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Examiners' Report
June 2015

GCE Physics 6PH05 01

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Introduction

The assessment structure of unit 5 mirrors that of other units in the specification. The examination consisted of 10 multiple choice questions, a number of short answer questions and some longer, less structured questions with synoptic elements incorporated throughout.

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 Q14(b), Q15(a), Q16(a), Q16(c), Q18(b), and Q18(d) tended to be clustered at the lower end of the scale.

In general, 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 clearly set out and accurate solutions evident. Occasionally, in calculation questions the final mark was not awarded due to a missing unit. Most candidates understood the convention that in the 'show that' question 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 was evidence that some candidates have problems in appreciating the magnitudes of calculated values. This was particularly noticeable in Q18(c)(ii) in the energy calculation for the fusion reaction, where a misunderstanding of the nature of the unit MeV/c^2 for particle masses led to answers many orders of magnitude larger than the correct answer being calculated and accepted by candidates.

Scientific terminology was used imprecisely and incorrectly in a number of responses seen on this paper. There was confusion demonstrated between atoms, molecules, nuclei and particles. This was particularly important in Q18(d), in which a reference to nuclei rather than atoms or particles is essential.

Once again, there were examples of candidates disadvantaging themselves by not expressing themselves using suitably precise language. This was particularly the case in extended answer questions such as Q16(c)(ii), Q17(c)(iii) and Q18(d), where candidates had knowledge of the topic, but were sometimes unable to express it accurately and succinctly.

Some candidates did not spend enough time reading the question before they started to write their answer. Some responses to question Q13(a)(i) focused on a large amplitude (which was stated in the question) rather than a large energy transfer. Similarly Q16(c)(i) asked candidates to consider the forces acting on the sand, but many candidates referred exclusively to the acceleration.

Diagrams are an important way to communicate information and it should be expect that A2 candidates be able to draw diagrams that show all the essential features, as in question Q17(a) where a sketch graph was required. Although some candidates drew the curve carefully and added appropriate detail, such as the wavelength for maximum intensity, this was not always the case.

A free body force diagram should have been the basis for the explanation required in Q16(c)(i). The majority of candidates who drew this diagram gained some credit, although many candidates did not think to include such a diagram to assist in their explanation. Similarly, in Q17(c)(iii) credit could have been gained from a good labelled diagram. However, only a minority of candidates drew a diagram, and only a minority of the diagrams seen included sufficient detail.

The space allowed for responses was usually sufficient. However, candidates should be encouraged to consider the number of marks available for a question, and to use this to inform their response.

Responses to the multiple choice questions were generally good, with 8 of the questions having 70 % or more correct answers. In order of highest percentage correct they were: Q10 (96%), Q9 (92%), Q5 (89%), Q8 (84%), Q2 (82%), Q4 (81%), Q3 (75%), Q1 (72%), Q7 (54%), and Q6 (51%).

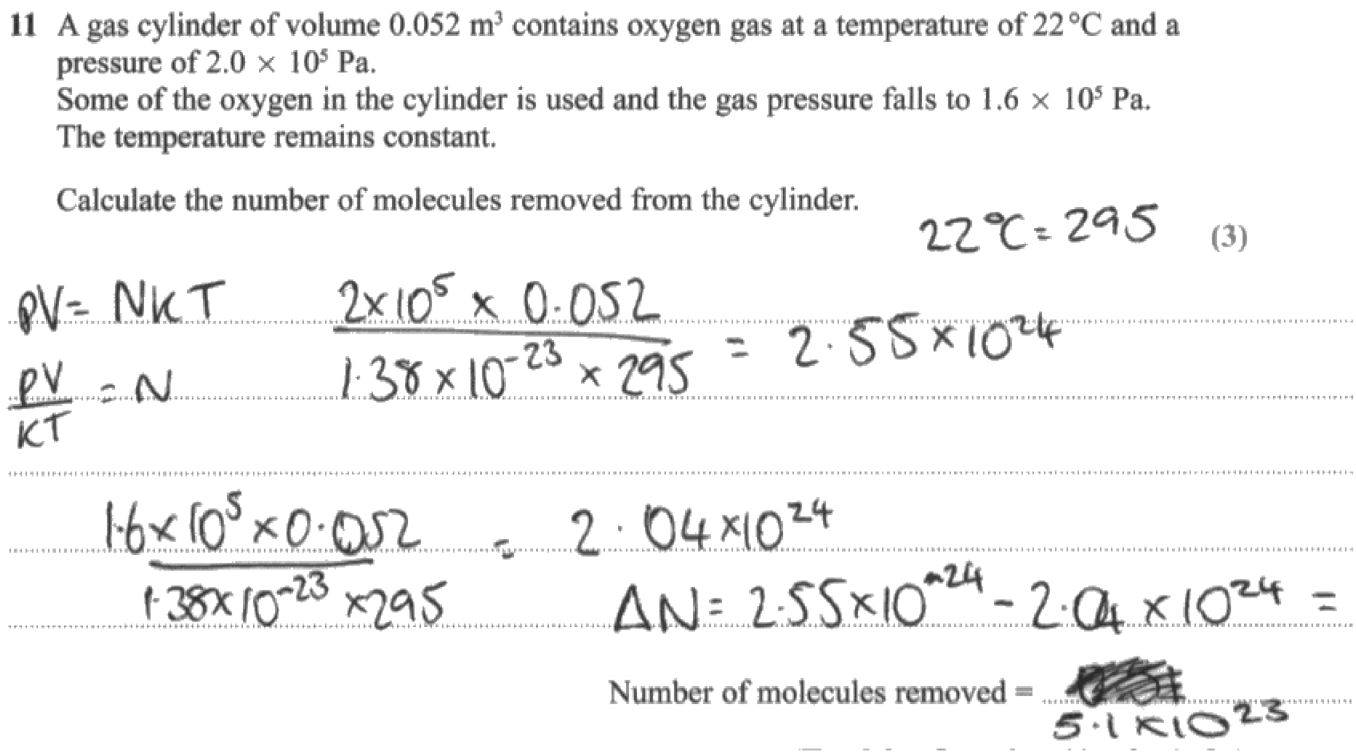
Q6 was answered correctly by about half the candidates. The correct answer was answer C (free oscillation), although answer B (forced oscillation) was a popular distractor.

Question 11

In general this question was very well answered, with the vast majority of candidates scoring full marks.

Some candidates did not convert the temperature to kelvin and used 22 °C instead of 295 K. Occasionally the use of pV/T = constant was seen, although this scored zero marks.

A small minority of candidates attempted to use $pV = nRT$ to calculate the number of moles removed and then convert to the number of molecules. Such solutions could score full marks, although only if candidates also used $n = N/N_A$. Since neither R nor N_A is provided in the data section of the paper, the potential for errors to creep into such a method of solution is great.



11 A gas cylinder of volume 0.052 m^3 contains oxygen gas at a temperature of 22 °C and a pressure of 2.0 × 10^5 Pa.
Some of the oxygen in the cylinder is used and the gas pressure falls to 1.6 × 10^5 Pa.
The temperature remains constant.

Calculate the number of molecules removed from the cylinder.
(3)

22°C = 295

$pV = NkT$ $\quad \frac{2\times10^5 \times 0.052}{1.38\times10^{-23}\times 295} = 2.55\times10^{24}$

$\frac{pV}{kT} = N$

$\frac{1.6\times10^5\times0.052}{1.38\times10^{-23}\times295} = 2.04\times10^{24}$

$\Delta N = 2.55\times10^{24} - 2.04\times10^{24} =$

Number of molecules removed = 5.1×10^{23}

ResultsPlus
Examiner Comments

The candidate has substituted twice into the gas equation and then subtracted to calculate the correct answer.

ResultsPlus
Examiner Tip

Leave all figures on your calculator when finding a small difference between two numbers.

$$\frac{pV}{T} = \frac{pV}{T} \qquad pV = NKT$$

$$\frac{(2-1.6)\times10^5 \times 0.052}{1.38\times10^{-23} \times (22+273)} = N = 5.109309752\times10^{23}$$

Number of molecules removed = 5.12×10^{23}

ResultsPlus

Examiner Comments

The candidate has realised that (other than N) pressure is the only variable, and so their solution is very compact.

$$pV = NkT$$

$$N = \frac{pV}{kT} = \frac{2\times10^5 \times 0.052}{1.38\times10^{-23} \times 22} = 3.43\times10^{25}$$

$$= \frac{1.6\times10^5 \times 0.052}{1.38\times10^{-23} \times 22} = 2.74\times10^{25}$$

$$3.43\times10^{25} - 2.74\times10^{25}$$

Number of molecules removed = 6.9×10^{24}

ResultsPlus

Examiner Comments

The temperature has not been converted into kelvin, and so this response only gains the first marking point for "use of" the gas equation.

ResultsPlus

Examiner Tip

Always convert temperatures to kelvin when using the ideal gas law.

Question 12

Despite there being a number of places to slip up in this question, nearly all candidates gained 4 marks. The most common mistakes were to forget to square v when calculating the kinetic energy, or to include a unit error. Some candidates omitted the unit and others used

^{o}K. Occasionally solutions were seen in which the mass of the brakes instead of the mass of the car was used.

A small number of candidates did everything correctly but then decided to add 273 to their answer.

12 A car of mass 1200 kg is travelling at a speed of 25 m s^{-1}. During braking, 25% of the kinetic energy of the car is transferred to the brake pads.

Calculate the increase in temperature of the brake pads.

total mass of brake pads = 5.3 kg
specific heat capacity of brake pads = 450 J kg^{-1} K^{-1}

(4)

$KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 1200 \times 25^2 = 375000$ J

25% = 93750 J = ΔE

$\Delta E = mc\Delta\theta$

$\frac{93750}{5.3 \times 450} = 39.31$ K

Increase in temperature = 39.31 K

ResultsPlus
Examiner Comments
This is a fully correct solution which gains all 4 marks.

$\Delta E = mc\Delta\theta$ $E_k = \frac{1}{2}mv^2 = \frac{1}{2} 1200 \times (25)^2 = 375000$

$\frac{375000}{2} = 187500$

$\frac{187500}{85.3 \times 450} = \Delta\theta = 78\,°C$

Increase in temperature = 78 °C

ResultsPlus
Examiner Comments

The candidate has taken 50% rather than 25% of the kinetic energy, and so their final answer is incorrect.

ResultsPlus
Examiner Tip

Be careful when taking data from the question to use in a calculation.

Question 13 (a) (i)

Almost all candidates scored this mark.

Question 13 (a) (ii)

A good proportion of the answers seen hinted at correct answers but the vague language used sometimes made it difficult for credit to be given. Rather than a clear statement that sound waves from the loudspeaker are forcing the glass into oscillation at or close to its natural frequency, statements such as 'the glass is forced to vibrate', or 'sound makes the glass vibrate' were seen. A number of candidates referred to the large amplitude of oscillation but omitted any reference to the efficient transfer of energy.

(ii) Explain why this effect occurs.

(2)

The glass will oscillate at a natural frequency. If the glass is periodically forced at the natural frequency it will oscillate with maximum amplitude, the sine wave forces the glass to oscillate, so energy is given to the glass.

ResultsPlus
Examiner Comments

There is just enough here for the first marking point, although the statement referring to the energy transferred to the glass is not strong enough for the second marking point.

ResultsPlus
Examiner Tip

Always aim to describe all aspects in sufficient detail using appropriate terminology when giving descriptive answers.

(ii) Explain why this effect occurs.

(2)

All objects have a natural frequency at which they vibrate. Sound of the same frequency will add to, or amplify, this natural vibration, eventually causing the object to be damaged.

ResultsPlus
Examiner Comments

This response is not worth any credit. Although there is reference to some technical terms, the response does not identify the salient physics.

ResultsPlus
Examiner Tip

Use technical language carefully in answering questions such as this - include all appropriate detail.

Question 13 (b)

Quite a lot of vague or incorrect answers were seen to this question, and it was often difficult to decide whether the candidates meant energy from the glass or the loudspeaker. Answers referred to oscillations, vibrations, and energy without specifying what or where.

Some candidates thought that the energy is transferred to the rubber band directly from the speaker, rather than

energy being transferred to the rubber band from the glass.

Similarly, candidates often ignored the interim heating of the band and gave answers along the lines of 'energy is dissipated to the surroundings'.

Candidates needed to be explicit and state that energy is being transferred from the glass to the rubber band resulting in an increase in the internal energy of the elastic band.

A number of candidates gave the definition of damping rather than relating it to the glass and band, and quite a few wrong answers referred to the rubber band altering the natural frequency of the glass.

(b) A rubber band may be placed around the glass to provide some damping. This would reduce the amplitude of vibration and prevent the glass from shattering.

Explain how a rubber band around the glass would provide damping.

(2)

The rubber band would remove energy from the system, some of the kinetic energy of the glass would be transferred to work done in stretching the rubber band, in absorbing energy it would reduce the amplitude of vibration of the glass

(Total for Question 13 = 5 marks)

ResultsPlus

Examiner Comments

In this response the energy transfer is quite poorly described, although there is sufficient detail provided for the first marking point to be awarded. There is no reference to what happens to the energy once it has been transferred to the rubber band, and so the second marking point is not awarded.

ResultsPlus

Examiner Tip

Planning your response will help you to write your answer out logically and with no omissions and a minimum of repetition.

Question 14 (a)

(i) This question proved to be a good discriminator, as less able candidates often did no more than attempt to write down Newton's law of gravitation. The more able candidates were able to take this equation and use it to obtain the required result. Some candidates calculated a value for the tangential speed (1028 m s^{-1}) and then used this value to obtain the required result.

Some candidates attempted to use the Kepler formula for the time period of a satellite. As a result they did not score full marks as they had not obeyed the command given to 'show that' the product was about 4.1×10^{14} m^3 s^{-2}. A few candidates did not give the required number of significant figures and lost the answer line mark.

(ii) This was well answered, although a significant minority forget to take the square root, so ended up with a radius of several billion kilometres.

(a) (i) Using the data provided, show that the product GM is about 4.1×10^{14} m^3 s^{-2}, where M is the mass of the Earth.

(3)

$\Sigma F = m\omega^2 r \qquad F = \frac{GMm}{r^2} \qquad m\omega^2 r = \frac{GmM}{r^3}$

$\frac{4\pi^2}{T^2} = \frac{GM}{r^3} \qquad GM = \frac{4\pi^2}{T^2} \times r^3$

$\frac{4\pi^2 \times (3.86 \times 10^8)^3}{(2.36 \times 10^6)^2} = 4.077 \times 10^{14}\ m^3\ s^{-2}$

(ii) At the surface of the Earth g is measured to be 9.81 N kg^{-1}.

Calculate a value for the radius of the Earth.

(2)

$g = \frac{F}{m} \Rightarrow g = \frac{GM}{r^2} \qquad r = \sqrt{\frac{GM}{g}} \qquad \sqrt{\frac{(4.077 \times 10^{14})}{9.81}}$

$= 6.45 \times 10^6\ m$

Radius of the Earth = 6.45×10^6 m

ResultsPlus

Examiner Comments

This is a well set out solution that is clear to follow and leads to the correct answers.

(a) (i) Using the data provided, show that the product GM is about 4.1×10^{14} m^3 s^{-2}, where M is the mass of the Earth.

(3)

$r = 3.86 \times 10^8 \quad T = 2.36 \times 10^6$

$T = 2\pi/\omega \quad \omega = \frac{2\pi}{T} = 2.66 \times 10^{-6}$

$a = r\omega^2 = \frac{GM}{r^2} \quad GM = \omega^2 r^3$

$GM = (2.66 \times 10^{-6})^2 \times (3.86 \times 10^8)^3 = 4.08 \times 10^{14}$ m^3 s^{-2}

(ii) At the surface of the Earth g is measured to be 9.81 N kg^{-1}.

Calculate a value for the radius of the Earth.

(2)

$9.81 = r\omega^2 \quad mg = \frac{GMm}{r^2} \quad 9.81 = \frac{4.08 \times 10^{14}}{r^2}$

$r^2 = \frac{4.08 \times 10^{14}}{9.81} = 4.16 \times 10^{13}$

Radius of the Earth = 4.16×10^{13} m

ResultsPlus

Examiner Comments

In (ii) the candidate forgets to take the square root to calculate the final answer.

ResultsPlus

Examiner Tip

Check carefully for indices when substituting into equations.

Question 14 (b)

This should have been a straightforward question, although in general it was poorly answered. Very few candidates referred to the inverse square law (in words or symbols) and those that did failed to link it to small force or field because of large distance. The poor verbal reasoning demonstrated by many candidates, who were unable to make simple statements such as: 'g varies according to inverse square law with distance', points to a need for candidates to think before they write and to re-read what they have written before they move on.

Candidates often leapt upon the comparison with the Sun and ignored the size of the Earth's pull.

Most answers referred to the Sun having a bigger force than the Earth or just said the force wasn't enough. Many seem to think that force and field strength are interchangeable.

Vague answers such as 'the Sun's gravitational field is very large so it will pull the asteroids out of orbit' and 'the asteroids don't have a stable orbit because the Sun pulls them away' effectively repeated the question, and so didn't gain credit.

Question 15 (a)

Definitions of activity were vague with very few candidates stating 'rate of decay of nuclei'. Although m

ost candidates had the right idea (i.e. rate) they either failed to say what was decaying or referred to 'sample', 'particle', 'isotope' or 'substance'.

Question 15 (b) (i)

A majority of candidates explained that background radiation needed to be removed before an average was calculated, although too many just said 'background' without further comment. It was not felt that a reference to the existence of the background count rate was worthy of credit without a reference to how this changed the counts that had been recorded. A few answers erroneously referred to the cosmic microwave background radiation.

Question 15 (b) (ii)

Most candidates were able to say that the decay process is random (often accompanied by the word 'spontaneous'). Most candidates understood that a mean was required, however not all were sufficiently explicit in detailing that this needed to be calculated from the measurements rather than a measurement made in and of itself.

It was felt that at this level candidates who wrote down that the average count would be 'found', 'got' or 'obtained' instead of 'calculated' had not given enough detail.

Many candidates discussed removing anomalies, and references to accuracy, reliability, etc. were also seen.

Question 15 (b) (iii)

The vast majority of candidates gave logical and well-presented statements leading to the correct answer to this standard and straightforward calculation.

The main reason for answers not scoring full marks was a muddled use of seconds and days or being unable to convert from a number calculated to an activity.

A number of candidates unnecessarily worked out λ in from time in seconds when it could have been done using time in days more simply. Common errors included using an initial activity of dry seaweed (2.5 Bq) or taking 30 days as the half-life.

Those who correctly identified 30 days as 3.75 half-lives were mostly not able to go any further with this method,

not knowing how to deal with a non-integer number of half-lives. Some candidates simply chose to multiply or divide the current count rate by 3.75.

(iii) The measurements were repeated with the same sample of seaweed 30 days later. Calculate the new corrected count rate of the sample.

half-life of iodine-131 = 8.0 days

(3)

$A = A_0 e^{-\lambda t}$ $\lambda = \frac{\ln 2}{8} = 8.66 \times 10^{-2}\ \text{day}^{-1}$

$A = 6.38 e^{-(8.66 \times 10^{-2})(30)}$

$A = 0.47\ \text{Bq}$

New corrected count rate = 0.47 Bq

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Examiner Comments

This is a succinct solution leading to a correct answer.

(iii) The measurements were repeated with the same sample of seaweed 30 days later. Calculate the new corrected count rate of the sample.

half-life of iodine-131 = 8.0 days

(3)

$\lambda = \ln 2 / t_{\frac{1}{2}} = 1.003 \times 10^{-6}$

$t_{\frac{1}{2}} = 3600 \times 24 \times 8 =$

$= 691200\ s$ ✓

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

$= 68 e^{\frac{-1.003\times10^{-6}}{2592000}}$

30 days = 2592000

$= 0.147$

New corrected count rate = 0.147 Bq

ResultsPlus
Examiner Comments

This candidate has converted the half-life into seconds unnecessarily. Their value for the decay constant is correct, as is the conversion of the time interval into seconds. However, the exponential equation substituted into is incorrect, and this response only gains the first marking point.

ResultsPlus
Examiner Tip

Check that equations are written down correctly before substituting numerical values.

Question 15 (b) (iv)

Most candidates were satisfied to address only one factor in the radiation risk. Most candidates were able to understand that close proximity or contact was needed for there to be a risk from beta radiation. It was much less common to read answers showing that candidates understood that the risk was minimised due to the (relatively) short half-life.

There were clear descriptions of the ionising nature of beta particles and many candidates said that beta particles would penetrate the skin, but few considered the half-life of the isotope (despite the calculation in 15(b)(iii).

Those who discussed half-life usually said it was quite long, and didn't realise that after about 40 days (or 5 half-lives) the activity would have fallen to negligible levels.

(iv) There is a moderate risk to the public from the accumulation of iodine-131 in the seaweed. Explain why.

(2)

β particles are weakly ionising so they don't pose too much of a threat to humans however they can penetrate the skin so longer exposure can cause some problems. Iodine 131 is still present in the seaweed after a month then though it decays at a much smaller rate and is less threatening.

(Total for Question 15 = 9 marks)

ResultsPlus

Examiner Comments

This response is quite confusing, although by stating that the beta particles are able to penetrate the skin there is enough for the first marking point. In the remainder of the response the candidate appears to be comparing beta-particles with the radioactive iodine, and although there is a reference to the half-life it is not clear if this is a relatively short or long time.

ResultsPlus

Examiner Tip

Read through your answers to ensure that what you have written makes sense.

Question 16 (a)

This question was quite poorly answered, with only a small number scoring full marks.

Many candidates confused the motor effect here with electromagnetic induction (Faraday and Lenz's laws) and resonance. Quite a few candidates said that the wire experienced an 'electromotive force' when carrying a current in a magnetic field, instead of just 'a force'.

Of those who described the motor effect there were some good clear answers.

*(a) Explain why an alternating current in the coil causes the cone to oscillate with the frequency of the alternating current.

(3)

Alternating current means that as the current switches direction, the force applied switches direction so both are proportional to each other which means the frequency of oscillation will match that of the alternating current.

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Examiner Comments

This response is typical of a number that were seen in which the candidate focuses on only part of the question. The candidate states why the cone oscillates with the frequency of the alternating current, but says nothing about the origin of the force that is causing the coil to oscillate and hence drive the cone.

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Examiner Tip

Always relate your answers to the whole question.

Question 16 (b) (i)

Many candidates seem to have been drilled in the definition of SHM, and most knew the description that was expected. Many candidates lost marks due to poor use of language. More successful candidates gave textbook definitions, whereas less successful candidates omitted 'from the equilibrium position' when referring to displacement. Less successful answers included the motion where period was not related to amplitude. The equation was often quoted but the terms were usually not defined.

(i) State what is meant by simple harmonic motion.

(2)

Simple harmonic motion is an oscillation in which the acceleration of an object is directly proportional to its displacement from the midpoint and is directed towards the midpoint.

ResultsPlus

Examiner Comments

This says enough for 2 marks.

This response is quite brief, and misses the important reference to where displacement is measured from.

(i) State what is meant by simple harmonic motion.

(2)

The force is proportional to the displacement and acts towards the position of equilibrium

ResultsPlus

Examiner Comments

In SHM displacement has to be from the equilibrium point.

Question 16 (b) (ii)

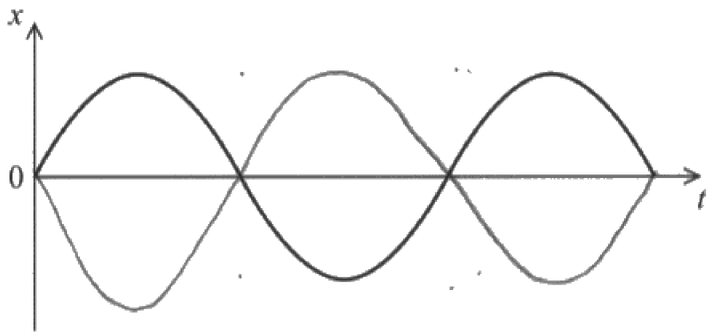
Nearly all candidates attempted to draw the correct curve, but a significant number lost a mark due to amplitude varying along the curve. Some c

andidates drew surprisingly poor diagrams with the amplitude below the x-axis often larger than above it. Candidates who drew construction lines were most successful in producing correct minus sine curves.

(ii) The graph below shows how the displacement x of the cone varies with time t.

Add another line to the graph to show how the acceleration of the cone varies over the same time interval.

(1)



$x = A\cos\omega t$

$v = -A\omega\sin\omega t$

$a = -A\omega^2\cos\omega t$

ResultsPlus
Examiner Comments

The first maximum drawn is considerably larger than the other maxima.

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Examiner Tip

Take care when sketching graphs – all essential features must be correct. It may help to draw guiding points to help you draw the curve.

Question 16 (c)

(i) This was not done well. Although most candidates managed to score marking point 1 by identifying the two forces on the cone, many stated that the upward force became greater than the weight as the amplitude was increased until eventually the sand 'jumped off the cone'. A not insignificant number felt it happened due to matching the frequency to the natural frequency of the sand.

Candidates did not always read the question carefully, and so some described accelerations rather than forces.

(ii) This was much better answered, as candidates often realised that the only force acting was the weight, and so a = g. The simple pendulum equation was sometimes used, but was not given any credit.

(c) Some sand is sprinkled onto the cone. The sand oscillates vertically with the frequency of the cone. Keeping the frequency constant, the current is increased. This increases the amplitude of oscillation of the cone.

At a particular amplitude of oscillation the sand begins to lose contact with the cone.

(i) By considering the forces acting on a grain of sand, explain why this happens.

(3)

The sand experiences the force F=mg at all times. The sand also experiences a reaction force when in contact with the cone. At a particular amplitude, the cone will accelerate faster than gravitational acceleration so the sand loses contact. As acceleration of the cone downwards increases the reaction force on the sand decreases, as reaction force reaches zero, contact is lost.

(ii) At a particular frequency, when the amplitude of the cone is 0.25 mm, a grain of sand loses contact with the cone.

Calculate this frequency.

(3)

$a = r\omega^2$ $a = g$ $\omega = 2\pi f$

$a = r \times 4\pi^2 \times f^2$

~~$f^2 = \frac{g}{8\pi^2}$~~ $f^2 = \frac{g}{4\pi^2 \times r}$ $f = \sqrt{\frac{9.81}{4\pi^2 \times (0.25 \times 10^{-3})}}$

$a = r \times 4\pi^2 \times f^2$ $f =$ ~~31.53Hz~~ 31.527Hz

$\frac{g}{r \times 4\pi^2} = f^2$

Frequency = ~~31.53Hz~~ 31.53Hz

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Examiner Comments

In (i) the candidate has almost said enough for full marks. However, the second marking point is not awarded, as the equation resulting from applying Newton's 2nd law to the forces has not been stated. In (ii) the solution is correct and scores full marks.

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Examiner Tip

Wherever possible, relate answers to descriptive questions to clearly stated relevant equations.

Question 17 (a)

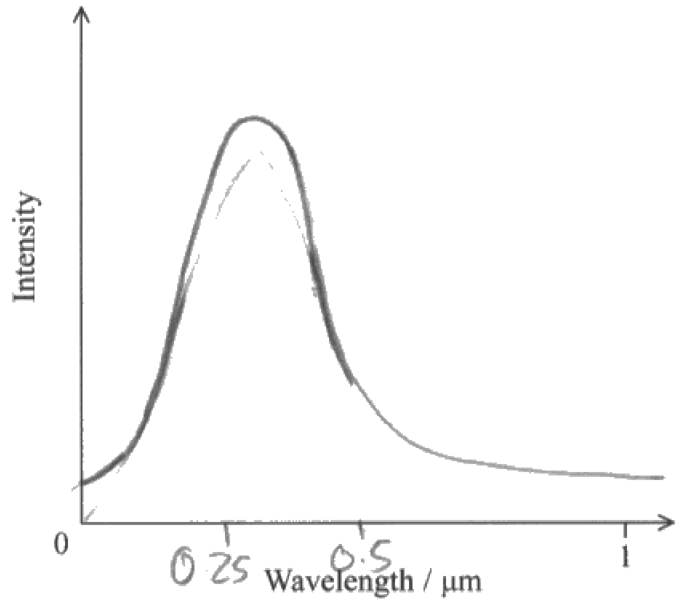
Most peaks were labelled correctly, but curves were carelessly drawn. At least half failed to score because they cut the 'intensity' axis or were not noticeably asymmetrical.

The shapes drawn here were more like frequency response curves than that for the intensity variation of intensity of black body radiation.

17 Rigel A in the constellation of Orion is one of the brightest stars in the sky. It is a massive blue variable star with an intensity peak at a wavelength λ_{max} of 0.25 μm.

(a) On the axes below, sketch a graph of the intensity of radiation emitted by Rigel A against the wavelength of that radiation.

(2)



ResultsPlus
Examiner Comments

The curve has a positive intercept on the intensity axis and the peak is not at 25 μm, so no marks awarded.

ResultsPlus
Examiner Tip

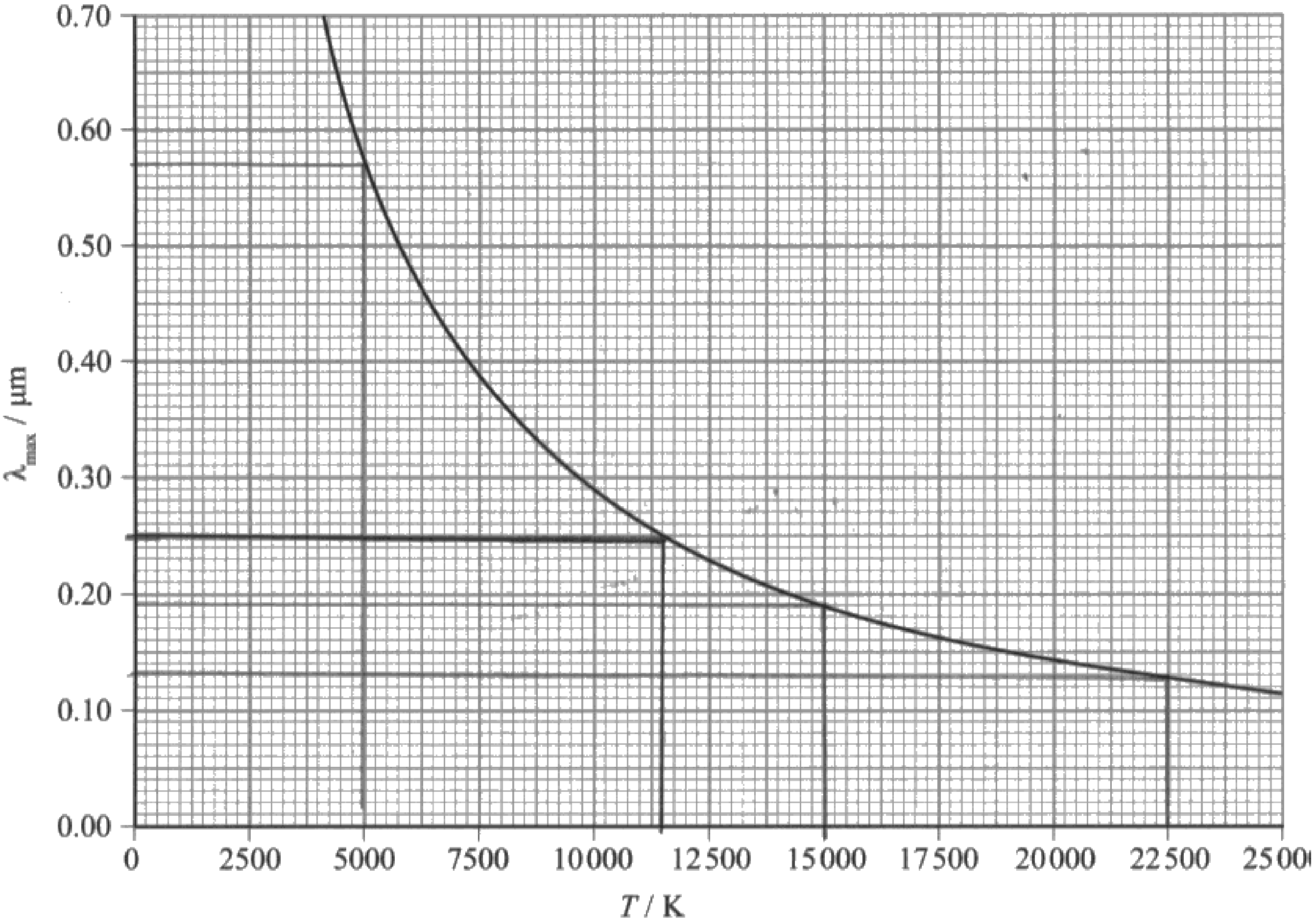
Practise sketching graphs.

Question 17 (b)

(i) Most candidates read the value from the graph correctly, although occasionally there was a missing unit. A small number of candidates read T for λ_{max} = 0.70 μm, indicating that they were not sure what λ_{max} was.

(ii) Where full marks were not scored it was usually because candidates had only used one pair of values from the graph instead of two or three.

(b) The graph below shows how λ_{max} varies with temperature T for a black body radiator.



(i) Use the graph to estimate the surface temperature of Rigel A.

(1)

11500 K

(ii) Show that the graph is consistent with Wien's law.

(3)

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

$5000 \times 0.57 \times 10^{-6} = 2.85 \times 10^{-3}$ mK

$11500 \times 0.25 \times 10^{-6} = 2.88 \times 10^{-3}$ mK   all values $\approx 2.898 \times 10^{-3}$ mK

$15000 \times 0.19 \times 10^{-6} = 2.85 \times 10^{-3}$ mK

$22500 \times 0.13 \times 10^{-6} = 2.93 \times 10^{-3}$ mK

ResultsPlus

Examiner Comments

This is a correct response, scoring full marks.

(i) Use the graph to estimate the surface temperature of Rigel A.

(1)

11500

(ii) Show that the graph is consistent with Wien's law.

(3)

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

$11500 \times (0.25 \times 10^{-6}) = 2.875 \times 10^{-3}$

$\frac{\Delta y}{\Delta x} = \frac{(0.55 - 0.05) \times 10^{-6}}{(16000 - 3000)}$

$= 3.84 \times 10^{-11}$

ResultsPlus

Examiner Comments

The mark is not awarded in (i) as the units have been omitted. In (ii) there is a mark for 'use of' Wien's equation, but no other credit.

ResultsPlus

Examiner Tip

Remember to give units for all final answers that you quote.

Question 17 (c) (i)

This was very well answered, with all but a handful of candidates able to state what astronomers understand by the term 'standard candle'.

Question 17 (c) (ii)

In this question the words 'calculate', 'determine', 'measure', were often, but not always, used correctly. The flux of star has to be measured and then the distance to star can be calculated.

Some candidates referred to calculating the radiation flux from stars instead of measuring it. Some candidates thought that you could 'measure' the distance to a standard candle rather than calculating it. Some candidates lost marks unnecessarily by writing incomplete statements such as 'measure the flux' or 'calculate the distance', without mention of star or standard candle.

There were some vague responses about how the inverse square law is used to calculate distances to standard candles. Sometimes the equation involving inverse square law was quoted with no explanation of how it would be used or what the symbols meant. Few candidates stated the meaning of symbols in the radiation flux equation. Some candidates made comparisons of luminosities rather than a clear statement that a standard candle is an object of known luminosity.

*(ii) Describe how astronomers use standard candles.

(3)

They measure the period of varying luminosity and from this they find the stars luminosity. They can compare the relative brightness on Earth of this star to other stars to estimate their luminosity. Once they know luminosity, they measure the radiation flux received on Earth from that star and use it to calculate the distance of the star from Earth.

$$d = \sqrt{\frac{L}{4\pi F}}$$

ResultsPlus

Examiner Comments

This response gives enough for the first and third marking points to be awarded, although the symbols in the equation are not explained and so the second marking point is not given.

ResultsPlus

Examiner Tip

Ensure when relating answers to relevant equations, that the meanings of symbols are clearly stated.

Question 17 (c) (iii)

This was well done by some but quite poorly by others. Only a few candidates described the idea of trigonometric parallax well.

A surprising number of candidates did not score marking point 1 either because they made no attempt to explain what was meant by trigonometric parallax or they made vague statements about 'the movement of a star' but did not mention that this movement was relative to the fixed background of stars.

Most candidates understood the issues with measuring the parallax angle, however a small minority attempted to explain why stars need to be a certain minimum distance rather than answering the question that was asked. There was a quite a lot in candidates' answers about the uncertainty in the measurement of the parallax angle, but a surprising number of candidates did not clearly state that at large distances the angle would be too small to measure from Earth, and that this is what limits the distance that can be calculated.

(iii) Explain why stars have to be within a certain distance from the Earth for trigonometric parallax to be useful.

(2)

The stars must be close enough to the Earth for a change in the angle compared to more distant stars which appear to be fixed. If the angle is too small in the 6 months, the star will not have appeared to move on the background of distant 'fixed' stars because the star is too far away to create a large enough angle to be measured.

ResultsPlus
Examiner Comments

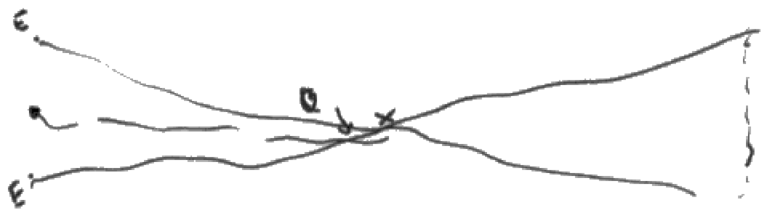
This candidate has confused some of the description, but there is still enough here for full marks to be awarded.

(iii) Explain why stars have to be within a certain distance from the Earth for trigonometric parallax to be useful.

(2)

As the stars get further away the angles get smaller and hence harder to measure. This means there is more error associated with the measurements.

(Total for Question 17 = 12 marks)



ResultsPlus
Examiner Comments

This response includes a diagram that might have resulted in the first marking point being awarded if it had been better drawn. As it stands, there is enough for the second marking point in the description preceding the diagram.

ResultsPlus
Examiner Tip

If you draw a diagram, make sure that it is labelled and clear to make out.

Question 18 (a) (iii)

A number of candidates did not attempt to answer the question '**why** can astronomers deduce the areas are small' instead they tried to explain **how** astronomers deduce the area (including references to H-R diagrams and Wien's law).

Those that realised they could use the Stephan-Boltzmann law usually managed at least two marks. However, some candidates who had the right idea did not use the equation, and so could only score marking point 1 and marking point 2. Sentences such as, 'a white dwarf is hot and has a small luminosity so it must have a small area' were quite common.

*(iii) Stars known as white dwarf stars have small surface areas. Explain how astronomers have deduced this.

(3)

Using the H-R graph we Can get a Value f for the white dwarfs Temperature and luminosity and Substitute these Values in to the equation $L = 4\pi r^2 \sigma T^4$

ResultsPlus

Examiner Comments

This response scores zero. It only refers to how we would obtain the temperature and luminosity (assuming that an H-R diagram had been plotted), but neither gives an indication of the relative sizes, nor try to apply data to Stefan's law to show how A would be determined.

ResultsPlus

Examiner Tip

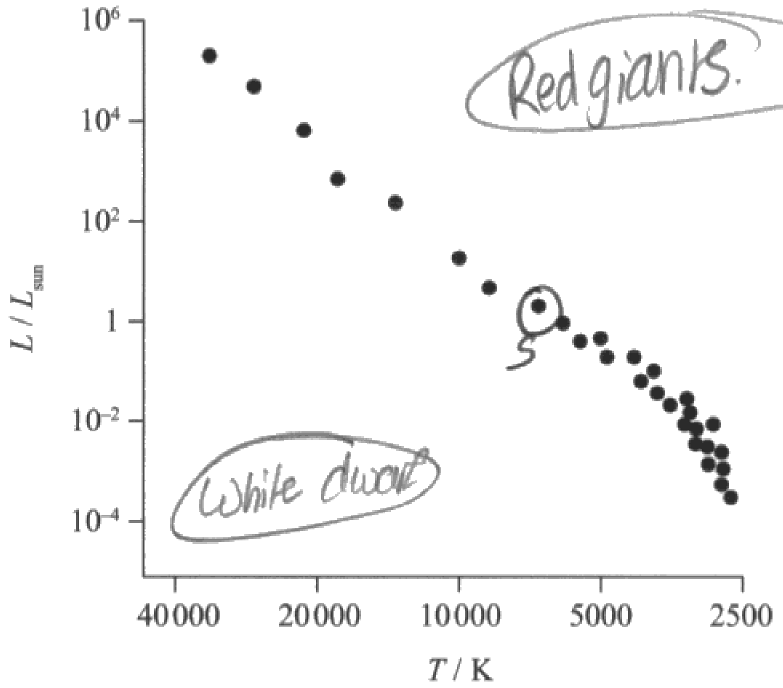
Always base your explanations on physical principles.

Question 18 (a) (i-ii)

Most of the time the mark for identifying the Sun in (i) was awarded, and when it wasn't it was usually because candidates had indicated a region rather than a specific point on the diagram. This may have been due to carelessness, or perhaps candidates were unsure of the luminosity scale.

In (ii) candidates were usually able to identify an area on the H-R diagram in which red giants were likely to be found. They were less successful at identifying an area in which white dwarf stars could be found, with many candidates indicating that white dwarfs would only be located extreme bottom left of the diagram.

(a) The H-R diagram below shows a number of main sequence stars.



(i) Label the position of our Sun on the diagram.

(1)

(ii) Label on the diagram the regions in which white dwarf and red giant stars would be located.

(2)

ResultsPlus
Examiner Comments
This response shows red giants considerably hotter than our Sun, although the white dwarf region is suitable.

ResultsPlus
Examiner Tip
Label diagrams carefully.

Question 18 (b)

Most candidates realised that the temperature would fall as the star cooled. Many then went on to relate this to the Stephan-Boltzmann's Law, but few talked about the star contracting as a result of gravitational forces as the outward radiation pressure reduced.

However, a common approach was to start from the standpoint of a star having a finite amount of energy and then implying that it was 'obvious' that it would become less luminous as it 'used up' its energy. Candidates should be aware that marks are usually awarded for reference to relevant physical laws and equations, and so they should attempt to identify appropriate theoretical laws in an explanation of this type.

In the absence of fusion, no energy would be created so the star will have a set amount of energy to begin with. As the star releases this energy, in the form of heat and light, the amount remaining will decrease and therefore the temperature will decrease and so will the luminosity of the star.

ResultsPlus
Examiner Comments

In this response the process is dealt with in terms that are too general and as a result only the mark for a decrease in temperature can be awarded.

ResultsPlus
Examiner Tip

Always base your explanations on physical principles.

As the stars would have a finite supply of energy to radiate, as they got older the output would decrease, like a lightbulb in a circuit as the battery runs out.

ResultsPlus
Examiner Comments

This candidate uses an interesting analogy, but insufficient reference is made to the physical conditions of a cooling star and the relevant principles that would apply.

Question 18 (c) (i)

The nuclear equation was nearly always completed correctly and a proton or hydrogen nucleus usually identified. Deuterium was a common wrong answer, although there didn't seem to be any indication in the nuclear indication that anything other than hydrogen would be formed. Perhaps candidates were familiar with deuterium often being involved in fusion reactions and gave their answer without reference to the proton and nucleon numbers of X in their balanced equation.

Question 18 (c) (ii)

This was a fairly straightforward calculation that nonetheless seemed to be beyond a number of many candidates.

Most made some attempt at subtracting masses, although this sometimes involved incorrect masses (e.g. adding the mass of a proton, neutron and lithium nucleus together and then subtracting twice the mass of a helium nucleus).

For less successful candidates, unit conversion was a cause of confusion. A significant number did not understand the unit MeV/c^2. As a consequence many solutions were seen that contained convoluted workings involving the square of the speed of light. Usually these resulted in unrealistic values for the energy released.

In the conversion of the energy to joules a power of ten error was sometimes seen (i.e. use of 1.6×10^{-19} instead of 1.6×10^{-13}).

(ii) Calculate, in joules, the energy emitted in this stage of the cycle.

(3)

	Mass / MeV/c^2
Proton	938.3
Neutron	939.6
Helium	3727.4
Lithium	6533.8

Mass defect = $6533.8 + 938.3 - 2 \times 3727.4$ $1\ MeV = 1.6 \times 10^{-13}\ J$

$= 17.3\ MeV/c^2$

$E = 17.3\ MeV$

$= 17.3 \times 1.6 \times 10^{-13}\ J$

$= 2.77 \times 10^{-12}\ J$

Energy = 2.77×10^{-12}

ResultsPlus

Examiner Comments

This is a correct solution, expressed clearly and logically.

(ii) Calculate, in joules, the energy emitted in this stage of the cycle.

(3)

	Mass / MeV/c^2
Proton	938.3
Neutron	939.6
Helium	3727.4
Lithium	6533.8

Mass deficit = ~~(6533.8)~~ $(6533.8 + 938.3) - (2 \times 3727.4)$

$= 7472.1 - 7454.8$

$E = mc^2$

$= 17.3$ MeV/c^2

Energy in Joules = $\frac{(17.3 \times 10^9) \times (1.6 \times 10^{-19})}{\text{~~(3×10^8)~~}} \times (3 \times 10^8)^2$

$= 249120$ J $= 2.5 \times 10^5$ J

Energy = 2.5×10^5

ResultsPlus
Examiner Comments
This is an example of a response from a candidate who is unsure how to deal with the unit MeV/c^2. The final answer is quite large, but this has been ignored by the candidate.

Question 18 (d)

Only a minority of candidates managed succinct answers for this. Whereas candidates have a good understanding of the containment issues in fusion reactors, the requirements for very high densities are less well understood and explained. Although many responses described plasma containment conditions, detailed descriptions of temperature and density requirements were relatively rare.

Most candidates got the idea of high temperatures, but usually accompanied this with high pressures rather than high densities. The second marking point was often missed because discussion went straight from high temperatures to 'overcome repulsive forces' without mentioning energy.

A common mistake was to use particle, atom or molecule instead of nucleus/nuclei. At this level candidates should be aware that it is nuclei that are fusing. A number of candidates quoted financial reasons as opposed to Physics reasons. Marks are awarded for correct Physics, rather than vague references to other man-made factors.

(d) In 1967 Bethe received a Nobel Prize in Physics for his work on understanding the fusion processes in stars.

Explain why sustainable fusion has not yet been achieved for the generation of electrical power.

(4)

* to overcome the electrostatic repulsion of atoms.

For fusion to take place high pressure and ~~temper~~ high temperature exceeding 1×10^7 K * which is difficult on earth, the plasma needs to be confined by magnetic fields and can't touch the container or will fail, currently the energy put in to produce a fusion reaction is more than the energy produced so it currently isn't viable.

(Total for Question 18 = 18 marks)

ResultsPlus
Examiner Comments

This is an example of a response in which a number of partially correct statements are made. Electrostatic repulsion is identified, but of atoms not nuclei. High temperature (exceeding 10^7 K) is specified, but not linked to high energy nuclei. High pressure, rather than density, is specified. Out of everything that has been written only the reference to the containment issue warrants a mark being awarded.

ResultsPlus
Examiner Tip

Plan your answer to a question like this before you start to write, and ensure that you always use appropriate specialist terminology when giving descriptive answers.

Paper Summary

Based on their performance, candidates are offered the following advice:

- ensure they have a thorough knowledge of the physics for this unit
- read the question and answer what is asked
- make a note of the marks for descriptive questions and include that number of different physics points
- show all their workings in calculations
- try to base the answer for descriptive questions 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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