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Examiners' Report
January 2012

GCE Physics 6PH05 01

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Introduction

Once again the paper gave candidates the opportunity to demonstrate their understanding of a wide range of topics from this unit. All of the questions elicited responses across the range of marks, but marks for Q14, Q16 (b), and Q18 (d) 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. In general, very good responses were seen for such questions. Re-arrangement of equations was sometimes poorly attempted, leading to marks being lost. Candidates should be encouraged to substitute numerical values into an equation before attempting a re-arrangement, as this may demonstrate a correct use of the equation even if the final answer is incorrect due to poor algebra.

Occasionally in calculation questions the final mark was lost due to an incorrect or missing unit. This was particularly apparent in Q19(c)(iv). Although H, and therefore its unit, might be less frequently met than some quantities in the unit, it is to be expected that an A2 candidate should be able to derive $ms^{-1}/m = s^{-1}$.

Most candidates understood the convention that in a "show that" question it is necessary to give the final answer to at least one more significant figure than the value quoted in the question. Perhaps because the answer to Q13(b)(ii) was 0.602 many candidates lost the final mark, as they gave 0.6 as their answer.

Reasoning and explanation type questions need careful interpretation of the question and subsequent planning of the explanation or argument before the final answer stage is reached. In this way candidates may ensure that all relevant points are included in their answer in a logical sequence. The use of bullet points should be encouraged, as is some thought to the structure of answers to such questions. In this way candidates may ensure that they answer all the points required by the question. In addition, reference to the marks allocated to each part of a question will tell them how many points or statements they should be making.

As is often the case, candidates disadvantaged themselves by not actually answering the question and in not expressing themselves using suitably precise language. This was particularly the case in extended answer questions such as Q14 and Q19, where candidates obviously had knowledge of the topic, but could not express it in the context required.

Although some well-structured, succinct answers to questions were seen it is clear that a good proportion of the candidates sitting the exam would benefit from more time being spent applying the physics that they have learnt to the types of extended answer question commonly met in A2 papers.

Scientific terminology was used imprecisely and incorrectly in a number of responses seen on this paper. The confusion between atoms, molecules, nuclei and particles was clear from the way in which these terms were often used interchangeably. Similarly candidates used terms such as element, isotope and nuclide inappropriately throughout their answers to Q18 and Q19. At A2 level it is to be expected that, where candidates use such terms, they do so with accuracy.

In Q13 and Q17 candidates were asked to "sketch" graphs. The word "sketch" is used because it is not expected that candidates will use graph paper and plot points. However, all essential detail should be included. So if a candidate is to attain full marks a sketch should be drawn carefully enough to be physically correct showing all the important features. In many sketch graphs that were seen it was not clear if the amplitude or time period stayed constant etc. Those candidates who used a ruler to check approximate magnitudes and who marked key values from the question on the axes scored more highly than those who made a cursory free hand sketch. In such cases, carelessness in drawing rather than lack of candidates' understanding of concepts led to marks not being awarded.

The space allowed for responses was usually sufficient. However, candidates need to remember that the space provided does not have to be filled. If they 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.

Question 11

Many candidates made over-complex and convoluted calculations to obtain the ratio. It was disappointing to see that a significant number of candidates could not go from $F = GMm/r^2$ to $g = GM/r^2$ without error; many candidates dropped the r^2 and wrote r instead. The final answer was not always given as a decimal fraction, leading to further loss of a mark. Some candidates gave a protracted description that earned no marks as it involved no quantitative information. It is normally the case that in a question in which numerical values are supplied a request to compare requires the candidate to find a numerical ratio.

11 In a physics lesson a student learns that the Earth is 81 times more massive than the Moon. Searching the Internet, she is surprised to discover that the gravitational field strength at the surface of the Earth is only 6 times greater than that at the surface of the Moon.

Use the above data to compare the radius of the Earth with that of the Moon.

(3)

the radius of the Earth is only 6 times larger than the moon. although the Earth has a much denser core meaning it is 81 times more massive than the moon.

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Examiner Comments

The candidate has repeated information they were given, but their response doesn't answer the question.

11 In a physics lesson a student learns that the Earth is 81 times more massive than the Moon. Searching the Internet, she is surprised to discover that the gravitational field strength at the surface of the Earth is only 6 times greater than that at the surface of the Moon.

Use the above data to compare the radius of the Earth with that of the Moon.

(3)

• $g = \frac{-GM_{Earth}}{r^2}$ • $\frac{\text{Mass of Earth}}{\text{Mass of Moon}} = \frac{81}{1}$

$\therefore \frac{-GM_{Earth}}{r_E^2} \div \frac{-GM_{moon}}{r_{moon}^2} = \frac{6}{1}$

$\Rightarrow \frac{M_{Earth}}{r_E^2} \div \frac{M_{moon}}{r_m^2} = \frac{6}{1}$

$\Rightarrow \frac{M_{Earth}}{r_E^2} = 6 \times \frac{M_{moon}}{r_m^2}$

$\Rightarrow M_{Earth} \times \frac{1}{r^2} = 6 \times M_{moon} \times \frac{1}{r^2}$

$\Rightarrow 81 \times \frac{1}{r_{Earth}^2} = \frac{6}{r_{moon}^2}$

$\Rightarrow \frac{r^2_{moon}}{r^2_{Earth}} = \frac{6}{81} \Rightarrow \frac{r_{moon}}{r_{Earth}} = \frac{\sqrt{6}}{9}$

(Total for Question 11 = 3 marks)

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Examiner Comments

This is a correct method, but the final answer is not fully calculated.

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Examiner Tip

Always work out numerical answers fully, giving a decimal fraction where appropriate for your final answer.

Question 12 (a)

This was answered successfully by a large proportion of candidates. The most common mistakes were in not squaring the radius or not taking the fourth power of temperature. Some candidates did not convert radius and temperature into correct units. A few did not use the correct formula for area.

12 The Earth can be considered to be a black body radiator at a temperature of 25 °C.

radius of Earth = 6380 km

(a) Calculate the total power radiated from the Earth.

(2)

~~P = 4π~~ $L = \sigma \times 4\pi r^2 \times T^4$

$= (5.67\times10^{-8}) \times 4\pi \times (6380\times10^3)m \times (25+273)^4 K$

~~= 0.01 W~~ $= 3.6\times10^{10}$ W

~~= 360 × 10³ W~~

Total power radiated = 3.6 ~~...~~ × 10¹⁰ W

ResultsPlus
Examiner Comments

The radius is not squared at the substitution stage.

ResultsPlus
Examiner Tip

Check carefully as you go from a statement of the formula to the substitution.

12 The Earth can be considered to be a black body radiator at a temperature of 25 °C.

radius of Earth = 6380 km

(a) Calculate the total power radiated from the Earth.

(2)

$L = 4\pi r^2 \times 6 \times T^4$

$= 4 \times \pi \times (6380)^2 \times (273+25)^4$ W

$= 4.03 \times 10^{18}$ W

Total power radiated = 4.03×10^{18} W

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Examiner Comments

The Stefan-Boltzmann constant has been omitted at the substitution stage.

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Examiner Tip

Physical constants are given in a list at the end of the question paper.

Question 12 (b)

This question yielded mostly correct answers with very few conversion errors. However, the

(b) Calculate the wavelength of the peak energy radiation for the Earth.

(2)

$\lambda_{max} T = 2.898 \times 10^{-3}$ mK

$\Rightarrow \lambda_{max} \times 298 = 2.898 \times 10^{-3} \times 10^{-3}$

$\Rightarrow \lambda_{max} = 9.72 \times 10^{-9}$ km

Wavelength of the peak energy radiation = 9.72×10^{-9} km

ResultsPlus
Examiner Comments

The candidate seems to convert the wavelength from m to km when making the substitution.

ResultsPlus
Examiner Tip

Use SI units throughout in any calculations that you carry out.

(b) Calculate the wavelength of the peak energy radiation for the Earth.

(2)

$\lambda_{max} T = 2.898 \times 10^{-3}$

$\lambda = 9.72 \times 10^{-6}$

Wavelength of the peak energy radiation = 9.72×10^{-6}

ResultsPlus
Examiner Comments

There is a unit penalty here.

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Examiner Tip

Watch out for units - all final answers should be quoted with appropriate units.

Question 12 (c)

Most candidates correctly identified the wavelength as lying in the infra-red region of the em-spectrum. It is expected that candidates will be able to match up wavelengths with regions of the spectrum.

Question 13 (a)

Although many correct definitions were given, poor use of English often prevented candidates from being given full credit. In good responses, the idea of proportionality together with an opposite direction between acceleration/force and displacement was clearly stated. However, when marks were lost it was usually because candidates did not qualify the word "displacement" with "from the equilibrium position".

13 (a) Define simple harmonic motion.

(2)

Oscillation where acceleration is directly proportional to displacement & is directed towards mean position. Time period is constant for any amplitude.

ResultsPlus

Examiner Comments

The displacement from the mean position is not clearly stated.

13 (a) Define simple harmonic motion. ~~$a = -\omega^2 x$~~ ~~$a^2 = -\omega^2 x a$~~. $a = -\omega^2 x$.

(2)

Simple harmonic motion happens when the frequency is inde-pendant of the amplitude. A ~~s~~ restoring force always acts from the centre point. And the acceleration is ~~inverset~~ directly proportional to the ~~ampt~~ distance moved with a negative gradient.

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Examiner Comments

There is a lot of information given here, but nothing that gains a mark.

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Examiner Tip

Learn definitions of key things in advance of the examination.

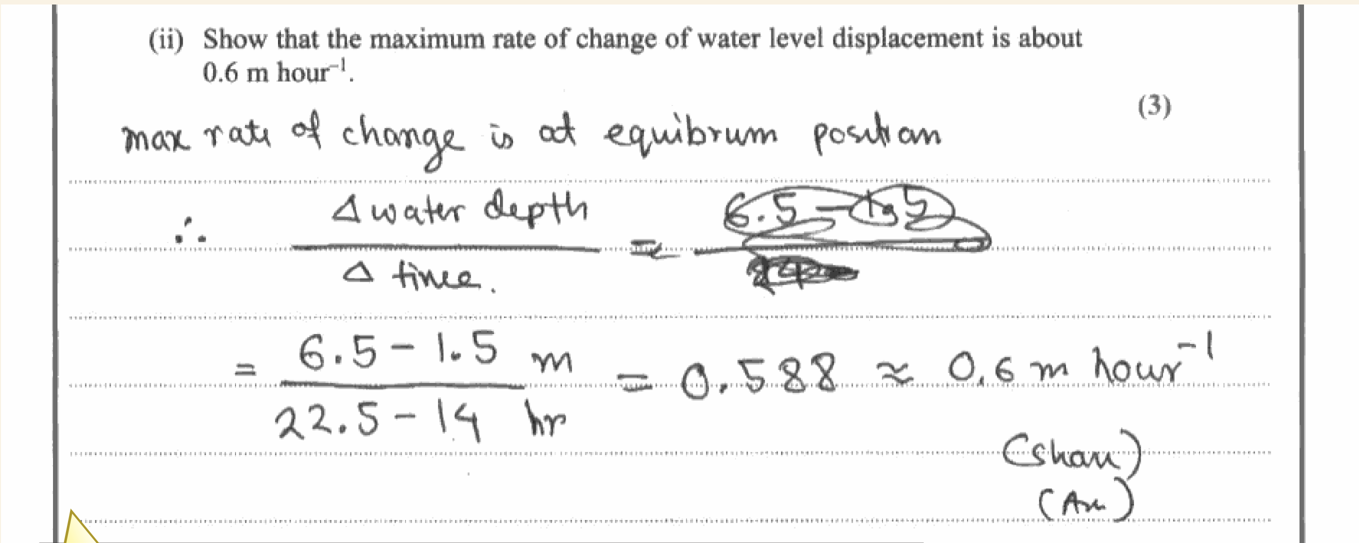
Question 13 (b) (i)

It was surprising how many candidates could not read off simple information (amplitude and time period) from a graph and give a correct unit. Peak-to-peak displacement was often seen for amplitude as well as a simple reading of the peak value of displacement from the graph (the most common wrong answers seen for amplitude were 4.6 or 6.1). In addition close but inaccurate values for both A and T were seen too frequently.

Question 13 (b) (ii)

Many good answers were seen, with clearly structured calculations leading to answers within an acceptable range. However, the handling of significant figures was disappointing in a number of cases. In a 'show that' question candidates must give an answer to at least one more significant figure than given in the question.

Most candidates calculated the answer from vmax = ωA. Those who followed this route using v = Aωsin(ωt) often failed to realise that sin(ωt) = 1 at maximum, so scored only the first mark. Those following the gradient method often scored 2 marks. Some values for both Δs and Δt were impossibly large (but gave an answer within the acceptable range). As a teaching point, perhaps the use of tangents to curves as a means of finding the gradient of a curve needs greater emphasis.


(ii) Show that the maximum rate of change of water level displacement is about 0.6 m hour^{-1}.

(3)

max rate of change is at equibrum position

$\therefore \frac{\Delta \text{water depth}}{\Delta \text{time}} =$ [illegible]

$= \frac{6.5 - 1.5 \text{ m}}{22.5 - 14 \text{ hr}} = 0.588 \approx 0.6 \text{ m hour}^{-1}$

(show)

(Ans)

ResultsPlus

Examiner Comments

The candidate has clearly shown that the maximum rate of change of water level displacement is as given in the question.

(ii) Show that the maximum rate of change of water level displacement is about 0.6 m hour[-1].

(3)

maximum $v = a\omega$ $\quad \omega = \frac{2\pi}{T} = \frac{2\pi}{24.5}$

$v = 2.3 \times \frac{2\pi}{24.5}$

$v = 0.5899$ m hour^{-1}

so the maximum rate of change of water level is about 0.6 m hour^{-1}

ResultsPlus

Examiner Comments

This candidate has used the values they read from their graph in a calculation. Again, the value given in the question is clearly shown.

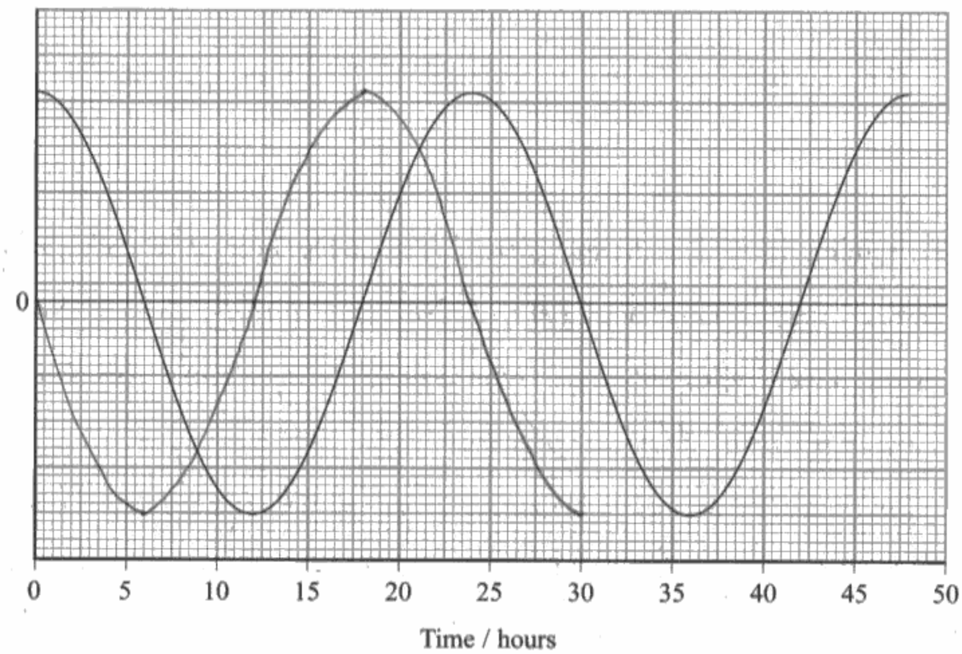
Question 13 (b) (iii)

The first mark was often not scored, but the second mark was. Poor draughtsmanship sometimes led to the loss of this mark as well. The vast majority of candidates communicated the idea of constant amplitude (most choosing the same amplitude as the curve already there) though a common error was in the type of curve. The most common mistake was to draw a sine wave starting at 0 and then going positive or to draw a cosine wave.

Graph sketching is still a skill many students need to perfect. The drawing of sine curves would be helped in many cases by identifying key points on the axis before drawing in the curve. Clearly some candidates have been taught this, since the dots were visible on their scripts. This generally produced better graphs.

(iii) On the axis below sketch how the rate of change of water level displacement varies with time for the interval 0–30 hours. The variation in water level displacement with time has been drawn for you. You need not add any numerical values to the y-axis.

(2)



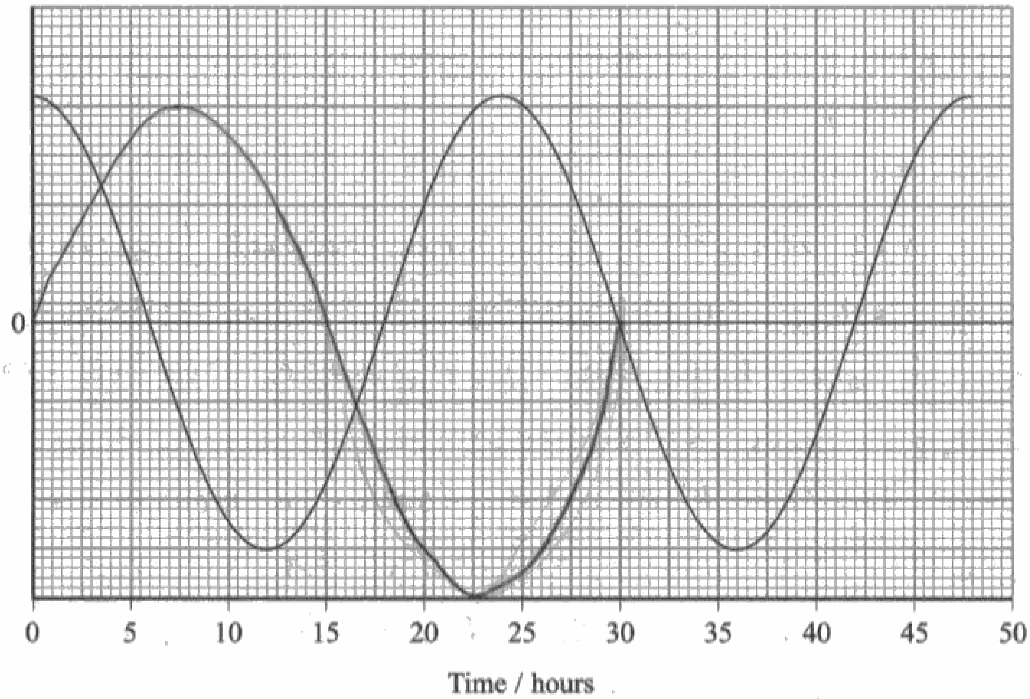
ResultsPlus

Examiner Comments

This is a well sketched graph.

(iii) On the axis below sketch how the rate of change of water level displacement varies with time for the interval 0–30 hours. The variation in water level displacement with time has been drawn for you. You need not add any numerical values to the y-axis.

(2)



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Examiner Comments

The graph shape is wrong, and neither amplitude nor time period are correctly drawn.

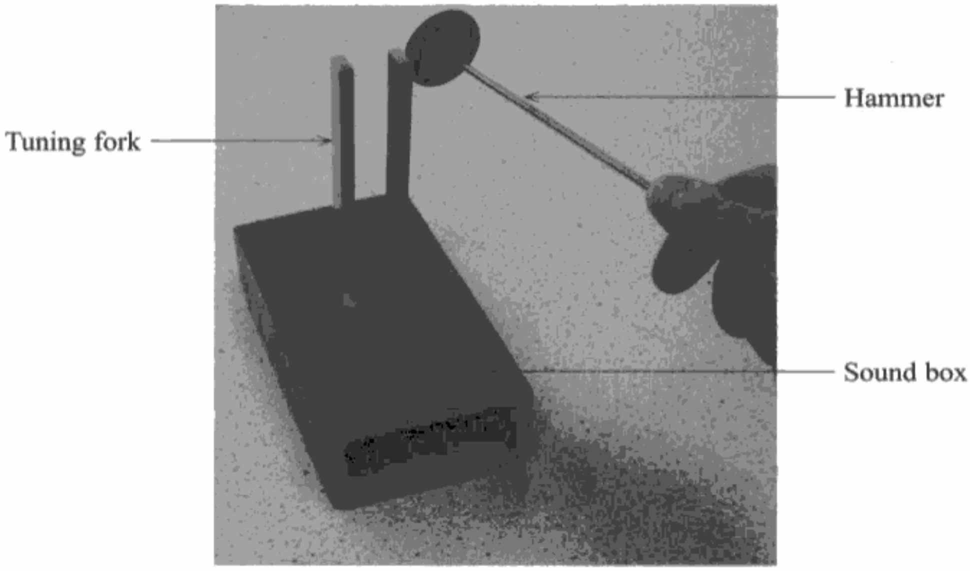
Question 14

Many candidates referred to resonance as part of their explanation, and the first four marking points, relating to resonance, were the ones most commonly awarded. However candidates often talked about resonance between the hammer and the tuning fork. In better answers candidates were able to identify how and why the vibrations were transferred.

References to damping were seen in a number of scripts. However, the mention of a rubber hammer in the stem seemed to prompt quite a few candidates, if they referred to damping at all, to do so in connection with the hammer striking the fork rather than with the action of the sounding box.

Only good candidates were able to say why the sound might last for a shorter time when the sounding box was present. Some candidates gave reasons for the sound lasting for a longer time when the fork was connected to the box.

***14** When a tuning fork is struck with a rubber hammer, a pure sound of fixed frequency is produced. The photograph shows a tuning fork connected to a wooden sounding box.



- The sounding box amplifies the sound produced when the tuning fork is struck.
- The sound lasts for a shorter time than if the tuning fork were to be struck identically but without the sounding box.

Explain these observations.

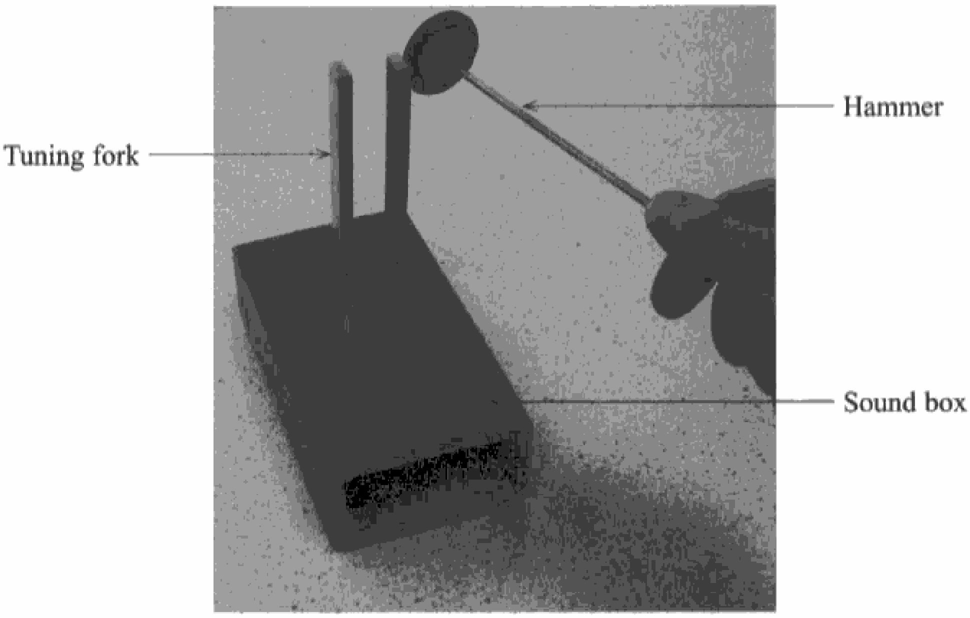
(5)

When the tuning fork is struck it vibrates and this vibration causes the sound box to vibrate at maximum frequency. Because the natural frequency of the box matches with that frequency produced by the fork. This is called ~~tes~~ resonance and due to resonance the sound box ~~ap~~ amplifies sounds with maximum energy.

ResultsPlus
Examiner Comments

The candidate scores marks for 3 out of the first 4 marking points.

*14 When a tuning fork is struck with a rubber hammer, a pure sound of fixed frequency is produced. The photograph shows a tuning fork connected to a wooden sounding box.



- The sounding box amplifies the sound produced when the tuning fork is struck.
- The sound lasts for a shorter time than if the tuning fork were to be struck identically but without the sounding box.

Explain these observations.

(5)

When the tuning fork is struck, sounding box absorbs energy and transfer to sound energy in higher amplitude due to closed surface.

The sound lasts for longer without the sounding box, because the sounding box absorbs some of the energy from the tuning fork and the ~~amp~~ vibration is damped. So it lasts for shorter time. ~~Fu~~ ~~id~~

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Examiner Comments

The candidate has correctly linked damping of the vibration to the sound lasting for a shorter time.

Question 15 (a)

Many correct answers were seen. Unnecessary and sometimes incorrect conversions to kelvin temperatures were occasionally carried out. Candidates need to be aware that a temperature difference in kelvin is numerically identical to the same temperature difference in celsius, therefore there is no need to carry out a conversion.

Question 15 (b)

(b)(i) was well answered, although there were some power conversion errors.

In (b)(ii) many answers suffered from lack of specific detail - responses referring to the efficiency of the washing machine and vague statements of "heat loss" were common. To gain credit candidates need to say where the "lost" energy might go. Only about half the candidates could give the answer that no energy was lost to the surroundings.

(b) (i) The power of the heater is 2.5 kW. Calculate the minimum time it takes for the water to be brought to the correct temperature.

(2)

minimum time taken = $\frac{\text{Energy supplied}}{\text{Power}}$

$= \frac{3 \times 10^6}{2.5 \times 10^3}$

$= 1200$ s

Minimum time = 1200 s

(ii) State an assumption you made in your calculation.

(1)

No energy is lost to the surroundings

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Examiner Comments

This response gains all 3 marks.

Question 15 (c)

The vast majority of responses seen gained full credit. Forgetting to convert from kW to W, and missing or wrong units meant that some candidates were not awarded the second mark. However, the main errors seemed to come from candidates who attempted to use E=VIt; in these cases power was often substituted for the energy.

Question 16 (a)

Very few students could explain clearly that the Moon is held in place by the gravitational pull of the Earth. The mutual attraction between the two bodies was a common way of expressing candidates' understanding. A large proportion of candidates were not able to demonstrate a clear grasp of what affects the radius of Moon's orbit. Most answers indicated gravitational force provided by the Earth was involved. Some lost marks by presenting a list of possible factors.

16 (a) The Moon orbits the Earth in a circular path.

Explain why the Moon maintains this circular path and what determines the radius of the path.

(2)

~~It~~ There is a centripetal force on the Moon that maintains this circular motion. The ~~velocity~~ speed of the moon determines the radius of the path.

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Examiner Comments

The identification of a centripetal force is not enough here - the candidate needs to say that it arises from the gravitational pull of the Earth on the moon.

16 (a) The Moon orbits the Earth in a circular path.

Explain why the Moon maintains this circular path and what determines the radius of the path.

(2)

Gravitational ~~fet~~ force of earth acts as the centripetal force on Moon. This resultant forces causes the moon to follow circulat path rather than following a straight line along a tangent to its orbit. Mass of earth determines the radius and the velocity with which ~~moon~~ moon is rotating.

$$F = \frac{G m_e m_m}{r^2} = \frac{m_m v^2}{r}$$

$$\Rightarrow \frac{G m_e}{v^2} = r.$$

$m_e \rightarrow$ mass of earth

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Examiner Comments

This response scores both marks.

Question 16 (b)

The most commonly awarded mark was for a reference to a centripetal force. However, very few candidates seemed to understand the application of Newton's 2^{nd} law to circular motion. Centrifugal force was commonly seen, along with the bottom of the bucket attracting the water and holding it in the bucket. There was still the tendency in some candidates' minds to think of the centripetal force as an actual physical force, in addition to weight and reaction, instead of it being provided by the weight and reaction.

Candidates who knew that there was a centripetal force, often attempted to explain the lack of downwards motion by using Newton's 3^{rd} law and have a 'centrifugal' force making the water move outwards. Very few candidates seemed to understand that the weight of the water was supplying the centripetal force and so long as the required force was greater than weight the weight could not pull the water down.

The question asked about a minimum speed, but this was not always addressed in the responses, with some candidates even suggesting that water would come out of the bucket if the speed was too great. Where candidates were able to get the connection linking the forces correct, there was generally no problem in arriving at an expression for the minimum velocity.

(b) A bucket is swung in a vertical, circular path as shown.

The bucket is half filled with water and swung. The water stays in the bucket, even at the top of the circular path, as long as the speed of the bucket exceeds a certain value.

Explain why.

(3)

According to centripetal force, the water in the bucket at the top of the circular path experiences a force of $(mg - \frac{mv^2}{r})$ N. When the value of v ~~increases~~ exceeds a certain limit, the resultant force becomes greater

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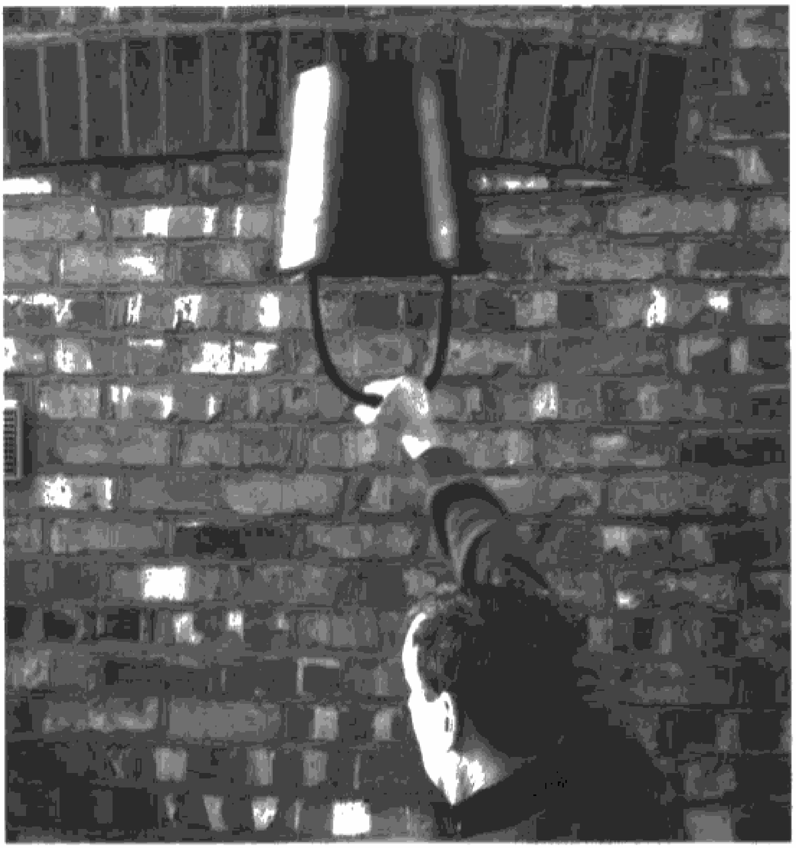
Examiner Comments

The candidate seems to be saying that there is a maximum speed before the water will come out of the bucket.

(b) A bucket is swung in a vertical, circular path as shown.



The bucket is half filled with water and swung. The water stays in the bucket, even at the top of the circular path, as long as the speed of the bucket exceeds a certain value.

Explain why.

(3)

The water in the bucket feels a centripetal force while moing in the circular path. By newtons 3rd law, there is an equal but opposite force acting on it, which is acting outwards of its circular path. when the resultant force acting on it is zero, it stays in the bucket.

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Examiner Comments

This is a common misconception - that the centripetal force is balanced by an outward force.

Question 17 (a)

The most successful answers to this question were through the use of $T=2\pi\sqrt{(m/k)}$.

A few failed to gain any marks by choosing to use the simple pendulum formula, or by setting the acceleration to 9.81m s^{-2}.

Question 17 (b) (i)

Most candidates knew about a decrease in amplitude, and so the second mark was usually awarded. Vague answers relating to energy loss in general without relating it to the system in the question led to the first mark being withheld. A lot of candidates did not state clearly that energy is dissipated or lost from the system. References to energy transfer need to be clear that energy is being transferred out of the oscillating system.

(b) The oscillations of the pan are damped.

(i) Explain what is meant by this statement.

(2)

It means the oscillation is opposed by damping force, the energy is absorbed by damping, so the oscillation decreases.

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Examiner Comments

This response comes close to being awarded a mark, but overall the statements are too vague. e.g. which part of the oscillation decreases?

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Examiner Tip

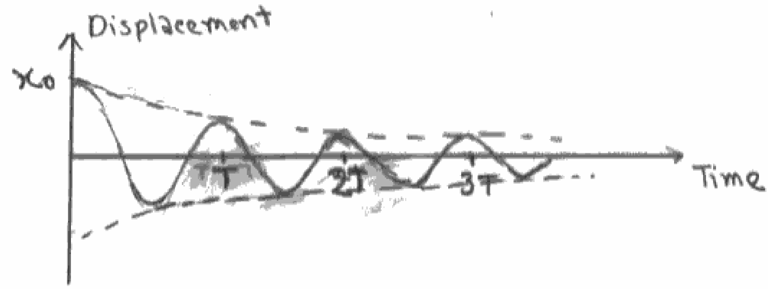
Be specific when you are giving an explanation.

Question 17 (b) (ii)

The first two marking points were gained by most, although the sketches were often poor with no evidence of pre-plotted points to help with the curve drawing. The final mark was lost by most candidates because the time period of their curve decreased over time. It might be that the majority of candidates still think that the period of the oscillation reduces when a system is damped, but good candidates identified points on the time axis which would give their graph a constant period.

(ii) Sketch a graph to show how the displacement of the damped pan varies with time.

(3)



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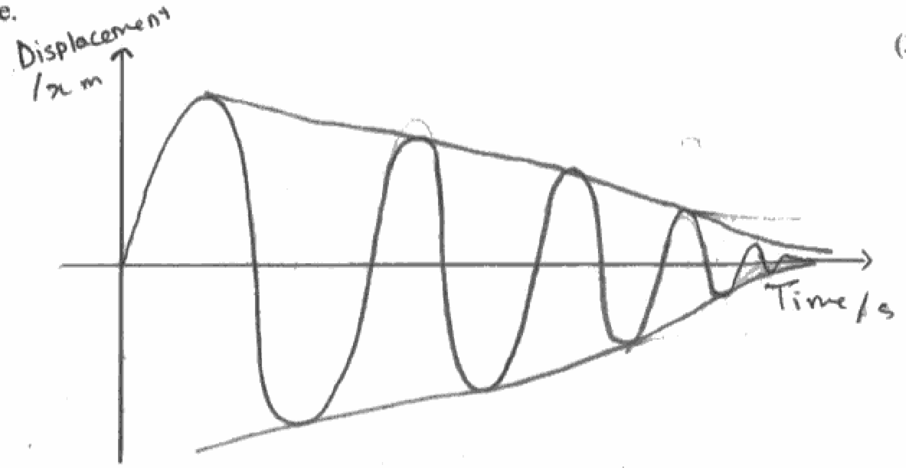
Examiner Comments

This is an example of a clear sketch.

(ii) Sketch a graph to show how the displacement of the damped pan varies with time.

(3)



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Examiner Comments

The time period decreases substantially from the first oscillation to the last.

Question 18 (a)

Many candidates only described what isotopes are. In too many responses there was no mention of the nucleus, candidates preferring instead to refer to atoms or molecules or particles. Most candidates were too vague about what was decaying. Very poor terminology and sloppy statements (such as 'emitting 'radioactive particles', or describing α, β, γ radiations as being radioactive) were commonly seen.

It is the nuclei that are unstable – not atoms, molecules, etc. Candidates should know that radiation is emitted from a nucleus within the atom and that the radiations themselves are not radioactive.

18 The radioactive isotope carbon-14 undergoes decay with a half-life of 5730 years. While an organism is living, it takes in carbon from the atmosphere and the ratio of carbon-14 to the stable isotope carbon-12 in the organism is constant. After death the ratio changes, as the carbon-14 continues to decay but no more carbon is taken in. This is the basis of radiocarbon dating.

Archaeologists have used radiocarbon dating to pinpoint the date of construction of Stonehenge, an ancient stone circle in south west England. The archaeologists unearthed dead organic material from under the stones and sent a sample of it to Oxford University for analysis. Scientists at the university determined that the ratio of carbon-14 to carbon-12 in the sample was only 60% of that found in living organisms.

(a) Explain what is meant by a radioactive isotope.

(2)

An Isotope refers to the same specific element ~~of a specific~~ but has a different number of neutrons.
The word 'radioactive' means that it emits radiations and undergoes decay.

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Examiner Comments

The response refers to "it" rather than "the nucleus".

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Examiner Tip

Be careful of referring to quantities as "it" in your answers. The examiner has to guess what "it" means.

18 The radioactive isotope carbon-14 undergoes decay with a half-life of 5730 years. While an organism is living, it takes in carbon from the atmosphere and the ratio of carbon-14 to the stable isotope carbon-12 in the organism is constant. After death the ratio changes, as the carbon-14 continues to decay but no more carbon is taken in. This is the basis of radiocarbon dating.

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(a) Explain what is meant by a radioactive isotope.

(2)

Radioactive isotope has an unstable nuclei, that give out radiation or particles to become stable. Its decay is random and spontaneous.

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Examiner Comments

The first sentence is enough for 2 marks.

Question 18 (b)

General knowledge that "which nucleus will decay next" and "when a given nucleus will decay" are unpredictable was good, but issues occurred in the terminology used. After writing the phrase "we do not know which nucleus will decay" quite a few candidates omitted to add the word "next", which is necessary to establish that the decay is random (since all nuclei will decay eventually). Few candidates were able to express the fact that there was a probability of decay in a given time.

(b) Radioactive decay is a random process. Explain what this means.

(2)

Radiactive decay is a random process which implies that the radiation is haphazard and the decay process ~~do not follow~~ does not occur in an orderly process. It is uncertain that 'when or how it will decay,' ~~or the~~

ResultsPlus

Examiner Comments

There is nothing here that is worth a mark. The final sentence comes closest to gaining a mark, but it is just too vague.

(b) Radioactive decay is a random process. Explain what this means.

(2)

It ~~cann~~ is not possible to predict which nuclei will decay next ~~when~~ or how many atoms will decay in a given set ~~of~~ of time.

ResultsPlus

Examiner Comments

The first part of the response is worth 1 mark.

(b) Radioactive decay is a random process. Explain what this means.

(2)

* ~~a~~ the radioactive element decays at a random manner
* it decays to form different ~~so~~ element at different times, with no fixed property of decaying

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Examiner Comments

No marks here.

Question 18 (c)

Many correct answers were seen, with most candidates able to gain the first three marks. However, not all were able to tackle the final equation and calculation.

The ratio N/N_0 was generally substituted with the correct value though some inserted 60 and forgot it was a percentage. Some problems arose by candidates using 40% rather than 60%. A few answers brought in the mass numbers of the carbon isotopes, writing the ratio as 12/14.

Candidates could have saved a lot of time if they didn't bother to convert time into seconds in this question. Poor conversions such as 360 days in a year and the omission of 24hrs in a day when using seconds were not as uncommon as might be expected.

(c) Calculate the decay constant of carbon-14 and hence the time since Stonehenge was constructed.

(6)

$\lambda = \ln 2 / t_{1/2}$

$= \ln 2/(5730 \times 365 \times 24 \times 60 \times 60) =$ ~~3.84~~ $4.09 \times 10^{-12}\ s^{-1}$

Say that $N_0 = 10$, ∴ N must be 60% of 10 = 6.

$N = N_0 e^{-\lambda t}$ $\ln N = \ln N_0 - \lambda t$ $\ln N + \lambda t = \ln N_0$

$\lambda t = \ln N_0 - \ln N$ $t = \ln N_0 - \ln N / \lambda$

$t = (\ln 10) - (\ln 6) / 4.09 \times 10^{-12} = 1.25 \times 10^{11}\ s$

$= 3960$ years

Time = 3960 years

ResultsPlus
Examiner Comments

Apart from an arithmetic error this is all correct. Final mark is not awarded, as the answer is incorrect.

(c) Calculate the decay constant of carbon-14 and hence the time since Stonehenge was constructed.

(6)

$\lambda = \frac{\ln 2}{t_{1/2}}$ ⇒ ~~$\lambda = \frac{\ln 2}{570}$~~ ⇒ $\lambda = \ln 2/5730 = 1.2 \times 10^{-4}$.

∴ the decay constant of Carbon 14, $\lambda = 1.2 \times 10^{-4}$.

ResultsPlus
Examiner Comments

A typical weaker response, gaining the first 3 marks.

Question 18 (d)

Most grasped the idea that the amount of C-14 varied somehow, but fewer described the variation in terms of the C-14 to C-12 ratio. Quite a few stated the age as lower than calculated and very few communicated the lack of comparing 'like with like' in the calculations. Some responses concluded that "the date would be less" which is a good example of poor language skills obscuring what might be a correct understanding / interpretation.

"It will make no difference" or "the decay constant / half-life will change" were seen quite often, and it was also quite common for the information given to be interpreted in the opposite way from that intended.

(d) The rate of production of carbon-14 in the atmosphere has decreased since Stonehenge was constructed. Explain how this would affect the scientists' calculations of when Stonehenge was constructed.

(3)

The amount of carbon-14 in living organisms now will ~~have~~ be less than the amount of carbon-14 present in the organic material when that organism is still living. Thus, the ~~percentage~~ ratio of carbon-14 to carbon-12 in the sample should be less than 60% of that found in living organisms. The calculated time will be less than the actual time since Stonehenge was constructed.

ResultsPlus
Examiner Comments

This response says enough for all 3 marks to be awarded.

(d) The rate of production of carbon-14 in the atmosphere has decreased since Stonehenge was constructed. Explain how this would affect the scientists' calculations of when Stonehenge was constructed.

(3)

Rate production is decreased, ~~A ∝ N~~ $A \propto N$ so, activity also decreases. Half life becomes longer and the decay constant becomes smaller. The calculations would be affected.

$\lambda \propto \frac{1}{t_{\frac{1}{2}}}$

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Examiner Comments

No marks here. It was a reasonably common incorrect response to say that the decay constant becomes smaller.

Question 19 (a)

In general candidates scored well in explaining the process of nuclear fusion and in describing and explaining the conditions, but generally scored very badly in explaining why it is difficult to replicate conditions outside of a star.

Many responses showed familiarity with the nature and requirements of fusion, but with a lack of accurate expression. For instance 'molecules' were said to fuse, mass was 'changed' (without reference to the fact that it was lost), and the very high temperature was to ensure that the electrostatic repulsion between 'atoms' was overcome. Candidates should know that plasma in stars and in fusion reactors it is much too hot for molecules and atoms to exist, so it is nuclei that fuse. Also, a small number of candidates confused fusion with fission.

Most candidates did not seem to appreciate problems with the containment of a very hot plasma and the problems with any containment vessel. It is a pertinent question to ask in teaching this section of the specification why, after over half a century of trying, we still have not developed the technology required.

*(a) The conditions needed for fusion to occur make it difficult to replicate outside of a star.

State and explain:

- how the process of fusion is able to release energy
- the conditions necessary for fusion to occur
- why the conditions are difficult to replicate outside of a star.

(6)

Fusion is done by building a larger molecule from smaller molecules. The resulting molecule will have a smaller mass then the seperating smaller molecules before fusion. The decrease in mass creates energy.

High temperature and high pressure are needed for fusion to occur.

No container on Earth can hold such a hot substance with that extremely high temperature. The pressure required for fusion can hardly be built up on Earth.

ResultsPlus
Examiner Comments

Just 2 marks here - for the high pressure and the confinement problems. The reference to molecules is worrying at this level.

*(a) The conditions needed for fusion to occur make it difficult to replicate outside of a star.

State and explain:

- how the process of fusion is able to release energy
- the conditions necessary for fusion to occur
- why the conditions are difficult to replicate outside of a star.

(6)

~~The fu~~ In fusion, products have greater binding energy per nucleon than then ~~it~~ the reactants. This means the products are more tightly bound and they have less mass. This decrease in mass is ~~conver ne~~ released as energy according to ~~$E=mc^2$~~ $\Delta E=\Delta mc^2$. Both high temperature and high density are required. High temperature is needed to ~~maintain~~ overcome electrostatic repulsion between the nuclei and high density is for high collision rate. It is difficult to maintain high temperature because heat is lost and create ~~cp.~~ confinement problems.

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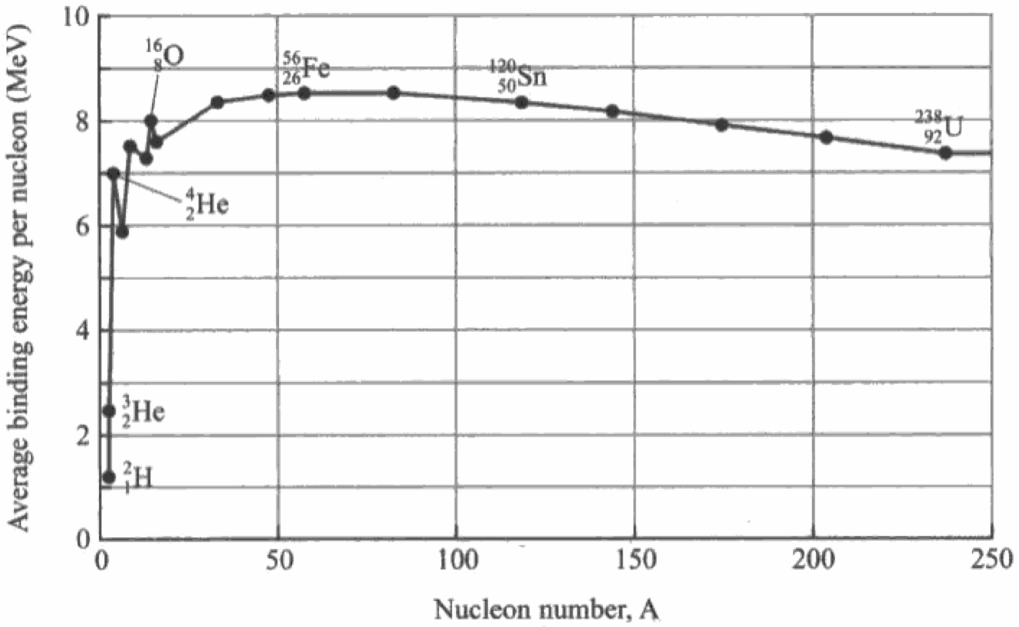
Examiner Comments

This is an example of a good response which covers most of the 3 areas well.

Question 19 (b)

This question part was quite poorly answered. The first mark was commonly awarded but the second two were rarely given. Candidates recalled that fission took place for A > 56 and fusion took place for A < 56 but showed no clear understanding of why this was the case. General comments on the binding energy change when a nucleus is formed from separate protons and neutrons were also quite common. Some candidates were too sloppy in stating B.E. as opposed to B.E./nucleon to discuss the stability of a nucleus; they did not realise that nuclei heavier than iron will have larger B.E.s by virtue of increased numbers of nucleons.

(b) The graph shows the average binding energy per nucleon for a range of isotopes.



Massive stars can only produce elements up to iron (Fe) in their cores by fusion. Use information from the graph to explain why.

(3)

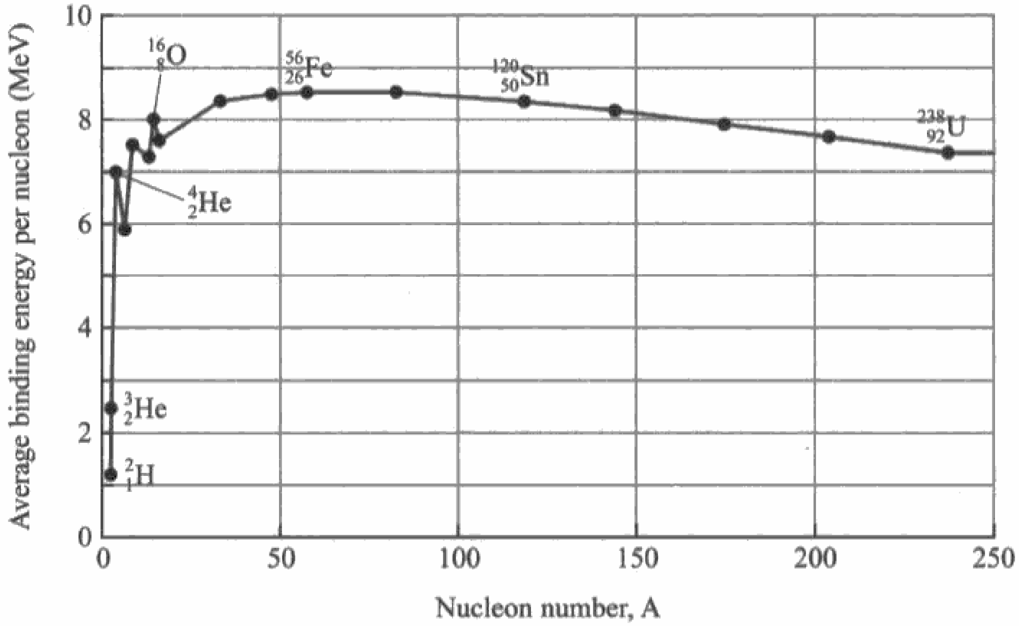
~~The~~ Iron has the greatest average binding energy per nucleon, hence it is most stable and thus no matter it is a large atom or a small atom, the ~~[illegible]~~ tendency is to ~~it is a~~ attain the configuration of Fe.

ResultsPlus

Examiner Comments

Just 1 mark for the reference to Fe having the greatest binding energy per nucleon.

(b) The graph shows the average binding energy per nucleon for a range of isotopes.



Massive stars can only produce elements up to iron (Fe) in their cores by fusion.
Use information from the graph to explain why.

(3)

It is because the fusion will ~~to~~ only proceed with the product of reaction has a greater nuclear binding energy than the reactant particle to increase its stability. ~~When the~~ Iron has the greatest average binding energy per nucleon than the other atom ~~with small~~. Thus, smaller atom will tend to fuse together by fusion to form Iron. However, with nucleon number greater that Iron, the ~~to~~ nuclear ~~bing~~ binding energy decrease, thus ~~it tends to~~ they tends to undergo fission to increase nuclear binding energy but not fusion to decrease the ~~to~~ average binding energy per nucleon ~~to decrease~~ which decrease their stability.

ResultsPlus
Examiner Comments

This response is worth the first 2 marks. There isn't enough to award the 3rd mark, although the response comes close.

Question 19 (c) (i)

Many answers talked about the uses of standard candles without actually clearly stating what a standard candle was. However, those candidates who knew what a standard candle is gave answers to the point.

A type 1a supernova occurs when a white dwarf star in a close binary system accumulates matter from its companion star. This eventually leads to a supernova outburst. Type 1a supernovae are used by astronomers as standard candles.

(c) (i) State what is meant by a standard candle.

(1)

* standard candles are used to measure distance of a star using ~~triangular~~ ~~to~~ imaginary triangles

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Examiner Comments

This response says what a standard candle is used for, rather than saying what a standard candle is. This was typical of a minority of responses.

Question 19 (c) (ii)

Most candidates correctly answered this question part.

Question 19 (c) (iii)

Many correct answers to this item were seen, but although the majority of candidates knew the answers, a few did not seem to know the difference between a galaxy moving away from us and galaxies moving apart. Some just said that the universe was expanding, which didn’t answer the question posed.

Question 19 (c) (iv)

While there were many correct values calculated, candidates were not always able to identify the units for H_o from the equation. Some used the red shift ratio as the velocity. Some candidates played it too smart, giving answers in parsecs.

(iv) The redshift is measured to be 0.064. Calculate a value for the Hubble constant.

(3)

$0.064 = \frac{v}{3\times10^8}$

$v = 1.92\times10^7\,ms^{-1}$

$1.92\times10^7 = H_o \times 9.30\times10^{24}$

$H_o = 2.06\times10^{-18}$

Hubble constant = 2.06×10^{-18}

ResultsPlus

Examiner Comments

Correct answer, but unit penalty applied. Interestingly the candidate does give units for the speed.

(iv) The redshift is measured to be 0.064. Calculate a value for the Hubble constant.

(3)

$z = \frac{v}{c}$

$0.064 \times 3\times10^8 = v$

$v = 19200000\ ms^{-1}$

$v = H_o \times d$

$H_o = 4.84\times10^{17}$

Hubble constant = 4.84×10^{17}

ResultsPlus

Examiner Comments

An incorrect re-arrangement of the Hubble's Law equation and so an incorrect final answer. The mark for use of the Hubble's Law equation cannot be awarded, as the substitution is not shown.

ResultsPlus

Examiner Tip

Always show substitutions into equations that you quote.

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.

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