AQA

AS
PHYSICS

7407/2 Paper 2
Report on the Examination

7407
June 2016

Version: 1.0

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General comments

This is Paper 2 of the first series of a new AS specification. The paper is in three sections: the two questions in Section A examine the knowledge, skills and understanding associated with the practical aspects of the course; Section B consists of two questions examining content across the AS specification; Section C contains thirty multiple choice questions assessing content from all of the AS topics.
A problem associated with question 9 meant that this question was withdrawn. The maximum mark on the paper was therefore 69 and there was evidence of performance across almost the whole mark range.

Section A

Question 1

This question was about the determination of the Young modulus of the metal of a wire, one of the six required AS practicals. It gave students the opportunity to demonstrate familiarity with a range of practical equipment and techniques.
The work seen suggested that the majority of students were familiar with the experiment and could process the raw data. Problems arose when students were asked to comment on the effect of changing the dimensions of the wire, for example.

1.1 Vernier scales are a common feature of the equipment used to measure extension in a Young Modulus determination. Many students were unable to give the correct answer, however, with 2.8 mm a fairly common error.

1.2 Students were allowed to carry an error forward from 1.1 and many students were able to read the scale correctly. Where the answer to 1.1 fell outside the graph some students attempted to extrapolate or carry out a y=mx+c calculation; these students may have benefited from checking their answer to 1.1 first.

1.3 Most students were able to correctly compensate for the zero error in the calliper reading, although adding it to obtain 0.37 mm was fairly common. Some students also attempted to use the 20.14 mm value seen at the top of figure 3.

1.4 This calculation was reasonably well carried out with the majority of students getting at least 3 marks out of 4. Although students should be encouraged to use the gradient of figure 2 to help calculate a value of E, the use of individual points was acceptable on this occasion. It was common to see the values obtained in the previous three sections used to work out the cross sectional area, and then the strain and stress separately, before combining them to calculate E. The two common errors in this approach were the use of the diameter for the radius, and missing out "g" in the calculation of the force. Several students also made powers of ten errors in the cross-sectional area calculation, or mixed their units in the calculation of strain. This commonly led to the fourth mark being lost. Students should be encouraged to set out their answers logically so that it is easier to check for errors. Some students inevitably lost marks if they made an error attempting to perform the calculation in one go. Over reliance on the data sheet also led to problems with some students using $F=k\Delta l$, and using the Boltzmann constant for k.
Any errors from 1.1, 1.2 or 1.3 were carried forward so that no student was denied the opportunity to earn subsequent marks.

1.5 When guiding students with their responses to questions such as this it is important to emphasise the need for clarity in expression, as examiners cannot credit ambiguous or vague answers. To gain credit, answers required an outcome (eg the extension increases) and consequence (the percentage uncertainty in E decreases). It was common for students to miss out the word 'percentage' but on this occasion this was not penalised. There were several different correct approaches but each was accompanied by its own common errors. For example, students who simply stated that the wire would get longer, rather than the extension would increase, failed to get the mark. Students who based an answer on the increased percentage uncertainty in the measurement of the diameter often failed to go on to state how this would affect the percentage uncertainty in the value of E. It was also relatively common to see incorrect physics, for example answers claiming that the value of E would be affected.

Question 2

2.1 Students should expect to be required to interpolate between grid lines when plotting points. Most students were able to do this satisfactorily, but errors reading the ε scale were surprisingly common. Another issue was associated with the style of point used. The standard has been long established in the legacy EMPA and ISA tests: thick points or blobs were not accepted.

2.2 Thick, discontinuous, faint or straight lines forfeited this mark. Whilst some excellent lines were seen in answer to this question, some lines were thick enough to obscure the points. The line was expected to pass within half a grid square of all of the points. It was common to see careless drawing near the last point (392,1241), which lost the mark. Where it was clear that the points were incorrectly plotted far from the trend line it is surprising that students did not go back and check their answer to 2.1.

2.3 An error was carried forward from their answer to 2.2 and most students were able to read the maximum correctly to half a grid square. However, it was common to see 1456 (the maximum in the table) even when the line on the graph did not support this value. 1335 was a common incorrect answer, suggesting that students were treating the ε axis as a numberline.

2.4 This question discriminated in favour of those who could write without ambiguity. Examiners were looking for an answer that explained that θ_n could be found from figure 6 simply by reading off where the value of G was zero (280 ^{o}C). Answers that discussed the difficulty of reading the value from figure 5 as there is a range of values for which ε is at, or close to, a maximum, also gained credit. Unfortunately many students implied that the gradient of figure 6 was easier to measure, or stated that finding where the gradient was zero was easier on figure 6 (seeming to suggest that there is such a point on figure 6). Some erroneously wrote about the relative difficulties of reading a point from a straight line rather than a curve. It was also relatively common to see comments referring to the different scale ranges in the two diagrams.

2.5 Many very good answers to this question were seen, clearly demonstrating an understanding of the equation of a straight line and an ability to obtain data, such as the gradient, from a graph. An alternative acceptable approach was to use the values from two points and solve the two simultaneous equations produced. Many students incorrectly thought α was the value of G where the line touched the y-axis, and extrapolated the line back and extended the axis to find this point. Others mistakenly took α to be the gradient.

2.6 Although many correct answers were seen, some suggested that several students were unfamiliar with the term “full scale deflection”, despite this being defined in the question. Others did not spot the μ on the answer line, writing down a value of 0.1 without changing the unit to match.

2.7 There were many answers expressed so poorly that credit could not be given. Common examples were “the scale is too large”, “the divisions are not small enough” and “the scale does not have enough divisions”. Discussions related to accuracy gained no credit either. The best answers made it clear that the resolution of the meter was unsatisfactory, supporting this with a relevant calculation, such as the change in pd represented by one division (2000 μV). There was consideration made for answers based on an incorrect answer to 2.6. For example, those who had calculated the full-scale deflection to be 0., could gain credit for arguing that the range of the meter was inadequate. Several unsuccessfully argued that it was the susceptibility of the analogue meter to parallax error which made it unsuitable.

Section B

Question 3

This question required students to apply their knowledge and understanding of physics to a simple seismometer. Although the diagram contained a lot of information, and there was a relatively long stem to the question, there was no evidence to suggest that students found the context particularly demanding.

3.1 This was a multi-step calculation that most students found fairly straight forward. The common errors seen were wrong substitution of diameter (or use of a wrong formula for volume) and power of ten errors arising from calculation of volume in cm^3. Students who have difficulty converting between cm^3 and m^3 would be better advised to work in m from the outset. Generally “show that” questions are used to provide unsuccessful students the data they would need to complete further parts of the question. Students should be reminded to provide at least 1 sf more than the “show that” value, and they should be discouraged from trying to calculate an answer backwards. Another error is forcing their answer to be near the “show that” value: many students were denied consequential error marks when, having made an error, they attempted to manipulate their answer to obtain a numerical value near 5. For example, students who used 5 cm for the radius could obtain a value of 4.2 kg for the mass. Many would then miss out the step (multiplying by g) to determine the weight, as they had already reached a value near to 5 perhaps. Many modern calculators generate results as fractions or surds. No credit is given for final answers given in such a form or with recurring notation but there is no penalty for this with intermediate results. However students should be discouraged from doing this because it makes the work less transparent and inhibits error-checking. The rounding down of intermediate results compromises the chance of full credit; any rounding down, eg to the same significant figures as that of the least accurate data should not be done until the final stage is complete.

3.2. There were two potential errors in answers that often led students to lose at least one mark. Many students did not take the centre of mass of the ball into account, and therefore did not include the radius when calculating the distance to the pivot. Some students worked through their answers in cm, but wrote the moment unit as Nm.

3.3 Many good answers were seen to this multi-step calculation and this was a good discriminator. Some students were unable to suggest much beyond picking F=5 N and rearranging $F = k\Delta l$ (given on the data sheet) to produce $\Delta l = 0.05$ m. Spotting that this was a 3 mark question may have led some of them to realise that a more complicated calculation was needed. Others tried to calculate the extension by dividing turning moment by stiffness or by multiplying distance from the pivot by stiffness. A number of students did not attempt this question.

3.4 This was a fairly demanding question that aimed to get students to think about the reason for having the heavy ball in the seismometer. Successful answers were able suggest that, in the very short length of time involved, the ball would barely move and therefore the arm holding the pen would pivot about the ball, causing the upwards line. Many incorrect answers were seen: some students were convinced there was a third law or conservation of momentum explanation while others said the spring, having become compressed, then pulled the arm up. It seemed that many felt that the downwards accelerating seismometer took the ball with it and so the line went downwards. No credit was earned for saying the pen or the arm did not move, likewise any suggestion of an 'up and down' motion of the pen (although 'up then down' could earn a mark).

Question 4

This question linked several parts of the AS specification together, including radioactivity, electricity and energy. It also allowed for the testing of some parts of the first chapter of the specification: "measurements and their errors".

4.1 This question caused few students any difficulty. The few errors seen tended to be linked to using 2 for the nucleon number of the alpha particle.

4.2 The equation needed for this question is on the data sheet, and it was therefore disappointing to see how many students were unable to perform the calculation correctly. Most commonly students confused output and input powers, obtaining an answer of 6W. A moment's reflection should have shown that this could not be sensible. Due to the use of 100 W in the stem, answers were accepted regardless of the number of significant figures but any rounding down had to be correct and recurring notation was rejected.

4.3 This was much more accessible with only a few students being unable to get the correct answer. The few errors seen included answers that used 1700 W (ie the answer to 4.2), perhaps carrying on the problem with input and output power in this context.

4.4 There were several routes through this question and all were given credit. A popular solution was to calculate the total circuit resistance (10.24 Ω) for an output power of 100 W, then reverse-working using the parallel resistor formula (or perhaps just dividing 45 by 10.24) to find the (non-integer) result for number of resistors. Rounding down gave the required result but a few rounded up and forfeited a mark. Those using their result from 04.2 rather than 100 W were able to get some credit.

4.5 There was evidence to suggest that many students were unfamiliar with this conversion and that some centres may have overlooked this part of the specification. The most popular approach was to find the equivalent J value of the kW h and divide by the number of seconds in a year but the same idea using energy in W h was also successful. Many near misses involved mixing units, dividing W h by 3600. Disappointingly many students did not attempt this question.

4.6 Answers to this question suggested very few students were familiar with the idea of an 'order of magnitude' calculation. Many students who produced an answer for 4.5 did not then realise that the solar panel on Mars produced the same average power output as that on Earth. Given that the intensity of solar radiation was about the same in both situations they were looking for a solar panel with a surface area about the same as that in a typical domestic setup on Earth. Having grappled with this very few then appreciated that the answer required was to be given to the nearest power of ten (10 m^2 was the expected result). Again, many did not attempt the question.

Section C

This section consisted of 30 multiple choice questions covering all of the topics in the AS specification. A problem associated with question 9 meant that this question was withdrawn. There was some evidence to suggest that some students were unfamiliar with this form of assessment and that they would have benefitted from more practice. In particular students should be made aware that they can write on the paper to perform any necessary calculations and that, when the correct answer isn't obvious, eliminating incorrect answers increases the likelihood of a guess being correct. Given that there is no negative marking (ie no penalty for incorrect answers), it was surprising to see some of the answers left blank.
Many students did not use the correct method to mark, or correct, their answer as laid out at the beginning of the section. Whilst benefit of the doubt was given to many of these answers on this occasion, students should be made aware that they increase the likelihood of their intentions being understood if they follow the instructions in the paper. This includes the clear instruction that only one answer per question is allowed: any indication of more than one answer being provided immediately lost the mark.

5 Although decay series per se are on the A2 specification, this question tested the consequence of alpha and beta decay on proton number, as well as the student's understanding of isotopes. It proved to be very accessible with 84% of students getting the correct answer. The most common distractor was C, confusing alpha and beta decay perhaps.

6 Students generally find most aspects of the particle physics topic fairly straightforward. This question was no exception with 83% of students remembering the need for two gamma photons to be produced. A was the most common distractor, chosen by students who forgot this important point perhaps.

7 With 87% of students choosing the correct answer, few students had any difficulty with this question. The remaining answers were fairly evenly spread between the three distractors.

8 This was the most accessible question on the paper with 95% of students able to recall the quark structure of an antiproton. C was the most popular distractor, chosen by students confusing protons and neutrons perhaps.

9 This question was removed prior to the exam. There was no evidence to suggest that students were disadvantaged by this.

10 Approximately two thirds of students spotted that a bigger energy jump was needed to produce a photon of UV, and therefore chose D. Distractors A (the smallest energy jump) and C (the next smallest) were chosen by a similar number of students who failed to make the link between energy and frequency perhaps.

11 Multiple choice questions involving the algebraic manipulation of an equation, rather than the use of data, are fairly common. 62% of students were able to see that the alpha particle would have four times the mass, therefore four times the momentum, and one quarter of the wavelength. The most popular distractor, D, was chosen by students who missed out the last step, perhaps. C was also a common incorrect answer, perhaps chosen by students who thought that the fact alpha particles contain two protons was significant.

12 This question required students to work out the wavelength of the sound wave, and then calculate the phase difference of two parts a certain distance apart. 45% of students correctly identified the correct answer. Approximately 35% thought A was correct, using π, rather than 2π, as the phase difference for two points a whole wavelength apart, perhaps.

13 This proved to be one of the more demanding questions on the paper, with 39% of students being correct, despite the equation being in the data booklet. The most popular distractor was C, chosen by students having difficulty dividing $\sqrt{2}$ by 2 perhaps. Unsurprisingly B was also popular, the answer obtained if the two changes cancelled out.

14 57% of students correctly identified D as the appropriate answer. The other students were split almost evenly between the distractors, with A being slightly more popular.

15 It was pleasing to note that 74% of students were sufficiently familiar with white light single slit diffraction to give the correct answer here. Approximately 10% of students gave the answer D, suggesting that they were unaware that any effect would occur.

16 This question proved to be quite demanding, with 40% of the students giving the correct answer. Nearly 30% chose D, confusing angles of reflection and refraction perhaps.

17 This straightforward calculation proved to be very accessible with 85% of the answers correct. It is worth pointing out that only about 2% of students chose D, an answer greater than the speed of light in a vacuum.

18 Surprisingly the most popular distractor here was B, perhaps highlighting students' confusion with mass and weight. 70% were able to identify the correct answer.

19 Being able to interpret graphs is another important skill commonly tested by multiple choice questions. 67% of students were able to spot that graph B correctly represented the variation of the gradient of the velocity-time graph with time. The most popular distractor was A, perhaps due to students eliminating C and D as being obviously incorrect, and being able to go no further.

20 Students should be warned about multiple-choice questions that have an apparently very straightforward solution. Approximately the same number of students gave the incorrect response B as gave the correct response in this question. Presumably they calculated the speed for the second half of the journey, and took the average of the two speeds rather than calculating the total distance divided by the total time.

21 This question is a fairly demanding projectiles problem, requiring students to realise that at half the time of flight (2s) the ball would be at its highest point, and using $s = ut + ½ at^2$ for the remainder of the vertical motion, with u=0 ms^{-1} and a = 1.6 ms^{-2}. Only 32% of the students were able to do this, with approximately half of the answers being B, which may have been a guess as it seemed feasible.

22 68% of students identified the correct answer to this question. The most popular distractor was B, given by students believing that the sideways force must somehow reduce the forward speed.

23 The correct answer was given by 43% of students. Unsurprisingly perhaps, A was the most popular distractor.

24 Over 68% of students were able to recall, or work out, the significance of the area under a force-displacement graph. Those who chose B (approximately 20%) were probably confusing force-displacement with force-time.

25 Occasionally students are presented with multiple choice questions which require them to work out the “incorrect” answer. This will be highlighted by a bold “not” in the question. The fact that only 40% of students managed to find the correct answer may indicate that this could have caused difficulties, although this is contradicted by the small number (2%) of students choosing the watt. The most popular distractor, D, may have been chosen because of its apparent complexity.

26 This calculation proved to be very accessible, with 84% of students giving the correct answer. It should be noted that, in a written paper, students who use the suvat equations would not get the same credit as those who correctly equate GPE and KE, despite the two approaches giving the same answer.

27 This proved to be a very demanding question with only 29% of students giving the correct answer, although it proved to be quite discriminating. Students were required to calculate the kinetic energy of the car, and divide this by the distance to find the average decelerating force. The same answer could be obtained by calculating the acceleration using the suvat equations, and using F=ma. Slightly more students gave the answer C than gave the correct answer, perhaps neglecting to square the speed when calculating the kinetic energy.

28 54% of students were able to perform this relatively straightforward calculation. Surprisingly D was the least popular distractor, suggesting students had more problems with correctly using seconds rather than minutes than dealing with the m in mA.

29 With 55% of students giving the correct answer, this question proved to be reasonably accessible. This may be because the experiment is often carried out with a protective resistor in series with the diode. The most popular distractor, D, indicates some confusion between current and pd. A relatively high number of students opted for C, suggesting some difficulties working out whether the diode was reverse biased or not.

30 Many students have difficulties with electricity questions. Using multiple choice questions such as this one may help deal with some misconceptions. The correct answer was given by 40% of students, but nearly 50% believed that adding a resistor in parallel would reduce the current (and hence the charge) through R, despite being told that the cell has negligible

resistance. Presumably the students believed that the current through the cell does not change, and therefore the current is shared between the two resistors.

31 It is clear from answers to this question that few students (approximately 13%) had much understanding of how using high voltage power lines reduces energy loss. In fact the correct answer proved to be the least popular of the choices. The current through a transmission line is found from the power being delivered and the voltage of the line (P=IV). Hence higher voltages result in lower currents. The power dissipated is then related to the current in the line, and the resistance of the line. Students were expected to use P=IV to calculate the current in the line, and then use the power loss (1%P) = I^2R to calculate the resistance. Responses suggested that many students believe that the 132kV is dropped across the line, rather than between the line and earth.

32 This proved to be more demanding than expected, with more students choosing A than the correct answer (D). This was perhaps due to students realising that thermistors had something to do with temperature, without realising that the higher the temperature the lower the resistance. It may be that these students rejected the other answers without checking them as an understanding of resistors in series and parallel should have led to the correct answer.

33 Students familiar with the characteristic for a fixed resistance were probably led to answer B without reading the question. This proved to be the most popular answer despite it being incorrect. Approximately 20% were sufficiently careful with their reading, or sufficiently familiar with the practical, to give the correct answer, A.

34 This calculation was fairly demanding with only 27% of students giving the correct answer. In fact answers B, C and D proved to be almost equally popular, suggesting a fair amount of informed guessing was going on. It may have been made easier had a circuit diagram been provided. In the absence of one, students should be encouraged to draw their own in the spaces on the paper.

Mark Ranges and Award of Grades

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