AQA

A-LEVEL
PHYSICS
7408/3A: Paper 3A
Report on the Examination

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General Comments

The paper proved to be the most accessible so far, with a mean mark just below 50% of the maximum. These questions also proved more discriminating than those in the 2018 paper, with students finding almost every mark to be accessible. The only exception was in question 01.4, where very few could score all three marks.

We need evidence that students have *practical* experience of laboratory work. They should be able to write with authority, particularly about the assessed practical activities. Students should avoid answers that lack clarity or contain generalisations. For example, when asked to suggest ways of reducing uncertainty, students often write 'Check the calibration of instruments'. Other common ideas are the use of several sets of apparatus to compare results, or an insistence that all the measurements are made by the same person. Such responses do not gain credit at this level.

Students should also take care to use appropriate scientific language. In question 2, students needed to write convincingly about the determination of water volume; there were the usual instances of 'scales to weigh the water' where 'balance to find mass' is required from an A-level student. This is a recurring problem that teachers may wish to address.

Students generally showed more confidence with questions that tested their mathematical skills. Many knew how to combine percentage errors correctly. A 'show that' problem (02.5) was well-answered, provided students noted that the relevant curve was exponential. Extended working, (eg in 01.6, 02.5 and 03.7), revealed clear work that could be followed without too much difficulty.

The general issue of rounding of data requires some comment. An example is seen in question 03.2, where many correctly deduced that the length of the wire was 0.578 m, but then felt obliged to give the wavelength as 1.16 m, (presumably to preserve significant figures). This was allowed, as it was also in 02.3 (where some truncated their final answer of 19.8% to 20%). However, in such a problem the preservation of significant figures should not apply to the number of figures in the number as a whole, but only to figures after the decimal place. Secondly, students who truncated their result in 03.2 then had to decide which result to use in 03.3 and in 03.4. Provided working is transparent the examiners can give credit, but it is a different matter when students show a value 1.16 in the substitution whereas the outcome shows that they must have used 1.156.

Unfortunately, due to the answer to question 02.2 being provided on the 7408/3BD 'Turning Points in Physics' paper, this question had to be withdrawn. This was to ensure that students sitting the other options' papers were not disadvantaged; **all** students entered for A-level Physics were thus awarded 1 mark for question 02.2.

Question 01

This question addressed some of the ideas implicit in required practical activity 12. It had some unusual twists, including the problem involving the *N*-*Z* plot (Figure 2). This was answered confidently by the more able students.

The impression in 01.1 was that most students had at least seen a sealed source. We wanted students to write about the safety procedures that *they* would employ when working with such sources. No credit was given for describing any responsibilities that belonged to a teacher or radiation protection supervisor. The use of tongs and 'do not point the source at anyone' were the most popular ideas. 'Replacing the source in the castle after the experiment' was another wellknown procedure. Generalised comments such as ‘wear a lab coat’ did not score, nor did vague ideas such as ‘stay a safe distance away’. This question discriminated very well.

In 01.2 the correct answer was given by more than 50% of students. In 01.3, well over half supplied all of A, B and I to earn full credit.

In 01.4 we expected students to know that the background count rate should be measured, with the source effectively removed to eliminate the key source of systematic error. We also hoped that they know enough about the random nature of background radiation to appreciate that a long integration time can reduce percentage uncertainty. These provided the main thrust in many of the arguments put forward, but sometimes examiners found that the expression of these ideas was too vague. We wanted students to return the source to its castle or to remove it entirely from the laboratory; comments such as ‘put the source far away’ were not acceptable. Less popular, but viable, suggestions were to carry out the measurement in the same place (or on the same day) as that of the main experiment. Some students suggested that anomalies should be rejected when determining background count rate. These students need to re-examine their understanding of the nature of radioactive decay.
Comments such as ‘check the tube is zeroed’ and ‘use a counter with greater resolution’ gained no credit. A number of students erroneously assumed that A_b was the rate during the test of the inverse-square law. The majority scored no more than 1/3 and only very few scored 3/3.

In 01.5, the working seen on Figure 4 confirmed that the minimum thickness most students were looking for required the use of 5.5 MeV. However, many then appeared to think that the scale was linear between the gridlines, often producing a result of 11 mm or 13 mm for the thickness. Others, having correctly identified 12 mm as the thickness corresponding to 5.5 MeV, ignored the instruction to deduce the *minimum* thickness. They then rounded up to 20 mm to provide a margin of error. There was strong representation at each mark.

In recent years, students have become used to questions (01.6) that test an understanding of the equation $y = mx + c$. The majority gave clear reasoning to justify k = (*gradient*)^2 and went on to provide a successful numerical answer, exactly in line with examiners’ expectations. The problem for many was providing a correct unit with their result; mm $\text{Bq}^{0.5}$ was often seen. Students performed very well in this question, with about 40% scoring at least 5/6.

In 01.7 it was possible to predict with reasonable certainty what the value of e should be, so we needed a convincing calculation. Several creditable approaches were seen, but scale drawing ideas and extrapolation off the grid were rejected. One common error was the incorrect substitution of data into $d = \sqrt{\frac{k}{A}} - e$, so, if using a point on the line eg d = 230 mm, $\frac{1}{\sqrt{A}}$ = 0.6, students wrote $230 = \sqrt{\frac{k}{0.6}} - e$. Another frequent mistake was to mix units for k and d. Due to such errors, over half the students failed to score anything; nearly a third of the cohort, however, obtained full credit.

Question 02

This question tested experimental design, interpretation of logarithmic scales and the mathematics of an exponential process. The expected method was to collect water (using a measuring cylinder) in a certain time (measured with a stopwatch) and to determine the flow rate from $\frac{volume}{time}$.

The idea of timing the collection of a certain volume was rejected by examiners due to the problem of the very slow flow rate suggested by Figure 8.
In 02.1, we found that some students had misinterpreted the intention of the question. Instead, they gave a long and detailed description of how the internal volume of tube T could be determined. Many went on to explain that *Q* was this internal volume, divided by the time taken for T to empty.
The expected approach was to measure the volume of water leaving T in a fixed time. We did not accept the suggestion of recording the increasing volume at regular intervals and finding *Q* from the gradient of a graph of the variation of volume with time.
Use of a measuring cylinder to collect the water was popular, although some wrote more vaguely about using measuring beakers. We accepted an indirect approach to finding the volume, eg by measuring the mass of water collected using a balance. Most who took this approach remembered to tare the balance beforehand. The need to use a stopwatch to measure a time interval was sometimes overlooked.
More effective responses from students gave relevant detail about reading the volume in the measuring cylinder; this suggested that question 03.3 from 2018 had not gone unnoticed. Many explained that extending the time over which water was collected reduced the percentage uncertainty (in the time). However, some students continue to limit themselves through their incorrect use of technical vocabulary, or ambiguous statements such as '*Q* = volume collected over the time taken.' The question discriminated well in favour of the more able students.

Question 02.2 was withdrawn (see explanation in the 'General Comments' section above).
In 02.3, most students realised that 6.4% was the percentage error in $\frac{Q}{h}$ and, by changing the subject, they arrived at $\eta = \frac{\pi \rho g}{128} \times \frac{h}{Q} \times \frac{d^4}{L}$. The percentage uncertainty in η depends only on the percentage uncertainties in $\frac{Q}{h}$, *d* and *L*, so success in the question rested on whether students understood how to combine these, taking account of the fourth power in the equation. Although there were many correct responses (answers of 19.8 % far outweighing those of 20 %), and most knew what to do with the 4, some did not know they had to add all three percentages. Well over a third of the students obtained full credit.

In 02.4, students identified appropriate techniques, although the suggestion that they illustrate their idea with a sketch was, as noted in previous reports, too often ignored. The use of a set square was very popular. However, if students were going by what they could see in Figure 9 and if the square was used in contact with the bench and by itself, it had to be truly enormous to do the job. Here, a sketch was required to satisfy examiners. Otherwise, a metre ruler was needed to extend the vertical edge alongside the tube. We did not allow the suggestion that a set square could be placed on tube T because this will disturb the tube. The use of a plumb line or spirit level was also frequently seen, but credit was withheld in the absence of a clear description. At the risk of repetition, even a basic sketch helps the student to score the mark. 'Use of a spirit level' sounds plausible until an examiner has seen sketches with a spirit level placed horizontally on the open end of the tube!
Inevitably, there were students insufficiently prepared for this type of problem. Such students suggested that the tube can be compared with the rod of a clamp stand, or invented methods in which the meniscus is compared with graduations on the tube. Just below half of the students scored the mark for this question.

In 02.5, students were told that Figure 10 showed an exponential curve. This did not deter some from treating it as a straight line, measuring the gradient, using $y = mx + c$ to find the half-life (thereby predicting 02.6), before working backwards to obtain λ. This method did not produce an acceptable result and no credit could be earned.

Use of $\frac{dy}{dt} = -\lambda y$ was seen occasionally, and could score providing the tangent to the curve drawn on Figure 10 was well judged. About a quarter of the students chose to use an approach based on $y = y_0 e^{-\lambda t}$, extracting the data they needed from two points on the graph. This approach was almost always successful.

In a 'show that' question, students *must* produce a result to at least one more significant figure than the question value, in this case 4.5×10^{-3}.

Most found 02.6 very straightforward and the wide range of acceptable values ensured that more than 60% earned credit, even with a slightly errant value for λ.

In 02.7, the key was to recognise the significance of the 30° and draw the line halfway between the dashed line and the time axis. It was possible to get full credit for drawing a straight line but, even so, about half the students did not score on this question.

Question 3

This question addressed some of the ideas behind required practical activity 1. Nevertheless, many stumbled using the CRO figures. Most knew what they were trying to do, but usually determined the period from insufficient cycles or failed to notice that the trace was not centred vertically. From then on, they were much more confident, and more able students had little difficulty in scoring well.

In 03.1, students without recent experience of the CRO struggled. However, about a quarter overcame the problem of the vertically displaced trace and obtained between 60 and 62 Hz for full credit. Students who rounded (correctly or otherwise) to 1 sf obtained no credit, as the rubric states 'an answer to 1 sf will not normally be acceptable, unless the answer is an integer, eg a number of objects'. Students found this the most challenging part of questions 03.1 to 03.4.

In 03.2, examiners almost always saw the expected read-off figures earning the first mark. About a third missed out on the second mark by failing to multiply the difference between their read-offs by 2, by leaving their result in cm, or by truncating to 1.2.

Of the 20% of the students who were unable to score in 03.3, some were unsuccessful because the answer they obtained was not a result of their working in $v = f\lambda$.

In 03.4, a small number used $c = \sqrt{\frac{T}{\mu}}$ and rearranged for μ, substituting their answer for 03.3.

However, the majority used $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$, being careful to avoid the obvious pitfall of substituting λ for L. Several students thought that T represented the period of the wave shown on the CRO trace, while others forgot to multiply 0.5 by 9.81 (when substituting for T). Another unsuccessful approach was to assume that μ was 0.5, the mass in kg suspended from the wire, divided by the distance between the bridges. Students' working was generally easy to follow, and more than half obtained at least one mark.

In 03.5, over 80% of the students gave the reading as 0.71 mm, while most of the remainder predictably thought that *d* was 0.53 mm.

Question 03.6 has been asked frequently and the students generally knew what we wanted, in many cases saying more than enough to earn full credit. Students should understand that repeating and averaging a measurement serves only as a simple check of a value obtained at a particular point, and does establish whether the rod is uniform. In 03.6, many gave fully successful descriptions about reducing random error when determining the diameter of a wire.
Examiners needed clarity that anomalies had been rejected before averaging, and some ambiguous answers left the examiner in doubt. Some students think that averaging can mitigate the effect of anomalies. Nearly half of the students scored only one mark because they gave an answer that only addressed one of the marking points, failing to notice that the question asked for procedure**s**.

In 03.7, almost half were able to deduce that $\rho = \frac{\mu}{A}$, and go on to use their 03.5 result to earn full credit. The most frequent error was to mix units, substituting *d* in mm while keeping μ in kg m^{-1}.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.