations (to 20)
or choose $l > 0.850$ m [1]

**(c)**

| $l$/m | Time for 10 oscillations/s | | | $T$/s | Log ($T$/s) | Log ($l$/m) |
|---|---|---|---|---|---|---|
| | $t_1$ | $t_2$ | $t_{av}$/s | | | |
| 0.850 | 7.23 | 7.25 | 7.24 | 0.72 | –0.143 | –0.071 |
| 0.750 | 5.89 | 5.93 | 5.91 | 0.59 | –0.228 | –0.125 |
| 0.650 | 4.74 | 4.80 | 4.77 | 0.48 | –0.321 | –0.187 |
| 0.550 | 3.65 | 3.77 | 3.71 | 0.37 | –0.431 | –0.260 |
| 0.450 | 2.64 | 2.84 | 2.74 | 0.27 | –0.562 | –0.347 |

Penalty [–1] for incorrect headings
Penalty [–1] for use of natural logs

Values of $T$ [1], values of log $T$ [1], values of log $l$ [1] → **all** to ⩾ 2 dp [3]

**(d)** $y$-axis scale [1], points [2], line [1] [4]

**(e)** $n$ = grad = 0.54/0.35 = 1.54 △ – large [1] consistent grad [1] [2]
Their intercept [1]
Consistent value for $A$ [1] [2] [4]

**(f)** $E = \frac{16\pi^2 M}{A^2 b d^3}$ Removing square root [1]

$E = \frac{16\pi^2 \times 0.3}{(0.55)^2 \times 25 \times 10^{-3} \times (5 \times 10^{-3})^3}$ Correct subs [1]

$E = 5.01 \times 10^{10}$ Pa $E = \frac{1.52 \times 10^{10}}{A^2}$ [1] [3] 18

**Total** **90**