Examiners' Report
Principal Examiner Feedback

January 2023

Pearson Edexcel International Advanced Subsidiary Level in Physics (WPH12)
Paper 01: Waves and Electricity

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General Comment

This paper covers the content of Waves and Electricity, specification points 33 to 80. Section A contains 10 multiple choice questions, whilst Section B contains 70 marks of longer answer questions, including one 6 mark linkage question, where students need to present their answer in a logical sequence.

This section of the specification also contains 5 of the IAS core practicals from CP4 to CP8. Usually, at least one of these appears in one of the longer questions in Section B. On this occasion, Q17 was related to Core Practical 8, regarding the determination of the e.m.f. and internal resistance of a cell. On this occasion, the graphical method in the question was different to the way that it is normally undertaken, which provided an additional level of challenge to the students.

Section A - Multiple Choice Questions

Although the paper as a whole performed similarly to other series of this unit, the multiple choice section was perhaps a little less well answered. Five of the multiple choice questions were correctly answered by less than 50% of the students and only one question (Q1) was correctly answered by more than 70% of the students.

The most commonly incorrect answer was Q3, which was correctly answered by just 36% of students. The majority of incorrect answers were C, which is a standard definition of total internal reflection. In this case, however, the light was travelling towards a boundary from a less dense to a more dense substance, so total internal reflection was not possible.

Surprisingly few correctly answered Q7. Most of the incorrect answers were B, where students had presumably assumed that, in descending from the n=3 level, the electrons would either drop to n=2 or n=1. Although this is true, a further emission would take place when the electron that had dropped to n=2 dropped back down to n=1.

Section B

Q11

This question was generally well-answered, with over half of the students achieving all 3 marks. The most common mistakes related to marking point 3, specifically the conclusion at the end. Having calculated a value for mass of 9.10×10^{-31} kg, some students considered that this was not close enough to the value of 9.11×10^{-31} kg to conclude that it was an electron. However, at just 0.1% away from the true value it should have been obvious that this was close enough to make the conclusion that it was an electron. However, as the two values were slightly different on the third significant figure, we did allow students to say that the values were "similar" or "about the same".

Q12(a)(i)

Although almost a third of the students scored all 3 marks on this part of the question, it was disappointing to see so many who did not recognise that the angles given on the diagram were not the angles of incidence and refraction. As a result, the majority of those scoring 1 mark here had calculated sin(32°)/sin(50°), giving an answer of 0.69. Some of those who clearly recognised that the refractive index of an individual substance cannot be less than 1.00 then inverted the same calculation, which also resulted in a score of 1 mark.

Some students had attempted to use a protractor to measure the angles directly from the diagram, but this is not necessary if the angles are given on the diagram already.

Q12(a)(ii)

The drawn ray only needed to be refracted away from the normal line and rays that had been clearly been refracted by much more than they really would be by a material of refractive index 1.32 were still accepted. In spite of this, many drew a ray that was refracted upwards (in terms of the drawn diagram), usually parallel with the ray that entered the prism. Presumably this was a result of considering the prism as a rectangular glass block, with parallel sides.

Q12(b)

This question was generally very well answered, with two thirds of students scoring both marks. The majority of 1 mark responses were caused by students failing to add units to their answers. Those who scored 0 either did not use the speed of light in their calculation, or decided to use the refractive index they calculated in (a)(i).

Q13(a)

Students clearly found this question far more challenging than had been expected. Although the link between a greater diameter and a greater cross-sectional area should have been easily spotted, the majority of students made no reference to area at all. Those who did rarely recognised to mention that the area of Z was four times that of W. Even some of the stronger answers commonly included no reference to the wires directly e.g. “if the wire has a greater area, it has a smaller resistance and a greater current”, without saying it was Z that had a greater area than W.

Some answers were also not fully comparative e.g. “Z has a smaller resistance than W, so the current in Z increases”. This would score MP2 as there is a direct comparison between the wires, but not MP3 as it is not saying that the current in Z would be greater than that in W. The reason why this is important is made clear when seeing other answers such as “Z has a smaller resistance than W, so the current in Z increases. This means that the current in W also increases”.

This was an explanation question, so it was not acceptable to answer the question using algebraic methods. Some students combined multiple equations without any steps to explain what they were doing.

Q13(b)

Over 92% of the students picked up at least one mark on this question, with roughly equal numbers scoring 1 mark, 2 marks, 3 marks or 4 marks overall. There was no particular trend for incorrect answers, although the majority of those with an incorrect cross in the drift velocity row had answered that W and Z would have the same value. Perhaps this related to the fact that in part (a) they had the same drift velocity when in parallel.

Q14(a)(i)

A generally well-answered question, with the majority scoring all 3 marks. The main mistakes were centred around a failure to apply the resistors in parallel formula correctly (usually failing to invert 11/3000). As this was a "show that" question, a reverse argument could only score 2 marks (refer to Section 4.2 in the instructions at the start of the mark scheme). The most common of these approaches was to use 6V along with a calculated combined resistance to show that the current would be close to 23mA.

Q14(a)(ii)

This part was less successfully answered than part (i), largely due to the need to substract their answer to (i) from 12V prior to doing the power calculation. As such, many students ended up scoring MP2 only for use of dimensionally-correct values in the calculation of power.
As the "show that" value from (i) was 6V, it became clear that those using 6V in their calculation of power could not be distinguished from those who used (12-6)V, so full credit was given to those who used 6V in the calculation, regardless of whether there was evidence they had subtracted their answer for (i) from 12V.
Oddly enough, there were also completely incorrect methods that resulted in students calculating the "correct" answer. For example, those who used 12V (instead of 5.73V) and 1100 Ohms would also achieve an answer of 0.13W if they used $P = V^2/R$. So this was definitely a question where the correct answer could not guarantee that full marks were going to be achieved.

Q14(b)

Almost a third of students scored 2 marks out of 4 on this question. The majority of these scored MP1 and MP2 for the resistance comment linked to a lower ammeter reading. A significant number of students did not appear to recognise that the voltmeter was not connected across the thermistor, so the remainder of their answer often just mentioned about the reading on the voltmeter increasing. Considering that both MP2 and MP4 could only be awarded if MP1 and MP3 (respectively) were achieved, it is hardly surprising that very few students scored either 1 mark or 3 marks.
Students need to be able to apply their understanding to different scenarios

than they way they have been taught. It is generally taught that the resistance of a thermistor decreases when the temperature increases. However, this question was specifically asking what happened in this circuit when the temperature decreased. As such, only MP1 (for converse argument) was awarded to those who answered the whole question on the basis of temperature increasing in this circuit.

Q15(a)

This is not the first time on this unit that the Linkage question (indicative content) has related to the superposition of waves. As a result, there were quite a lot of pleasing answers. There were also a quite similar number of students scoring totals of 1 mark, 2 marks, 3 marks, 4 marks and 5 marks. The main mistakes in answering the question came from generic descriptions being used in place of ones that were specific to this scenario. For example, those stating that constructive interference occurred when the path difference between the two waves arriving at a point was a whole number of wavelengths did not gain credit for the second indicative content mark, as in this situation the only constructive interference taking place was when the path difference was zero.
It should also be noted that the nature of this question (requiring coherent and logically structured answers) meant that additions to the diagram showing waves spreading out from the gaps did not gain any credit unless it was also described in the answer space.
The only other aspect of note here is that a number of students confused path difference and phase difference in their answer e.g. "destructive interference takes place when there is a path difference of pi radians". This mixing does not gain credit. Path difference needs to be in terms of wavelengths or metres, phase difference in terms of radians or degrees.

Q15(b)

This was not very well answered, with less than 10% of students scoring both marks. Students were clearly not aware, on the whole, that two light sources could never be coherent as the light is released in quanta. The majority of incorrect answers referred to the logistics of the experiment itself, such as needing a single slit card, or to have the lamps closer together or further apart.

Q16(a)(i)

Although it was a multi-step calculation, this question was answered very successfully. Almost two thirds of the students scored full marks, with an average score of just over 3 out of 4. Although not listed in the mark scheme, it was possible to gain full credit for a ratio of intensity values, although this was very rarely seen completed successfully; the significant majority used the method shown.
Occasionally, students did not calculate area correctly or at all, with a single distance (1.20m or 0.80m) being used, or doing an area of a circle calculation (with either 1.20m or 0.80m being used as the radius).
As shown in the mark scheme example of calculation, the answer could be expressed as a decimal or as a percentage. There were very few examples

seen where the answer was expressed as 0.14%, but these were not able to access MP4.

Q16(a)(ii)

Most students were not able to access these marks, generally due to vague responses which did not answer the question. A number of answers were accepted, although vague references to the time of day were not given credit. Although certain weather conditions were accepted, answers such as "the weather might change" were not.

Q16(b)(i)

A standard set of definitions, but not particularly well-answered due to a lack of mention of vibrations or oscillations in many of the answers. The two alternatives of the mark scheme cannot be mixed and matched, so the reference to being perpendicular to the direction of wave travel can only be accepted if the student is talking about the direction of vibrations, not the plane of vibrations.

Q16(b)(ii)

Although it was common to see discussion of polarising/Polaroid filter(s), very few students recognised the requirement for only one of them, rather than two. This is also another area of the paper where many answers were too vague e.g. "take a polarising filter and point it towards the sun. If the filter is rotated, there will always be light coming through". This is not specific enough for MP2 as the description does not conclusively state that the intensity does not change at all.
Those describing the use of two polarising filters could only score MP1.

Q17(a)

A fairly straightforward rearrangement of an equation to score 2 marks, with a significant majority of students scoring both marks. The most common mistakes were to start with the given equation and work back, often creating incorrect "start" equations.

Q17(b)

Most centres undertaking a practical to establish the e.m.f. and internal resistance of a cell would typically use a graph of V against I to determine the e.m.f. from the y-intercept and the internal resistance from the negative value of the gradient. This graph was different, as the rearrangement meant that the e.m.f. was the gradient and the internal resistance was the negative of the y-intercept. This clearly caused some confusion for some people, who appeared to be using their calculations from this graph to give answers that would be relevant for the more common V-I graph. This probably explains why more than a third of the students scored 0 marks, although around a third also scored full marks.

Students should be aware that all numerical answers should be followed by units, where appropriate, whilst fractions such as $\frac{3}{2}$ are not accepted either.

Q17(c)

A surprising number of students failed to gain any credit on this question. It is possible that some might have read "the power dissipated by the internal resistance *r* decreases" as "the internal resistance *r* decreases", although most appeared to just generally not have a good grasp of what was going on in this scenario. Even the quoting of equations relevant to MP2 were usually in terms of the load resistance *R* instead of the internal resistance *r*. Even students who did the most challenging parts of the question often failed to state that the student was correct, resulting in them not being awarded MP3.
The most commonly-awarded marking point was MP1, usually for the comment about the current decreasing.

Q17(d)

Quite a few students recognised that the graph needed to be steeper when an additional cell was added, there was often little care in ensuring that their graph had exactly double the gradient of the original one. Those who managed this often failed to recognise that the graph would also cross the *y*-axis at - 4 Ohms. Due to these factors, only around 1 in 8 students scored all 3 marks here.

Q18(a)(i)

A generally well-answered question with more than 40% of students scoring full marks. A significant number of students either failed to square *v* in the kinetic energy equation, or used other equations altogether (probably as the quesiton did not state the word "kinetic" prior to "energy of these photoelectrons".
Once an energy had been established, there were a large number who managed to convert the Joule energy into electronvolts. Just a small number multiplied by *e* instead of dividing.

Q18(a)(ii)

Having calcuated the kinetic energy in part (i), it was surprising to see so many students going through the whole calculation again in part (ii). There was an error carried forward on this part so those who had calculated it incorrectly in (i) would not be withheld marks for the same mistake in (ii).
When attempting to calculate photon energy, a number of students used the speed of the electrons rather than the speed of light, usually resulting in the work function being calculated as a negative value.
If correctly calculated, the photon energy was less than any of the work function values for Aluminium, Zinc or Iron. This, on its own, was not accepted as justification that the metal was magnesium, as the calculation needed to be completed to show that the work function was similar to that shown for magnesium.

Q18(b)

Considering that other, quite similar, questions have been asked during the lifetime of this specification, it was surprising that this was not answered as well as expected. Almost half of the students scored no marks at all, although it is possible that some of this stemmed from the fact that by now it was the last page of the exam paper. In spite of this, there was very little sign that people struggled to complete the paper in the time allocated, as the majority of students wrote answers for (b) and (c).
By far the most commonly-awarded mark was MP3, although some who were familiar with the one-to-one nature of the interaction between photons and electrons picked up MP1.
Some of the common issues with these types of questions cropped up again in this series. Most notably, a number of students thought that the question was about energy levels in atoms rather than the photoelectric effect. Also, a number of students failed to use the correct words for "photon" and "photoelectron", using ambiguous terms such as "proton" or "photo". This often resulted in sentences such as "the energy of the photons is fully absorbed by the photons".

Q18 (c)

As a final question, which was also not that easy a question, this performed a little bit better than expected, with a significant number of students recognising that the intensity was clearly related either to the number of photons received or the number of electons released. Although energy was discussed by many in their answers, it was not always clearly demonstrated that they were aware that the intensity did not affect the energy (of either the photons or electons).

Summary

Overall, this paper has been answered in a very similar way to those in previous series of this specification. The calculations have generally been very clearly laid out, and are usually quite easy to pick out the key marking points from. Some of the more complex calculations are answered really well and there are relatively few mistakes made when calculating. However, as has often been the case, the longer written answers can be less clear and are often quite vague.

Q14(b), Q15(a) Q17(b-d) are all questions where students would not gain full credit unless they adapted their knowledge to the situation described in the question. Learning generic descriptions of the behaviour of thermistors, interference of waves and using V-I graphs for e.m.f. practicals will not always be relevant to the question at hand. More time should be spent encouraging students to consider different scenarios rather than standard situations, so that they can apply their understanding.

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