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Examiners' Report
June 2016

IAL Physics WPH05 01

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Introduction

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 15c, 16bii, 17b, and 19e 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 missing unit. 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 16bii, 17b, and 18b where candidates sometimes had knowledge of the topic, but could not express it accurately and succinctly. Candidates could most improve by ensuring that they describe all aspects in sufficient detail and always use appropriate specialist terminology when giving descriptive answers.

Scientific terminology was used imprecisely and incorrectly in a number of responses seen on this paper. In particular, descriptions of energy transfer implying that energy is lost were commonly seen.

Once again there was confusion demonstrated between atoms, molecules, nuclei and particles. At A2 level it is to be expected that, where candidates use such terms, they do so with accuracy.

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.

There was evidence of candidates learning previous schemes in the expectation of earning marks. 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.

Question 11 (a)

This question was answered well, with most candidates scoring full marks. The usual reason for not awarding full marks was that the change in temperature was confused with the final temperature of the water. Occasionally candidates made unnecessary conversions from °C to K. Although a final answer in kelvin could score full marks, mistakes in the conversion sometimes meant that the final mark was not awarded.

(a) Calculate the temperature of the water leaving the shower.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(3)

$\Delta E = mc\Delta T$

$\frac{\Delta E}{T} = \frac{m}{T} \times c \times \Delta T$ $\qquad 6200 = 0.075(4200)(\Delta T)$

$\Delta T = \frac{6200}{(0.075)(4200)} = 19.68253968$

$18 + 19.68253968 = 37.68253968$

$= 37.7\ °C$

Temperature of water leaving the shower = 37.7 °C

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Examiner Comments

This is a correct solution.

Question 11 (b)

This should have been a straightforward 2 marks for most candidates, although it was surprising how often the second mark could not be awarded due to candidates not specifying that the actual output temperature of the water would be lower than their calculated value. Candidates sometimes made vague reference to efficiency not being 100%, or talked about energy being lost.

(b) When measured, the temperature of the water leaving the shower was not as calculated. Explain why.

(2)

There is heat loss. not all the heater of heater are transferred into water, and the heat of water might transfer into surroundings.

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Examiner Comments

The idea that heat is transferred to the surroundings is clear, but the effect on the water temperature is omitted.

(b) When measured, the temperature of the water leaving the shower was not as calculated. Explain why.

(2)

The temperature was lower than calculated because not all thermal energy was transferred to the water to heat it. Some was dissipated to the surroundings, heating the air around it and ~~transfering~~ increasing the kinetic energy of the nearby air molecules.

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Examiner Comments

The candidate attempts to describe the effect on the water temperature, but only states that it changes.

(b) When measured, the temperature of the water leaving the shower was not as calculated. Explain why.

(2)

The temperature was lower than calculated because not all thermal energy was transferred to the water to heat it. Some was dissipated to the surroundings, heating the air around it and ~~transferring~~ increasing the kinetic energy of the nearby air molecules.

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Examiner Comments

This response is worth 2 marks.

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Examiner Tip

Refer to energy transfer rather than energy loss. Be sure to specify where the energy is transferred to.

Question 12 (a)

The question requires candidates to show that the ratio of gravitational forces is about 200. Hence a correct answer for the ratio would not be given full credit unless it was shown that the value quoted was a ratio of forces. Some candidates used the expression for the gravitational field strength, $g = GM/r^2$, without making any reference to the gravitational force, and so full credit could not be given.

(a) Show that the gravitational force of the Sun on the Earth is about 200 times greater than the gravitational force of the Moon on the Earth.

(2)

$$g(\text{Sun}) = \frac{(2.0\times10^{30})G}{(1.5\times10^{11})^2}$$

$$g(\text{Moon}) = \frac{(7\times10^{22})G}{(3.8\times10^{8})^2}$$

$$\frac{g(\text{sun})}{g(\text{moon})} = \frac{(2.0\times10^{30})G}{(1.5\times10^{11})^2} \times \frac{(3.8\times10^{8})^2}{(7\times10^{22})G}$$

$$= 183.4$$

$= 183$ times greater

Examiner Comments

Although the candidate has obtained the correct numerical answer, they have not demonstrated the link between g and F.

(a) Show that the gravitational force of the Sun on the Earth is about 200 times greater than the gravitational force of the Moon on the Earth.

(2)

$F(\text{Sun and Earth}) = \dfrac{G m_E (2\times10^{30})}{(1.5\times10^{11})^2}$

$F(\text{Earth and Moon}) = \dfrac{G m_E (7\times10^{22})}{(3.8\times10^{8})^2}$

$\dfrac{G m_E (2\times10^{30})}{(1.5\times10^{11})^2} \div \dfrac{G m_E (7\times10^{22})}{(3.8\times10^{8})^2}$

$= \dfrac{2\times10^{30}}{(1.5\times10^{11})^2} \times \dfrac{(3.8\times10^{8})^2}{7\times10^{22}} = 183.3650714 = \underline{183}$

grav'l force of Sun on Earth 183 times grav'l force of Moon on Earth.

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Examiner Comments

This response is worth 2 marks.

Question 12 (b)

(i) This was straightforward, although some candidates did not use the symbols specified in the question. Since D and x were given on the diagram it is to be expected that these would be used by candidates in the two expressions.

(ii) It was common to see at least 1 mark for responses to this question. However, some candidates tried to use the inverse square law to demonstrate that the gravitational effect of the Sun on the Earth was very weak compared to that of the Moon. Such responses ignored the very large difference in mass between the Sun and the Moon, and so were based on a fallacious argument.

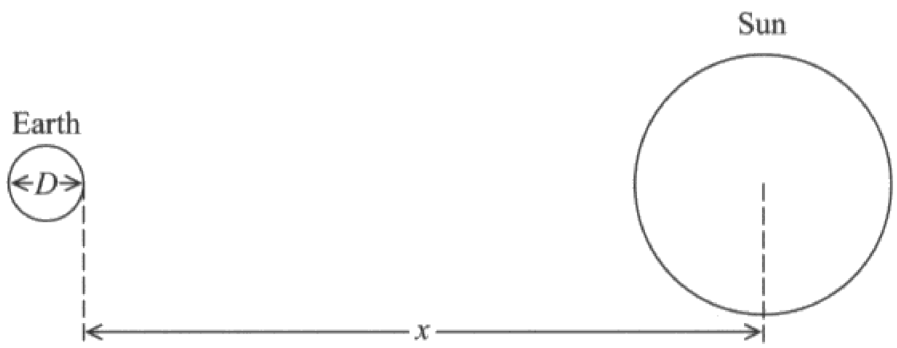
(b) The tides depend on the difference in the gravitational field strength produced by the Sun and the Moon on opposite sides of the Earth.

Gravitational field strength at a point, due to the Sun, is given by $g = \frac{GM}{r^2}$

where M = mass of Sun

r = distance of the point from the centre of Sun (not to scale).

The diagram shows the Earth and the Sun.



(i) State two expressions for the gravitational field strength at opposite sides of the Earth, due to the Sun.

(1)

$g = \frac{GM}{x^2}$ $\qquad$ $g = \frac{GM}{(x+D)^2}$

(ii) Use these expressions to explain why the Sun has a relatively small effect on the tides.

(2)

The diameter D of the Earth is very small ~~compared~~ ~~compared~~ compared to the distance x of the Earth from the centre of mass of the Sun. Therefore the difference between x and (x + D) is very small meaning the difference between x^2 and $(x + D)^2$ is also small. This means that the ~~at~~ ~~gravitational field strength~~ difference in gravitational field strength ~~on~~ of the Sun on opposite sides of the Earth is small, so Sun has relatively small ~~small~~ effect on tides.

(Total for Question 12 = 5 marks)

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Examiner Comments

This response scores full marks.

(i) State two expressions for the gravitational field strength at opposite sides of the Earth, due to the Sun.

(1)

1) $g = \frac{GM}{(x)^2}$

2) $g = \frac{Gm}{(x+d)^2}$

(ii) Use these expressions to explain why the Sun has a relatively small effect on the tides.

(2)

Since g is inversly proportional to distance, the ~~B~~ more the distance between the Sun and point measured, the less force will be exerted. ~~So at~~ for ~~the side of the Earth the tides will have a lower force~~. So the resultant force acting on the earth would have a huge R, so the force is small.

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Examiner Comments

This candidate does not use the symbols given in the question in (i), and their answer to (ii) does not score any marks.

ResultsPlus
Examiner Tip

Always use standard symbols in equations.

Question 13 (a)

The inverse relationship between the age of the universe and H_0 was generally well understood. However, there was confusion as to the meaning of the two different values quoted in the question. Many candidates assumed that the decrease in H_0 was due to the 23 years that had elapsed between the two determinations, and so they made general statements about the universe aging, rather than making links between the value of H_0 and scientists' estimate of the age of the universe.

(a) State, with a reason, a conclusion about the age of the universe that can be drawn from the change in the value of the Hubble constant.

(2)

$V = H_0 d$ $\quad \frac{d}{t} = H_0 d$ $\quad \frac{1}{t} = H_0$ $\quad t = \frac{1}{H_0}$ where t is the age of universe. Clearly, the value of Hubble constant become small when measured in 2013 compared to 1990, meaning that, unsurprisingly, the age of Universe is increasing since $t \propto \frac{1}{H}$

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Examiner Comments

This candidate thinks that the Hubble constant has changed as a result of the time that has elapsed between the measurements.

(a) State, with a reason, a conclusion about the age of the universe that can be drawn from the change in the value of the Hubble constant.

(2)

The age of the universe is found by $\frac{1}{H_0}$, and when changed, the age of the universe seems to be increased. and as $\frac{1}{H_0}$ is an over estimate of the age of the universe, t_u (age of the universe) must be less than $\frac{1}{H_0}$ as the universe is expanding less now.

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Examiner Comments

This response gains the first mark, but the references to the age of the universe are confusing and so the second mark cannot be awarded.

Question 13 (b)

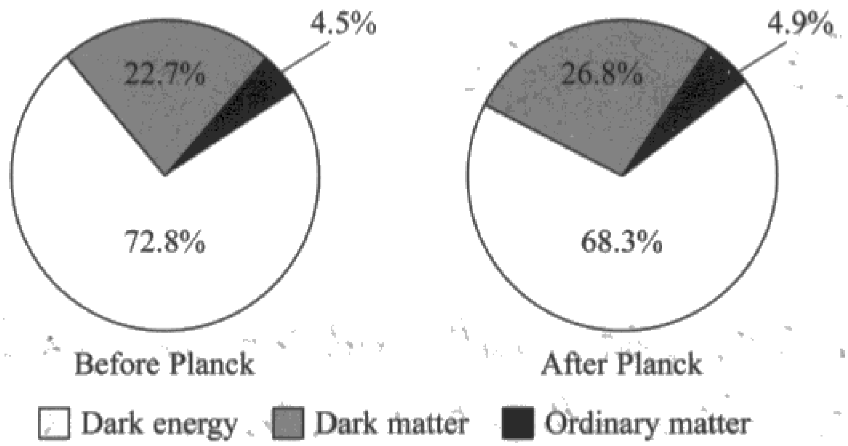
(i) Most candidates understood that dark matter is matter that cannot be seen, and they expressed this idea in a number of ways. However, the idea that we know that it exists due to the gravitational forces it exerts was less often stated. A number of candidates seemed to think that dark matter is a perfect absorber of radiation, hence it cannot be seen. The nature of dark matter is currently unknown, and hence statements that give such detail about dark matter would seem to be highly speculative. A simple statement that dark matter does not interact via the electromagnetic interaction would be sufficient to meet MP2.

(ii) That there is a relationship between the amount of dark matter in the universe and its eventual fate was referred to by most candidates. However, many responses referred to an increase in the critical density of the universe, rather than an increase in the density of the universe (which might mean that the density would then exceed the critical density).

References to an open, a closed and a flat universe were all seen, as were references to an eventual "big crunch". When candidates are describing the ultimate fate of the universe they should be sure to explain the meanings of the terms that they use.

(b) The universe is believed to consist of dark energy, dark matter and ordinary matter.

The relative amounts of dark energy, dark matter and ordinary matter believed to exist in the universe have changed as a result of data from the Planck satellite.



(i) Explain what is meant by dark matter.

(2)

Dark matter is thinly spread matter, thought to consist mainly of hydrogen, spread throughout the universe. It is so thinly spread that we cannot detect it. It is theorised to exist due to a large mass discrepancy found when viewing the rotation of galaxies, as it was calculated that a much greater mass was needed.

(ii) Suggest how data from the Planck satellite, concerning dark matter, might change our ideas on the future of the universe.

(2)

Ifs our new ~~reading~~ estimate for the mass of the universe increases our estimate for the density of the universe past the critical density value, we will have a 'closed' universe scenario, and the universe will eventually start contracting. If our density value is less than the critical value, we will have a open universe scenario.

(Total for Question 13 = 6 marks)

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Examiner Comments

In (i) there is no reference to dark matter having mass, and so only 1 mark is awarded here. In (ii) there is enough for both marking points.

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Examiner Tip

Be specific and use technical terms wherever possible.

Question 14 (a)

Quite a large number of candidates omitted to incorporate the fact that there are 4 springs into their calculation. As a consequence such solutions only scored 2 marks, since the final answer was incorrect. Some candidates tried to incorporate $f = 1/T$ into the equation for T, so that they calculated f in one go. Although this is fine in principle, those candidates who did this incorrectly were not awarded the "use of" mark, since they were not substituting numbers into a physically correct equation.

(a) Calculate the natural frequency of oscillation of the box when it is carrying the equipment.

(3)

$T = \frac{1}{f}$

$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$= \frac{1}{2\pi}\sqrt{\frac{450}{4.3}}$

$= 1.63$ Hz

Natural frequency = ~~1.63 Hz~~ 1.63

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Examiner Comments

This candidate has combined the time period equation with $f = 1/T$, but they have not included a factor of 4 to account for the 4 springs.

(a) Calculate the natural frequency of oscillation of the box when it is carrying the equipment.

(3)

$T = 2\pi \times \sqrt{\frac{4.3}{450 \times 4}} = 0.307$

$f = \frac{1}{0.307} = 3.26$ Hz

Natural frequency = 3.26 Hz.

ResultsPlus

Examiner Comments

This response scores full marks.

Question 14 (b)

This is a standard definition, and candidates should be ready to state this without difficulty. However, it was common to see just 1 mark being awarded, on account of the point from which displacement is measured not being specified. Few candidates were able to gain the final mark, since their statements of why the system was an example of simple harmonic motion were usually a restatement of what they had said for the first two marking points.

(b) State what is meant by simple harmonic motion and why the oscillation of the box is an example of this.

(3)

Simple harmonic motion is a periodic motion in which the acceleration is directly proportional to displacement from a fixed point and is always directed towards this point. In spring the oscillation starts from a fixed point and spring accelerates directly proportional to displacement from that point.

ResultsPlus
Examiner Comments

This response is worth 2 marks for the definition of s.h.m. The final sentence fails to add anything worth the final marking point.

ResultsPlus
Examiner Tip

Learn the conditions for effects such as s.h.m., resonance etc.

Question 15 (a) (b)

(a) This question was well answered, with most candidates able to use the pressure equation to obtain the pressure exerted by the gas.

(b) This question required some careful consideration of the data provided if a correct solution was to be produced. Most candidates ignored the number of molecules that remain in the canister, and solutions that took this approach could score full marks. However, candidates were often unclear as to where the factor of 50 came into the calculation. This meant that a number of candidates did not obtain a correct value for *V*.

(a) Show that at a temperature of 293 K the pressure exerted by the gas in a balloon is about 1×10^5 Pa.

(2)

$pV = NkT$

$p(8.2\times10^{-3}) = 2.2\times10^{23} \times 1.38\times10^{-23} \times 293$

$p = \dfrac{2.2\times10^{23} \times 1.38\times10^{-23} \times 293}{8.2\times10^{-3}} = 1.08\times10^{5}\ \text{Pa}$

(b) At a temperature of 293 K the pressure in the canister when full of helium is 2.3×10^6 Pa. Calculate the volume of the canister.

(2)

$pV = NkT \qquad 2.3\times10^{6} \times V = 50(2.2\times10^{23}) \times 1.38\times10^{-23} \times 293$

$V = \dfrac{50 \times 2.2\times10^{23} \times 1.38\times10^{-23} \times 293}{2.3\times10^{6}} =$

Volume = $0.02\ \text{m}^3$

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Examiner Comments

This response shows all the calculations correctly, but the answer to (b) is only given to 1 significant figure.

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Examiner Tip

Final answers should always be given to enough significant figures for the accuracy of the final answer to be checked.

Question 15 (c)

Questions asking candidates to explain pressure changes in terms of molecular momentum changes have been set previously, although this was the first time that the number of molecules (rather than the temperature) decreased. Some candidates replicated previous mark scheme answers that referred to average molecular kinetic energy decreasing, although most did acknowledge that it was the reduced number of molecules in the canister that was the key change. However references to particles instead of atoms, the collisions between atoms rather than with the walls of the container, and the change in momentum rather than the rate of change of momentum were seen all too frequently.

(c) The pressure in the canister decreases as helium is used to fill the balloons. Explain why this is the case, including ideas of momentum in your answer.

(✗) Pressure ∝ N (number of molecules) thus as N falls, P falls.

(3)

• As helium is used to fill the balloons, the total amount of helium molecules in the canister decreases.

• As temperature and volume remain constant, the momentum of each ~~part~~ molecule remains unchanged. However, due to there being less molecules in the canister, the total number of collisions by them against the walls of the canister, per unit time, will decrease, thereby leading to a reduction in the rate of change of momentum as ~~they~~ the molecules collide with the walls. Since Force = $\frac{\Delta \text{momentum}}{\text{time}}$, the average force exerted on the canister will fall, thus so will pressure.

(Total for Question 15 = 7 marks)

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Examiner Comments

This response has enough for all the marks, but the bulleted list is only partially effective.

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Examiner Tip

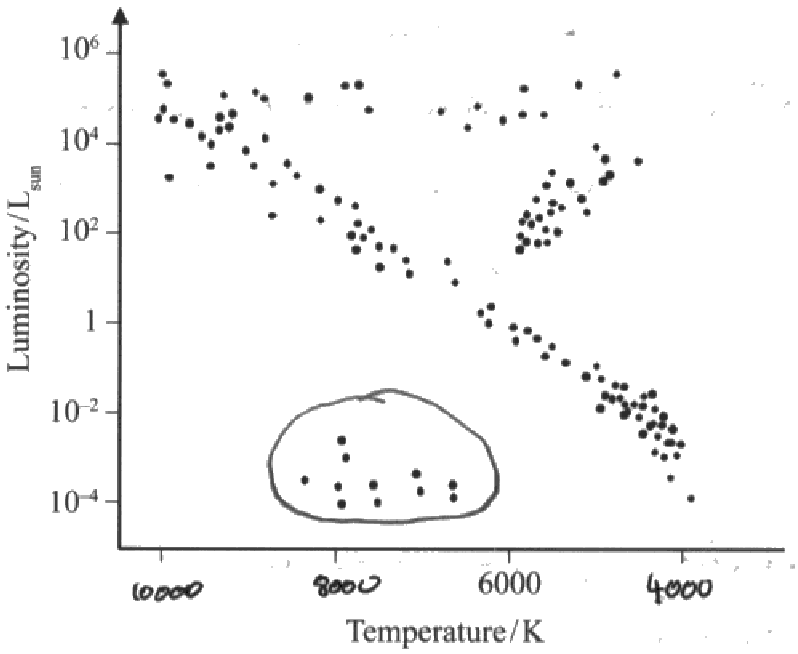
When outlining a process you need to be clear what is happening at each stage. A bulleted list is often helpful.

Question 16 (a) and (b) (i)

(a) Most candidates added a reverse temperature scale to the diagram, but not all of these candidates made the scale approximately logarithmic.

(b)(i) This was well answered, with the vast majority of candidates selecting the appropriate area.

16 The Hertzsprung-Russell diagram is a plot of luminosity against temperature for a range of stars.



(a) Add a suitable temperature scale to the diagram.

(2)

(b) (i) Circle the area on the diagram where you would expect white dwarf stars to be located.

(1)

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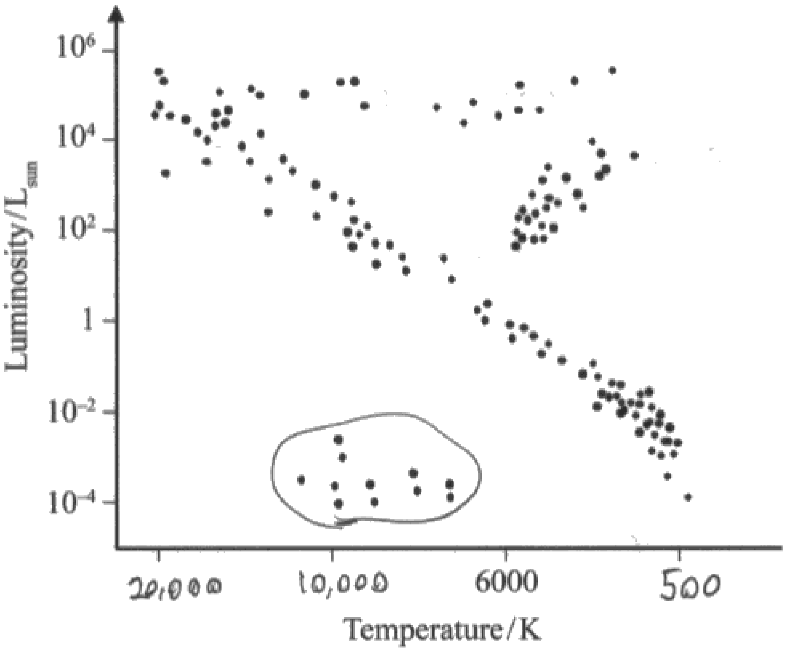
Examiner Comments

The temperature scale is a reverse scale, but it is linear and not logarithmic.

16 The Hertzsprung-Russell diagram is a plot of luminosity against temperature for a range of stars.



(a) Add a suitable temperature scale to the diagram.

(2)

(b) (i) Circle the area on the diagram where you would expect white dwarf stars to be located.

(1)

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Examiner Comments

The temperature scale indicates that some main sequence stars have a surface temperature of only 500 K. This is too low; we might expect the lower end of the temperature scale to be at least 2500 K.

Question 16 (b) (ii)

The response to this question was disappointing. Most candidates seemed to think that the question required them to write at length about the physical processes that occur in a main sequence star before it becomes a white dwarf. This often meant that detail relating to the star once it was in the white dwarf stage was crammed into the last couple of lines of the answer. Only a small minority of candidates made it clear that fusion had ceased in the star, and few gave any indication why the stars are known as *white* dwarfs.

*(ii) Explain, in terms of the physical processes occurring in the star, why white dwarf stars are so named and would be located in this area.

(4)

After the hydrogen fusion inside the main sequence star finishes, it's luminosity and size increases to become a red giant and helium fusion starts. As the helium fusion finishes, all helium used up, the star collapses as the gravitational energy is big enough (or bigger than pressure due to fusion) to become a white dwarf. White dwarfs have high luminosity and high temperature after the explosion (supernova). After some time, white dwarfs starts cooling off and their temperature decreases turning into a brown dwarf into a black dwarf. Also, we can refer to Wein's law that as the temperature increases, the wavelength decreases so it even appear white.

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Examiner Comments

There is too much in this response about the processes leading up to the formation of a white dwarf.

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Examiner Tip

Structure your answers to aid understanding. Try not to use more space than is provided - think before you begin to write.

*(ii) Explain, in terms of the physical processes occurring in the star, why white dwarf stars are so named and would be located in this area.

(4)

• No fusion reaction is occuring ~~to~~ in the dwarf star.

• So no energy is released, hence it has small luminovsity.

• Temperature of the dwarf is low

• ~~Sin dwo~~ Since dwarf star emmits no visible light it does ~~not~~ is not ~~a~~ visible at night, that's why dwarf star is not in the main sequence.

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Examiner Comments

There is a mark for stating that there is no fusion occurring in the star. However, nothing else in the response is worthy of credit.

Question 17 (a) (i)

This question tests a standard piece of knowledge, and it was well answered in the main. Some candidates were not awarded the second mark as a result of their response making reference to a large amplitude of oscillation. The size of the amplitude varies according to the system being forced into oscillation. In some systems the amplitude is large even though resonance is not occurring. What we know about a system being driven into oscillation at its natural frequency however is that the amplitude will be a maximum.

17 A drum is played by striking a circular membrane with a drumstick. The resulting vibration of the membrane may produce resonance.

(a) (i) Explain what is meant by resonance.

(2)

When the driven force oscillates at a driven frequency near the natural frequency of the object ~~pro~~ transfering the max amount of energy with highest amplitude

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Examiner Comments

This response is worth 2 marks.

17 A drum is played by striking a circular membrane with a drumstick. The resulting vibration of the membrane may produce resonance.

(a) (i) Explain what is meant by resonance.

(2)

When the applied frequency is equal to the natural frequency the object begins to move with a very large amplitude.

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Examiner Comments

This response just about gets the first marking point, as applied frequency can be taken to be driving frequency in this context. However, there is not enough for the second marking point.

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Examiner Tip

Know and use technical words correctly.

Question 17 (a) (ii)

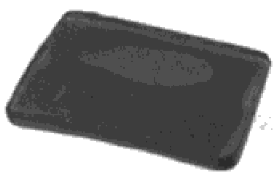
The expected answer was given in many cases, but some candidates tried to complicate the situation by considering the amplitude or by discussing energy transfer through the membrane of the drum.

Question 17 (b)

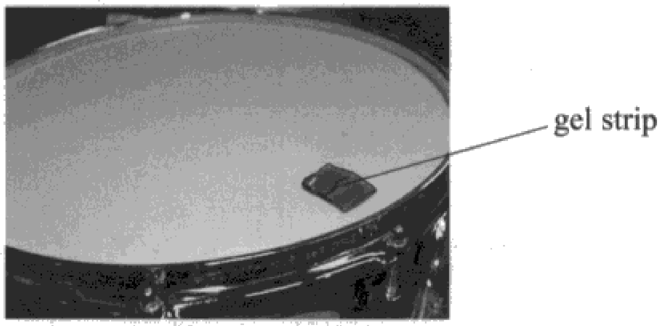
(i) Although it was clear that most candidates had an understanding of what is meant by damping, the ability to express this clearly was lacking in some cases.

(ii) Responses indicated that candidates understood that the gel was absorbing energy from the drum as it changed shape. However, there were many references to the deformation of the gel being plastic without an attempt to explain what this means.

(b) The sound produced when the drum is struck may persist for too long and so damping is used. Some drummers attach strips of a gel to the drum membrane. The gel is able to deform plastically and hence shorten the time that the drum sounds.



gel strip



gel strip attached to drum skin

(i) State what is meant by damping.

(2)

Damping is a method of absorbing the energy ~~due~~ of the system and it would decrease the amplitude of assiclation by absorbing energy and will dissipate in other the forms. ~~It will not~~

(ii) Explain how a gel that can deform plastically is able to produce damping.

(3)

A gel can deform plastically by absorbing energy from the osscillation and is used to ~~in the or~~ increase the potential energy of the gel so that ~~it~~ it deforms plastically using that energy. This produces damping as it would decrease the amplitude of osscilation by absorbing energy ~~and~~ from system and ~~dissipating it in the~~ using it to deform the gel.

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Examiner Comments

In (i) there is enough for the second marking point, but not the first. In (ii) there is just enough for the first marking point, but nothing further.

ResultsPlus
Examiner Tip

Use technical language carefully in answering questions such as this.

Question 18 (a)

(i) This was answered well, although some candidates forgot to convert the distance from the Earth to the Sun to m before substituting into the expression for the radiation flux.

(ii) This question required candidates to use the Stefan-Boltzmann equation. Some candidates forgot to multiply the luminosity of the Sun by a factor of 100 and so had a power of ten error in their final answer. Some candidates indicated in their substitution that they intended to raise the temperature to the fourth power, but then did not do so when they performed the calculation.

18 At the top of the Earth's atmosphere the measured radiation flux of the Sun is 1.36 kW m^{-2}.

(a) (i) Show that the luminosity of the Sun is about 4×10^{26} W.

distance from Earth to the Sun = 1.50×10^8 km

(2)

$F = \frac{L}{4\pi d^2}$

$L = (1.36 \times 10^3) \times (4\pi) \times (1.5 \times 10^8 \times 10^3)^2$

$= 3.85 \times 10^{26}$ W

(ii) The luminosity of a star depends on its surface area and temperature.

Calculate the radius of a star that has a surface temperature of 4000 K and luminosity 100 times that of the Sun.

(2)

$L = \sigma 4\pi r^2 T^4$

$100 \times 3.85 \times 10^{26} = (5.67 \times 10^{-8}) \times (4\pi) \times r^2 \times (4000)^2$

$r^2 = 3.38 \times 10^{27}$ m

$r = 5.81 \times 10^{13}$ m

Radius of star = 5.81×10^{13} m

ResultsPlus
Examiner Comments

This response gets full marks for (i), but squares T in (ii) rather than raising it to a power of 4.

Question 18 (b) (i)

Most candidates realised that they had to calculate a Doppler shift or a relative velocity value. Some candidates thought that the observed wavelength was longer than the emitted wavelength and so stated incorrectly that there was a red shift or that the star was receding from the Earth. Perhaps because of the confusion in identifying the two wavelengths some candidates substituted 654.58 nm (instead of 656.29 nm) into the bottom line of the Doppler shift equation. Although this gave an answer that was almost the same as the correct answer, such responses were not awarded full marks since they had made an error in their data selection.

Since both wavelengths were quoted in nm it was unnecessary to convert the values into m when substituting into $\Delta\lambda/\lambda$. Candidates should be aware of this, as complicating the calculation with unnecessary conversion factors often leads to arithmetic errors.

State what conclusion can be made about B030D from this data. Your answer should include a calculation.

(3)

$$\frac{\Delta\lambda}{\lambda} = \frac{656.29 - 654.58}{654.58} = 2.61 \times 10^{-3}$$

$$\frac{v}{c} = \frac{\Delta\lambda}{\lambda} \quad v = 7.8 \times 10^{5} \text{ m/s}$$

It has a compressed wavelength. So this star is moving towards us.

ResultsPlus
Examiner Comments

This response looks correct, but the wrong wavelength has been substituted into the denominator of the equation.

Question 18 (b) (ii)

A fair proportion of candidates identified the student's statement as being incorrect, although the explanation given often resulted in 1 rather than 2 marks. Sometimes Wien's law was referred to in a general way without a convincing link to this particular application. Some candidates tried to calculate the temperature of B030D and comparing it to the temperature of the star referred to in Q18(a)(ii).

(ii) A student states that blue stars are cooler than yellow stars. Use Wien's law to comment on the accuracy of this statement.

(2)

Wien's law states that $\lambda_{max} \propto \frac{1}{T}$. Since blue stars emit wavelengths of light that are smaller than yellow stars, they must have higher temperatures.

ResultsPlus
Examiner Comments

This response gives just enough detail for 2 marks.

Question 19 (a) (i)

This was generally well answered, although there was a significant minority of responses that did not gain all 3 marks. As candidates first start to balance nuclear equations before they meet the content of this unit maybe it is an aspect of the specification that is overlooked when preparing for the assessment.

Question 19 (a) (ii)

The vast majority of candidates knew that random meant that the next to decay could not be predicted, but the issue was with the next what. Many candidates referred to atoms or particles and so were not awarded the mark. Candidates should be aware that radioactive decay is a nuclear rather than an atomic process.

(ii) State what is meant by decays randomly.

(1)

We do not know when it will decay.

ResultsPlus
Examiner Comments

This response is close to gaining the mark, but we do not know what "it" is and so this scores zero.

(ii) State what is meant by decays randomly.

(1)

We ~~cannot~~ don't know when will the decay happen and which particle will decay

ResultsPlus
Examiner Comments

This response refers to particles rather than nuclei and so does not get the mark.

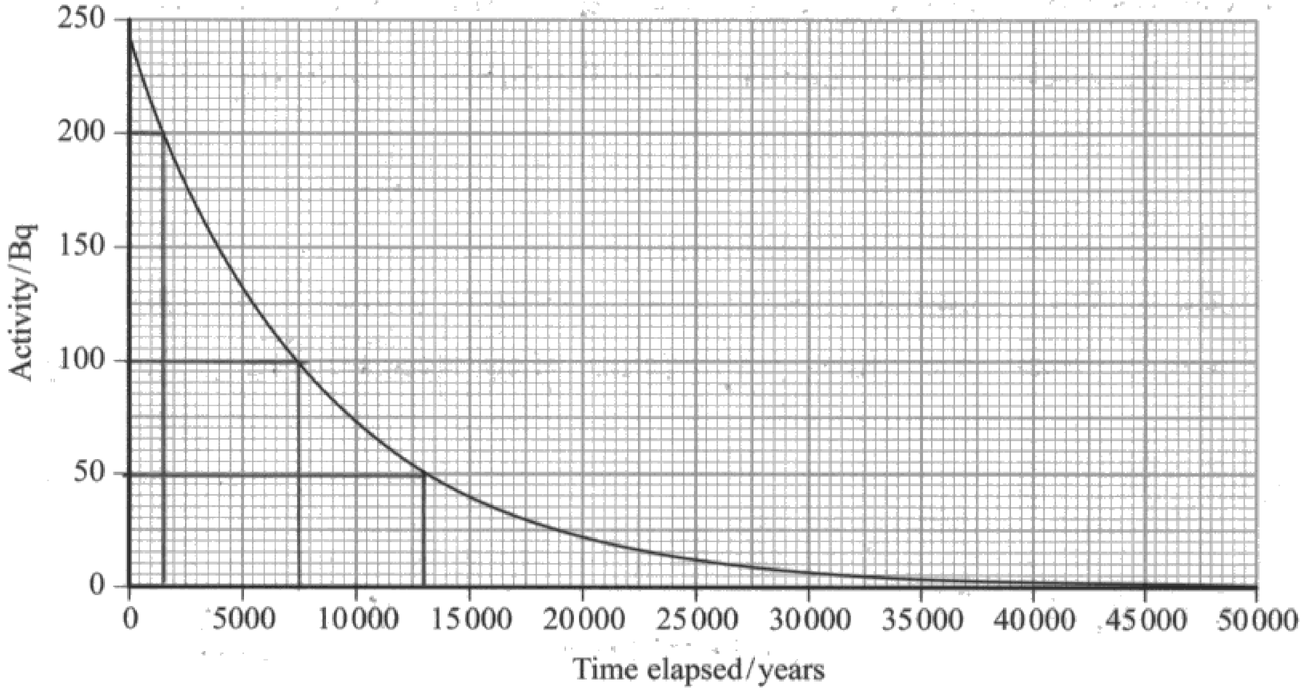
Question 19 (b)

Most candidates were content to perform just one half-life determination (usually based on activities on 240 Bq and 120 Bq). To gain full credit here it was expected that candidates would consider at least 2 half-lives and then calculate an average.

(b) Carbon is taken in by living organisms throughout their lives. Whilst an organism is alive, the ratio of carbon-14 to carbon-12 in the organism stays the same.

From the time that the organism dies, the ratio of carbon-14 to carbon-12 decreases. Hence certain ancient objects can be dated using the decay of carbon-14.

An activity-time graph for carbon-14 is shown.



Use the graph to show that the half-life of carbon-14 is about 6000 years.

(2)

· Time for activity to decrease from 200 Bq to 100 Bq was (7500 – 1500) years so 6000 years.
· Time for activity to decrease from 100 Bq to 50 Bq was (13000 – 7500) years so 5500 years.
Average between the 2 is 5750 years.

ResultsPlus
Examiner Comments

This response is worth 2 marks. Another way to get the same result would have been to have read off the time interval for the decay from 200 Bq to 50 Bq and then divided by 2 to calculate the average half-life.

Question 19 (c) (i)

The most common response seen was to "account for background radiation" which was insufficient. Candidates needed to communicate the idea that the background count rate was increased due to the presence of background radiation. Many expressed this by stating that the background count rate had to be subtracted from the recorded count rate. Some candidates got close to this by stating that background radiation had to be subtracted from the recorded count rate, but this was not close enough for a mark to be awarded.

Question 19 (c) (ii)

The two alternatives given in the mark scheme were seen quite frequently, although some candidates made reference to the background count rate.

Question 19 (c) (iii)

A number of excellent responses were seen to this question, although some candidates calculated a value for the decay constant but progressed little further than this. In calculating the decay constant λ, many candidates converted the half-life into seconds, obtaining a value for the λ in s^{-1}. Since they then obtained a value for the time elapsed in s, many converted this back to years. Those candidates who calculated λ in yr^{-1} calculated a value for the age of the sample directly in years.

rate varies.

(iii) Calculate the age of the ancient object.

Assume the half-life of carbon-14 is 6000 years.

(3)

$10.9 = 29.6\, e^{-\lambda t}$. $A = A_0 e^{-\lambda t}$.

$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{6000\,\text{year}} = 1.55 \times 10^{-4}\ yr^{-1}$

$\frac{10.9}{29.6} = e^{-1.55\times10^{-4} \times t}$.

$-0.999 = -1.55\times10^{-4} t$.

$t = 6445.24$ year.

Age of ancient object = 6445.24 year

ResultsPlus

Examiner Comments

This candidate seems to be carrying out the required procedure for full marks, but an arithmetic error means that they get an incorrect final answer.

(iii) Calculate the age of the ancient object. *not placed*

Assume the half-life of carbon-14 is 6000 years.

(3)

$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{6000 \times 365 \times 24 \times 60^2} = 3.66 \times 10^{-12}$

$N = N_0 e^{-\lambda t}$ $A = A_0 e^{-\lambda t}$

$10.9 = 29.6 \times e^{-3.66 \times 10^{-12} \times t}$

$t = 2.73 \times 10^{11}$ s

(8648 years)

Age of ancient object = 2.73×10^{11} s

ResultsPlus
Examiner Comments

This response is worth all 3 marks, but the candidate needlessly converts times into seconds and then back into years at the end of the calculation.

Question 19 (d)

Most candidates recognised that the time scale involved was far too long for a carbon-14 determination of the age. Many candidates stated that too many half-lives had elapsed and that the activity from any carbon in the skull would be negligible. Some realised that the carbon content of the skull would be negligible anyway, and so the method would be invalid.

Question 19 (e)

Responses to this question were quite disappointing, with candidates sometimes making sweeping generalisations about the statement rather than picking the statement apart and correcting any inaccurate physics. More perceptive candidates were able to read the statement with a critical eye.

There was some confusion over binding energy, with some candidates stating that it is the energy released when a nucleus is split up into its constituent nucleons. These candidates were probably thinking about the energy released when the binding energy per nucleon increases during the process of fission or fusion. Few candidates corrected the idea that atoms undergo fission, and when describing fission many omitted to say that the process occurs when massive nuclei split into less massive nuclei.

*(e) A website includes the following statement about heavy nuclei:

> Particles in the nucleus are held together by a force scientists call nuclear binding energy. It is possible to overcome the binding energy in some large atoms, such as uranium atoms, causing the atoms to undergo fission.

Comment on this statement.

(4)

Binding energy is the energy needed to split a nucleus into its constituent parts. The force that holds particles in the nucleus together is actually the strong nuclear force. During nuclear fission the binding energy is not 'overcome'. The uranium isotope absorbs a low energy neutron then fissions into two daughter nuclei and some neutrons. The mass of the daughter nuclei is less than the mass of the original nucleus. This means that the binding energy per nucleon in daughter nuclei is greater. Hence energy was released.

ResultsPlus
Examiner Comments

This response picks up on most of the anomalies in the website's description, although there is little reinforcement that it is nuclei rather than atoms that undergo fission. Although marking points are met, the candidate's response reads rather like their own description rather than a critique of the description found on the website.

ResultsPlus
Examiner Tip

If you are asked to comment on a statement, be sure to identify aspects which are correct and aspects which are incorrect or misleading.

Paper Summary

In order to improve their performance candidates should:

- Ensure they have a thorough knowledge of the physics for this unit.
- Read the question and answer what is asked.
- For descriptive questions, make a note of the marks and include that number of different physics points.
- Show all their workings in calculations.
- For descriptive questions, try to base the answer around a specific equation which is quoted.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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