Examiners' Report
Principal Examiner Feedback

October 2020

Pearson Edexcel International Advanced Level in Physics (WPH15) Paper 01

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Introduction

The assessment structure of WPH15 mirrors that of unit 4. It consists of 10 multiple choice questions, a number of short answer questions and some longer, less structured questions. As it is 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 is the first time the specification has been examined and the paper included questions on two topics that are new to this paper: gravitational potential in Q15(b)(ii) and specific latent heat in Q19(c)(ii). The responses to both these questions were disappointing, revealing a poor understanding of the physics in these topics.

The paper includes the use of specific command words as detailed in the specification, Appendix 9: Taxonomy. It is recommended that centres ensure that their students understand what is required when responding to such questions. In this paper where the command word was deduce, evaluate or assess, the final mark could sometimes not be awarded on otherwise good responses because a final appropriate comment was missing.

Some students are muddled by the significance of letters which have a variety of meanings depending on the context. The letter c is used to represent the speed of light in a vacuum, specific heat capacity and as the constant in the equation for a straight line $y = mx + \mathrm{c}$.

The letter k is used to represent a general constant of proportionality as well as the stiffness of the object in the Hooke's law equation, the Boltzmann constant and the Coulomb's law constant. This confusion led to incorrect values being substituted in calculations.

Students are expected to know the equations for the circumference of a circle, the surface area of a sphere and the volume of a sphere. Failure to be able to recall these relationships led to errors in Q16(c) and Q17(a).

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, they should indicate clearly where that response is to be found.

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.

Q 11

This was well answered by many. A common response that included insufficient detail was that both fields have similar equations. Some thought that both field are radial.

Q 12(a)

Whilst most were able to identify that this change in wavelength is an example of the Doppler effect, it was unusual to see responses that could explain that this effect is caused by the gravitational force exerted by the massive planet on the star. Some students do not understand that in physics describing something as 'massive' means having a very large mass, not a very large size.

Q 12(b)

Many students misread the question and did not realise that the value of $\Delta\lambda$ was given as well as the value of λ. Although most attempted to use the correct equation, it was unusual to arrive at the correct value for the velocity of the star because an incorrect value was substituted for $\Delta\lambda$

Q 13

The question asked for an *explanation* of the difficulties involves with fusion as a viable source of power on earth and students were guided to refer to the conditions necessary for fusion to occur. Marks could not be scored by a simple statement of either the difficulties or the conditions.

In common with the way questions on this topic were marked on the 2015 specification, detail is required for each marking point. Many students clearly knew something of the topic but did not give the fine detail required.

Most could relate the high temperatures required to the need to overcome the repulsive force but failed to identify either the particles involved or that the energy they require is kinetic energy, thus not fulfilling marking point 1.

The responses that attempted to explain the requirement for high densities suggested that the physics is not well understood. High pressure is a result of high density, not a requirement in itself.

Often the reason given for possibility of the container melting was the high temperature needed for the fusion process rather than the plasma touching the container.
Where students did give a creditworthy response it was often because they were able to relate containment problems with the need to have strong magnetic fields.

Q 14(a)

The majority of responses scored both marks. Almost all understood that in a 'show that' question, it is essential to show working and to give the final answer to at least one more significant figure than the 'show that' value.

Q 14(b)

A common error was to take $E=P/t$ instead of $E = Pt$
A number of students made no attempt at this question

Q 15(a)

Question 15 begins by giving a graph which shows how the gravitational field strength g of the Earth varies with distance from the centre of the Earth. Then in part (a) students are asked to show that g obeys an inverse square law. The expectation was that students would take data from the graph which they would treat appropriately to show this relationship. Those who used this method were often able to score all the marks.

Approximately half the students attempted to show the relationship algebraically. The majority of these, having derived $g=GM/r^2$, did not remember to add that both G and M are constants. The inverse square law will only hold if this is true.

Q 15(b)(i)

Having just considered the variation of the gravitational field strength with distance from the centre of the Earth it was surprising that many students were not able to identify that the reason why the given expression, $\Delta E_{grav} = mg\Delta h$, cannot be used to calculate the change in gravitational potential energy of the satellite, is that g is not constant.

Q 15(b)(ii)

Despite having been told that $\Delta E_{grav} = mg\Delta h$ cannot be used to calculate the change in gravitational potential energy of the satellite, many students proceeded to attempt to do so. This expression is only valid for a uniform gravitational field. It is a reasonable approximation to use it for a very small region of a non-uniform field. To attempt to use it in this question, covering a distance of 5 times the radius of the Earth, is incorrect physics.

Those that realised that they needed to use the expression for gravitational potential often used incorrect values of distance, or muddled the masses of the satellite and the Earth.

Q 16(a)

Very few creditworthy responses were seen for this question. The command to state where the stars would be located on a Hertzsprung-Russell diagram was not well understood, eliciting such answers like red giant or white dwarf. Those that did realise that the stars would lie on the main sequence usually failed to identify that they would be a t the top of the main sequence or at the top left hand side of the diagram.

Q 16(b)

Wien's law was generally applied correctly to obtain a correct answer. However, the unit for Wien's constant included in the equation (m K) seemed to encourage a few students to apply a factor of 10^{-3} as a 'conversion' to their answer.

Q 16(c)

Whilst most selected the Stefan Boltzmann equation to attempt to calculate the radius of the star there proved many ways to go wrong in its application.

In the table the luminosity of the stars are given as multiples of the Sun's luminosity, something which it is expected that students will have met in their study of Hertzsprung-Russell diagrams.

Many used the luminosity of Alnilam as 5.37×10^5 without realising that they needed to multiply by the value of L_{Sun}. Those that made this error found the radius of the star to be approximately 1 mm. Students should be encouraged to look critically at numerical answers like this and to realise that they must have made a mistake.

Others did not remember that *A,* the surface area of the star is $4\pi r^2$. Some forgot to raise the temperature to the power 4 whilst others forgot to find the square root of their calculated value of r^2.

Q 16(d)

The most straightforward way to do this kind of comparison is to find the ratio of the intensities of the two stars, but this method was not often seen. It was acceptable to calculate the two intensities separately and also to take various short cuts resulting in the correct ratio of 1.25, even if this was not explicit, for the first two marking points.

The command *deduce* is new for this specification and it is essential for the 3rd marking point that a clear comparison is made between the luminosities of two stars and a statement of which gives the lower luminosity.

Students that attempted the comparison without any calculation rarely wrote anything creditworthy. They simply stated that luminosity or distance values were higher or lower. Coming to a convincing conclusion requires the differences to be quantified.

Q 17(a)

This is an example of an extended calculation with the command deduce. Almost all responses showed an attempt to use the ideal gas equation with the temperature converted to Kelvin and hence satisfied marking points 3 and 4.

A significant minority could not successfully use the given value of circumference to find the volume of the football, however many students did arrive at the correct value of the pressure inside the football.

Only some students realised that they also needed to take account of atmospheric pressure in order to decide whether the football met FA rules. The final marking point included both a numerical component and a statement about whether the football met FA rules.

Q 17(b)

It was very pleasing that most students were able to structure their answers logically although it was rare to see the full argument. The question asked for an explanation in terms of the motion of the molecules but some students based their whole answer on the ideal gas equation, either failing to mention the motion of the molecules at all or adding a sentence at the end as an afterthought.

The command word is *explain* and as in other questions with this command, detail was lacking in many responses.

Whilst most knew that there is a relationship between kinetic energy and temperature, the marking point was frequently not awarded because it is the **mean** or **average** kinetic energy of the **molecules** that decreases as the temperature is decreased.
The most common points that were seen were indicative content points 2 and 6. Very few students mentioned that the change of momentum of a molecule as it collides with the container wall decreases, indicative content point 3.

Although comments were made about collisions they often lacked detail. It is necessary to identify that it is the collisions with the container not collisions with other molecules that are relevant. In order to relate force to a change in momentum it is essential to refer to the **rate** of change of momentum

Q 18(a)

Surprisingly, this was poorly answered although questions of this type have frequently been asked on the old (2015) specification.

Q 18(b)(i)

Many did not seem to have read the complete introduction to the question and hence a common incorrect answer was fusion.

Q 18(b)(ii)

Another extended calculation, but the command in this question is to *assess*.

The first four marking points were awarded for the process of calculating the velocity *v* of the ions and reaching the correct value. Whatever method was attempted, students were almost always able to show that they knew how to convert the units of energy and mass and so were awarded marking points 1 and 2. The most common error was to attempt to use $E = mc^2$ with the energy and mass of a calcium ion.

The final marking point could only be awarded if the calculated value of *v* is compared with the speed of light and a valid conclusion made. This means that even if the calculation went wrong, the marking point could still be awarded. The requirement is that the students should be aware that when the velocity approaches the speed of light then relativistic effects become important. In this context, a value of *v* less than 10% of the speed of light is not going to cause relativistic effects and so such a speed is not described as relativistic. It is expected that students will know that it is not possible for speed to be greater than, or equal to the speed of light.

Q 18(c)

Almost all responses showed a correct calculation of the decay constant and many were able to complete the calculation using the exponential equation to find the original number of atoms in the sample. Those that did not reach the final answer made a variety of errors including muddling N and N_0 and using the half-life instead of 2.5 ms in the exponential equation.

Q 18(d)

The command for this question is *explain*. This means that a precaution must be stated and justified. Many responses listed a number of precautions. Others attempted a justification but gave a very general comment e.g. alpha radiation is very ionising, or alpha radiation causes damage to cells, instead of the more detailed physics expected at this level.

Q 19(a)

In order to comment on the website suggestion, it is necessary to study the graph provided which shows how the energy absorbed by a water molecule depends on frequency of radiation, and to consider how this can be related to a knowledge of resonance.

Most students simply wrote down what they understood by resonance. These statements, whilst often correct definitions of resonance, do not address the question, make no reference to the graph and gain no credit.

The expectation was that students would realise that the graph shows that the maximum energy is absorbed at about 10 GHz and that therefore the natural frequency of the water molecule must be about 10 GHz. Then to notice at the top of the page the question tells us that the frequency used in the microwave oven is 2.45 GHz which is not the natural frequency and so resonance is not occurring.

Q 19(b)(i)

Students are not expected to have any prior knowledge of the idea that the microwave radiation causes the water molecules to rotate. They were expected to apply their understanding of the links between internal energy, average kinetic energy and temperature to this new situation.

The question was poorly answered with the majority writing nothing of relevance. Many who thought that resonance was taking place, answered in terms of a maximum transfer of energy.

Q 19(b)(ii)

Whilst many responses suggested that students understood that the key point is that ice is a solid and water a liquid, they often then answered apparently in terms of density, saying that molecules are 'tightly packed' in ice. Others suggested that the reduced efficiency might be due to energy being required to melt the ice. Some realised that in liquid water the molecules would be more able to move around but they did not relate this to the rotation of the molecules.

Q 19(c)(i)

Generally, this question was well answered with the efficiency correctly calculated and a comment included that the manufacturer's claim was not valid.

As in Q14(b) some students could not rearrange $E=P/t$ to make E the subject.

Q 19(c)(ii)

This calculation involving a change of state as well as a temperature change proved very challenging with many students failing to take account of the energy required to rise the temperature of the melted ice to the final unknown temperature. Most students could be awarded marking points 2 and 3 for their attempts to use $\Delta E = mc\Delta\theta$ and $\Delta E = mL$.

Q 20(a)

Despite the requirement to understand the conditions for simple harmonic motion being on both the new and the old specification and having been a frequent question in the past, many students used vague terminology and omitted a clear reference to equilibrium 'position'.

Q 20(b)

This question was poorly answered with only a minority able to see their way through the several stages in the calculation. A significant number were not able to deduce from the question that the amplitude of the oscillation is 3.5 cm and that the value of Δx to be used in the Hooke's law equation is 16.5 cm.

Q 20(c)

Whilst the given graph of displacement against time was clearly familiar, instead of the more usual question about velocity or acceleration, students were asked to consider the kinetic energy of the oscillating mass. Most did not think carefully about this, failing to realise either that the kinetic energy must always be positive or that the frequency must be twice the frequency of the given graph.

Q 20(d)

Many recognised that this question was about damping and were able to score 2 of the 3 marks. Only a few were able to explain satisfactorily why this occurs, identifying that there would be viscous forces or drag forces that would act on the mass as it moves through the water. Many that did attempt an explanation tried to do it in terms of upthrust which is not relevant in this situation.