Pearson Edexcel

# Examiners' Report
# Principal Examiner Feedback

## October 2021

Pearson Edexcel International Advance Subsidiary Level
In Physics (WPH12)
Paper 01 Waves and Electricity

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**Introduction**

This unit assesses students' understanding of the topics of Waves and Electricity (specification points 33 to 80). Section A has 10 multiple choice questions, whilst section B contains a mixture of short and long answer questions, calculations, and one 6 mark linkage question.

As with all A level courses, this paper assesses both the ability of students to understand the content, and their ability to apply this understanding to a number of different applications.

This section of the specification contains core practicals 4 to 8. These are practicals that students are expected to have undertaken themselves, and questions about these practicals can be asked within the papers.

## Section A – Multiple Choice

The multiple choice section of the paper proved challenging, especially Q6 and Q7, both of which were correctly answered by 23% and 27% of the students, respectively. It is possible that the combination of more than one aspect made these questions less accessible to some students. Q1 and Q5 were also answered incorrectly by more than half of the students sitting the exam. The best answered question was Q10.

## Section B

### Q11 (a)

Overall, this part of Q11 scored well, with an average mark just above 2 out of 3. Over half of the students scored all 3 marks, including the conclusion that the material was Cubic Zirconia. Although the main mark scheme outlines one method to achieve the correct answer, a significant number of these students used an acceptable alternative method whereby they calculated the refractive index for each of the materials and then compared it to the value for refractive index using the angles given.

Of those unable to achieve full marks on the question, the main mistake was from students substituting speeds as *n* in the equations they quoted. As a result, these students often scored 0 marks.

### Q11(b)(i)

Most of the students answered this question using the method that is listed as the first alternative on the mark scheme. In spite of commonly working out the correct critical angle, a number of students failed to realise that this would lead to total internal reflection taking place at the boundary, with many showing a refraction out of the diamond at an angle of 24°. A significant proportion of students were not entirely sure which calculation they needed to perform, with several attempts shown in the answer space.

For those students scoring the higher marks on the question, it was often the 4$^{th}$ marking point that was not achieved, due to not realising that this was not a 45° prism. As such, the reflected ray from the boundary was not at right angles to the incident ray.

A small minority of students were still working on the presumption that the material in this question was the cubic zirconia from the first part of the question. However, they could still score the 1$^{st}$ marking point (method mark) and the 3$^{rd}$ and 4$^{th}$ marking points (as all three named materials would experience total internal reflection at the boundary requested).

**Q11(b)(ii)**

As there were only two likely options for what might happen at this boundary in silicon carbide, the 2nd marking point was dependent on some correct Physics being stated (1st marking point). Unfortunately, the majority of students clearly felt that the question was being asked as the outcome was going to be different to the situation in part (i). However, the fact that the same outcome would occur was missed by most.

Marking point 1 was generally related to the data for silicon carbide being related to the data for diamond, but seeing as the speeds in a vacuum had been given in the question, this was not a relevant piece of data that could be used to score this mark. Many students did not offer any further data at this point. A number also seemed to rely on their understanding that diamonds have a very small critical angle (so assumed without looking at the data that silicon carbide would have a greater critical angle).

Only around 1 in 7 students scored both marks on this question.

**Q12 (a)**

Many students found difficulty applying their understanding to the situation provided in this scenario, with a significant proportion just quoting general definitions of how a stationary wave is formed. This question was meant to be related to the situation, so very few students mentioned that it was the water that reflected the wave (so did not achieve the 1st marking point). Those quoting general conditions for a stationary wave to form commonly scored the 2nd marking point.
A very common mistake was to discuss 'opposite waves' without making it clear that the waves were travelling in opposite <u>directions</u>. Some other students clearly misunderstood what was producing the stationary waves in this situation, often talking about waves on the surface of the water being reflected back by the edges of the tube.

**Q12 (b)(i)**

Most of the students scored the 1st marking point for a relevant use of the wave equation. However, students often find it difficult to remember that the distance from one node to the next is only half a wavelength rather than a full wavelength. In this case, as the distance was from a node to the adjacent antinode, the length of the air column was $\lambda/4$. As a result, almost half of the students just scored 1 mark on this question.

Those who recognised that the air column had a length of $\lambda/4$ generally ended up scoring all 3 marks on the question.

It is clear that a significant number of students have a good idea of the typical value(s) for the speed of sound in air, and a number who had calculated the speed in this question to be around 170 m/s went back and changed their working to show a calculation leading to 340 m/s instead. This perhaps explains why very few students scored 2 marks on this question.

**Q12 (b)(ii)**

Many students answered this question in a way that suggested they were focusing on the word 'accuracy' rather than relating the calculated value to the actual value for the speed of sound. As a result, there was much discussion of percentage uncertainty and errors in measurements as a principle, rather than specifically what effect this would have on the values for speed.

As there were only likely to be two effects that the effect described would have on the speed (increase or decrease), the 2nd marking point could not be awarded without some relevant Physics to explain why. This resulted in over 90% of the students achieving either 0 or 2 marks on this question.

**Q13 (a)**

A calculation question with multiple steps on the way to the answer, which was answered very well on the whole. More than half of the students scored all 4 marks with a perfectly correct answer here.
For those not achieving full marks, the most common mistakes were:

- using an incorrect formula to calculate the cross-sectional area of the wire (often using diameter instead of radius)
- incorrectly calculating the resistance of the wire
- assuming that *R* in the equation was resistivity

**Q13 (b)**

A common assumption made by the students answering this question was that both of the lamps would be operating at their stated 12V and their stated power rating(s). As a result, the most commonly-achieved score on this question was 1 mark (1st marking point), which involved calculations relating to normal operating conditions for the lamps.

It was rare for students to then go on and explain properly why this situation could not result in both lamps operating normally. For example, those who calculated the two different current values for the lamps in normal conditions did not often refer to the fact that as this was a series circuit, the lamps had to have the same current. Often, the current calculations were followed by a conclusion 'so the lamps do not operate normally' without further justification of why.

A significant number of students who calculated the two resistance values for the 1st marking point then went on to use their total resistance in order to work out the current in the circuit. This was clearly an invalid method to employ as this would not be the circuit current in this situation. Often this resulted in a conclusion that lamp B would have 16V and lamp A would have 8V, which cannot be known (as the resistance characteristics of each lamp can only be known for the given 12V in the question).

**Q14 (a)**

Many of the answers for this question scored 0 marks. This was generally as students used much of the answer space to repeat information that had been given in the question. Students should be aware that the photoelectric effect is closely related to energy and electron emission, neither of which were mentioned in the question.

The aspect of time delay was rarely discussed in most of the answers seen, with less than 10% of students scoring both marking points.

It is worth reminding centres that words underlined in mark schemes are ones that must be seen in order to award marking points. The fact that many students did not mention either energy or electrons immediately made them unlikely to score any marks here.

**Q14 (b)(i)**

A generally very well answered multi-step calculation again here, with almost half of the students scoring all 4 marks. The remaining students were spread fairly evenly across scoring 0, 1, 2 or 3 marks. As there were multiple steps to take, there were several aspects in which students could make mistakes. The most common of these were:

- not realising that they had to convert the work function from eV into joules.
- not using the correct electron mass value in $\frac{1}{2}mv^2$ (often using the charge of an electron instead)

Some students made the calculation a little more difficult for themselves by using the photon energy value given to calculate a frequency of radiation, and then converting it back into a photon energy for substituting into the Einstein equation. It was suprising how many students seemed to do this.

**14 (b)(ii)**

The original intention with this question was to set up a scenario whereby both of the stated changes took place at the same time. However, a number of students assumed that each was being considered separately. Thus the mark scheme was modified so that students taking this approach could still gain full credit. In spite of this, the 3rd marking point was rarely achieved, as very few students considered their conclusion carefully enough.

The focus of the question regarded the speed of electrons, so answers purely in terms of kinetic energy were not generally accepted unless they were subsequently linked to the speed of the electrons.

Although most students had been perfectly capable of applying the Einstein equation in part (i), most found it much more challenging to consider changes to this equation when asked in a more wordy form.

Perhaps it is worth suggesting that students, when faced with such a question, simply try to insert some numbers into the calculation they have just done to see what the outcome for the speed would be (if everything else in the equation remained constant). Far too many students appeared to think that increasing any factor in the equation would result in increasing the speed of the electrons, so many got both aspects the wrong way round by suggesting that a lower work function would lower the speed, and a higher wavelength would increase the speed. Just under 50% of the students scored 0 marks on this question.

**Q 15 (a)**

The majority of students scored either 0 or 3 marks on this question. The main reason for this discrepancy was that a significant proportion of students did not start from first principles to calculate the relationship. Instead, they started off with the resistors in parallel formula given on the equation sheet and tried to turn this from a formula with $1/R_T$ as the subject to a formula with $R_T$ as the subject. This is not what the question required, as such answers did not explain where the $1/R_T$ equation came from in the first place.

Many of the incorrect methods assumed that the p.d. across two parallel resistors would be different, so statements such as '$V_T = V_1 + V_2$' were commonly seen.

**Q15 (b)(i)**

A significant proportion of students did not make it entirely clear which resistors they were using for each component of their calculation. Many failed to recognise which resistors were in parallel with which other resistors, so it was common to see calculations that assumed that resistor O was in parallel with resistors N, P and Q. Some students also assumed that to calculate the resistance between A and B could be calculated without considering resistors P and Q altogether, showing a calculation for M, N and O only.

As this was a 'show that' question, there appeared to be a temptation for students to cease their calculations when they worked out that the resistance of the combination N, P and Q was 3.3 Ω, as this rounded to the requested 3 Ω from the question. In spite of this, over a third of the students managed to score all 3 marks on this question.

**15 (b)(ii)**

Although a significant percentage of students correctly identified resistor M as the one that needed replacing, most were unable to provide a correct or complete explanation as to why.

Some students named more than one resistor, meaning that the 1$^{st}$ marking point could not be awarded.

It is perhaps more obvious on this question why the 2$^{nd}$ marking point is dependent upon the awarding of the 1$^{st}$ marking point, as it would be impossible to provide logic for the choice of answer if the answer is not resistor M.

**16 (a)**

There was a fairly even spread of students scoring 0, 1, 2 or 3 on this linkage question. However, only around 10% of the students scored more than 3 marks, with IC points 1, 5 and 6 being the most likely to be missing or incomplete. Although the word ‘absorb’ is not underlined in the mark scheme, there needs to be the idea that energy has been absorbed by the atom in order for this process to happen, so IC1 was not gained if students simply mentioned about energy being given to the atom. Although many students discussed aspects related to IC5 and IC6, very few related it directly to this question, but rather towards a general understanding of why photons were emitted with particular wavelengths/frequencies.

IC2, IC3 and IC4 were commonly mentioned in answers, and students appeared to have a sound understanding of the process of electrons moving up energy levels and back down to release photons.

It is important to remember that such questions require comments that link together towards a final answer. Some students simply listed standard phrases about energy levels in atoms, and did not complete it in a logical order.

A number of students had answers which were clearly explaining the photoelectric effect, which is not relevant for this question e.g. discussing the fact that energy needed to be greater than the work function. Some also described both the photoelectric effect and energy levels in atoms in a hybrid-type approach.

**16 (b)**

Just over 20% of the students scored both marks on this question, demonstrating a thorough understanding of the reason. The majority of incorrect answers seemed to focus on highlighting why air was different from hydrogen without referring back to energy levels or the different gases present in the air. In spite of this, a significant proportion of students still managed to mention about the different gases present, even if they did not relate it to energy levels in the atoms.

**17 (a)**

Although there are broadly two separate avenues via which candidates could establish an answer to this question, it was impressive to see so many variations on the theme, and it was also pleasing to see such a high number of students arriving at the correct answer for all 5 marks (which was the most commonly-achieved score on this question).

With the variety of different aspects to the question, it appeared to be accessible to most of the students. The majority answered the question using the method that is shown as the first alternative on the mark scheme. It appeared to be more common to make a subtle mistake when students used the method indicated by the second alternative on the mark scheme. Usually, those who managed to score more than the first 2 marks went on to score all 5, with very few students scoring 3 or 4 marks.

It is also worth noting that, considering this was a multiple-step calculation, rounding during the working could lead to some notable discrepancy when it came to the final answer. So, for example, it was quite common to see an answer of 2.8 Ω, which had been correctly calculated with some rounding within the calculation. Although this does not appear in the mark scheme, such an answer could be accepted for all 5 marks if it was clear how the rounding had affected the final answer.

**17 (b)**

Unfortunately, a significant proportion of the answers to this question simply paraphrased the information already given at the start of the description in (b), so could not gain any credit. Another common error was to assume that the internal resistance of the cell had changed when the load resistance $R$ changed, which would not be the case. For some students, this resulted in them not achieving both marks even if they had mentioned both of the listed marking points e.g. if a student said 'the current and the internal resistance both decrease, so $Ir$ decreases', they could only score the 1$^{st}$ marking point.

**17 (c)**

Considering that this question related directly to a standard description of Core Practical 8, it was disappointing to see so many students scoring 0 out of 4 here. There were a surprisingly low number of students who discussed how the practical would actually be undertaken, with most concentrating directly on the graph to plot and how to interpret it (thus only having access to the 3$^{rd}$ and 4$^{th}$ marking points). Many of these also had an incorrect graph, so could not achieve the 3$^{rd}$ or 4$^{th}$ marking points either. Quite commonly, these incorrect graphs would include $R$ or $\varepsilon$ on one of the axes, when neither of these values can be assumed to be known before the experiment is undertaken.

**18 (a)**

Similar questions to this have been asked on the previous sittings of WPH12 since it started in the Summer of 2019. It is pleasing that more students are recognising the formula required for the area value that is inserted into the equation $I = P/A$. It was still disappointing to see a significant number of students, however, inserting the distance given in the question as an area, when this is clearly not dimensionally-correct. To award the 1st marking point, the area used in the equation had to be something which could be dimensionally-correct for an area.

Although more students are identifying the need to use $A = 4\pi r^2$ for this type of calculation, some clearly decided that the value of $1.50 \times 10^{11}$ m provided was a diameter rather than a radius, so they divided it by 2 before squaring it. This was not accepted for the 2nd marking point, as it was giving the same answer as using $A = \pi r^2$ with $1.50 \times 10^{11}$ m as $r$.

**18 (b)**

This part of the question was generally answered very well, with almost half of the students scoring all 3 marks. This is a pretty standard calculation on WPH12 papers, and most answered it in a logical way. Many students combined the two equations (as described in the brackets on the mark scheme) which is perfectly acceptable. The main way in which students ended up scoring 0 was by assuming that the given wavelength was $f$ in the equation $E = hf$.

**18 (c)(i)**

Although a relatively straightforward calculation, the fact that it was close to the end of the paper perhaps resulted in more students scoring 0 out of 2 than would normally be expected. It was clear that some were not aware of the fact that the speed of light was needed in the calculation. The only other recurring issue was the failure to halve the time in the calculation.

**18 (c)(ii)**

This is another part of the paper where the most common incorrect answers usually came from students who were just repeating what had been said in the question. However, a significant number of students produced a correct response from one of the options given.

**18 (d)**

As the last question of the paper, it was evident that a significant number of candidates had not answered this part. It is difficult to judge whether this was due to students running out of time or simply finding it difficult to interpret the information given. However, the fact that most students had answered the previous part of the question suggests that the latter case might be more likely.

Of those who answered the question, there was a high level of success with 1 or 2 marks being achieved. The majority of incorrect answers either directly or indirectly implied that the Doppler Effect was able to determine when the ice was flat or higher above sea level.

## Paper summary

The muliple-step calculation questions such as Q13 (a), 14 (b)(i) and 17 (a) scored very well, in a way seen on previous papers for WPH12. This shows a high level of confidence with manipulating equations. Very few examples were seen where equations were incorrectly rearranged, the majority being limited to Q14 (b)(i).

The more descriptive answers did not score as well and question 16 (a) was a key example of this.

As has been the case on previous series, the more difficult questions for students to master tend to be those where understanding has to be applied to novel situations. In particular, questions such as 11 (b)(ii), 12 (a), 12 (b)(ii), 13 (b), 14 (b)(ii), 16 (b), 18 (c)(ii) and 18 (d) did not score a particularly high average mark.

WPH12 contains four core practicals. It is expected that students are aware of both how the practical can be undertaken, and how it is interpreted (usually graphically). It was therefore disappointing that Q 17 (c) did not score higher, as it was not modified from the way that students would be expected to perform the practical.

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