ADVANCED
General Certificate of Education
2022

Physics

Assessment Unit A2 1

assessing

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

[APH11]

THURSDAY 26 MAY, AFTERNOON

MARK
SCHEME

Physics Subject Specific Instructions

It is essential that, before using the mark scheme, markers familiarise themselves with the following guidance.

General

To ensure that all candidates receive the same treatment, the mark scheme must be applied consistently.

The mark scheme for each question shows typical intermediate steps, the answer expected and the marks available for each part of the question.

In cases where a candidate has responded with a seemingly correct response which has not been anticipated in the mark scheme, the marker must make a professional judgement of the correct physics/validity of the response when awarding marks.

Brackets (...) are used to indicate information which is not essential for the mark to be awarded. Alternative answers are indicated by 'or', or the symbol for or, '/'.

Multiple/Cancelled Responses

If a candidate provides multiple responses, the general principle to be followed is that 'right + wrong = wrong'.

Responses considered to be neutral are not penalised. For example, if additional irrelevant information is given in an explanation that does not contradict the correct information given, the mark(s) can be awarded.

In a numerical problem if two different solutions are presented without a definitive answer on the answer line, credit should not be given. If an answer is given on the answer line, then the solution that has led to the answer given should be marked according to the mark scheme.

If a candidate clearly cancels their working by scoring it out, then this should not be marked. It is not the role of the marker to select from the candidate's response what should or should not be marked.

Marking Numerical Problems

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, if obtained from a valid starting point, gets full credit, even if all the intermediate steps are not shown.

This "correct answer" rule does not apply in situations where candidates have been asked to 'show your working' or 'show that'. These answers must be valid in all stages to obtain full credit.

The answer to a 'show that' question should be quoted to one more significant figure than that given in the question.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation.

The normal penalty for an arithmetical error is to lose the mark(s) for the answer/unit line. An arithmetic error should be penalised for one mark only. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value of a quantity given in a question.

10^n errors count as arithmetical slips and incur a penalty of one mark.

If a candidate rounds a value incorrectly this should be penalised one mark. However, care must be taken not to penalise a candidate for rounding correctly in parts leading up to their final answer in an unstructured numerical problem.

Answers should be given in decimal form. Fractional answers will not be credited with the answer mark.

Error Carried Forward

An ECF can occur between parts of a question or, in more unstructured numerical problems, within a part.

When an incorrect answer is carried forward from one question to the next, full credit should be awarded in the part where the incorrect answer is used, provided all the working is correct.

Within a part, ECF is applied where a candidate does an incorrect calculation, for example calculates a value for R incorrectly using V/I and then goes on to use their calculated value for R to calculate a resistivity value. The penalty is applied in the V/I calculation but then the value of R can be carried forward so that the remainder of the marks are available to the candidate provided all the remainder of their working is correct.

The ECF within a part will only apply in numerical problems where more than one calculation is required in a part.

Significant Figures

Candidates should show an awareness of using a sensible number of significant figures in their answers, based on the values given in the question. In SPH11, SPH21, APH11 and APH21, unless specifically asked for in the question, candidates will not be penalised for incorrect significant figures.

In SPH31, SPH32, APH31 and APH32, all answers should be given to a suitable number of significant figures and penalties will be applied in these papers unless otherwise stated in the mark schemes.

Units

In the majority of questions, the unit will be stated on the answer line.

When the unit is omitted, candidates will be clearly asked to state an appropriate unit and this will be credited in the mark scheme.

Where there is a final calculation required to get from the unit of the answer calculated to the unit on the answer line the required unit will be stated in the question. For example, if wavelength was calculated and the answer line was in nm a statement 'Give your answer in nanometres' would be included.

The unit on the answer line will generally be the SI unit but may in some cases be a more appropriate unit. For example, if values of mass in g and momentum in g cm s^{-1} were given, the unit on the answer line for speed could reasonably be cm s^{-1} without prompt.


COVID-19 Context

Given the unprecedented circumstances presented by the COVID-19 public health crisis, senior examiners, under the instruction of CCEA awarding organisation, are required to train assistant examiners to apply the mark scheme in case of disrupted learning and lost teaching time. The interpretation and intended application of the mark scheme for this examination series will be communicated through the standardising meeting by the Chief or Principal Examiner and will be monitored through the supervision period. This paragraph will apply to examination series in 2021–2022 only.

1 **(a)** **(i)** Angle swept out in one second   [1]

    (ii) Number of revolutions in one second   [1]

(b) **(i)** $\dfrac{3.25}{12.5} \times \dfrac{1000}{60}$ subs [1], conversions [1]   [2]

        $= 4.33$ [1]   [3]

    (ii) $r = \dfrac{624}{2} + 48 = 360\,\text{mm}\ (0.36\,\text{m})$ [1]

        $v = \dfrac{2\pi r}{T}$ or $v = \omega r$ and $\omega = \dfrac{2\pi}{T}$ [1]

        $T = \dfrac{2\pi \times 0.36}{4.33} = 0.522\,\text{s}$ (ecf for r)   (ecf for v)   [1]   [3]
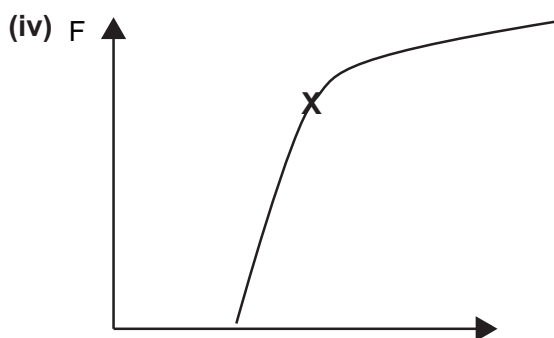
    (iii)
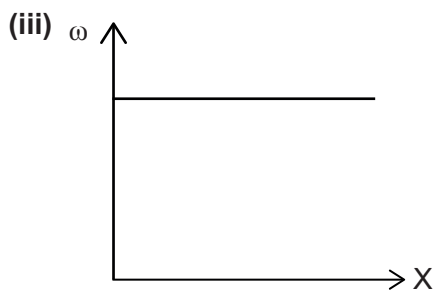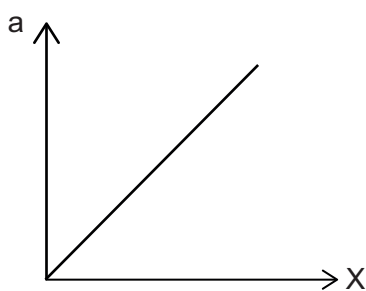
            [1]   [1]   [2]   10

2 **(a)** **(i)** $\Delta M = 0.15$, $x = 4.3$ [1]
             $0.15 \times 9.81 = k \times 4.3$ [1]
             $k = 0.342\,\text{N\,cm}^{-1}$ [1]   [3]

    (ii) $0.5 \times 9.81/0.342 = 14.3$ or $0.65 \times 9.81/0.342 = 18.6$ [1]
        $25.5 - 14.3 = 11.2$ cm   or $29.8 - 18.6 = 11.2$ cm
                                   (ecf for k and x)   [1]   [2]

    (iii) Unit conversion of x and k (if used)   [1]
          $= 0.5 \times 34.2 \times (18.6 \times 10^{-2})^2$ subs   [1]
          $= 0.592\,\text{J}$ [1]   [3]

    (iv)

                                      Straight section   [1]
                                      Crossing x-axis   [1]
                                      curve in correct   [1]   [3]
                                      sense

    (v) Marked at the end of the straight section of the graph   [1]

(b) $E = \dfrac{Fl}{A\Delta l}$ [1]

     $\tfrac{1}{2}F$ or $2 \times A$ [1]

     180×10^9 conversion   [1]

     $\Delta l = \dfrac{\tfrac{1}{2}(9.4 \times 9.81) \times 2.5}{1.5 \times 10^{-6} \times 180 \times 10^9}$ [1]

       $= 4.27 \times 10^{-4}$ m   [1]   [5]   17

AVAILABLE MARKS

13099.01 **F**

3 **(a)** ammeter & voltmeter or joulemeter correctly connected [1]
power supply, (switch) and heater in a correct circuit [1] [2]

(b) Indicative content
- Obtain mass (of container and oil) using (top pan) balance
- Obtain initial and final temperature of oil or change in temperature using thermometer
- record voltage (using voltmeter) and current (using ammeter) or energy supplied (from joulemeter)
- Time for $\geqslant 5$ mins using stopwatch or $\geqslant 20°$ increase and record time on stopwatch
- $Q = VIt$
- $Q = mc\Delta\theta_{oil} + mc\Delta\theta_{container}$
- $C = (Q - mc\Delta\theta_{container})/m\Delta\theta_{oil}$
- record highest temperature/stir before taking temperature reading
- Lid/insulation [8]

Response	Marks
Candidate identifies and describes **7 or more** of the points shown in the indicative content. There is a widespread and accurate use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are excellent. Candidates use the most appropriate form and style of writing. Relevant material is highly organised with clarity and coherency.	[7]–[8]
Candidate clearly identifies **5 or 6** of the points shown in the indicative content. There is good use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are good. Candidates use an appropriate form and style of writing. There is a good attempt to organise material.	[5]–[6]
Candidate clearly identifies **3 or 4** of the points shown in the indicative content. There is some use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are sufficient to make the meaning clear. Candidates use an appropriate form and style of writing. There is some attempt to organise material.	[3]–[4]
Candidates clearly identify at least **1 or 2** of the points shown in the indicative content. There is limited reference to scientific terminology. Presentation, spelling, punctuation and grammar may contain some errors. The form and style are of a satisfactory standard. There is only a limited attempt to organise material.	[1]–[2]
Response is not worthy of credit	[0]

10

4 **(a)** **(i)** When an (unstable) nucleus disintegrates emitting alpha, beta and gamma [1]

(ii) 1 disintegration per second [1]

(b) 4477/3 = 1492 [1]
1492/300 = 4.97 [1]
4.97 − 0.56 = 4.41 [1] [3]

(c) **(i)** A_o = 3395 [1]
λ = 0.0485 d^{-1} [1]
Subs into $A = A_o\,e^{-\lambda t}$ ecf [1]
A = 2008 Bq [1] [4]
(or use of ln equation)

(ii) λ = 5.614 × 10^{-7} s^{-1} [1]
$A = \lambda N$ subs   ecf [1]
N detected = 3.58 × 10^{9} or A = 1 × 10^{7} Bq [1]
N = 1.8 × 10^{13} [1] [4]   13

5 **(a)** **(i)** The energy possessed by/work done on an electron accelerated through a pd of 1 V or equivalent [1]

(ii) $E = mc^2$ [1]
1.66 × 10^{-27} × (3.00 × 10^{8})^2 = 1.494 × 10^{-10} J [1]
1.494 × 10^{-10}/1.60 × 10^{-19} = 9.34 × 10^{8} = 934 MeV [1] [3]
(931 from rounding)

(iii) 8.6–9.0 MeV [1]
50–60 [1] [2]

(iv) the breaking of a uranium nucleus into smaller nuclei creates [1]
nuclei with
Smaller mass number but larger BE/nucleon so energy has
been released [1] [2]

(v) $^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{144}_{54}Xe + ^{90}_{38}Sr + 2^{1}_{0}n$

Xe correct [1]
Sr correct [1] [2]

(b) **(i)** large mass causes gravitational confinement [1]
high density/high pressure creates the very high
temperatures [1] [2]

(ii) Inertial (confinement) [1]
Solid fuel pellet heated using laser/ion beams/x-rays [1]
Magnetic (confinement) [1]
Charged particles deflected [1] [4]

(c) Keeping (the plasma) confined at hot enough temperatures
for long enough for fusion to occur [1]
Producing more energy than that provided to begin the reaction [1]
The expense involved in producing fusion/building power station [1] [3]   19

6 **(i)** cos curve [1]
2 cycles in 2T [1]
Decrease in amplitude [1] [3]

(ii) the graph does not oscillate, non-zero initial displacement
which decreases [1]
but does not reach zero before T/4 [1] [2]

(iii) non zero initial displacement which decreases without
crossing the x-axis [1]
The displacement is zero at T/4 (by eye) [1] [2] 7

7 **(a)** $T = 2 \times \pi x \sqrt{\frac{0.65}{209}}$ [1]
$T = 0.350\,\text{s}$ [1] [2]

(b) amplitude = 0.02 m [1]
$\omega = \frac{2\pi}{0.35}$ [1]
eq or subs $a = \left(\frac{2\pi}{0.35}\right)^2 \times 0.02$ ecf for T and max displacement [1]
$a = 6.45\,\text{m s}^{-2}$ [1] [4]

(c) Displacement = –0.005 [1]
$-0.005 = 0.02 \cos\left(\frac{2\pi}{0.35}t\right)$ ecf for T, A and x [1]
$t = 0.102\,\text{s}$ [1] [3] 9

8 **(a)** **(i)** For a fixed mass of gas at constant temperature [1]
the pressure of the gas is inversely proportional to the
volume or product of p and V is constant [1] [2]

(ii) A horizontal line below the original line [1]

(b) $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$ [1]

$\dfrac{311}{286} = \dfrac{326}{T}$ correct pressures [1]

                                  correct temperature [1]

T = 300 [1]

300 − 273 = 27 °C   ecf for T [1] [5]

(c) **(i)** KE = 3/2kT
     = $3/2 \times 1.38 \times 10^{-23} \times 286$ [1]
     = 5.92×10^{-21} J [1] [2]

(ii) pV = nRT or Pv = NkT [1]
$311 \times 10^3 \times 1.03 \times 10^{-2} = n \times 8.31 \times 286$ [1]
n = 1.35 moles [1]
$1.35 \times 6.02 \times 10^{23} = 8.11 \times 10^{23}$ molecules [1]
$5.92 \times 10^{-21} \times 8.11 \times 10^{23} = 4800$ J [1]

Alternative
use of pv = 1/3 Nm <c^2> [1]
3/2 pv = 1/2 Nm <c^2> [1]
3/2 pv = 1/2 M <c^2> [1]
sub p and v [1]
ans [1] [5]   15

                                             Total   **100**