Examiners' Report
January 2011

GCE Physics 6PH05 01

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January 2011

Publications Code UA026594

Introduction

This is the second time that unit 5 of the new specification has been examined. In common with the first examination of this unit in the Summer 2010, this paper gave candidates the opportunity to demonstrate their understanding of a wide range of topics from the unit. All of the questions elicited responses across the range of marks, but the marks for Q15(b)(iii), Q17(e)(ii), and Q18(a) tended to be clustered at the lower end of the scale.

Once again, calculation and 'show that' questions gave candidates an opportunity to demonstrate their problem solving skills to good effect. In general, responses to such questions were well organised, calculations were accurate, and answers were given to an appropriate numbers of significant figures. There were few unit errors, but there were examples of power of ten errors in questions such as Q17(d) and Q18(b)(iii). As in the Summer 2010 examination, the most common way to lose marks in a calculation question seemed to be by failing to square, or raise quantities to a power of four as required in Q12(a), Q14(a)(i), and Q18(b)(iii). Re-arrangement of equations was sometimes poorly attempted leading to marks being lost. There were few examples of calculations where no working was shown, although a number of calculations had intermediate steps missing. If the solution to a numerical calculation has essential steps missing then marks will be lost if the final answer is incorrect.

It was pleasing to see that candidates were generally able to access the correct data and equations from the list provided. However, it was disappointing to see answers to Q11(a) in which $1/4\pi\varepsilon_0$ was used instead of the Boltzmann constant.

There were two question parts, for which it was clear that candidates need further guidance with the relevant specification item. Q14(b) relates to specification point 110, in which specific reference to kinetic and potential energy of molecules is made. No knowledge of latent heat is required, and the idea of bonds between molecules being broken during the melting process, although commonly expressed by candidates, is inadequate as a description of the mechanism as defined in this specification.

Q17(e)(ii) relates to specification point 137, which refers to a description of the process of nuclear fission. It is expected that candidates will know that a sustainable chain reaction can only occur if on average at least one neutron per fission goes on to cause another fission. In addition, candidates should know that, if on average more than one neutron goes on to cause another fission, the reaction would expand and quickly go out of control. It is not expected that candidates will be familiar with the processes of moderation or control in a nuclear reactor.

Answers to questions requiring either description or explanation tended to be less clearly organised than answers to calculation questions. Although there were examples of some very good answers where candidates used high levels of physical terminology in well-sequenced and logical answers, it was disappointing to see that arguments were often poorly set out with incorrect use of physical terminology. The use of bullet points to aid the clarity of a description or an explanation should be encouraged.

It is still clear that many candidates begin to answer the question before they have fully understood what the question is asking them to do. This was particularly apparent in Q13(b) in which many candidates related frequency shifts to an expanding Universe rather than relating such shifts to the context given. This was also the case in Q18(a), in which many candidates described a procedure completely unrelated to the experiment referred to in the question.

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 (on a separate sheet of paper).

Question 11

The "show that" calculation in part (a) was usually well done. Perhaps due to the wording of the question, candidates chose either to work out a temperature of 870 K or a pressure of 12.4 atmospheres. Either method allowed full marks to be gained, although some candidates who worked out the pressure obtained an answer in Pa and then simply put this equal to 12 atmospheres. To gain the final mark via this route it was necessary to see the conversion from Pa to atmospheres (and a value of 12.4 atmospheres).

In part (b), most candidates could explain on a molecular level the changes as the can is heated and the change of state occurs. Few could identify the difference between the can described in part (a) and the can in part (b) and just described the general effect of heating the can.

There were many good descriptions of pressure exerted in terms of atoms, although these did not gain credit. Many candidates failed to score because they did not take into account the liquid at all and did not mention atoms / molecules gaining energy in their account. At this level, it is expected that candidates will refer to atoms or molecules and not the more generic term particles.

Answer ALL questions in the spaces provided.

11 (a) A typical aerosol can is able to withstand pressures up to 12 atmospheres before exploding. A 3.0×10^{-4} m^3 aerosol contains 3.0×10^{22} molecules of gas as a propellant. Show that the pressure would reach 12 atmospheres at a temperature of about 900 K.

1 atmosphere = 1.0×10^5 Pa

(2)

$pV = NkT$

$(12 \times 10^5) \times (3 \times 10^{-4}) = (3 \times 10^{22}) \times (1.38 \times 10^{-23}) \times T$

$\frac{(12 \times 10^5) \times (3 \times 10^{-4})}{(3 \times 10^{22}) \times (1.38 \times 10^{-23})} = T = 869.5\ K \approx 900\ K$

*(b) Some such aerosol cans contain a liquid propellant. The propellant exists inside the can as a liquid and a vapour. Explain what happens when such an aerosol can is heated to about 900 K.

(3)

the liquid propellant will no longer exist as a liquid and will all be in vapour form. as the propellant will now take up more space therefore increasing the pressure exerted on the can ~~create~~ making it rupture and explode.

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Examiner Comments

In (a) the candidate has correctly calculated the temperature to at least 2 significant figures.

In (b) the candidate has only referred to liquid becoming vapour.

ResultsPlus

Examiner Tip

Always quote answers to "show that" questions to one more significant figure than that given in the question.

Question 12

In part (a), the same common faults were seen as in previous exams e.g. directly comparing the distances, failing to square the distances even though the correct formula had been quoted, and calculating the ratio the wrong way round.

In part (b), most could make a sensible comment on the ratio calculated in part (a) but too few could make a sensible physics based comment on interpreting the ratio. Too often answers referred to the radiation flux without indicating what this actually means. Few candidates explained that flux is the energy per unit area. Some candidates thought that the radiation flux was dangerous, hence the ratio should be as small as possible. Others obtained a ratio that was larger than 1 in part (a), but then gave an answer to part (b) that assumed that the ratio was less than 1 (and vice versa).

12 The planet Mars has a mean distance from the Sun of 2.3×10^{11} m compared with the Earth's mean distance from the Sun of 1.5×10^{11} m.

(a) Calculate the ratio $\dfrac{\text{Sun's radiation flux at distance of Mars}}{\text{Sun's radiation flux at distance of Earth}}$.

(2)

$F = L / 4\pi d^2$

$F_m / F_E = L / 4\pi d_M^2 \div L / 4\pi d_E^2$

$= L 4\pi d_E^2 / L 4\pi d_M^2$

$= d_E^2 / d_m^2 = (d_E / d_m)^2$

$= (1.5 \times 10^{11} / 2.3 \times 10^{11})^2$

$= 0.43$

Ratio = 0.43

(b) With reference to your answer in (a), comment on the suggestion that Mars could be capable of supporting life.

(2)

The radiation flux received by Mars is not even half of that received by Earth, but is still significant proportion. If Mars does sustain life, it would be completely different from life on Earth because it would require far less heat and light from the Sun to survive.

ResultsPlus Examiner Comments

In part (a) the calculation is clearly set out and the correct answer is obtained.

In part (b) there is a recognition that the radiation flux from the Sun on Mars is only half that on the Earth for the first mark, but the answer just falls short of the second mark.

ResultsPlus Examiner Tip

Make sure that you bring all relevant physics into any explanations that you give. Be as specific as you can with any scientific terms that you use.

Question 13(a)

Most candidates knew that standard candles are used to measure the distance of distant stars, but not all of these said that they had a fixed luminosity. Some stronger candidates were able to explain how the distance could be worked out by measuring the energy flux and using the inverse square law. The lack of appreciation of the difference between the luminosity and the radiation flux when using standards candles mostly lead to explanations of how the luminosity can be measured. Quite often candidates simply explained why they would use this method to find the distance over the parallax method. Lists of variables such as the distance, temperature, peak wavelength were often seen as quantities you could use the candles to find. The flux equation was quoted in many answers with few candidates managing a correct explanation of what they would use it to find.

(a) A Cepheid variable star is a type of standard candle. Discuss the use of standard candles in astronomy.

(4)

Standard candles, are used to calculate distances of distant Stars, by measuring the flux directly via, em emission lines and determing the wavelengths, you can deduce its tempreture hence luminosity. In addition you could use $F = \frac{L}{4\pi d^2}$ → using the measured flux and luminosity you can rearrange to calculate the distance.

ResultsPlus
Examiner Comments

The answer refers to measuring the flux of the star, using the inverse square law and hence calculating the distance. The candidate has missed out the most important feature of a standard candle - that it has a known luminosity.

ResultsPlus
Examiner Tip

Standard techniques, such as finding distances by using a standard candle, should be learnt so that they can be described quickly and clearly. Bullet points can be a good way of making a sequence of events clear.

Question 13(b)

Many candidates did not read the question carefully enough. Most knew about the concept of red shift. However, they mostly failed to identify the contraction and the expansion of the star as the mechanism for the movement of the source. Many answers just gave a general explanation of Doppler shift without mention of the source (or even in the context of expansion of the universe) or a link between movement and frequency change.

(b) As well as the variation in luminosity of the Cepheid, changes in the frequency of the detected radiation are also observed.

Suggest how the Doppler effect may account for these changes.

(2)

Doppler effect is the change in wavelength ~~due to~~ or frequency due to relative movement of the source from the observer. Red shift tells us that ~~speed~~ apart galaxies far away have greater speed hence $\frac{\Delta\lambda}{\lambda} = \frac{\Delta f}{f} = \frac{v}{c}$

ResultsPlus

Examiner Comments

The answer refers to a change in frequency, rather than an increase or decrease. In addition, there is no specific reference to the expansion and contraction of the star.

ResultsPlus

Examiner Tip

When describing the Doppler effect, be sure to say whether the frequency increases or decreases when the source moves away (or towards) the observer.

Question 14(a)

Most candidates produced good answers to part (a)(i) of this question and scored full marks. The main problem for few candidates who did not get full marks was the use of an incorrect formula for area. Some candidates tried to do a reverse calculation to show that ρ = 9130 kg m^{-3}. This approach scored a maximum of 2 marks.

The calculation in 14(a)(ii) was generally well done, although some candidates attempted a conversion to kelvin after the difference in temperature had been found.

(a) (i) Show that the mass of the wire is about 2000 kg.

density of copper = 8960 kg m^{-3}

(3)

$m = A\ell d$ 0.000

$\pi \times (\frac{1}{2} \times 1.63 \times 10^{-3})^2 \times 105 \times 10^3 \times 8960 = 1963.2$ kg.

(ii) The wire is initially at a temperature of 25 °C and its melting point is 1085 °C. Calculate the energy required to raise the temperature of the wire to its melting point.

specific heat capacity of copper = 385 J kg^{-1} K^{-1}

(2)

$E = mc\Delta\theta$

$= 1963.2 \times 385 \times 1060$

$= 8 \times 10^8$

Energy = 8×10^8 J

ResultsPlus

Examiner Comments

In part (a)(i) the calculation for mass is done all in one go, although the substitutions are clear and the final answer is correct.

In part (a)(ii) the calculation for the temperature change is not shown, but the answer is correct and full marks are scored.

Question 14(b)

Many candidates seemed to have an understanding of what the molecules were doing in the heating and melting stages, but failed to score marks because they did not give a description in terms of kinetic and potential energy. Many candidates who referred to an increase in kinetic energy during heating then just went on to talk about energy needed to break the bonds during melting, rather than an increase of potential energy. In a significant number of answers there was no clear link between the “before melting” and “during melting” stages in the answer.

(b) Once the melting point is reached, there is no further increase in temperature until all of the copper has melted. Discuss what happens to the energy of the copper atoms before and during the melting process.

(2)

The copper atoms gain energy, these are increased vibrations that are kinetic energy These vibrations cause the metalic bonds to break.

ResultsPlus
Examiner Comments

There is a reference to an increase in kinetic energy of the atoms, but we do not know at what stage in the heating process this occurs. The reference to “breaking bonds” is not awarded a mark, as we needed a specific reference to kinetic or potential energy.

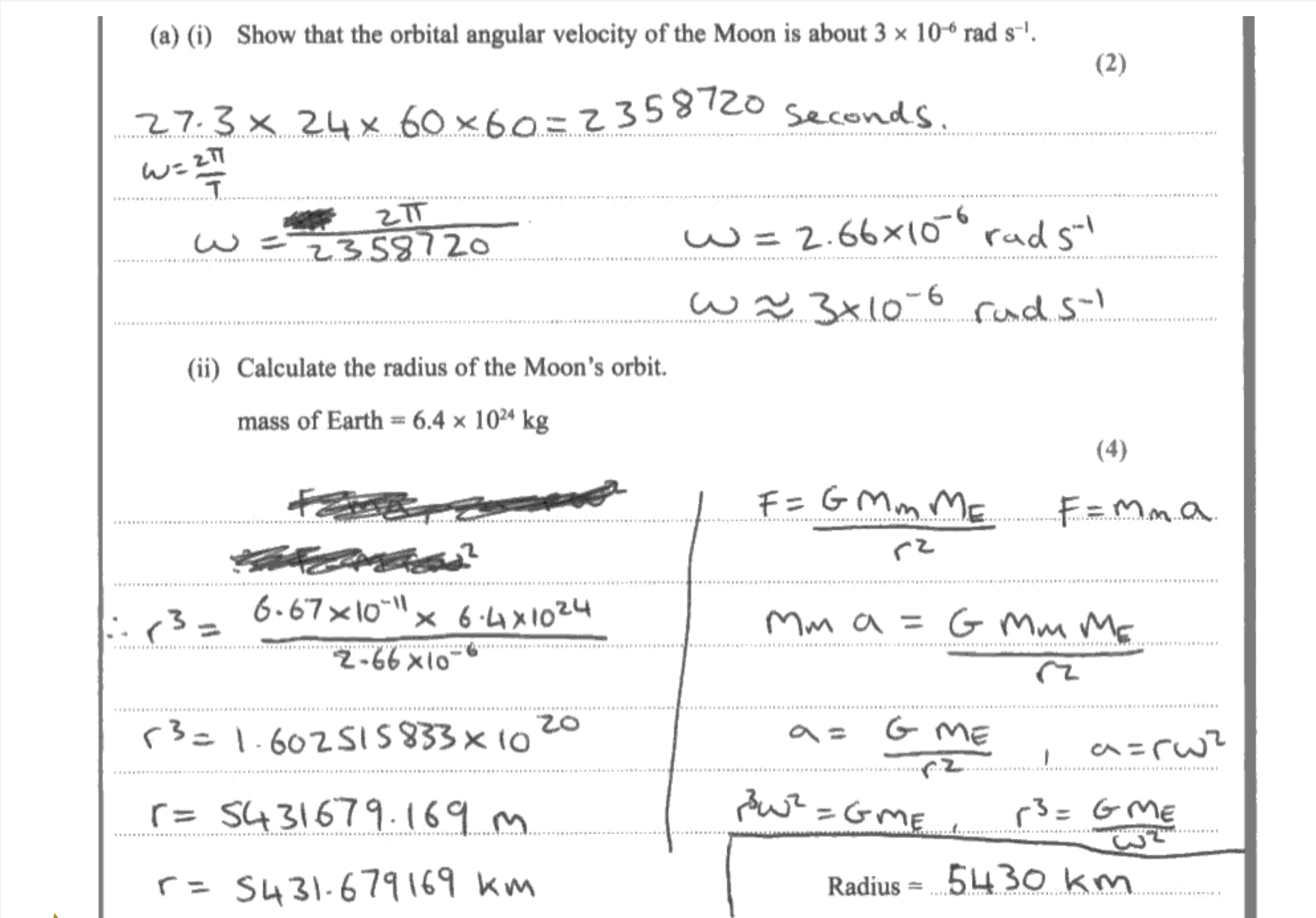
ResultsPlus
Examiner Tip

If you are asked to describe or explain something under two different conditions, make sure that you make it clear which description/explanation relates to which set of conditions.

Question 15(a)

Part (a)(i) was usually answered correctly.

In part (a)(aii), many candidates were able to equate the gravitational force to $\omega^2 r$ or v^2/r, but those who started with $g = GM/r^2$ usually equated g to 9.81 N kg^{-1}. Candidates gained the first two marks were sometimes let down by poor algebra, failing to score the last two marks because of incorrect mathematical manipulation of the equation to make r the subject. This was especially noticeable where they used v^2/r as the centripetal acceleration and then did not cube r on rearranging.



(a) (i) Show that the orbital angular velocity of the Moon is about 3×10^{-6} rad s^{-1}.

(2)

$27.3 \times 24 \times 60 \times 60 = 2358720$ seconds.

$\omega = \frac{2\pi}{T}$

$\omega = \frac{2\pi}{2358720}$ $\quad \omega = 2.66 \times 10^{-6}$ rad s^{-1}

$\omega \approx 3 \times 10^{-6}$ rad s^{-1}

(ii) Calculate the radius of the Moon's orbit.

mass of Earth = 6.4×10^{24} kg

(4)

$F = \frac{G M_m M_E}{r^2}$ $\quad F = M_m a$

$M_m a = \frac{G M_m M_E}{r^2}$

$a = \frac{G M_E}{r^2}$, $a = r\omega^2$

$r^3\omega^2 = G M_E$, $r^3 = \frac{G M_E}{\omega^2}$

$\therefore r^3 = \frac{6.67 \times 10^{-11} \times 6.4 \times 10^{24}}{2.66 \times 10^{-6}}$

$r^3 = 1.602515833 \times 10^{20}$

$r = 5431679.169$ m

$r = 5431.679169$ km

Radius = 5430 km

ResultsPlus

Examiner Comments

In part (a)(i) the candidate has successfully shown the value given in the question.

In part (a)(ii) the answer starts well, meeting the first two marking criteria. However, the candidate forgets to square the angular velocity in the radius equation, and so the final answer is incorrect.

ResultsPlus

Examiner Tip

Always check that you have carried out all of the mathermatical operations demanded by the equation.

Question 15(b)(i)

In part (b)(i) most candidates were aware that the time period would increase and provided an acceptable reason for it to score both marks. A few stated that the time period would increase, but were unable to explain this successfully in terms of w or v decreasing. Some made reference to Kepler's law, or the expression that they had derived in part (a)(ii).

(b) The Moon is gradually moving further away from the Earth because of the action of tides.

(i) State and explain how this increasing distance affects the moon's orbital period.

(2)

While the angular velocity remains the same ($v = \omega r$ so as r increases to keep the same angular velocity the actual velocity increases) As the angular velocity is the same the orbital period is the same.

ResultsPlus

Examiner Comments

The candidate starts with the wrong premise. The angular velocity does not remain the same, nor does the orbital time period.

Question 15(b)(ii)

This was a straightforward calculation, and the vast majority of candidates scored one mark. The mark was sometimes lost by converting the distance to metres, or by inverting the calculation.

Question 15(b)(iii)

This was answered poorly, with many candidates only scoring the mark for realising that the moon was closer in the past. The link to the gravitational force was expressed generally in many answers, and comments such as different from now rather than greater / stronger were often seen. References to different land mass configurations or water level differences causing differences in the tidal action were common. Only a minority of candidates managed a quantitative discussion leading to a conclusion that the rate would have been higher.

*(iii) In practice, the rate of increase of the orbital radius due to tidal action will not have been constant. Suggest why this rate of change might have been different in the very distant past.

(3)

In an Ice Age the waters would be frozen so tides would not have impacted the moon. The volume of water / size of the oceans has not been constant through time.

ResultsPlus
Examiner Comments

There is no reference to the distance of the Moon from the Earth in this answer. The candidate has not used the context of the previous parts of the question to bring some relevant physics into their answer.

ResultsPlus
Examiner Tip

Always begin any explanation from a consideration of the physics.
In a question consisting of parts numbered (i), (ii), (iii) the parts will be referring to the same situation.

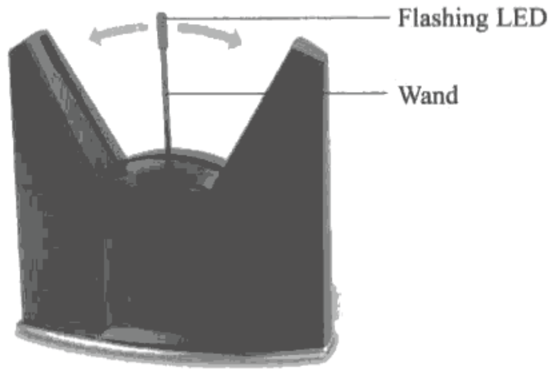
Question 16(a)

In part (a)(i) most could apply the formula well, but only about half remembered to double the time to get the time period and so 16 Hz was a very frequent wrong answer. Candidates need to take more care in reading the question to ensure that they access the correct data for their calculations.

Part (a)(ii) was well done. A small number of candidates identified the zero displacement point. This was not awarded the mark, as it was not clear in such answers from which point displacement was being measured.

For part (a)(iii) answers following the correct approach were quite common. However, some included a trig factor and proceeded to use numbers that gave a trig value other than 1. Failing to half the distance to obtain the correct amplitude value was also quite common. A significant group attempted to use speed = distance / time, completely ignoring the fact that this was simple harmonic motion.

16 Observing the display of a 'floating image' clock relies on the phenomenon of 'persistence of vision'. The clock has a wand with a set of flashing light-emitting diodes (LEDs) at its end. The wand oscillates rapidly back and forth and takes only 0.0625 s to sweep from one end to the other. The wand becomes almost invisible to the eye, while the flashing LEDs create a floating image effect.



(a) The tip of the wand moves with simple harmonic motion as it sweeps through a distance of 10.0 cm from one end to the other.

(i) Calculate the frequency of the wand's oscillation.

(2)

$f = \frac{1}{T}$ 0·1m = 0·0625 s

1 cycle = 0·0625 × 2

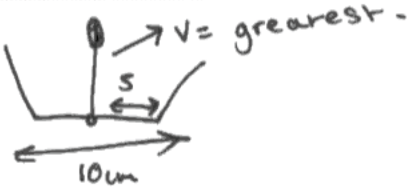
$f = \frac{1}{0·0625 \times 2} = 8Hz$

Frequency = 8Hz

(ii) The speed of the wand varies as it sweeps back and forth. At what point will the speed of the wand be a maximum?

(1)

At the centre of the sweep, (0.05 m).



(iii) Calculate the maximum speed of the tip of the wand.

$\omega = 2\pi f$

(2)

$V_{max} = -A\omega \sin \omega t$

$= (-0.1 \times 2 \times \pi \times 8) \times \sin(2 \times \pi \times 8 \times 0.125)$

$V = 5.02 \times 6.283 = 31.5\ ms^{-1}$

Maximum speed = $31.5\ ms^{-1}$

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Examiner Comments

The frequency is calculated correctly (sweep time is doubled to obtain the time for one oscillation) and so part (i) scores 2 marks.

In (ii) the position at which maximum velocity occurs is clearly indicated (the diagram reinforces this).

Part (iii) looks promising, but the trig factor is incorrectly calculated and the final answer is incorrect.

ResultsPlus

Examiner Tip

Always check the formula list to check for useful equations. In this case the required equation for maximum velocity is provided, and so the candidate did not need to include the trig factor.

Question 16(bi)

Most candidates seemed to know that during resonance, there is a large amount of energy transfer and or increase in amplitude, although in some answers the requirement that the resonant system be driven at its natural frequency was not clearly expressed.

(b) In normal operation the clock may make a faint ticking or humming sound. An unstable surface supporting the clock can result in noisy operation due to resonance.

(i) Explain what is meant by resonance.

(2)

When the frequency of the driving Force is equal to the natural frequency of the occilator.

ResultsPlus
Examiner Comments

In this response the condition for resonance is given, but not the result of meeting this condition.

ResultsPlus
Examiner Tip

Learn standard definitions in readiness for questions requiring them.

(b) In normal operation the clock may make a faint ticking or humming sound. An unstable surface supporting the clock can result in noisy operation due to resonance.

(i) Explain what is meant by resonance.

(2)

Resonance ~~is the frequency of an ob~~ is a phenomenon where an object will move according to the frequency applied. Each object has a value where it will move at a max. amplitude at a certain frequency.

ResultsPlus
Examiner Comments

In this response the result of the condition for resonance being met is given, but not the condition itself.

Question 17(a)

There were many good answers, and responses were regularly awarded two of the three marks, often for references to ionising power and β-radiation being able to penetrate the skin. Comments on absorption by aluminium and the half life consideration often lacked sufficient detail to award a mark.

*(a) Discuss the dangers to the youngsters of possessing this cylinder for 5 days.

(3)

Beta (β^-) radiation is extremely dangerous in long periods of time. It can cause mutation of cells as it can penetrate skin. It would be safe in the machine as alluminium stops it penetrating

ResultsPlus
Examiner Comments

This answer is only worth 2 marks, as the final point made is not specific enough. We need to know that a few millimetres of aluminium will absorb the radiation.

ResultsPlus
Examiner Tip

Be as specific as possible when describing properties of materials - don't assume that the Examiner will fill in the detail for you.

*(a) Discuss the dangers to the youngsters of possessing this cylinder for 5 days.

(3)

The dangers of ~~having~~ possesing the cylinder for 5 days is that is has a very high ~~actiw~~ activity so lots of radiation being released constantly also because it has such a high half life it would of barely decayed at all so the activity would have been constant.

ResultsPlus
Examiner Comments

This is a poor answer, although the point that the activity of the source would hardly have changed in the 5 days is just about made.

ResultsPlus
Examiner Tip

This answer consists of just one point. The question has 3 marks. We would expect that three separate points would need to be made for 3 marks to be awarded.

*(a) Discuss the dangers to the youngsters of possessing this cylinder for 5 days.

(3)

Beta radiation is relatively ionising and can penetrate human skin, unlike the more dangerous alpha radiation. Although the caesium was enclosed in a steel container, it had a high activity and the youngsters were in its vicinity for a long time.

ResultsPlus
Examiner Comments

This starts off looking promising, but only two creditable points are made - the moderate ionising power of beta radiation and the consequence that beta radiation can penetrate human skin. If more detail had been given on the effect of the steel container on the radiation another mark might have been awarded.

Question 17(c)(i)

Although some good textbook descriptions were seen, there was confusion is some candidates' minds between random and spontaneous. Radioactive decay is both random and spontaneous, but these are not the same and marks were not awarded for candidates who said that random decay meant that the nucleus would decay spontaneously.

(c) (i) The decay of caesium into barium is a random process. Why is the decay process described as random?

(1)

As you cannot predict when it will decay, as external factors do not effect it hence spontaneous.

ResultsPlus
Examiner Comments

The use of "it" leaves us unsure as to what is going to decay. The caesium sample is decaying all the time. A given caesium atom will decay at a time that we cannot predict. In addition, this candidate thinks that spontaneous and random are the same thing.

ResultsPlus
Examiner Tip

Learn the precise meanings of technical words.

(c) (i) The decay of caesium into barium is a random process. Why is the decay process described as random?

(1)

You can never predict when an atom will decay, it is spontaneous

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Examiner Comments

Although the candidate has used the word spontaneous here, the idea that the decay of an individual atom or nucleus is unpredictable is communicated sufficiently for 1 mark to be awarded.

Question 17(c)(ii-d)

In part (c)(ii), most candidates were able to calculate a correct value for the decay constant. A few candidates could not work out the number of seconds in a year.

In part (d), most candidates knew the exponential equation for decay and were able to use this in conjunction with $dN/dt = \lambda N$ to obtain the correct answer. Some candidates substituted initial activity into the exponential equation in place of the initial number of unstable nuclei, and then thought that they had arrived at the final answer.

(ii) Show that the decay constant for the caesium-137 is about $7 \times 10^{-10}\ s^{-1}$.

(2)

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

$\frac{\ln 2}{30 \times 365 \times 24 \times 60^2} = 7.3 \times 10^{-10}$

(d) In September 2007, 20 years after the cylinder was removed from the machine, the substance was still highly radioactive. Calculate the number of caesium-137 atoms remaining in the powder.

(4)

$A = -\lambda N$

$A/\lambda = N$

$\frac{5.2 \times 10^{13}}{7.3 \times 10^{-10}} = 7.12 \times 10^{22}$

Number = 7.12×10^{22}

ResultsPlus

Examiner Comments

Although the candidate omits the unit in part (c)(ii), this is still good for 2 marks as this is a "show" that question in which the units are given.

Part (d) has half of the calulation done correctly, although the number of atoms calculated is the initial value, rather than the the present day value.

ResultsPlus

Examiner Tip

Make a list of the data that you are given in a question, labelling each number with a standard symbol that represents what the data is.

(d) In September 2007, 20 years after the cylinder was removed from the machine, the substance was still highly radioactive. Calculate the number of caesium-137 atoms remaining in the powder.

(4)

$A = \lambda N$ $\quad$ $N = N_0 e^{-\lambda t}$ $\quad$ $-\lambda t = -0.441504$

$N = A/\lambda$ $\quad$ $= 7.4 \times 10^{22} \times e^{(-0.441504)}$

$= 5.2 \times 10^{13} / 7 \times 10^{-10}$ $\quad$ $= 4.8 \times 10^{22}$

$= 7.4 \times 10^{22}$

Number = 4.8×10^{22}

ResultsPlus
Examiner Comments

In part (c)(ii) the candidate has only given the final answer to 1 significant figure, and so only 1 mark is scored.

The calculation in part (d) is correct for full marks.

ResultsPlus
Examiner Tip

In "show that" questions always quote your final answer to at least one more significant figure than the value that you are given in the question.

Question 17(e)(ii)

Although some good answers were seen, many answers here referred to neutrons causing energy release in general terms. Although chain reaction regularly appeared in answers and there was often enough to justify the second mark, the first marking point was rarely matched.

(ii) Explain the significance to the operation of the reactor of the number of neutrons emitted in each fission.

(2)

3 of the neutrons need to be removed after each reaction otherwise the rate of reaction would accelerat uncontrolably exponenchaly.

ResultsPlus
Examiner Comments

This answer communicates the idea of the fission needing to be controlled, but says nothing about the condition for sustaining a chain reaction.

ResultsPlus
Examiner Tip

The answer gives just one point, but the question has 2 marks. We need to see one point per mark in the answer.

Question 18(a)

There were comparatively few candidates who worked out the principle of the experiment from the description given in the question and then went on to give the measurements needed for the method described. Many candidates simply chose to describe the electrical heating method for measuring the specific heat capacity of a metal block. Those that were based on the correct approach often lacked important detail, so could not be awarded the marks. Candidates need to be aware of the need to give sufficient detail when describing and explaining practical procedures. Most candidates were able to give a valid assumption, which could be credited even if they missed the point of the rest of the question.

(a) Describe an experiment you could carry out to measure the specific heat capacity of a metal, assuming that you have a number of metal washers which can be heated to a known temperature in a Bunsen flame and plunged into a container of water. State the measurements that you would need to make and give the theoretical basis of the calculation that you would carry out.

What assumption would you make in calculating the specific heat capacity of the metal?

(4)

Assuming that all energy would be transfered to water (although some will be lost through sound, this is how I would conduct the experiment: First heat the washers to a known temperature, then submerge in water for a fixed amount of time. After that time, measure the temperature of the metal. Use $\Delta E = mc\Delta\theta$ to calculate specific heat capacity (rearranged to $c = \Delta E / m\Delta\theta$).

ResultsPlus

Examiner Comments

The candidate has identified the assumption that must be made, but the focus of the experiment is on the washers rather than the water.

ResultsPlus

Examiner Tip

A bullet list of the measurements required would have been a suitable way to answer this question.

Question 18(b)(ii-iii)

Part (b)(ii) was mostly well done, with candidates choosing either to show that the temperature was 1450 K, or that λ max was 1.9 x 10^{-6} m. A small number of candidates tried to demonstrate that the constant in Wien's equation was 2.9 x 10^{-3} mK. This scored just 1 mark, for the use of the equation.

(ii) Show that a peak wavelength of 2.00 μm corresponds to a black-body temperature of about 1500 K.

(2)

$\lambda_{max} T = 2.898\times10^{-3}$

$2\times10^{-6}\,(T) = 2.89\times10^{-3}$

$T = 1445\ k \approx 1500\ k$

(iii) The coals have an average radius of 2.5 cm. Assuming that each coal behaves as a black-body radiator, calculate the rate at which energy is radiated from each coal at a temperature of 1500 K.

(3)

$L \Rightarrow 5.67\times10^{-8} \times (4\pi(2.5\times10^{-2})^2) \times 1500$

$\Rightarrow 6.68\times10^{-7}$ W.

ResultsPlus

Examiner Comments

In part (ii) the temperature is correctly shown to be about 15oo K.

In part (iii) the equation is wrongly quoted (temperature should be raised to the fourth power), and so the answer only gains credit for a correct substituion of the radius into the area expression.

ResultsPlus

Examiner Tip

Make sure that you check the formula list for the exact form of the equation that you are using.

(ii) Show that a peak wavelength of 2.00 μm corresponds to a black-body temperature of about 1500 K.

(2)

$\lambda_{max} T = (2.898 \times 10^{-3} \text{ m K})$

$\lambda_{max} = \frac{(2.898 \times 10^{-3})}{1500} = 1.932 \times 10^{-6} \text{ m} = 1.9 \mu m.$

3 × 2 = 6.

(iii) The coals have an average radius of 2.5 cm. Assuming that each coal behaves as a black-body radiator, calculate the rate at which energy is radiated from each coal at a temperature of 1500 K.

(3)

~~$F = \frac{L}{4\pi d^2}$~~ $L = \sigma T A$.

$4\pi r^2 = 7.9 \times 10^{-3}$.

$L = (5.67 \times 10^{-8}) \times 1500 \times (7.9 \times 10^{-3})$

$L = 6.7 \times 10^{-7} \text{ W s}^{-1}$

ResultsPlus

Examiner Comments

In (b)(ii) the candidate has correctly chosen to show that the peak wavelength is about 2 m m. This scores 2 marks.

In part (b)(iii) the equation is wrongly quoted, but the radius is correctly substituted into the area formula (a correct answer is obtained), and so 1 mark is awarded.

ResultsPlus

Examiner Tip

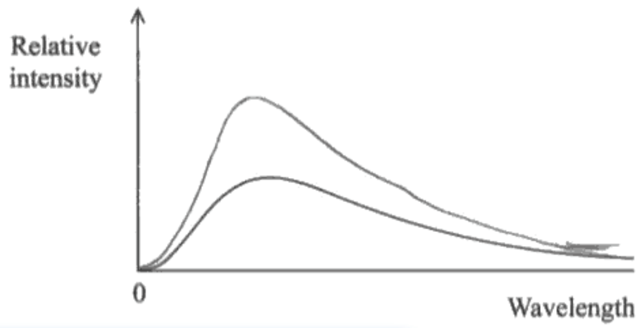
Check the formula list carefully for the correct formula.

Question 18(b)(iv)

Answer to this part indicated that the graph is not as well known as it should be. A large number of answers showed the peak too low, or shifted in the wrong direction, or both.

(iv) The graph shows the shape of the spectrum for radiation emitted from a black-body radiator at 1500 K. Add a second curve to show the shape of the spectrum for a temperature of 2000 K.

(2)



ResultsPlus
Examiner Comments

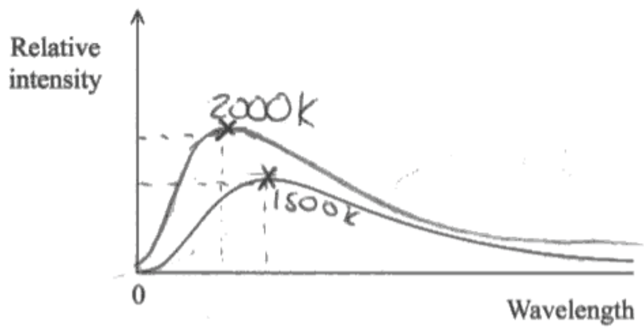
This is a good graph, scoring full marks. However, the peak is only shifted slightly to the left and so careful inspection was needed to decide if both marking criteria were met.

ResultsPlus
Examiner Tip

If you have to re-draw a graph, make sure that all important features are clearly marked.

(iv) The graph shows the shape of the spectrum for radiation emitted from a black-body radiator at 1500 K. Add a second curve to show the shape of the spectrum for a temperature of 2000 K.

(2)



ResultsPlus
Examiner Comments

This graph is clear, with the higher temperature curve being labelled. This identifies it unambiguously.

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