edexcel

ResultsPlus

Examiners' Report
June 2011

GCE Physics 6PH05 01

ALWAYS LEARNING

PEARSON

Edexcel is one of the leading examining and awarding bodies in the UK and throughout the world. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers.

Through a network of UK and overseas offices, Edexcel's centres receive the support they need to help them deliver their education and training programmes to learners.

For further information, please call our GCE line on 0844 576 0025, our GCSE team on 0844 576 0027, or visit our website at www.edexcel.com.

If you have any subject specific questions about the content of this Examiners' Report that require the help of a subject specialist, you may find our **Ask The Expert** email service helpful.

Ask The Expert can be accessed online at the following link:
http://www.edexcel.com/Aboutus/contact-us/

Alternatively, you can contact our Physics Advisor directly by sending an email to Stephen Nugus on ScienceSubjectAdvisor@EdexcelExperts.co.uk
You can also telephone 0844 576 0037 to speak to a member of our subject advisor team.

ResultsPlus

Get more from your exam results

...and now your mock results too!

ResultsPlus is Edexcel's free online service giving instant and detailed analysis of your students' exam and mock performance, helping you to help them more effectively.

- See your students' scores for every exam question
- Spot topics, skills and types of question where they need to improve their learning
- Understand how your students' performance compares with Edexcel national averages
- Track progress against target grades and focus revision more effectively with NEW Mock Analysis

For more information on ResultsPlus, or to log in, visit www.edexcel.com/resultsplus.
To set up your ResultsPlus account, call 0844 576 0024

June 2011

Publications Code UA028550

Introduction

This is the third occasion that Unit 5 of the new specification has been examined. 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 the marks for Q15(c), Q17(b), and Q18(b) 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, good responses were seen to such questions. However, whereas the majority of candidates produced solutions that were well organised, there was evidence of poor layout in a number of scripts.

Candidates should be aware that in answering numerical questions their work should be set out to enable the examiner to follow their reasoning. Candidates should also realise that they should substitute all values into an equation, as a wrong final answer with incomplete substitution in the previous steps will lead to little credit.

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.

Significant figures were a problem area for some candidates. Examples of incorrect rounding, too few significant figures used in the course of a calculation, or numbers rounded at each stage with a resulting inaccuracy in the final answer were all seen far too commonly for an examination at this level.

In some questions well known quantities attracted unit errors. Candidates should be encouraged to check units carefully for all quantities that they calculate.

Once again it was pleasing to see that candidates were generally able to access the correct data and equations from the list provided. However responses were seen to both Q14(b) and Q17(a)(i) in which 1/4 pe_o was used in place of the Boltzmann constant. Candidates need to be reminded that they should be familiar with all of the information provided in the data and equations section of the examination paper.

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.

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. This year there too many instances of candidates continuing their work on another part of the paper with little indication to the examiner where the continuation work was to be found.

Question 11 (a)

Most candidates identified that the key feature of a standard candle was that its luminosity is known. The most common mistake was to state that it was an object with fixed, standard or the same luminosity. A small number of responses described the method of using the standard candle to calculate distance, or named a type of stellar object without indicating that the luminosity of the object must be known.

SECTION B

Answer ALL questions in the spaces provided.

11 (a) State what astronomers mean by a standard candle.

(1)

An object (e.g. a sephid variable or type 1a supernova) whose luminosity is known - so its distance can be calculated accurately.

ResultsPlus

Examiner Comments

There is a large amount of detail included in this response, but the key idea of a known luminosity is clear.

SECTION B

Answer ALL questions in the spaces provided.

11 (a) State what astronomers mean by a standard candle.

(1)

A means of measuring the distance of a far off star by extrapolating ~~that~~ the distance of a known similar star. Usually done by using cepheid variables.

ResultsPlus

Examiner Comments

Again this response includes a lot of detail, but the key information (that the luminosity of the object is known) is missing.

Question 11 (b)

This was generally well-answered. The most common mistake was to get the wrong units (typically either leaving the unit out completely, or to use Wm^{-1}). In a small number of responses the distance wasn't squared.

(b) The luminosity of Sirius is 8.94×10^{27} W and its distance from the Earth is 8.08×10^{16} m.

Calculate the radiant energy flux of Sirius at the Earth.

(2)

$F = \frac{L}{4\pi d^2} = \frac{8.94\times10^{27}}{4\times\pi\times(8.08\times10^{16})^2} = 1.09\times10^{-7}$ W

Radiant energy flux = 1.09×10^{-7} W

(Total for Question 11 = 3 marks)

ResultsPlus

Examiner Comments

The flux is incorrectly given the same unit as the luminosity of the star.

ResultsPlus

Examiner Tip

Check units carefully for any final answers that you calculate.

(b) The luminosity of Sirius is 8.94×10^{27} W and its distance from the Earth is 8.08×10^{16} m.

Calculate the radiant energy flux of Sirius at the Earth.

(2)

$F = \frac{L}{4\pi d^2}$ $\quad \frac{8.94\times10^{27}\,W}{4\pi(8.08\times10^{16}\,m)^2} = 1.089$

Radiant energy flux = $1.09\ wm^{-2}$

ResultsPlus

Examiner Comments

The power of ten has not been included in the final answer.

ResultsPlus

Examiner Tip

Transfer numbers carefully from your calculator display. Remember to include the full standard form value.

Question 12

(a) In the main this was well answered. However, many ignored the terminology used in the question and referred to m_1 and m_2 in their answers. A common mistake was to equate m with m_1.

(b) If a candidate lost this mark it was generally through using the wrong unit. Although it might have been expected that the units for gravitational field strength would be well known at this level, N, or N m^{-2}, and even kg m^{-2} were seen. In some responses the units were omitted entirely.

12 (a) Derive an expression for the gravitational field strength *g* at a distance *r* from the centre of a mass *M*. Use the list of equations at the end of this question paper.

(2)

$g = \frac{F}{m}$ $\quad F = \frac{Gm_1m_2}{r^2}$

$g = \frac{Gm_1m_2}{mr^2}$

$g = \frac{Gm}{r^2}$

(b) Use your expression to calculate *g* at the surface of the Earth.

mass of Earth $M_E = 5.97 \times 10^{24}$ kg
radius of Earth $r_E = 6.38 \times 10^6$ m

$g = \frac{GM}{r^2}$ $\quad g = \frac{(6.67 \times 10^{-11}) \times (5.97 \times 10^{24})}{(6.38 \times 10^6)^2}$ (1)

$g = 9.78$ N kg^{-1}

$g = 9.8$ N kg

g = 9.8 N kg^{-1}

(Total for Question 12 = 3 marks)

ResultsPlus
Examiner Comments

It is not clear in (a) how g has been derived. m has been cancelled with either m_1 or m_2 which has then become m. Part (b) is correct.

ResultsPlus
Examiner Tip

When deriving a quantity, make sure that all the steps in your derivation are clear.

12 (a) Derive an expression for the gravitational field strength g at a distance r from the centre of a mass M. Use the list of equations at the end of this question paper.

(2)

$g = F/m$

$F = \frac{GMm}{r^2}$

$g = \frac{1}{m} \times \frac{GMm}{r^2}$

$= \frac{GM}{r^2}$

$g = (-)\frac{GM}{r^2}$

(b) Use your expression to calculate g at the surface of the Earth.

mass of Earth $M_E = 5.97 \times 10^{24}$ kg

radius of Earth $r_E = 6.38 \times 10^6$ m

(1)

$g = \frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(6.38 \times 10^6)^2} = 9.78$ N

$g =$ 9.79 N

(Total for Question 12 = 3 marks)

ResultsPlus

Examiner Comments

In part (a) the expression is correctly derived. However, in part (b) the unit for g is incorrect.

Question 13 (a)

Virtually every answer seen was correct with unit.

13 The heating element of a hair dryer supplies 2.1 kW to the air flowing past it.

(a) The hair dryer is connected to a 230 V supply.

Calculate the minimum current in the heating element.

(2)

~~E=VIt~~ $P = VI$ $I = \frac{230}{2100}$ $I = 0.1095238095\,A$

$I = \frac{V}{P}$ $I = 0.11\,A$

Current = 0.11A

ResultsPlus

Examiner Comments

The equation for P is re-arranged incorrectly and so neither the substitution nor the final answer score any marks.

ResultsPlus

Examiner Tip

Substitute values into the equation before re-arranging. That way you will get the "use of" mark, even if you final answer is incorrect.

Question 13 (b) (i)

Candidates were able to substitute into and manipulate the equation skilfully. Those who did not obtain the correct final answer either tried an incorrect method of converting to Kelvin, or subtracted the temperature of the air to give 10.6 °C as the final answer. A small number omitted unit, or omitted the C from °C.

Some candidates were able to identify the correct equation to use for this question, but failed to make the link that energy per second was power and that they could therefore use the power given in the previous part of the question.

Question 13 (b) (ii)

In general candidates scored badly here. Some started with the electrical energy in the element and did not go far enough to gain the second marking point. Some gave too much detail of the kinetic energy of the molecules in the element and failed to use the words 'heat' or 'thermal'. There was a generally poor understanding and use of the concept of heat. Energy changes were not well expressed and were often on a very basic level, displaying confusion between bulk kinetic energy of the air and the KE of the molecules.

(ii) Describe the energy changes that occur as air is blown past the heating element.

(2)

Thermal energy is transfered from the heating element to the cooler ~~a~~ air.
the air molecules have more energy ~~than~~ once ~~b~~ they have passed the heating element then they had before.

(Total for Question 13 = 6 marks)

ResultsPlus
Examiner Comments
The response just misses the second marking point, as it doesn't state that the air molecules have an increased *kinetic* energy.

(ii) Describe the energy changes that occur as air is blown past the heating element.

(2)

It changes from ~~thermal~~ thermal energy to Kinetic energy.

ResultsPlus
Examiner Comments
The candidate may know what is happening as air passes the heater, but this response is too vague to award either mark.

ResultsPlus
Examiner Tip
Ensure that your answers contain enough detail to be clear and unambiguous.

Question 14

a)(i) There were many straightforward answers using P/T is constant. However, a number of candidates tried to make this calculation much more complicated by using PV = NkT and working out V and N. Many of these went on to get the correct answer, but some gave up and did not attempt part 14b, when their use of PV=NKT would have been appropriate.

It was disappointing to see some candidates failing to convert 20 ^{o}C to 293K.

(a)(ii) There were many correct answers, constant mass or constant number of molecules being the most popular. The majority of other wrong answers centred around the idea that the ball was a perfect sphere.

In a number of answers the assumption that air behaves as an ideal gas was identified, which was fine. However, some candidates quoted individual assumptions of the kinetic theory (e.g. collisions between molecules are perfectly elastic etc.) and such answer did not gain credit.

(b) Candidates found this calculation demanding to complete. Volume calculation errors were common (powers of 10, using 4pr^2 instead of 4pr^3/3 or diameter instead of radius). Only a minority of candidates realised that they had to find a pressure difference; the majority found (successfully or unsuccessfully) the number of air molecules at one of the temperatures only. For those who did attempt to find the pressure difference, accuracy suffered when they calculated the numbers of molecules at the two pressures separately, rather than using the pressure difference in one calculation.

14 A football has a diameter of 22.5 cm. It contains air at a temperature of 20 °C and a pressure of 1.65×10^5 Pa. When the football is left in direct sunlight, the temperature of the air in the football increases to 40 °C.

In the following calculations, assume that the volume of the football remains constant.

(a) (i) Show that the new pressure exerted by the air in the football is about 2×10^5 Pa. **(2)**

$PV = nkT \qquad \frac{P_0 V_0}{T_0} = \frac{P_1 V_1}{T_1} \qquad V_0 = V_1$

$\frac{1.65 \times 10^5}{20+273} = \frac{P_1}{40+273} \rightarrow P_1 = 1.76 \times 10^5$ pa $\simeq 2 \times 10^5$ pa

(ii) State another assumption you made in your calculation. **(1)**

Assume air in ball of only inertial E as kinetic E assume no PE ∴ no intermolecular bonds between its gas molecules.

ResultsPlus

Examiner Comments

In part (ii) the assumptions made are those of the kinetic theory - not an assumption required to be able to use the gas law.

(b) Air is then released from the football until the pressure returns to its original value. P_2
Assuming that the temperature remains at 40 °C, calculate the number of molecules that escape.

313K

$V = \frac{4}{3}\pi r^3$
$= \frac{4}{3} \times \pi \times 0.1125^3$ (3)
$= 5.96 \times 10^{-3} m^3$

$\frac{P_1}{N_1} = \frac{P_2}{N_2}$

$N_1 = \frac{PV}{KT}$

$= \frac{(1.75 \times 10^5) \times (5.96 \times 10^{-3})}{(1.38 \times 10^{-23}) \times (313)}$

~~$= 2.28 \times 10^{23}$ molecules initially~~

$= 2.41 \times 10^{23}$ molecules initially

$N_2 = \frac{P_2 \times N_1}{P_1}$

$= \frac{(1.65 \times 10^5) \times (2.41 \times 10^{23})}{(1.75 \times 10^5)}$

$= 2.27 \times 10^{23}$ molecules at end

$(2.41 \times 10^{23}) - (2.27 \times 10^{23})$
$= 1.4 \times 10^{22}$

Number of molecules escaping = 1.4×10^{22}

(Total for Question 14 = 6 marks)

ResultsPlus

Examiner Comments

Rounding errors have led to a final answer that is less than the actual answer.

ResultsPlus

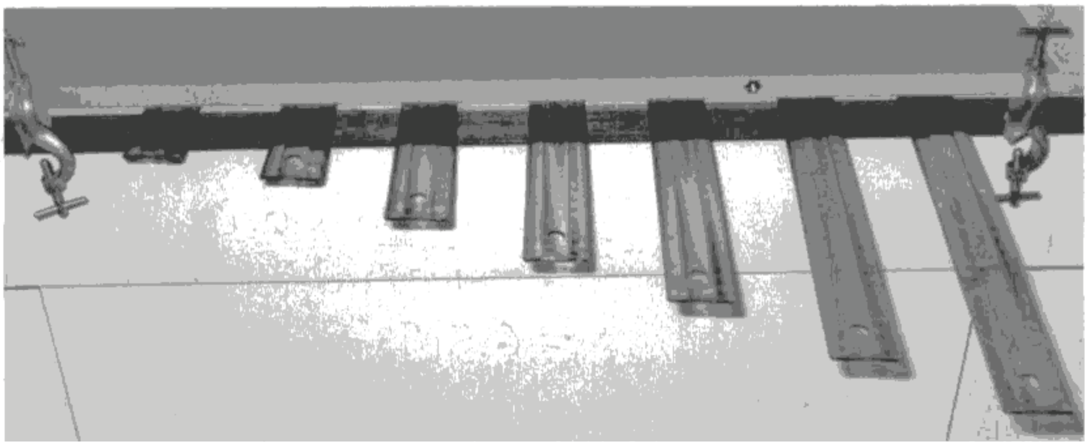
Examiner Tip

Be careful when rounding - keep enough significant figures in your calculator memory to ensure that your final answer does not differ appreciably from the expected answer.

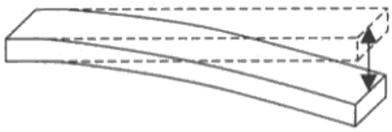
Question 15 (a)

This was a textbook definition, and was well answered by most. However, it was clear that some candidates did not realise that a standard definition was required. Answers referring to general features of a system exhibiting simple harmonic motion were seen from these candidates.

15 A student makes the "ruler piano" shown in the photograph.



One end of each ruler is held flat on the desk whilst the other end is set into oscillation. Each ruler oscillates at a different frequency. Some of the rulers produce an audible sound.



(a) State the condition for an oscillation to be simple harmonic.

(2)

$a = -\omega^2 x$ SHM occurs when the time period T is the same regardless of the speed (or acceleration) of the oscillation. The displacement x will increase as the speed increases, keeping the time period the same.

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

ResultsPlus
Examiner Comments

The response focuses on the isochronous nature of simple harmonic oscillators.
This is not a definition of s.h.m.
There is an equation included, but the symbols are not defined and so credit cannot be given for this.

ResultsPlus
Examiner Tip

If you are using an equation to define a quantity, make sure that you state what each symbol in the equation represents.

Question 15 (b)

This was calculated successfully by most of those who could work out the period. The most common error was in not realising that you had to halve 5cm to get the amplitude. Most candidates sensibly used the formula $v_{max} = \omega A$. Those who brought in the sine function invariably got wrong values for v_{max} because they substituted inappropriate times into the equation.

It was encouraging to see that many students are aware that answers to this type of question should not be left in terms of p.

(b) The end of one ruler moves through 5.0 cm from one extreme position to the other, and makes 10 complete oscillations in 4.5 s.

Calculate the maximum velocity of this end.

(3)

$V_{max} = A\omega$

$0.45 s^{c}$

$\frac{2\pi}{0.45}$

$0.05m \times 14.0 s^{-1}$

$= 0.7 m s^{-1}$

Maximum velocity = $0.7 m s^{-1}$

ResultsPlus

Examiner Comments

The amplitude is incorrectly substituted as 0.05 m.

Question 15 (c)

This question was very poorly answered. Most candidates simply ignored the reference to standing waves in the rubric. The most common way of gaining credit was to make a comment relating the length to the frequency, but many candidates did not explain that the frequency would *decrease* as the length was *increased*, and so they did not gain credit. These candidates said frequency would 'change' when the length 'changed' or that a 'different' length meant a 'different' frequency.

Other incorrect approaches were to talk about mass-spring systems, the simple pendulum and resonance. Some candidates were confusing amplitude with frequency and quite a few answers assumed there was a driving frequency somewhere which would resonate with one of the rulers.

(c) A standing wave is set up on each oscillating ruler.

Explain why each length of ruler oscillates at a different frequency.

(3)

The shorter the ruler, the smaller the maximum amplitude. As the possible amplitude becomes smaller less energy is needed to set it into oscillation. Therefore if similar amounts of energy are applied to all rulers, the frequency will vary as the rate of oscillations increase

(Total for Question 15 = 8 marks)

ResultsPlus

Examiner Comments

There is no reference to standing waves in this response. The physics included is inappropriate and incorrect for this context.

ResultsPlus

Examiner Tip

Check the wording of the question to find pointers for the way in which you should structure your response.

Question 16 (a) (b)

(a)(i) There were many correct answers to this question. The most common mistakes were to calculate the decay constant in yr^{-1}, rather than s^{-1}. Candidates should be encouraged to inspect the units for quantities given in questions carefully before they attempt a calculation. In this instance it should have been clear that, since the show that value was in Bq, they would have to work out a half-life in s^{-1}.

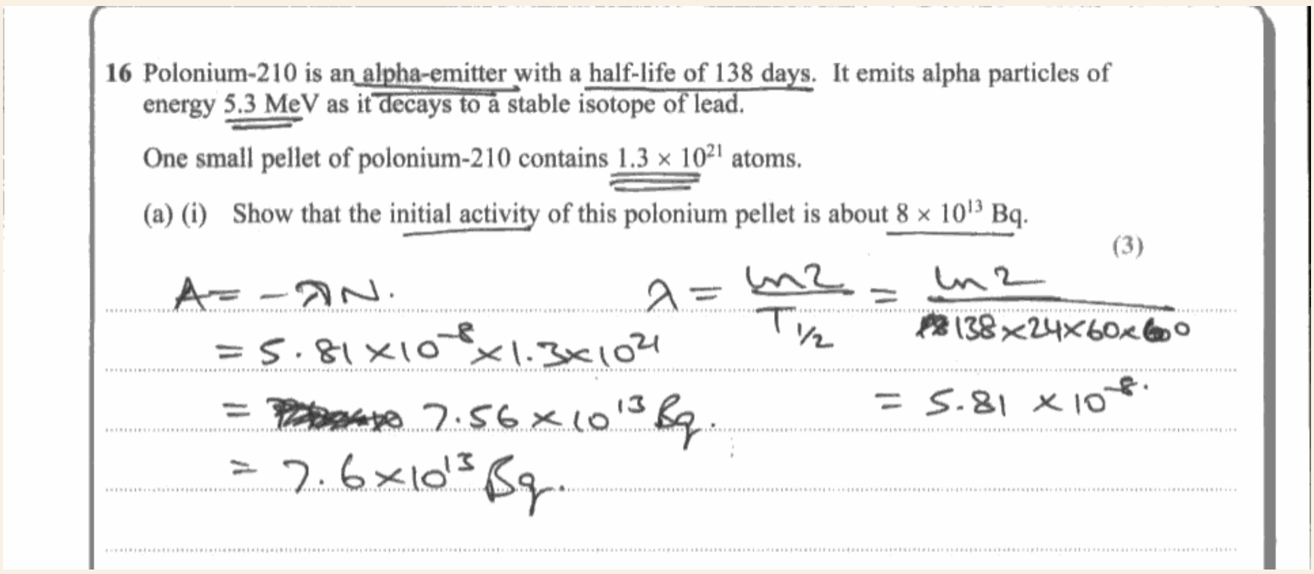
(a)(ii) Candidates tended to be able to either get all 3 marks relatively easily, or fail at the point they had converted MeV to J. Many candidates failed to appreciate the implication of power being energy per second.

(b)(i) The statement "5% of the energy released is radiated away" led a number candidates to assume that 5% was the amount to be discarded and that it was the 95% "remaining" that was to be used in the Stefan-Boltzmann's equation. Those who used 5% correctly generally went on to obtain the correct answer. A few candidates took 5% of the temperature they had worked out as their answer to the question.

A small number of answers seen used a converse argument to answer the question. i.e. they started with a temperature of 1000 K and worked backwards to show that about 5% of the power is radiated away. Working a 3 mark "show that" question in reverse in this way restricts the maximum credit to 2 marks.

(b)(i) The calculation was done well, often with the "show that" value for the temperature being used. Where candidates failed to score full marks it was mostly because the units were omitted from the answer.

(b)(iii) Many candidates did not identify that the peak wavelength lay in the infrared region of the em-spectrum. This showed that their appreciation of this topic was purely theoretical. It is a reasonable assumption to expect candidates at this level to know that a body at a temperature of about 1000K predominately emits infrared radiation. Gamma rays and UV were the most common incorrect answers.



16 Polonium-210 is an alpha-emitter with a half-life of 138 days. It emits alpha particles of energy 5.3 MeV as it decays to a stable isotope of lead.

One small pellet of polonium-210 contains 1.3×10^{21} atoms.

(a) (i) Show that the initial activity of this polonium pellet is about 8×10^{13} Bq.

(3)

$A = -\lambda N$. $\lambda = \frac{\ln 2}{T_{1/2}} = \frac{\ln 2}{138 \times 24 \times 60 \times 60}$

$= 5.81 \times 10^{-8} \times 1.3 \times 10^{21}$

$= 7.56 \times 10^{13}$ Bq. $= 5.81 \times 10^{-8}$.

$= 7.6 \times 10^{13}$ Bq.

(ii) Hence show that the rate of energy release by the pellet is more than 60 W.

(3)

$$\frac{5.3\times10^6\times1.6\times10^{-19}}{(3\times10^8)^2} = \frac{9.42\times10^{-30}}{5.81\times10^{-8}}$$

$= 1.62\times10^{-22}$

$1.62\times10^{-22}\times1.3\times10^{21}$

$= 0.21$

$$\frac{5.3\times10^6\times1.6\times10^{-19}}{5.81\times10^{-8}}$$

$= 1.46\times10^{-5}$

(b) The radius of the pellet is 2.25 mm and its equilibrium temperature would be about 1000 K.

(i) Assuming that 5% of the energy released is radiated away, show that this approximate value of temperature is correct.

(3)

$V = \frac{4}{3}\pi(2.25\times10^{-3})^2$

$= 2.12\times10^{-5}$

$pV = NkT$

$$\frac{p\times2.12\times10^{-5}}{1.3\times10^{21}\times1.38\times10^{-23}}$$

ResultsPlus

Examiner Comments

In part (a)(ii) the energy conversion is correct, but it is not clear what the rest of the calculation is about.
In (b)(i) an inappropriate equation has been selected.

(ii) Calculate the wavelength at which peak energy radiation occurs.

(2)

$$\lambda = \frac{2.898\times10^{-3}}{1000}$$

$= 2.898\times10^{-6}$

ResultsPlus

Examiner Comments

There is a unit error for the answer to (b) (ii), as the unit is not included.

ResultsPlus

Examiner Tip

Always check that units have been included.

Question 16 (c)

This was answered well, with most candidates writing so much about alpha radiation that they covered the marking points. Common mistakes were to talk about polonium penetrating the skin, alpha particles not penetrating the body or being stopped by a few cm of skin.

(c) Explain why very small quantities of polonium-210 are a health hazard only if taken into the body.

(2)

Gamma radiation is not very ionising when compared to alpha or beta. Alpha ~~a~~ is the most ~~ioning~~ ionising but cannot travel far in air and can't penetrate the skin. Beta can penetrate the skin but can't penetrate thin metals, making it easy to remove

(Total for Question 16 = 14 marks)

ResultsPlus

Examiner Comments

The answer includes enough about alpha radiation to gain both marks, but the unnecessary detail relating to beta and gamma radiation is a distraction and may have resulted in the candidate missing out an important aspect of alpha radiation required by the question.

ResultsPlus

Examiner Tip

Answer the queation that is on the paper - don't just write everything down that you know about a topic.

Question 17 (a) (i)

This was answered well. The most common mistakes were to use the wrong k for the equation, or to incorrectly convert the mass from u to kg. A common error was the omission of the 1.0087 factor. Occasionally the calculation was not completed and the answer to velocity squared was given.

Question 17 (a) (ii-iii)

(a)(ii) This was a straightforward question which was answered well.

(a)(iii) Most candidates could calculate a mass defect but forgot either all or some of the neutrons. They could all convert u to kg and use $E=mc^2$.

Many found it difficult to work out the fission rate, using E/P instead of P/E and hence finding the time between fissions instead of the rate. At this point it was clear that some did not know what G is as a prefix, using an incorrect factor of 10 in their substitution. For many of those candidates who did go on to obtain the correct final answer, missing units resulted in the final mark not being awarded.

(iii) Calculate the energy released in a single fission. Hence determine the rate of fission necessary to maintain a power output of 2.5 GW.

	Mass / u
^{235}U	235.0439
^{138}Cs	137.9110
^{96}Rb	95.9343

(4)

$\Delta m = (235.0439u + 1.0087u) - (137.9110u + 95.9343u + 2 \times 1.0087u)$

$= 236.0526u - 235.8627u$

$= 0.1899u$

$= 0.1899 \times (1.66 \times 10^{-27})$

$= 3.152 \times 10^{-28}$ kg

$E = \frac{1}{2}(3.152 \times 10^{-28})(3000)^2$

$= 1.42 \times 10^{-21}$ J

$P = \frac{E}{t}$

$\frac{1}{t} = \frac{P}{E}$

$= \frac{2.5 \times 10^9}{1.42 \times 10^{-21}} = 3.9 \times 10^{29}$ s^{-1}

Fission rate = 3.9×10^{29} s^{-1}

ResultsPlus

Examiner Comments

In (a)(iii) the candidate has used an equation for kinetic erngy, rather than the Einstein mass-energy equation. Also, the value for the speed of light is incorrect, and so the final answer would have been incorrect even if the 0.5 factor had been omitted.

ResultsPlus

Examiner Tip

Check formulae and data carefully from the list given at the back of the paper.

Question 17 (b) (i)

On the whole, answers to this question were disappointing. Conditions for fusion were relatively well known, but answers often lacked the detail needed to secure the marks. This is particularly true of the qualification of temperature and density as being very high.

Practical details for sustainable fusion were rarely mentioned, many candidates deciding instead to focus their whole argument upon vague statements about the relative amounts of energy required to be put into the reactor compared to the amount of energy released as a result. Containment issues were often treated very superficially, and were often based around the idea that it was too expensive to build a reactor, or maintain the extreme conditions.

(b) *(i) State the conditions for fusion and hence explain why it has proved difficult to maintain a sustainable reaction in a practical fusion reactor.

(4)

Fusion requires extremely high temperatures which take alot of resources to sustain. The pressure contained within a fusion reacter is also immense, so it is difficult to contain.
Fusion is a highly costly process, and is not sustainable in a practical fusion reacter.

ResultsPlus
Examiner Comments

This response only says enough to gain the first marking point (extremely high temperature).

(b) *(i) State the conditions for fusion and hence explain why it has proved difficult to maintain a sustainable reaction in a practical fusion reactor.

(4)

Very high temperatures and very high pressure. This provides the energy to overcome the electrostatic force of repulsion so the nuclei get close enough for the strong force to take over and fuse then together. It is difficult to do this as the very high temperatures required would melt the container. The fusion reactor's melting point is below the temperature required

ResultsPlus

Examiner Comments

This response contains enough detail for all 4 marks to be awarded.

Question 17 (b) (ii)

Even when the nuclear equation was correctly completed there was a wide variety of particle names identified.

Question 17 (b) (iii)

Candidates tended to make statements about fusion without reference to fission. There were few comparative statements. Many thought that fusion produces no radioactive products, and comparative statements about energy production seldom referred to unit mass. Answers in terms of abundance tended to focus on just one (e.g. hydrogen is readily available OR Uranium is a limited resource).

The idea that fusion is an intrinsically safer process since loss of containment causes it to stop, whereas a fission chain reaction might go out of control, was touched on, but not in enough detail for the mark. Usually the answer said 'it is safer because there is no chain reaction'.

(iii) Despite the difficulties, the quest for a practical fusion reactor continues.

State **two** advantages fusion power might have over fission power.

(2)

1 much more energy released

2 can be controlled more easily cause it is not a chain reaction.

(Total for Question 17 = 16 marks)

ResultsPlus

Examiner Comments

These two brief statements come close to gaining marks, but fall short due to lack of detail.

ResultsPlus

Examiner Tip

Read your answer back to check that it really is an answer to the question.

1 Fusion power does not create as harmful waste products as those created in fission, that are hard to dispose as they have very long half lives.

2 Obtaining Uranium 235 (enrichment) for fission is very costly & difficult.

ResultsPlus

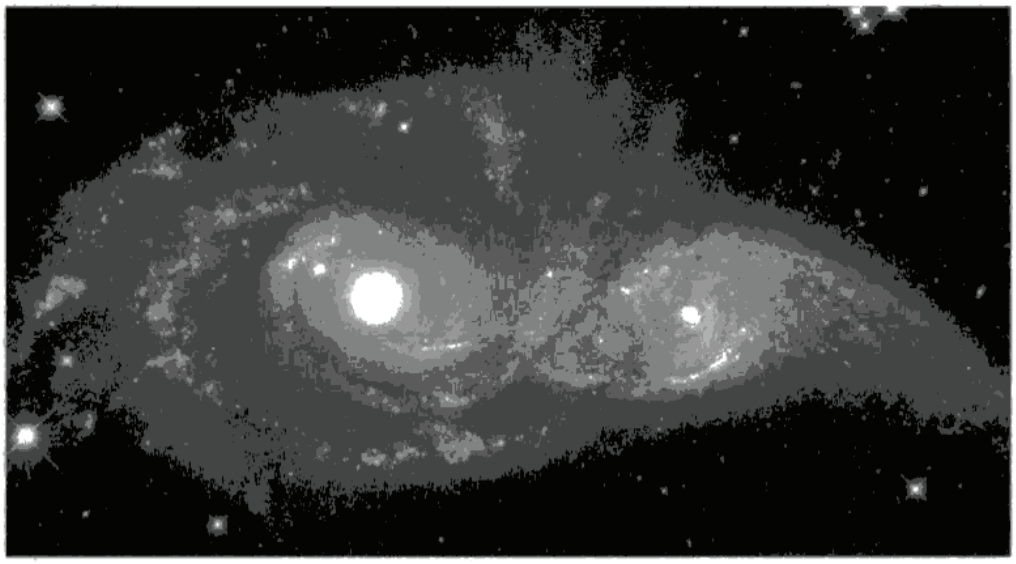
Examiner Comments

The first statement makes a comparison between fusion and fission, but the second statement does not.

Question 18 (a) (i)

The vast majority of answers scored 1 mark.

18 Current theory predicts that there is a massive black hole at the centre of every galaxy. It is suggested that if galaxies approach, then their central black holes begin to orbit each other until the galaxies merge.



In 2009, astronomers found convincing evidence of two such black holes orbiting as a binary system. From data collected, they estimated that the separation of the black holes was 3.2×10^{15} m and that their masses were 1.6×10^{39} kg and 4.0×10^{37} kg.

(a) (i) State the origin of the force that maintains the black holes in an orbit.

(1)

Centripetal force acting towards the centre of their orbit

ResultsPlus
Examiner Comments

The centripetal force is a name for the force acting towards the centre of the circular path, rather than being the origin of the force that maintains the black holes in a circular path.

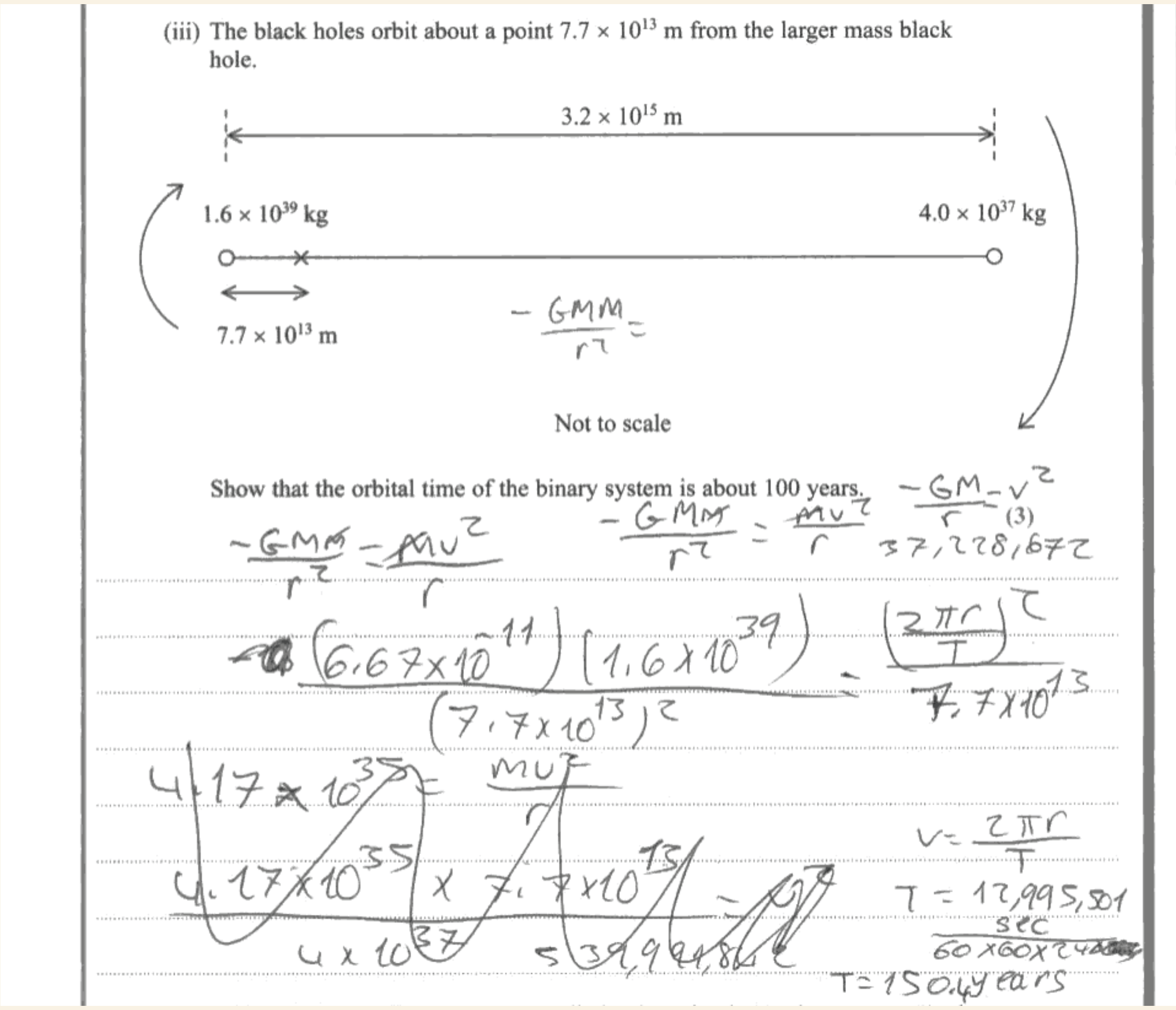
ResultsPlus
Examiner Tip

Read the question carefully, so that you are sure what you are being asked to do.

Question 18 (a) (ii-iii)

(a)(ii) Most calculated the value correctly. Omission of the square factor once the values had been substituted occasionally led to the loss of both marks.

(a)(iii) The majority of candidates who attempted this question followed a suitable method and arrived at an acceptable answer. A sizeable minority did not set out their calculations in an ordered way and as a result made errors that cost them some of the marks. In other responses in which marks were lost, an incorrect Kepler's Law approach was commonly seen.



ResultsPlus
Examiner Comments

The candidate has used Newton's 2nd law to equate the expression for the gravitational force to that for the centripetal force. This is incorrect, as the value of r is different for each of these. If the candidate had used the value of the gravitational force from (a)(ii), then they would not have made this error.

ResultsPlus
Examiner Tip

A quantity that you calculate in one part of a question is often used in a subsequent part. This is often the case in a question in which there is a "show that" calculation.

Question 18 (b) (i-ii)

(b)(i) This was generally well answered, although not all candidates could clearly express that red shift meant that the observed wavelength is longer. A common answer was that the 'light was shifted to the red', without a mention of wavelength or frequency.

Some candidates referred to the black holes and not the galaxies, which excluded them from the second mark.

The evidence for the expansion of the universe was well understood, if not always well expressed. Several referred to receding stars rather than galaxies and some candidates were clumsy with their wording, with suggestions that the galaxy itself was expanding.

(b)(ii) This was a challenging question for most candidates. Even those who probably knew what the answer was were finding it difficult to put into words. Most candidates who scored mark here just explained that the system is moving away and did not attempt to compare the relative velocities of the rotational motion of the black holes in relation to the much larger velocity of recession.

(b) As the black holes swallow up matter, radiation is emitted. To observers on Earth this radiation appears to be red shifted.

*(i) State what red shift means and discuss the conclusions that can be drawn from the observation that radiation from all distant galaxies is red shifted.

(3)

red shift is the 'shifting' of wavelengths due to the doppler effect of an object travelling away from us. ~~This As the black holes radiation is redshifted, that means that the black~~ If all radiation from distant galaxies is redshifted, that mean all distant galaxies are moving away from us.

ResultsPlus

Examiner Comments

The response refers to a shift in the wavelength, but it isn't clear what this means in terms of the value of the wavelength.

(ii) Suggest why the light from both black holes is red shifted, even though the black holes are orbiting each other and hence moving in opposite directions.

(2)

The universe is expanding.
Therefore it's possible to conclude that the entire binary system of Blackholes is moving away from the earth.

ResultsPlus

Examiner Comments

This response includes half of the answer - that the binary sytem is moving away from us - but omits making a comparison with this effect and the rotation of the black holes within the binary system.

Question 18 (b) (iii)

This question was generally well answered. The most common mistake was to use 0.38 as the velocity value, losing all 3 marks straight away.

(iii) The observed red shift for the two black holes was 0.38.

Calculate the distance of the merging galaxies from the Earth.

$H_o = 1.6 \times 10^{-18}\ s^{-1}$

(3)

$V = H_o d \qquad z = \frac{V}{c} \qquad zc = V$

$\frac{zc}{H_o} = d \qquad z = 0.38 \quad c = 3 \times 10^8\ ms^{-1}$

$= 4.38 \times 10^{25}\ m$

Distance from the Earth = $4.38 \times 10^{25}\ m$

(Total for Question 18 = 14 marks)

ResultsPlus

Examiner Comments

The candidate has written down all of the information needed to obtain a correct answer, but jumbled it up in one big incorrect substitution.

ResultsPlus

Examiner Tip

Work out quantities one by one before making a substitution to calculate a final answer.

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

Further copies of this publication are available from
Edexcel Publications, Adamsway, Mansfield, Notts, NG18 4FN

Telephone 01623 467467
Fax 01623 450481
Email publication.orders@edexcel.com
Order Code UA028550 June 2011

For more information on Edexcel qualifications, please visit
www.edexcel.com/quals

Pearson Education Limited. Registered company number 872828
with its registered office at Edinburgh Gate, Harlow, Essex CM20 2JE

Ofqual

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

cea
Rewarding Learning