Questions matter

A-level
Physics

7408/2 Paper 2

Report on the Examination

7408
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Question 1

01.1
Most students were able to answer this question successfully. A few students made an arithmetic error or did not provide the answer to at least 2 significant figures (sf).

01.2
There were many different routes through this question and most students found this very challenging, although 2 of the 3 marks were easily accessible. The first mark was for some relevant calculations and the last for the correct number of significant figures. Since the value used for the significant figures depended on which value the students used for n from question 01.1, different answers were accepted based on the value of n seen. For those who chose a route that did not require n, then an answer to 3 sf was correct. If n was calculated to 2 or 3 sf, then the number of significant figures in n determined the correct answer. If the value of 40 was used and the student had not calculated a correct value in 01.1, then either 1 or 2 sf was accepted since 40 is ambiguous. Students who identified 43 or 43.1 as the correct value of n should have recognised that 40 was therefore to 1 sf.
Many students were unsure about which mass to use in the equation $pV = \frac{1}{3}Nm(c_{\text{rms}})^2$ or $\frac{1}{2}m(c_{\text{rms}})^2$ with many confusing the mass of the particle with the mass of the gas.

01.3
Most students realised that absolute temperature was directly proportional to $(c_{\text{rms}})^2$ and therefore that the new temperature was the old temperature multiplied by four. Some failed to recognise that the question asked for the change in temperature, so the original temperature had to be subtracted. For those students who calculated the new temperature by doubling c_{rms} and using $\frac{1}{2}m(c_{\text{rms}})^2 = \frac{3}{2}kT$ they were also able to gain full marks. When they had used the wrong mass in question 01.2 and the same mass was used here, the mass cancelled out – giving the correct answer. If another mistake was made in question 01.2 then full credit cold be awarded here with an error carried forward (ecf).
A small number of students rounded their intermediate calculations which led to small errors in the final answer. While this is usually penalised, in this case this was felt to be unduly harsh as they were demonstrating good understanding of the physics involved, and so a range of acceptable answers was used. Only a very small number of students did not convert the temperature to K from °C.

01.4
Most students found the specific heat capacity and specific latent heat calculations straightforward and were able to gain two marks. However, most students were unable to calculate the correct mass of the water in the air accurately.

Question 2

02.1
This question proved challenging for most students. Some realised that the current was given by the *gradient* × *capacitance*, although not all of these realised that as the initial current was asked for, the gradient must be taken at time $t = 0$. Those answers which did not specify the initial gradient either in words or by annotating the graph were only able to score one mark.
The command word in the question was ‘*explain*’, so full marks required the answer to be justified. Thus, a full-mark answer had to identify $\frac{\Delta V}{\Delta t}$ as the gradient and also use $I = \frac{\Delta Q}{\Delta t}$ and $C = \frac{Q}{V}$. Many students did not differentiate between a change in potential and the value of the potential.

02.2
This question is based on a standard technique and proved accessible to many students.
It asked students to determine the time constant using the graph. Therefore, answers which calculated the time constant using RC and the approximate value of R given in the question were unable to score the first mark, although they could still score the second. Students could use a variety of techniques, the most straightforward being to read off the time for V_R to drop by a factor of e^{-1}. Some did not realise the graph started at 20 and just read off 27.5, but this error was rare. However, other techniques such as reading off two values and using $V = V_0 e^{-\frac{t}{T}}$ or using the half-life were also seen and accepted.
Nearly all students were able to calculate the resistance using $T = RC$ although, as a 'show that' question, the working had to be seen to award the mark. Normally, one more significant figure would be required than is given in the question; however, given the precision possible with reading from the graph, 2 sf was condoned with correct working.

02.3
This proved very challenging with most students scoring 1 or 0.
Students could use the data in the question to calculate V_0 and then use $V = V_0\left(1 - e^{-\frac{t}{RC}}\right)$. Most students who took this route were able to handle the algebra and scored well.
Only a few who tried to use $I = I_0 e^{-\frac{t}{RC}}$ were able to arrive at the correct answer. Most students who attempted this route calculated the current by dividing the voltage across the capacitor by the resistance of the resistor $\left(\frac{6}{2.4\times10^5}\right)$ and were only able to gain the second marking point. Only a few realised that the voltage given was the voltage across the capacitor and therefore the current was given by
voltage across the resistor = (*initial voltage –voltage across the capacitor*) ÷ *resistance*.

02.4
This question was accessible to most students who realised that the potential difference was proportional to $\frac{d}{\varepsilon_r}$. A few students had the ratio the wrong way up and scored one. Although students should know that physics answers should be given as an appropriately rounded decimal, the fraction $\frac{1}{8}$ was condoned in this case.

Question 3

Question 3 proved very challenging with a large number of students struggling to understand the geometry of the situation.

03.1
There were two approaches to this question.
Students could calculate the flux cut as $BA\cos\theta$, the time for the rod to fall using $s = \frac{1}{2}gt^2$, and then use Faraday's law where the emf is given by the change in flux divided by the time taken. The most common mistakes with this route were:

- missing out the $\cos\theta$ term, by not realising that B and A had to be perpendicular
- not realising that the area was given by the *length of the rod* × *height the rod fell through*.

Making either mistake still allowed two marks to be scored.

The most common approach was to use $\varepsilon = Blv$. However, most who tried this approach also failed to realise that B and v should be perpendicular and therefore missed out the $\cos\theta$ term. Students could calculate v either by halving the speed with which it hit the ground or by dividing the distance by the time to fall.

Attempts to use the equation for a rotating coil ($\varepsilon = BAN\omega \sin \omega t$) were unlikely to score, although they could gain a mark for the time for the rod to fall.

03.2
This question was very challenging, with most students not understanding the situation. Students confused the pole with the rod, sometimes explicitly and sometimes this could only be inferred due to the students' descriptions of the directions involved. Many students also did not realise the relevant direction was the direction of the motion rather than the orientation of the rod (or pole). These students were generally unable to access the explanation marks, although they could still score the descriptive marks.

To score well students had to appreciate that the dominant effect was the changing angle between the velocity of the rod and the direction of the magnetic field. However, some credit was given to those who realised that there was a contribution that depended on the magnitude of the velocity.

Many students contrasted the differences between the magnitude and direction of the emf between falling left and falling right rather than discussing the changes to the magnitude and direction of the emf as it fell to the left and then to the right. These students were able to gain two marks. However, few who attempted this route scored both marks as they failed to realise the emf changed value and it was therefore the mean emf rather than just the emf.

While some students did correctly describe the emf reducing when falling to the left and increasing when falling to the right, the explanations were harder due to the confusion about which directions were involved. The direction marks were the hardest to score with very few appreciating that the direction of the emf changed when the rod fell left, while it remained in one direction while falling to the right. Most who discussed the direction only compared the direction of the emf as the rod fell left with that of the rod falling right.

Question 4

Question 4 was one of the more accessible questions on the paper; it was generally answered well by students who were familiar with nuclear reactors.

04.1
This was the hardest part of question 4 with some students confusing the moderator and the coolant. While water can act as both moderator and coolant in some reactors, the question asked about the function of the coolant, not water in a reactor. There are also many reactors where water is not used, and the coolant and moderator are not the same material.

Since the question mentioned the cooling function of the coolant, answers which related to this were not accepted. To gain a mark the answer had to contain the idea of transferring heat energy to either the boiler or the turbine. Those answers which suggested the coolant itself was turned into a gas to turn the turbine were not accepted.

04.2
Most students could name relevant properties of the coolant. This question was answered well, although some students wrote about irrelevant properties. As there is a range of liquid coolants used in nuclear reactors, including sodium, any relevant properties to any of these reactors were accepted. A few students failed to gain marks due to suggesting the wrong value for the property, eg that a low specific heat capacity was desirable rather than a high one. As the question only asked the students to state the properties that should be considered, students did not need to say whether a property required a high or low value, but when that information was supplied it had to be correct.

04.3
This question also scored well. Most students knew that control rods were involved, although a small number referred to the moderator here. However, in order to score the first mark, students had to indicate that the control rods were inserted further into the reactor. Various ways of describing this were accepted but simply stating that control rods were used or giving an ambiguous answer such as '*control rods are raised and lowered*' was not accepted. Most students knew that the job of the control rods was to absorb neutrons and reduce the neutron flux and therefore the number of fission reactions. The idea was looked for rather than a specific wording.

A small minority again mixed up the function with the moderator and thought that slowing down the neutrons would be helpful.

Question 5

Question 5 proved very challenging, although 05.2 was reasonably accessible for students.

05.1
This question was very challenging, with most students gaining 1 or 0.
The first mark was for calculating the angular speed of $\mathbf{S_1}$. Some students did gain this mark although they did not know how to progress from there.
In order to make much progress with this question students had to realise that the centripetal acceleration was equal to the resultant gravitational field strength. They could then subtract the gravitational field strength of the Earth to determine the gravitational field strength of the moon.

Some students attempted to determine an effective mass to allow this period and then use this with $T^2 = \frac{4\pi r^3}{GM}$; this approach did not gain credit.

05.2
This question was much more accessible, with many students realising that this was a simple rearrangement of $g = \frac{GM}{r^2}$. It is unfortunate that the challenging 05.1 put some students off attempting the much more straightforward 05.2. Those who tried to use $T^2 = \frac{4\pi r^3}{GM}$ did not score here.

05.3
This question also proved to be very challenging. Students had to recognise that the forces or fields acted in opposite directions on $\mathbf{S_2}$. This was the most accessible mark and could be achieved in many

different ways, including by annotating **Figure 8**, although simply writing about being attracted to the moon and the Earth was not enough.
The second mark was for realising that $\mathbf{S_2}$ would be travelling too fast to orbit at the lower distance. Again, this could be expressed in a variety of ways by discussing speed, angular speed or the magnitudes of the fields or forces involved. This proved the most challenging mark to score.
The last mark was for stating how the moon reduced the resultant field or force to allow $\mathbf{S_2}$ to orbit the Earth at the correct speed at a lower radius.

Some answers referred to $\mathbf{S_2}$ requiring the same force as the moon to orbit with the same period. This idea was rejected, as the force depends on the radius and the mass, both of which are different. Some wrote about the gravitational forces of the moon and the Earth cancelling each other; this was condoned for the first marking point, but would have resulted in $\mathbf{S_2}$ moving in a straight line, rather than a circular orbit and was rejected for the second and third marking points.

Question 6

06.1
This proved more challenging than expected for a simple definition. Many students could not define electric potential.
The first mark was for mentioning the work done per unit change being (–)$4.0\ \mathrm{J}$. Many answers here gave the unit of work done as V rather than J and were therefore unable to score. The second mark was about moving from infinity to the point and was generally the most accessible mark. The last mark was for getting the direction of movement, the sign of the charge and the direction of energy transfer correct. Students could answer this in various ways, referring to a positive charge gaining energy when moving from the point to infinity; losing energy or having negative work done when moving from the point to infinity; or they could refer to the opposite direction but referring to a negative charge. In order to score here the sign of the charge had to be explicit.

06.2
Some students were confused by the context in what should have been a straightforward question. The students were provided with a potential–distance graph and asked to find the maximum potential. This should have been obtained as the gradient of the steepest part of the graph. As the graph had a long straight section around this point, a tangent did not need to be drawn, provided the data were taken from the straight section of the graph. As with all graph work, students were expected to take their data from well-spaced points for full marks.

Students who used the equation $\frac{\Delta V}{\Delta r}$ based on points from the graph that were not from the straight section were able to gain a mark for calculating the average field.

Most students were able to state the unit for the electric field, although a small minority could not.

06.3
This question was more challenging and required some understanding of the context for full marks. Nearly 40% of students realised that $E_k = \Delta Ep = e\Delta V$ and scored one mark. However, determining the correct ΔV was more challenging: only around 14% students realised it was the largest change in potential between the two points and were able to score two marks.

06.4

This question was very challenging for students both in their understanding of the context and their expression of their thinking. It was hoped that, by placing the electron at the edge of the confined group as shown in **Figure 9**, students would realise the electrons were repelled by the electrodes and remained within the group. However, many students were misled by question 06.3, not realising the difference between the two scenarios and thought that the electron moved to the right. Students who thought the electron moved to the right could gain marks by linking the graph to the motion.

A wide variety of answers was accepted for relating the motion of the electron to the information in the graph, but this still proved very challenging. Often answers mixed up concepts like potential energy and potential. It was hoped that 06.2 and 06.3 would have directed the students to talk about field and forces or potential energy being converted into kinetic energy, but many failed to make these links.
Those students who realised that the electron would oscillate were generally able to score highly, but only those who really understood the context were able to make that link. Although the motion was not SHM, this answer was accepted as realising this was not applicable is beyond the scope of A-level.

Question 7

07.1
The best approach to this question about the use of logarithmic graph paper was to recognise that three orders of magnitude were represented in the data, which could not be shown effectively on a linear scale. However, comments about the decay being exponential or allowing the creation of a linear graph were accepted. This proved to be accessible.

07.2
This question was also accessible although only a small number were able to score full marks. Many students did not score full marks because they did not draw a line on the graph and attempted to use the points to get their data. It is important that students realise that when provided with points on a graph it is expected that a line is drawn from which to take data.

There were various approaches to determining λ from the graph. Two points could be used with the equation $N = N_0 e^{-\lambda t}$ or the half-life could be used with $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$. Some students realised that

λ = –gradient of a $\log N$ against t graph. However, most who used this method did not realise that using a log scale did not form the logarithm of the values. They were able to score three marks for this method, one for the line, one for reading values off the scale and one for realising the significance of the gradient. Only a few took logs (either base 10 or base e) and scored full marks using this method. Those who used $A = -\lambda N$ generally did not realise that as the activity depended on the number of “undecayed” dice, this was only valid for one throw and not over an extended range.

For the last mark the determined value had to be compared with 0.25 to justify a four-sided dice.

07.3
This question was reasonably accessible. However, many students who wrote about handling the radioactive source with tongs, did not mention that the tongs had to be long. The measures described had to be ones that are relevant to sources used in schools. Students were then asked to consider how their safety measure could be adapted to a much more active source used in a hospital. Students were not expected to be familiar with a hospital setting (although those who were could use this knowledge),

but rather to make a reasonable suggestion based on the activity given. Many students were able to make reasonable suggestions here.

07.4
This question was also accessible although misconceptions about radiation were still seen, with a small minority expressing wrong ideas about X-rays remaining in the body or causing the body to become radioactive.

The first mark was for students recognising that X-rays were ionising radiation and linking that to a concrete example such as damaging or killing cells or causing cancer.
The second mark was for recognising the balance between risk and benefit in the use of radiation in medicine. Few students were sufficiently explicit about balancing risk and benefit, so answers which only mentioned minimising risk were condoned.

Multiple Choice Questions 8-32

The multiple-choice questions covered parts of the specification not covered in Section A. The distractors in these questions were written with common errors and misconceptions in mind. These questions are therefore an extremely useful resource when preparing students.

The multiple-choice questions proved challenging. However, a number of questions were found to be straightforward by students. These included B9, B17 and B30 which were all answered correctly by at least 60% of students.

The questions found to be the most difficult were B12, B21, B24, B29 and B32 – answered correctly by fewer than 35% of students.

The most common answer was not the correct answer in the following questions.
12 – the most common answer to increasing the efficiency of the transformer was increasing the thickness of the iron layers in the core, perhaps mixing up the core with the coil. The correct answer of decreasing the frequency (to increase the time for the change in flux and therefore decrease the eddy currents in the core) was the second most popular option.
21 – when considering the radius of a synchronous orbit for a planet with twice the mass of the Earth and one quarter of the day length, the correct answer was the third most popular answer.
24 – the most common answer to what was equal to ε_0 confused the permittivity and relative permittivity, although among the other answers based on equations that contained ε_0 the correct answer was most common.
29 – when asked about what could be deduced about the size of the nucleus from alpha scattering, the most common answer was that it was about 10^{-15} m; students failed to realise that this was an estimate for the distance of closest approach and therefore bigger than the radius of the nucleus. The next most popular answer did recognise this aspect but associated it with the actual radius of the nucleus rather than the distance of closest approach or they mixed up the size order of negative powers of ten. The correct answer ($< 10^{-14}$ m) was the third most popular choice.
32 – the most common answer to working out the age of the rock did not include the nuclei that had decayed into lead as coming from uranium originally and did not therefore add the number of lead nuclei to the current number of uranium nuclei to get the original number of nuclei.

Mark Ranges and Award of Grades

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