ADVANCED
General Certificate of Education
2022

Physics

Assessment Unit A2 3B

assessing

Practical Techniques and Data Analysis

[APH32]

WEDNESDAY 11 MAY, MORNING

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.

Graphs

In marking **graphs** you will have to exercise some professional judgement, but other features must be marked strictly according to the scheme.

The mark(s) for "Scales" is normally awarded only if the plotted points occupy at least half of the printed graph along each axis. In addition, the scale must be to an easily manageable factor, such as 1:2, 1:4, 1:5, 1:10, 1:20. A factor of, for example 10 mm to represent 30 cm does not score because of the difficulty of accurately plotting or reading off values.

Points plotted correctly means to within ± one small square(± 2 mm) on the printed grid in either x-or y-direction. The marker's professional judgement comes in here.
One mark is to be awarded for drawing the best fit line through the points. Do not agonise over scoring (or not) this mark, your professional judgement will allow you to come to a decision very quickly.

In measuring the gradient, the mark for a "large triangle" means that either rise or run (or both) must be at least 5 cm on the printed graph/grid. Some candidates do not draw their triangle, but use points read off from the line. Provided the rise and/or run in this virtual triangle meet the 5 cm criterion, the mark is scored. Beware of candidates who read off their gradient points directly from a table. The marker must check that the points used actually on the line and meet the 5 cm test.

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.

					AVAILABLE MARKS

1   **(a)**   age = 4.07 × 10^{17} [1]
            s   [1]   [2]

      (b)   **(i)**   a correct extreme fit line drawn   [1]
                  shallower   [1]   [2]

             (ii)   large triangle and correct subs   [1]
                  consistent gradient   [1]
                  consistent maximum age   [1]   [3]   7

2   **(a)**   **(i)**   Microphone   [1]

             (ii) $T = \frac{1}{f}$ or subs   [1]
                  1   [1]
                  ms cm^{-1} [1]   [3]

            (iii)   0.2 V cm^{-1} [1]

      (b)   **(i)**   T measured across more than one wave   [1]
                  T = 2.15 – 2.25 × 10^{-3} s   [1]   [2]
                  ecf **a(ii)**

             (ii)   f correctly calculated (ecf from part **(b)(i)**)   [1]
                  range calculated or % from 440 Hz calculated   [1]
                  correct statement about falling inside range   [1]   [3]   10
                  Only award third mark if supported by calculations

3   **(a)**   **(i)**   taking natural logs of both sides:
                  $\ln T = \ln T_o e - \frac{t}{k}$ [1]
                  separating right hand side, bringing down indices and ln e = 1:
                  $\ln T = \ln T_o - \frac{t}{k}$ [1]
                  rearrange and comparison to y = mx + c:
                  $\ln T = -\frac{t}{k} + \ln T_o$
                  $\ln T = -\frac{1}{k} t + \ln T_o$
                  y = mx + c   [1]   [3]

             (ii)   Determine gradient   [1]
                  k = –1/gradient   [1]   [2]

      (b)   **(i)**

Time/s	T/°C	ln(T/°C)
120	64	4.16
240	50	3.91
360	39	3.66
480	30	3.40
600	23	3.14
720	18	2.89

                  values correct   [1]
                  All given to 2 decimal places   [1]   [2]

             (ii)   scale and labels   [2]
                  points plotted correctly, [–1] for each error   [2]
                  best fit line   [1]   [5]

            (iii)   reads/calculates intercept as 4.3 ≤ c ≤ 4.5   [1]
                  $\ln(T_o) = c$ [1]
                  T_o correct for pupil's intercept value   [1]   [3]   15

4 **(a)** **(i)** position 1 = Ammeter [1]
position 2 = Voltmeter [1] [2]

(ii) Resistivity (allow resistance) is dependent on temperature or
equivalent [1]
so the circuit can cool down/maintain a constant temperature [1] [2]

(iii) metre rule [1]

any from:
- ensure wire is pulled straight (against edge)
- don't measure from end of metre rule
- read values in line/mention of parallax error [1]

micrometer screw gauge [1]

any from:
- do not over tighten
- check/adjust for zero error [1] [4]

(b) **(i)** $\rho = \dfrac{\pi V D^2}{4lI}$
subs V/I for R [1]
subs $\pi D^2/4$ for A [1] [2]

(ii)

Quantity	Reading	Absolute uncertainty	Percentage uncertainty
Voltage	0.41 V	±0.01 (V)	2.44%
Current	1.06 A	±0.01 (A)	0.94%
Length	91.2 cm	±0.1 (cm)*	0.11%
Diameter	2.64 mm	±0.01 (mm)	0.38%

$[\frac{1}{2}]$ marks for each round down [4]

(iii) $\rho = 2.3 \times 10^{-6}$ Ωm [1] ± 4.25%[2] ecf from **(ii)**
give [1] for addition without doubling D SE 3.9%

or
Max/Min Method:

$\rho = 2.3 \times 10^{-6}$ Ω m [1]
$\rho_{max} = 2.4 \times 10^{-6}$ Ω m or $\rho_{min} = 2.2 \times 10^{-6}$ Ω m [1]
$\Delta\rho/\rho \times 100 = 4.3\%$ [1] [3]

(iv) 1×10^{-7} Ω m
Must be 1 sig fig [1] 18

Total	**50**