Examiners' Report

Principal Examiner Feedback

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Pearson Edexcel International Advanced Level In Physics (WPH05) Paper 01 Physics from Creation to Collapse

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The assessment structure of WPH05 mirrors that of other units in the specification. It consists of 10 multiple choice questions, a number of short answer questions and some longer, less structured questions. As an A2 assessment unit, synoptic elements are incorporated into this paper. There is overlap with circular motion and exponential variation in Unit 4, but also overlap with some of the AS content from Units 1 and 2.

This paper gave candidates the opportunity to demonstrate their understanding of a wide range of topics from this unit, with all of the questions eliciting responses across the range of marks. However marks for questions 11, 12(b), 12(c), 13(c), 14(a), 14(b), 15(a)(iii), 15(b)(iii), 16(a)(i), 16(c), 17(b), 17(c)(ii), and 17(c)(iii) tended to be clustered at the lower end of the scale.

Calculation and 'show that' questions gave candidates an opportunity to demonstrate their problem solving skills to good effect. Some very good responses were seen for such questions, with accurate solutions which were clearly set out. Occasionally in calculation questions the final mark was lost due to a power of 10 error. In general candidates were able to give correct units for quantities that they calculated. Most candidates understood the convention that in the "show that" questions it was necessary to give the final answer to at least one more significant figure than the value quoted in the question.

Once again there were examples of candidates disadvantaging themselves by not actually answering the question, or by not expressing themselves using suitably precise language. This was particularly the case in extended answer questions such as 11, 14(b), 15(c), 16(a)(i), 17(b)(ii), 17(c)(ii), and 17(c)(iii) where candidates sometimes had knowledge of the topic, but could not express it accurately and succinctly. Candidates could most improve by ensuring they describe all aspects in sufficient detail and always use appropriate specialist terminology when giving descriptive answers.

The space allowed for responses was usually sufficient. Candidates should be encouraged to consider the number of marks available for a question, and to use this to inform their response. If candidates either need more space or want to replace an answer with a different one, they should indicate clearly where that response is to be found.

The response to the multiple choice questions was generally good with 6 of the questions having 70 % or more correct answers and none with less than 50% correct answers. In order of highest percentage correct they were: Q2 (89%), Q1 (86%), Q7 (85%), Q8 & Q9 (77%), Q4 (70%), Q5 (69%), Q3 (61%) and Q6 & Q10 (60%).

There was some evidence of candidates learning previous mark schemes in the expectation of earning marks. This was true in 11 and 17(b)(ii), where answers were seen from some candidates that identified the key points but too briefly. Candidates should be encouraged to work with mark schemes in preparation for their exam. However, it is important that they understand that mark schemes are written for examiners, and so sometimes refer to what examiners expect to see rather than giving a complete answer.

Q11 The majority of candidates realised that this question related to annual parallax. These candidates generally described the parallax method well, although the most common error was failing to state that the distant stars appeared fixed. Diagrams were commonly used, and this was a good way to score full marks. However, many candidates obtained full marks without reference to a diagram.

Many candidates did not gain MP2, as they failed to point out that the background stars appeared fixed or did not move. Some left these stars off the diagram and did not seem to realise that it would be impossible to measure a change in angular position without a reference point.

The use of the word ‘wobble’ confused some candidates, who thought it referred to the variation in luminosity of Cepheid stars. These candidates went on to describe the ‘standard candle’ method. Others referred to Wien’s law. A small minority of candidates seemed to believe that stellar distances are determined by a pulse echo technique

Q12(a) This was done well by most candidates; calculations were mostly correct and averages attempted clearly. A small proportion of candidates did not gain MP1, as they calculated the average using only two of the three final temperatures. Another common error was to add 273 to the rise in temperature. Some candidates had difficulty with powers of ten when using the value for density.

Q12(b) Few candidates scored both marks on the question. The most likely statement to score marks was a reference to keeping the crisp near to the test tube to avoid heat loss to surroundings.

References to stirring and parallax error when reading of the thermometer were also common scoring points. In some responses where the idea of avoiding parallax was attempted, poor language often lost the mark (e.g. statements such as ‘keep eye at parallax level’).

By far the most common answer not to score marks was not letting the thermometer touch the test tube, closely followed by ideas of insulating the test tube.

Q12(c) Many candidates spotted the difference in values of the crisps but failed to emphasise the extent of that difference. To score the marks the idea that the stated energy value is *much* greater than the calculated value was needed. Following on from this, merely stating that heat/energy is lost to the surroundings without being specific was the main reason for not scoring MP2. A bald statement about heat being lost to the surroundings was insufficient for this MP to be awarded. Only a minority of candidates successfully communicated that not all the energy had been released from the crisp in the burning process.

Q13(a) Most candidates equated the gravitational and centripetal forces, but a significant minority failed to substitute correctly. Such candidates either used the wrong mass (i.e. mass of ISS rather than that of Earth), or forgot to add the orbital height of the ISS to the radius of the Earth. Many candidates used $mr\omega^2$ and many used mv^2/r, but the wrong distance was often used and cubes and squares were incorrect.

Those attempting to include $T = 2\pi/\omega$ in one large calculation often forgot to square π. When ω was calculated first, they usually scored at least 2 marks, for the use of their (wrong) value of ω in the time period calculation. This suggests that candidates should be advised not to attempt multi-stage calculations in one go. There were a small number who attempted to equate g with $\omega^2 r$ but used g = 9.81 N kg^{-1}.

Q13(b) Many candidates scored well on this question part. Other than using the wrong equation and calculating F instead of g, a missing distance in the denominator was the main reason for candidates not scoring the marks. The use of a ratio was occasionally seen although disappointingly this method was often unsuccessful.

A surprisingly large number of candidates wrote $F = GM/r^2$, and were obviously confused about the difference between gravitational force and field strength. Some calculated a force using $F = GMm/r^2$.

Where candidates calculated the value incorrectly there were some answers well outside of the range of what would seem to be a reasonable answer. Candidates should have been able to sense check their answers and repeat the calculation.

Q13(c) This was a poorly answered question. The vast majority of candidates just stated something along the lines of 'gravity is too weak to feel at this distance', and attempted to justify by quoting field strength equation and saying that the distance was so large.

Those candidates who scored marks usually referred to the idea of the gravitational force being used as a centripetal force. It was extremely rare for MP2 to be awarded, although a few candidates did try to explain a lack of reaction force. There were more suggestions that it was the resultant force rather than the reaction force that was zero.

Q14(a) Surprisingly for a straightforward definition, this was a very poorly answered question. Many answers were incomplete rather than being wrong. Most defined activity merely as the rate of decay, or the number of 'particles' that decay in a 'certain time'. Of those attempting a fuller definition, many lost the mark for referring to atoms, molecules or particles rather than nuclei.

Q14(b) This question required logical thought processes and a clear use of language to communicate the key steps in the process adequately. Unfortunately, candidates frequently wrote what they knew about different types of ionising radiation and the relevant absorbers rather than describing the correct practical procedure.

Most candidates referred to measuring background radiation, but the MP most commonly missed was putting the source close to the GM tube. This detail was either omitted or candidates suggested too large a distance (i.e. 3 cm or more). Most candidates had a good understanding of which absorber would block or reduce which type of radiation, but failed to score marks because they didn't refer to the named sources (e.g. they made statements such as 'if the paper blocks it, it's alpha').

Some candidates were very confused, thinking that if radiation passed through paper the source was americium, and if you only used aluminium it would not stop the radiation from the americium, because you needed paper to stop the alpha radiation

In summary the instruction to describe an experiment seems to have been overlooked by many candidates, who focussed on a theoretical description of greater or lesser accuracy. This gives the impression that candidates had never seen such an experiment, which is a worry.

Q14(c) This calculation was well carried out, with the vast majority of candidates scoring all three marks. Mistakes were seen when candidates took logs or attempted to work in seconds. There was no need to convert the half-life to seconds here, as the decay constant could be calculated in years^{-1}. Those converting times to seconds were more likely to make arithmetical errors, but still usually managed the first two marks.

A small number of candidates approximated the number of half-lives to 3 and so calculated an approximate value for the time elapsed. It is expected at this level that candidates would use the exponential decay equation to obtain an accurate value.

Q15(a)(i) The vast majority of candidates could balance this equation correctly.

Q15(a)(ii) The mass difference was usually identified by candidates and a correct statement given. A small proportion of candidates merely mentioned mass deficit and did not elaborate, and a few thought the mass increased.

A number of candidates based their explanation on changes in binding energy. The changes in binding energy are a consequence of energy being released in the reaction, and so it was not deemed sufficient to base an explanation on binding energy changes in this instance.

Those managing the first mark often quoted the Einstein mass-energy equation without making it clear that it was the decrease in mass that became energy, hence they did not state enough to gain MP2.

Q15(a)(ii) Many candidates simply stated the law of conservation of momentum, but only a few mentioned that the initial momentum is zero. A large number talked about the fragments needing to move away so that they didn't keep on fusing, and a number of references to 'preventing a chain reaction' were seen. Surprisingly, some candidates thought erroneously that the fragments moved away from each other due to Coulomb repulsion.

For the second marking point a reiteration of the stem 'move away' was often stated. As this was already stated in the question, an elaboration of this was required for a mark to be awarded.

Q15(b)(i) This was generally well answered, but a significant minority of candidates did not include proton numbers at all. Some candidates mistook the nucleon numbers given in the diagram for multiples of nuclei involved in the reaction.

Q15(b)(ii) This calculation was generally well done, although some candidates found it hard to deal with the mass unit MeV/c^2. A significant number could not convert MeV/c^2 to J correctly. It was common to see mass differences multiplied by c^2 or divided by e. A small number omitted the factor of 10^6.

Q15(b)(iii) A lot of candidates had the right idea here but a lack of precision with language let them down. For MP1, they needed to reference nuclei, <u>kinetic</u> energy and electrostatic repulsion. A surprising number of candidates referred to atoms/molecules or particles instead of nuclei, and some candidates didn't specify what it was that required high kinetic energy.

Q15(c) On the whole this was well answered with most candidates having some idea about the physics required. Imprecise language or a lack of a comparison often meant that candidates did not score both marks.

A large proportion of candidates appreciated that hydrogen was in greater abundance than uranium for MP1, but MP2 was less often awarded. It was common to see ideas about fusion releasing more energy than fission, often phrased in terms of "more energy per gram for fusion". Answers referring to the cost, or bland statements that fusion is easier/harder than fission were also seen.

Q16(a)(i) This is a definition that has been examined a number of times in previous series. It is therefore to be expected that good candidates will have learnt an acceptable version of this definition.

Although it was pleasing to see that most candidates knew the definition, a number of candidates failed to specify that displacement had to be from the equilibrium position. These candidates usually went on to score MP2. A few candidates used distance instead of displacement, and there were some instances where candidates did not know this definition at all and referred to constant amplitudes and/or frequencies.

Q16(a)(ii) This question was very well answered by the vast majority. Mistakes in calculation were rare, but those failing to score were usually trying to use $v = f\lambda$. Another common error among the few incorrect calculations was to have an incorrect value for sin ωt or a power of 10 error.

A small number of candidates displayed very little knowledge of simple harmonic motion by attempting a simple distance/ time calculation.

Q16(a)(iii) The majority of candidates scored at least 1 mark for this question, although a number of candidates made no attempt to draw a graph. Some very careful graph sketching was seen and, although few negative cosines were drawn, correct graphs were very common.

Drawing a constant period proved tricky for some, and the sensible technique of drawing a few guide lines or points was underused. Some drew a single straight line from the origin and a small number of triangular waveforms were seen.

Q16(b)(i) Although most recognised the need to match the natural frequency of the loudspeaker unit, they talked about a 'particular' frequency rather than a driving or forcing frequency, so failed to meet MP2. Maximum energy transfer was described by many candidates, but quite a few referred to an increasing amplitude, forgetting that this was in the stem of the question. Most candidates referred to resonance.

Q16(b)(ii) Many candidates have a good idea of the process of damping and were able to score both marks.

Some candidates were less successful at describing the idea of energy being transferred away from the speaker unit. References to the damper absorbing the energy were often described well enough to score marks, but vague references to the energy being dissipated to the surroundings were insufficient, since this would happen with or without the damper.

Some candidates referred to altering the natural frequency of the speakers, which would not be appropriate in this context.

Q16(c) This question was poorly answered. Although the majority of candidates were able to refer to the correct frequency for each speaker, few were able to relate the size of the speakers to these frequencies.

It was reasonably common to see the speaker size being related to wavelength. This may be as a result of a question based around a drum set in a previous series.

A small number of candidates recognised that the tweeter needs to vibrate 'fast', but did not refer to acceleration or mass. A few tried to link tweeter and woofer sizes with resonance.

Q17(a) MP1 was often awarded, as most candidates referred to red shift or increasing wavelength, often going on to describe comparing wavelengths of radiation received from a with that in the laboratory.

MP2 was awarded far less frequently as many candidates made no reference the Doppler Effect, but just said that the galaxies were receding. There was frequent reference to $v = H_0 d$, which scored no marks as it isn't an answer to this question.

Q17(b)(i) Although there were some candidates who gave the exact answer on the mark scheme, most candidates missed the point of this question. Many weak responses just stated the trend or pattern in the table. Even when some of these responses mentioned Pegasus, there was not enough comparison with the other data for a mark to be awarded.

It was common to see attempts to calculate H_0 but with no comment about any significance of the answers. Many just said 'the further away they are the faster they go' with no reference to Pegasus.

Q17(b)(ii) This question was a good discriminator, as a full range of marks was seen. Some candidates' responses described the parallax method or Hubble's law. Since it is stated that Pegasus is too far away for parallax to be used and the data provided is Hubble's original data, it should have been clear that neither of these methods was appropriate in this context.

Candidates who realised that this was a question about standard candles did reasonably well, although a common mistake was to think that Pegasus was the standard candle and that the radiation flux of Pegasus was measured.

Marks were often lost for stating the equation without defining the variables in the equation they used for radiation flux.

Some candidates seemed to believe that distance of Pegasus could found by a pulse echo technique! This may be an indication that these candidates have not updated their knowledge of astronomical techniques since GCSE.

Q17(c)(i) The majority of candidates scored full marks in this question. The main error was to not show the differences in y and x for MP1, although some candidates read a pair of values from the graph rather than to calculate the gradient.

Accepting values in the range 5.0×10^{16} s - 5.3×10^{16} s allowed most candidates to score MP3. Answers not in the acceptable range were usually due to misreading the graph, rather than ignoring the intercept.

Some candidates calculated a value of 5×10^{16} s for the age of the universe but didn't realise that this needs to be written as 5.0×10^{16} s for the "show that" mark to be given.

Q17(c)(ii) This was a poorly answered question, with most candidates scoring no more than 1 mark. Some candidates stated that distances to galaxies had been underestimated, but didn't link this to the gradient of the graph.

Errors in measurement and large uncertainties were by far the most common answers not to score marks. Candidates typically stated that there was a large uncertainty in the distances, rather than these distances being underestimated

It was very common to see dark matter and critical density being used in explanations. A small number of candidates did mention an expanding universe, but few linked this to acceleration. No references to the speed in being smaller in the past were noted.

Q17(c)(iii) Although a small number of perfect responses were seen, this question was misunderstood by most candidates. This may be a combination of the novel nature of the question and the need to bring in ideas from unit 2.

Many candidates were answering in terms of the present (more energetic photons, higher frequency and shorter wavelength). It has not occurred to them that what we are seeing is the past. Some are then using this to argue for a blue shift so the universe is contracting.

The majority of answers made reference to the increase in mass of electrons and made no reference to the photons mentioned in the stem of the question. "Increasing electron mass changes the critical density" was often a starting point for arguing about the fate of the universe. Candidates then went on to discuss the 'big crunch', often throwing in a reference to dark matter for good measure.

It is clear than many candidates had not read the question stem carefully enough and took elements of the answers to previous questions that had dealt with the fate of the universe and used this as the basis of their answer.

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