AQA

AS LEVEL
PHYSICS

7407/2

Report on the Examination

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General Comments

There were opportunities for students across the range of ability to demonstrate their knowledge and understanding of physics.

Higher performing students typically produced supporting work in their calculations that was structured, clearly demonstrating the thought processes used to determine the answer. The quality of explanations made by these students was high; their arguments were often detailed and supported by sound logic and use of physics principles and equations.

Lower performing students can improve their performance in a number of areas. It is good practice to summarise all data by writing it in the answer space along with the relevant formula to be used. The formula should have a subject and each step in the calculation should be presented. Too often, the working is either absent or difficult to follow, making it difficult to award any compensatory marks for partial working. When attempting an explanation, the students should endeavour to link their response to facts and physics principles learned from the specification.

There was some evidence to suggest that students found the paper too long. Significant numbers of non-attempted questions were seen in question 4 of section B and the later questions in section C. It is hoped that with more past paper practice, students will be able to manage their time more effectively in future exams.

Section A

Question 1

01.1 The success-rate on this question was more than 90%. Common wrong answers seen included $21.1\ \Omega$ and $8.2\ \Omega$, both suggesting that the students did not read the question carefully enough. ($21.1\ \Omega$ is the sum of all four resistors while $8.2\ \Omega$ is the value of the largest single resistor.)

01.2 This showed a much greater range of attainment by students; over 60% of students obtained 2 marks. Many students offered $6.1\ \Omega$ as the answer, treating the series combination of 2.2 Ω and 3.9 Ω as the lowest possible value. Other students did not invert the sum of in the final step, leaving their answer as $0.71\ \Omega$.
A significant number of candidates were unable to add two fractions:

$$\frac{1}{2.2} + \frac{1}{3.9} \text{ and believed the answer to be } \frac{1}{6.1}$$

Another common incorrect response was

$$\frac{1}{8.2} + \frac{1}{6.8} = 0.27$$

This error clearly demonstrated a poor understanding of the effect on resistance of combining resistors in parallel, and a lack of knowledge of the mathematical process used to determine the resistance of two resistors in parallel.

01.3 Students' level of achievement in questions involving internal resistance would be improved if they were encouraged to concentrate on the effect the current has on the terminal pd. Students are expected to treat voltmeters as ideal, that is having infinite resistance. This being the case, students should recognise that the current is zero and therefore the terminal pd equals the emf.

Students had difficulty with this question, suggesting significant gaps in their understanding of emf, terminal pd and resistance. Many students stated that resistance between X and Y is zero when there is no resistor connected between X and Y.
This misunderstanding led students to believe that a current was flowing and/or all the voltage was across the internal resistance. Others stated that the voltmeter was the only component in the circuit without stating why this meant that it read the emf, or students stated that without a resistance between X and Y there was nowhere else the voltage could be lost than across the internal resistance.
Students need to be made aware of the fact that the voltmeter cannot directly read the lost volts and should be encouraged to consider the formula in this form:

Terminal pd = $\varepsilon - Ir$

A significant number of students believe that in a parallel circuit, or a series circuit that includes a voltmeter connected in parallel, resistance increases when a switch is closed. These students will state that current decreases when a switch is closed thus neglecting the fact that the resistance between the contacts of the open switch can be considered infinite compared to resistance elsewhere in the circuit.
High quality answers addressed the very high resistance of the voltmeter and the effect this had on the current and the lost volts.

01.4 Many students thought that the resistance in the circuit increased when the resistors were added between X and Y. These students often stated that the current in the circuit decreased when resistors were added.
Other students stated that the voltage decreased because it was now shared between these (external) resistors. This response showed a lack of appreciation of the fact that the voltmeter was connected across both resistors, as well as demonstrating a lack of awareness regarding the impact of the internal resistance. Students were required to relate the sharing of the voltage between the internal and external resistances.
The focus of many answers was incorrect. This question is about terminal pd, internal resistance and current. Students should remember to make sure their answers address these main points; too often the answer centred on limited descriptions of what would happen to the two resistors connected between X and Y.

01.5 Students should be aware of the need to quote numerical answers in section A to an appropriate number of significant figures. Students did not obtain the mark when they quoted $\frac{V}{R}$ as $0.12\dot{6}$ rather than as 0.13

01.6 Many students plotted (0.115, 0.48) instead of (0.13, 0.48). Reading of scales needs to be done with care to avoid this type of error. The line of best fit needs to be drawn with due care. Students should be encouraged to draw lines of uniform thickness without any discontinuities.

01.7 It is considered good practice to draw a gradient triangle on the line of best fit. Students were expected to draw a suitably large gradient triangle where the change in voltage was at least 0.5 V. In general, the triangle should be as large as possible, choosing points that can be read accurately. The points used should be indicated by labelling of the values on the line and subsequent working should be clearly presented.
In cases where a student used a single point from the line and substituted this into the equation of the line they received a maximum of 1 mark.
Common errors seen included:

- Read-off error of the y co-ordinate at the point the line cuts the x-axis;

- Read-off error of the x co-ordinate at the point the line cuts the x-axis;
- Choosing to use a gradient triangle that was too small.

01.8 The first mark was straightforward, awarded for stating that the number of values available was less in the new method. Many students were under the impression that in the second method the resistors could not be connected in parallel. Answers that discussed the range were treated as neutral because the question asked the students to consider the number of different values of R available in method 2 compared to method 1. The second mark was harder to achieve; the students had to appreciate that this method yielded 6 values for R. Less than 20% of students obtained both marks.

Question 2

02.1 This question asked students to explain why taking repeat readings was desirable in determining a value for w. Many students stated that this enabled a mean to be determined but did not explain the advantage of this. The question required students to explain why the mean was an improvement over a single reading. Appropriate, technical language was expected and students would do well to familiarise themselves with the glossary of terms in the online Practical Handbook.

02.2 Just over 20% of students performed this calculation correctly. Many students correctly calculated the mean of w but then used $\pm$ 0.01 mm as the absolute uncertainty rather than $\pm \frac{\text{range in } w}{2}$.

02.3 Higher achieving students performed well in this calculation, with 30% of students obtaining 2 marks. The calculations presented by these students were structured in an easy-to-follow way. Lower achieving students were less sure about how to proceed with this calculation but compensatory marks were available for certain partially correct workings shown. Students should be encouraged to set out their working in a way that demonstrates their thinking to the examiner. Marks can only be awarded for working seen on the script.

02.4 / 02.5 The term precision was used to describe the **resolution** of the Vernier scale. This term was not used in the manner defined in the Practical Handbook and will not be used in this way again. It is not believed that the use of the term here disadvantaged any student; this is a piece of equipment that uses the type of scale students are expected to have used as described in section 7.1 ATe on page 80 of the specification.
Surprisingly, less than 20% of students read the Vernier scales correctly. A very large number of students ignored the zero on the sliding Vernier scale and read off the values as 80.5 mm and 78.3 mm respectively.

02.6 Many students carried out this calculation correctly, but too often this was preceded by poor reading of the Vernier scale. Weaker students often got confused with powers of ten, wrongly converting from centimetres to metres, often in the final stage. Some students misunderstood the situation and simply found the mean of the answers from part 02.4 and part 02.5.

Section B

Question 3

03.1 A question asking a student to "Show that" is asking the student to demonstrate clearly their logic in arriving at the provided answer. The marks are awarded for clear communication of the steps taken in the working. Where lapses occur, such as no 'subject', no formula, or no rearrangement of terms, then the student is not demonstrating that logic with sufficient detail. Students should be encouraged to pay attention to the way their working is laid out in this type of question. Many students were awarded 3 marks by having unambiguous, explicit working.

03.2 Typically, high performing students demonstrated clear understanding through the working presented in the determination of the phase difference. However, other students were very unsure of how to use **Figure 9** to find the phase difference. Some of these students determined the time difference to be 0.05×10^{-14} instead of 0.04×10^{-14}. Students need to take care when reading off data from graphs to ensure that such readings are sufficiently accurate.

03.3 Some students ignored the direction to use the data provided to compute the value for g arrived at by the gravimeter and simply quoted $g = 9.81\ ms^{-2}$. Other students attempted to use the data to obtain a value close to 9.8 and in this case errant doubling and halving was seen. Able students typically approached this question in a structured way, producing working that was clearly presented and easy to follow. A significant number of students failed to quote the final answer to 3 sf, instead leaving it as 4 sig figs or rounding to 2 sig figs.

03.4 A very large number of students read a single point of the curve and divided the distance by the time. Another common mistake was the use of d = 0.12 rather than t = 120 ms.
This read-off error led to tangents being drawn at the wrong point on the curve.
Students who drew a tangent generally arrived at an accurate answer that was inside the allowed range. Power of ten errors were tolerated where students kept their time in milliseconds rather than converting to seconds. Tangents drawn were of variable quality; it was difficult to ascertain the unique point on the curve that the drawn line touched.

03.5 A common incorrect answer was acceleration, while a significant number of students thought that it was the average speed of the mirror. Good quality responses identified the gradient at $120\ ms$ as the instantaneous speed.

Question 4

04.1 A significant number of students had difficulty with this question. Common wrong answers included:

- Mass divided by charge
- The charge = $53 \times 1.6 \times 10^{-19}$ arriving at an answer = 3.9×10^{7}

Other students could not recall the units for specific charge; the coulomb and the joule were common wrong answers. Students who did not express the unit using index notation did not receive the mark.

04.2 Many students could not convert 1300 eV into its equivalent 2.1×10^{-16} J.
A common error seen was $1300 \div 1.6 \times 10^{-19} = 8.125 \times 10^{21}$

04.3 A wide range in the quality of response seen here. Those who obtained 3 marks typically presented their working in a way that demonstrated a good understanding of the calculation required. Students who made some progress typically by determining the number of xenon ions in 79 kg obtained some credit. There was a significant number of non-attempts seen.

04.4 Some students thought that the helium ion had more charge than the xenon ion because helium had a higher specific charge. On this basis, they stated that the helium ion had a greater speed. Getting the correct relationship between specific charge and mass was a sign of quality. Others thought that helium's greater specific charge meant it had a greater mass than xenon. Despite this error, students were still awarded the higher speed mark for helium. Other students confused specific charge with activation energy and gave answers in terms of combustion rates.
Students often confused the terms speed and acceleration. A common error was to state that the acceleration of the helium ion was greater, without linking this to a greater speed. Better students made reasoned arguments regarding the relationship between energy, speed and momentum. Frequently, they stopped short of linking this to the thrust exerted on the space craft. In these cases, the students would limit their answer to momentum change of the propellant rather than relating this to the effect on the spacecraft.

Section C

As stated last year, 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 their selected answer being correct.
Students need to be made aware of the need to follow the instructions in the paper on how to select their answer. As was the case last year, any indication of more than one answer being provided immediately lost the mark.

Question 5

27% of students selected the correct answer here. Most students attempted to use equations of motion but failed to appreciate the direction of the acceleration and were unable to resolve to find the component of the weight parallel to the slope. Those who were successful most frequently used the principle of conservation of energy to find the work done by the frictional force.

Question 6

Students are generally quite strong on the topic of particle physics; over 60% of students obtained the correct answer, with distractor C being a common incorrect answer. Students need to be made aware that hadrons can interact via all four fundamental forces and that the weak interaction is not exclusive to leptons.

Question 7

Many students found this question a challenge with just over 50% selecting the correct answer. Students should be encouraged to check specification content and ensure they understand each statement. This type of calculation will be expected knowledge across the life of this specification.

Question 8

The most popular incorrect response was distractor B. Students need to ensure that they have taken account of the information and avoid pitfalls of this type. Terms such as number of neutrons and nucleon number should be treated with caution; it is important that students can distinguish between these terms in questions such as this.

Question 9

45% of students selected the correct answer, with 33% of students incorrectly selecting distractor B. Students seemed unwilling to consider the total momentum as being zero despite this application of momentum conservation being clearly stated in the specification content.

Question 10

Just over 60% of students identified the electromagnetic radiations in order of decreasing wavelength. The most common incorrect answer was distractor A. Students need to be encouraged to read questions carefully and take note of the inequality signs.

Question 11

Distractor C was selected by almost 35% of students. This response indicated a limited understanding of what is meant by a transverse wave or an assumption that an option, which suggests some type of restriction, has been phrased correctly.

Question 12

This proved one of the most accessible questions in section C, with nearly 80% of students selecting the correct answer. However, it was noted that the supporting working was not particularly convincing. Many students used the ratio of 4:2:1 for the current ratio rather than the ratio ¼: ½: 1. This error may have resulted in students obtaining the wrong answer if asked for the current in either the 4 Ω or 1 Ω resistor.

Question 13

Just over 50% of students selected the correct answer. The most frequent incorrect response was distractor D; students were familiar with the possible non-conservation of strangeness in decay but did not know that strangeness must be conserved in the production of strange particles.

Question 14

Only 35% of students answered this question correctly. The most popular incorrect response was distractor C. Knowledge of the phase relationship between points on a stationary wave is expected. Students should be familiar with characteristics of a stationary wave, not simply limited to no net energy transfer and node / antinode positions.

Question 15

This was an accessible question with 87% of students selecting the correct response. The most frequent incorrect response was distractor A, with weaker students unable to recognise the vector nature of momentum.

Question 16

This moments calculation proved to be very challenging, with only 17% of students selecting the correct answer. Distractors A and B were the most popular incorrect answers with each being selected by approximately 35% of students. This error was caused by students disregarding the weight of the uniform metre rule.
Students should be encouraged to read the question carefully and include all forces and their respective distances to the pivot before undertaking any moments calculation.

Question 17

91% of students selected the correct answer.

Question 18

This calculation was performed correctly by over 70% of students. The most frequently selected incorrect answer was distractor B. Students applied little physics here and simply found the product of 12, 6.5 and 5.

Question 19

Most students were able to determine the momentum gained by the object. Each of the distractors gained about 15% of student responses.

Question 20

The most frequently selected distractor was B, accounting for 30% of the responses. It would benefit students to emphasise that the maximum kinetic energy depends only on the frequency of the incident radiation and the work function of the metal surface. Increasing the power, without changing the frequency, will only increase the number of photons incident on the surface every second, and will not increase the energy each photon carries. It would have had to have been clearly stated that the frequency had been doubled as a means of doubling the power for distractor B to have been the answer.

Question 21

This question was little more than recall of the features of the graph of maximum kinetic energy against frequency of incident radiation. Over 60% of students correctly selected the correct answer.

Question 22

Just over 50% of students got this question correct. Distractors B and C were the most commonly selected incorrect answers. Students should be aware of how to plot linear graphs for equations in the form $y = k / x$.

Question 23

Approximately 35% of students selected distractor A as their answer. Students need to be able to recall that wavelength decreases as velocity decreases as light enters a more optically dense medium.

Question 24

This question was set up to test the students' ability to spot that 35° was not the angle of incidence. This indeed proved to catch a lot of students out, with almost 60% of students selecting distractor A. Errors of this type can be minimised by completing the ray diagram and marking the angle to be determined. Doing this gives the students a chance to take stock of the information, making it less likely to misinterpret the data.

Question 25

The majority of students selected the correct answer. Of those who got it wrong, most of them chose distractor C (20% of all responses); these students could not determine how increasing the distance between the slits and the screen affected the spacing of the maxima. A quick sketch of the grating and typical pattern of the maxima would certainly have aided students in making this connection.

Question 26

30% of students opted for distractor D; this was mostly due to having eliminated distractors A and B, and guessing between C and D. The majority of those who attempted an analysis of base units did this correctly, recognising that distractor D was a permissible unit.

Question 27

Less than 20% of students selected the correct answer. Nearly 40% of students selected distractor C and in doing so failed to notice that the angle required was double 23.6°. Students need to pay close attention to the wording in questions as this type of extra detail is typical of multiple choice questions.

Question 28

Less than 50% of students selected the correct answer. Distractor B was the most frequently selected incorrect response. In selecting distractor B, students did not take account of the horizontal motion of ball **X**.

Question 29

Almost 50% of students selected distractor B. Students were unable to see that the force was the same on both masses. Students often have difficulty in distinguishing between force and acceleration, as was the case here. The smaller mass will experience a greater acceleration but this is due to its inertia and not the size of the force it experiences. As momentum is conserved, then the momentum lost by one object is equal to the momentum gained by the other. The magnitude of the momentum change is the same for both objects. The forces acting between the objects can only act while they are in contact, therefore the time over which the momentum change occurs is the same for each.

$$\text{Momentum change} = \text{impulse} = \text{force} \times \text{time}$$

$$\text{Same force} = \frac{\text{same momentum change}}{\text{same contact time}}$$

Alternatively, these forces are internal forces in a two-body system, constituting an example of Newton's third law, and must be equal in magnitude.

Question 30

Most students selected the correct answer. A significant number of students selected distractor D, believing this statement was incorrect. **X** has a greater breaking stress since the force applied to it is greater than the force applied to **Y** at the point of breaking.

Question 31

Most students correctly identified B as the correct statement regarding superconductors. Distractor A proved a popular choice as many students are reluctant to recognise that superconductors have no resistance and prefer statements that suggest that superconductors have almost zero resistance.

Question 32

40% of students selected the correct answer. The most popular distractor was C; students had difficulty dealing with the fact that doubling the radius quadrupled the cross-sectional area. Where students had supporting working, with the resistivity formula, they had usually performed the calculation correctly.

Question 33

The low level of success here was surprising; less than 50% of students correctly identified the correct answer. In preparation for the exam, students would do well to be able to sketch all such graphs from memory, making any such graph instantly recognisable in questions like this.

Question 34

Over 10% of students did not select any answer. It is important that students develop exam technique to include a final page check to ensure all questions have been seen. Only 35% of students selected the correct answer; this demonstrates a lack of familiarity with the properties of LDRs and potential divider circuits.

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account on how students have performed for each question.

Mark Ranges and Award of Grades

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