Examiners' Report
June 2014

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(c), Q15(b)(ii), Q16(c), Q16(d), Q17(b)(ii), Q18(a)(iii) and Q18(c) 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 solutions which were well crafted, clearly set out and accurate.

Occasionally in calculation questions the final mark was lost 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(a)(ii) with energy per fusion, where a misunderstanding of the nature of the unit GeV/c^2 for particle masses led to answers many orders of magnitude larger than the correct answer being 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. At A2 level it is to be expected that, where candidates use such terms, they do so with accuracy.

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(a)(ii), Q17(b)(iii) and Q18(c), 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 Q18(c) focused on the *conditions for fusion* rather than considering the *technical difficulties*. Similarly, if a question asked candidates to answer 'with the aid of calculation' as did Q12, then full marks would only be awarded if a calculation was included in the candidate's response.

Diagrams provided important means of communicating information and it should be expect that A2 candidates be able to draw diagrams to achieve this, as in question Q17(b)(ii) where a sketch graph was required. Although some candidates drew the curve carefully and added appropriate detail, such as the frequency for peak amplitude and a width which ignored the effects of damping, this was not always the case.

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 6 of the questions having 70 % or more correct answers.

In order of highest percentage correct they were: Q9 (96%), Q6 (88%), Q4 (76%), Q2 (74%), Q3 (71%), Q5 (71%), Q1 (69%), Q8 (63%), Q10 (59%), and Q7 (31%).

Q7, which has the lowest percentage of correct answers, revealed a common misconception amongst candidates. The correct answer was only chosen by a minority of candidates, with a large proportion choosing the incorrect response A. This was presumably on the basis that a damping force would have to 'oppose' the acceleration. However, to remove energy from the oscillating system the damping force must always be in the opposite direction to the velocity of the oscillating mass, hence the correct response is B.

Question 11

This question was generally well answered although some candidates missed out on the second mark as a result of omitting the unit.

Apart from this, the most common errors were using *g* instead of *G*, and halving or not squaring the separation given in the question.

SECTION B

Answer ALL questions in the spaces provided.

11 Mars is our nearest neighbour in the solar system. In August 2003 the distance between Mars and the Earth was the closest in recorded history at 5.6×10^{10} m.

mass of Mars = 6.4×10^{23} kg

mass of Earth = 6.0×10^{24} kg

Calculate the gravitational force between Mars and the Earth when they were at this distance.

(2)

$F = \frac{G m_1 m_2}{r^2}$

$F = \frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23} \times 6.0 \times 10^{24}}{5.6 \times 10^{10}} = 4.6 \times 10^{27}$ N

Gravitational force = 4.6×10^{27} N

ResultsPlus
Examiner Comments

Although the candidate has written down the gravitational force equation correctly, when values have been substituted into the equation the separation has not been squared. The final answer is incorrect, and the candidate doesn't score the 'use of' mark.

ResultsPlus
Examiner Tip

Check carefully for indices when substituting into equations.

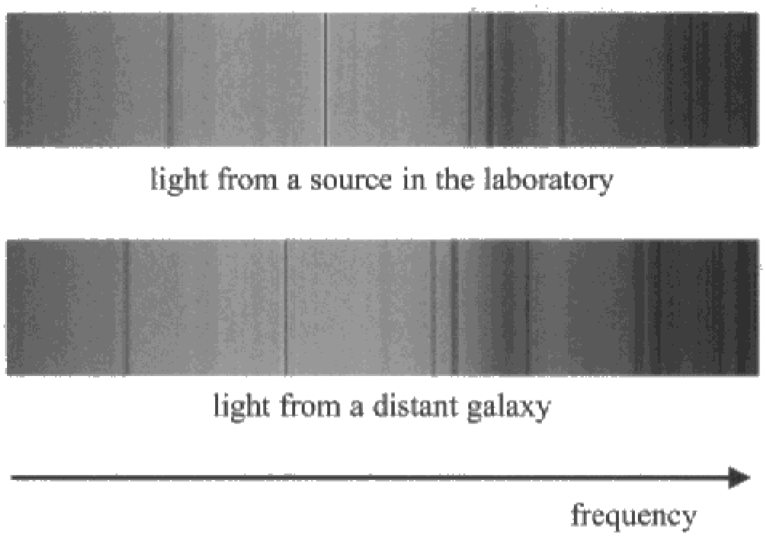
Question 12

Most candidates realised that the galaxy was receding and then went on to gain at least 1 mark from using the red shift equation. However, a significant minority used the frequency of the spectral line from the galaxy in the denominator rather than the frequency of the spectral line in the laboratory.

Some candidates simply converted frequency to wavelength to see if it was longer. They got no credit for this other than MP1, since this gives no more information than that given in the question already. Candidates calculating the wavelength before finding the change often rounded too early.

Despite being prompted to make a calculation, some candidates just referred to the recession of the galaxy.

12 The spectra below show dark absorption lines against a continuous visible spectrum.



A particular line in the spectrum of light from a source in the laboratory has a frequency of 4.570×10^{14} Hz.
The same line in the spectrum of light from a distant galaxy has a frequency of 4.547×10^{14} Hz.

With the aid of a calculation state what should be concluded about the distant galaxy. (3)

$$z = \frac{\Delta f}{f} = \frac{4.570 \times 10^{14} - 4.547 \times 10^{14}}{4.570 \times 10^{14}} = 0.005$$

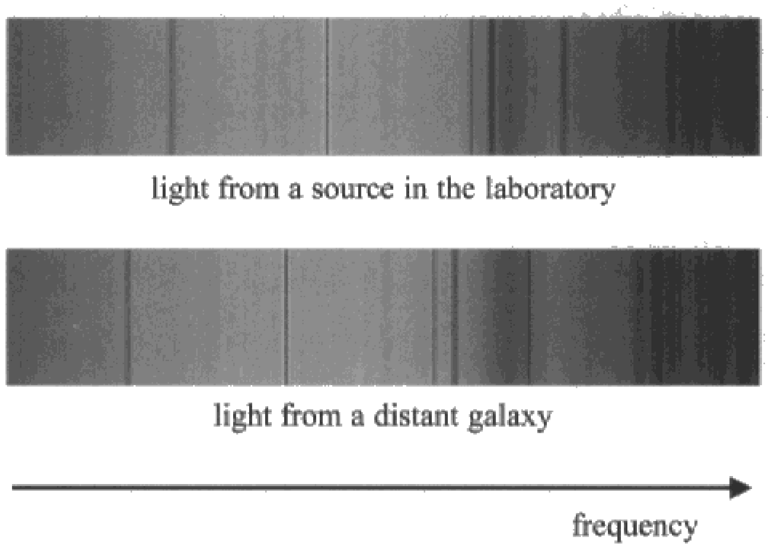
The galaxy is moving away from Earth because the light is red-shifted. The frequency of light from the galaxy is lower than the laboratory value.

ResultsPlus

Examiner Comments

The candidate has identified that the galaxy is moving away from the observer (Earth) and calculated the red shift correctly. They have not gone on to calculate the recessional velocity, although this is not required for full marks.

12 The spectra below show dark absorption lines against a continuous visible spectrum.



A particular line in the spectrum of light from a source in the laboratory has a frequency of 4.570×10^{14} Hz.
The same line in the spectrum of light from a distant galaxy has a frequency of 4.547×10^{14} Hz.

With the aid of a calculation state what should be concluded about the distant galaxy.

(3)

$c = f\lambda \quad \therefore \quad \lambda_{lab} = 3 \times 10^8 / 4.57 \times 10^{14} = 6.56 \times 10^{-7}$

$\lambda_{galaxy} = 3 \times 10^8 / 4.547 \times 10^{14} = 6.59 \times 10^{-7}$

The light from the distant galaxy has a longer wavelength, thus according to the principle of doppler shift, it can be said that the galaxy is moving away from us

ResultsPlus

Examiner Comments

In this response calculations for the wavelengths are carried out. Although this allows the candidate to deduce that the observed wavelength is increased from the lab value, this doesn't provide any more information than noting that the frequency is reduced. The response only gains the mark for identifying that the galaxy is moving away from us.

Question 13 (a)

This was a well answered question, and most candidates knew the correct definition. Some candidates did not appreciate the importance of using 'molecules' or 'atoms' and used the term 'particles'. At this level it is expected that candidates will refer to molecules or atoms.

13 (a) Explain what is meant by internal energy of a liquid.

(2)

It the sum of of all the kinetic energy of the molecules in the liquid plus the sum of all the potential energy between the molecules.

ResultsPlus
Examiner Comments

This is a good response, with both marking points clearly expressed.

13 (a) Explain what is meant by internal energy of a liquid.

(2)

The internal energy is the sum of kinetic energies and velocities of the liquid's particles.

$\Delta E = mc\Delta\theta$

ResultsPlus
Examiner Comments

The response identifies a sum of energies, but there is no mention of potential energies, and particles are specified rather than atoms or molecules.

ResultsPlus
Examiner Tip

Know and use technical words correctly.

Question 13 (b)

The vast majority of candidates made the correct calculation in part (i). Many then went on to make a correct calculation in part (ii). However, some candidates substituted incorrect temperature differences, or specific heat capacities. Some candidates tried to convert temperatures from °C to K before calculating the temperature difference. Some candidates calculated the temperature difference correctly and then went on to add 273 (K) to the difference.

Most comments relating to the assumption were sensible, although there was a tendency just to say 'energy is lost' with no further details. Candidates should be aware that energy is never lost, although there is often a transfer of energy to the surroundings which, unless taken into account, may lead to discrepancies in calculated values.

(b) A cup of tea contains 175 g of water at a temperature of 85.0 °C. Milk at a temperature of 4.5 °C is added to the tea and the temperature of the mixture becomes 74.0 °C.

(i) Show that the internal energy of the water decreases by about 8 kJ as its temperature decreases.

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

$Q = mc\Delta t$

$= 0.175 \times 4200 \times 11$

$= 8085$ J

$= 8.085$ kJ

(ii) Calculate the mass of milk that was added to the tea. State an assumption that must be made.

Specific heat capacity of milk = 3900 J kg^{-1} K^{-1}

(3)

$8.085 \times 10^3 = m \times 3900 \times 11$

$m = 0.188$ kg

188g

Mass of milk = 188g

Assumption There is no heat loss during transfer of Energy

ResultsPlus
Examiner Comments

Although the first calculation is correctly carried out, the value obtained for the mass of milk added to the tea is wrong, as the temperature difference has been incorrectly worked out.

The assumption is too vague for credit to be given.

ResultsPlus
Examiner Tip

Be careful when taking data from the question to use in a calculation. List data using standard symbols to help you avoid making errors.

(b) A cup of tea contains 175 g of water at a temperature of 85.0 °C. Milk at a temperature of 4.5 °C is added to the tea and the temperature of the mixture becomes 74.0 °C.

(i) Show that the internal energy of the water decreases by about 8 kJ as its temperature decreases.

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

(2)

$\Delta E = mc\Delta\theta$ $\Delta\theta = -11°$ $0.175 \times 4200 \times -11 = \Delta E$

$\Delta E = -8085\text{J}$

= decrease of about 8kJ

(ii) Calculate the mass of milk that was added to the tea. State an assumption that must be made.

Specific heat capacity of milk = 3900 J kg^{-1} K^{-1}

(3)

It has to be assumed that the internal energy of the milk is equal to that of the ~~mixture~~ than loss of water energy with no losses to surroundings.

$\Delta\theta = 69.5°$

$m = \frac{\Delta E}{c\Delta\theta} = \frac{8085}{3900 \times 69.5}$

$= 2.98 \times 10^{-3}$

Mass of milk = 2.98×10^{-3}

Assumption It must be assumed that the loss of water energy is equal to the gain of milk energy with no loss to the environment

(Total for Question 13 = 7 marks)

ResultsPlus
Examiner Comments

The two calculations are carried out correctly, but the units are omitted from the value for the mass of milk added.

The assumption gives just enough detail for credit to be given.

Question 14 (a)

Most candidates correctly identified $pV = NkT$ as being the correct equation to use, and a good number then went on to complete the calculation successfully. A common error was not converting the temperature from °C to K.

(a) The pressure of the air in the tyre is 5.8×10^5 Pa. In an attempt to improve performance air is pumped into the tyre until the pressure at 20 °C is 6.5×10^5 Pa.

Calculate the number of air molecules that must be pumped into the tyre.

(3)

$pV = NkT$ old: $p = 5.8 \times 10^5$

Befor: $N = \frac{pV}{kT} = 4.159865 46 \times 10^{22}$ $T = 293$

$V = 2.9 \times 10^{-4}$

Aft: $N = \frac{pV}{kT} = 4.661918188 \times 10^{22}$ $k = 1.38 \times 10^{-23}$

new: $p = 6.5 \times 10^5$

$4.66191888 \times 10^{22} - 4.15986546 \times 10^{22} = 5.0205 \times 10^{21}$ air molecules

Number of molecules = 5.0205×10^{21}

ResultsPlus
Examiner Comments

This response gains full marks. The candidate has retained a large number of significant figures for the two values of N that they calculate. This can be important for the significant figures in the final answer, when two similar numbers are being subtracted.

ResultsPlus
Examiner Tip

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

(a) The pressure of the air in the tyre is 5.8×10^5 Pa. In an attempt to improve performance air is pumped into the tyre until the pressure at 20 °C is 6.5×10^5 Pa.

Calculate the number of air molecules that must be pumped into the tyre.

(3)

$\Delta P = (6.5 \times 10^5) - (5.8 \times 10^5)$

$= 70000 Pa$

$\Delta N = \frac{\Delta P V}{kT} \Rightarrow \Delta N = \frac{70000 \times (2.9 \times 10^{-4})}{(1.38 \times 10^{-23}) \times (273+20)}$

$N = 5.02 \times 10^{21}$

Number of molecules = 5.02×10^{21}

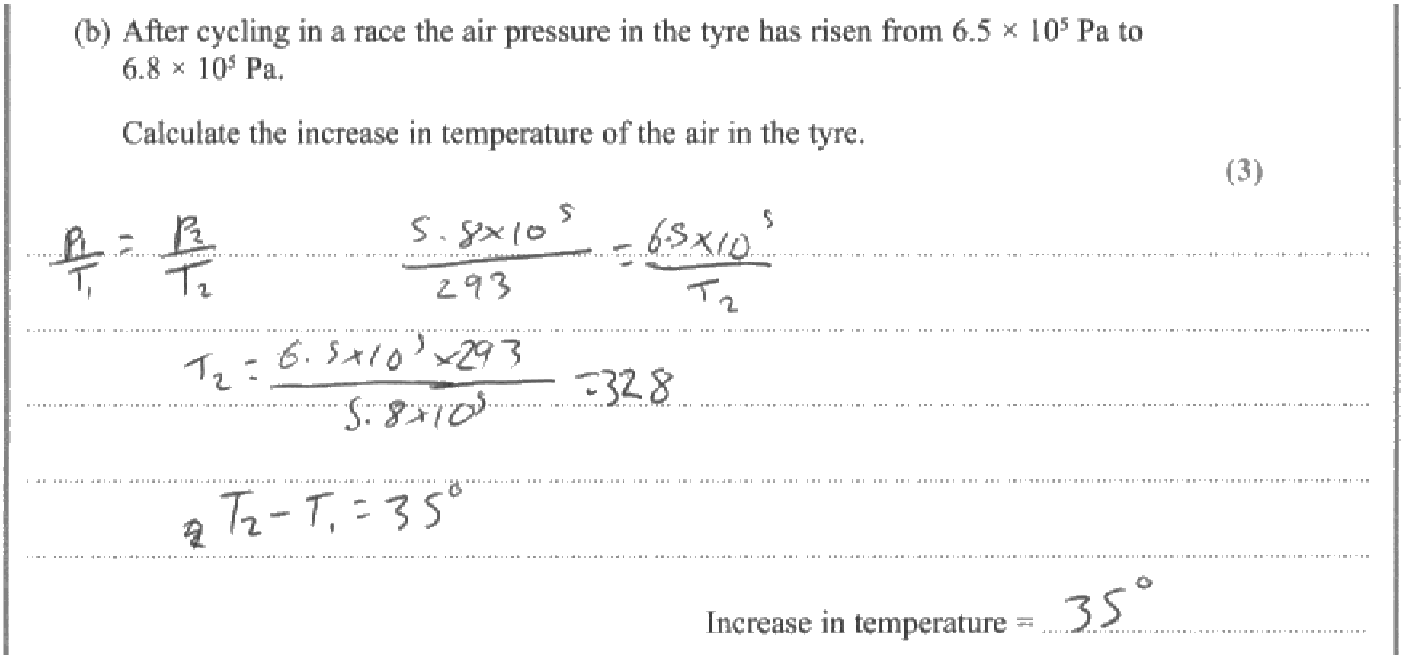
ResultsPlus
Examiner Tip

The candidate has calculated a pressure difference to use in the gas equation. This leads to the correct answer with no loss of significant figures.

Question 14 (b)

A good proportion of candidates used the route of $P_1/T_1 = P_2/T_2$, but once again, some failed to convert °C to K. Those who failed to realise that *p* is proportional to *T* took a long route using $pV = NkT$. This was problematic as often candidates confused *N* with D*N* or *p* with D*p*.

A common mistake was to calculate the temperature of the difference in pressures giving an incorrect temperature of about 125K.



(b) After cycling in a race the air pressure in the tyre has risen from 6.5×10^5 Pa to 6.8×10^5 Pa.

Calculate the increase in temperature of the air in the tyre.

(3)

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $\quad \frac{5.8\times10^5}{293} = \frac{6.5\times10^5}{T_2}$

$T_2 = \frac{6.5\times10^5 \times 293}{5.8\times10^5} = 328$

$T_2 - T_1 = 35°$

Increase in temperature = 35°

ResultsPlus
Examiner Comments

Although this candidate remembers to convert temperatures from Celsius to kelvin, they have used an incorrect pressure in their calculation and hence their final answer is wrong. Additionally they have omitted the units for the temperature difference.

ResultsPlus
Examiner Tip

Always convert temperatures to kelvin when using the ideal gas law. Remember to give units for all final answers that you quote.

Question 14 (c)

This was not answered well. The vast majority of candidates identified that the kinetic energy increased, but some missed linking this to *what* possessed increased kinetic energy. Very few candidates then went on to link the pressure on the container with collision rates and changes in momentum. Too many candidates wrote of the number of collisions as opposed to the collision rate. Candidates often failed to mention rate of collision, momentum change, or collision with the walls of the ball, going on instead to use the gas laws as an 'explanation'.

(c) Explain why the pressure increases when the air is heated in a tyre of fixed volume.

(3)

When air is heated, the air particles in the tyre gain kinetic energy and move faster. It collides with the surface of the tyre more frequently. The volume of tyre is fixed, thus, the rate of collision increase. As rate of collisions increases, pressure increases.

ResultsPlus

Examiner Comments

This response says enough for the first 2 marking points, although the detail relating to the rate of change of momentum is missing. Hence neither of the final 2 marking points could be awarded.

ResultsPlus

Examiner Tip

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

(c) Explain why the pressure increases when the air is heated in a tyre of fixed volume.

(3)

Due to the fixed gas laws. At a constant mass and volume, pressure is directly proportional to temperature. This is because as the temperature increases, the air molecules have more energy. This increases their movement and collision rate with each other and the surface. Therefore increasing the pressure

ResultsPlus

Examiner Comments

This response makes reference to the gas laws, although these describe rather than explain the variation in pressure as the air is heated. There is an idea that rate of collision is important, but it is not clear where the collisions leading to an increased pressure are occurring.

Question 15 (a) (i)

This was not as well done as might have been expected. As it is included in GCSE specifications candidates may be assuming that their GCSE knowledge is sufficient.

Common errors included responses which describe the biological effect of ionisation, responses which confuse what is knocked out/off, and responses which give an example of an ionising radiation rather than describing the process.

15 When a photographic film that is not exposed to light is placed near to a source of ionising radiation the film darkens.

(a) (i) State what is meant by ionising radiation.

(1)

It changes the structure of the molecules the radiation comes into contact with

ResultsPlus
Examiner Comments

This is a typical response which refers to a biological effect which may result from ionisation.

ResultsPlus
Examiner Tip

Be specific and use technical physics terms wherever possible.

15 When a photographic film that is not exposed to light is placed near to a source of ionising radiation the film darkens.

(a) (i) State what is meant by ionising radiation.

(1)

Radiation that damages DNA, and creates ions from atoms it comes in contact with removing electrons, creating ions

ResultsPlus
Examiner Comments

Although the candidate refers to damage to DNA, there is a clear indication that the ionisation process removes electrons from atoms.

Question 15 (a) (ii)

This question tests basic recall and as such was a very well answered question.

Question 15 (b) (i)

This was also a very well answered question, although where candidates failed to score full marks it was usually because they believed that gamma radiation would be stopped by 0.5 cm of lead.

Question 15 (b) (ii)

This question was not answered well, with many responses not scoring any marks at all. Perhaps the reference to radiation in the question led candidates to talk about electromagnetic radiation, although candidates should have realised that, given the context, a reference to some sort of particle was required.

Some candidates identified that neutrons could be the nature of the additional radiation, although responses often lacked details on explaining why they weren't then detected by the film, (for example only saying neutrons weren't ionising, rather than explaining why this was the case).

Some of the more able answers were for stating that positrons might be produced, as the vast majority of answers went on to talk about annihilation. Some candidates referred to background radiation, but failed to indicate its low count rate as a reason for it not being detected.

(ii) In a nuclear power plant there may be other radiation present which would **not** be detected by a film badge.

Suggest what type of radiation this is and why it would not be detected by a film badge.

(2)

fission produces high speed neutrons this wouldn't be detected as it wouldn't interact with the photographic film

ResultsPlus
Examiner Comments

Although neutrons are identified for MP1, there is no indication that they are uncharged particles and so MP2 is not awarded.

ResultsPlus
Examiner Tip

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

(ii) In a nuclear power plant there may be other radiation present which would **not** be detected by a film badge.

Suggest what type of radiation this is and why it would not be detected by a film badge.

(2)

Positron emission - not detected as the positrons annihilate almost instantly with nearby electrons

ResultsPlus
Examiner Comments

This response gains both marks.

Question 16 (a)

In (i) the majority of candidates were familiar with the concept of red shift, and knew that this was due to the source receding. However, they often failed to appreciate that this is an effect only perceived by the observer. Some candidates referred to 'shifting to the red end of the spectrum' as opposed to increase in wavelength.

Part (ii) is a 'standard' question that candidates should have rehearsed in advance of the examination. Although the question required candidates to state that they would both measure and compare the emission spectra wavelengths, many candidates failed to discuss the experimental method required to make a red shift calculation. Details such as references to 'measuring', 'wavelength' and 'frequency' were often omitted and, all too often, candidates used ambiguous terms such as 'light' or 'spectral lines' without linking the relevant quantities of the equation to what had to be measured.

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

(2)

when the observed wavelength ~~from an~~ of radiation from an object is longer than its actual ~~waveleng~~ wavelength

*(ii) Explain how redshift can be used to determine the velocity of a galaxy relative to the Earth.

(3)

if the value for redshift is $z = \frac{\Delta\lambda}{\lambda}$ measure the change in wavelength from the object and calculate z and since $z \approx v/c$ the value for velocity of the galaxy can be found

ResultsPlus
Examiner Comments

In (i) the candidate gains MP1, but omits any reference to recession for MP2.

The brief description in (ii) gives just enough information for MP1 to be awarded.

ResultsPlus
Examiner Tip

Plan your answer to a question like this before you start to write. Planning your response will help you to write your answer out logically and with no omissions and a minimum of repetition.

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

(2)

RedShift, due to the doppler effect, is the ~~decrease~~ increase in wavelength of light (λ) emitted by a star travelling away from us. Making it appear '~~red~~ ~~shine~~ redder'. (as the light is 'stretched')

*(ii) Explain how redshift can be used to determine the velocity of a galaxy relative to the Earth.

(3)

Wavelength of element contained in stars spectral lines determined in lab. Wavelength of spectral lines of a ~~star~~ galaxy measured. Change in wavelength determined.

$\frac{\Delta\lambda}{\lambda}$ (change in wavelength / wavelength at lab's) $= \frac{v}{c}$ (relative velocity / speed of light) $= z$

$z \cdot c = v$

ResultsPlus

Examiner Comments

This response says enough for full marks to be awarded in both parts of the question.

Question 16 (b)

This is a straightforward enough question which most candidates answered very well. However, some candidates implied that 'standard candles' is a method to calculate distances, rather than 'standard candles' being objects used to enable distance measurements to take place.

(b) State what is meant by a standard candle.

(1)

This is a measure of luminosity of a Star. ~~of~~

ResultsPlus

Examiner Comments

This response indicates that a standard candle is a measurement scale rather than an object of known luminosity.

(b) State what is meant by a standard candle.

(1)

radiating stars that can be used to calculate ~~the~~ distances by comparing luminosities

ResultsPlus

Examiner Comments

This response does not include enough detail, as it is unclear that the standard candle has a known luminosity.

Question 16 (c)

This question was not answered well. While most candidates knew that an estimate for the age of the universe, $t = 1/H_0$, very few were able to explain (mathematically) why this was the case.

Those candidates who were astute enough to consider the dimensional analysis of Hubble's Law and how this may relate to time outlined the correct method very easily. Some candidates referred to finding the gradient on a velocity against distance graph to find H_0, but gave little indication as to why the reciprocal of this gradient should be the age of the universe.

(c) Explain how Hubble's law can be used to find a value for the age of the universe.

(2)

Using the relationship established by Hubble's law, Recession velocity is proportional to distance of the galaxies, we know that the constant is Hubble's constant which is $1/T_0$ where T_0 is the time since the galaxies first started moving apart as a result of the Big Bang. So $T_0 = \frac{1}{H_0}$ & $H_0 = \frac{V}{d}$.

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Examiner Comments

This response describes what Hubble's Law tells us, but says nothing worthy of credit for this particular question.

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Examiner Tip

Always relate your answers to the specific question given.

(c) Explain how Hubble's law can be used to find a value for the age of the universe.

(2)

The unit of Hubble's Constant is s^{-1} therefore the age of the universe in Seconds is $\frac{1}{H_0}$.

ResultsPlus

Examiner Comments

This response tries to justify the relationship between age of the universe and Hubble's constant by comparing units. Although a correct deduction is made, this is not an explanation and so does not score any marks.

(c) Explain how Hubble's law can be used to find a value for the age of the universe.

(2)

By $H_0 = \frac{v}{d}$, when $v = \frac{d}{t}$, $H_0 = \frac{d}{t} \times \frac{1}{d}$

$H_0 = \frac{1}{T}$

The age of the universe $= \frac{1}{H_0}$

ResultsPlus

Examiner Comments

Although there is detail missing from this response, there is a reasonable understanding of the process that must be applied.

Question 16 (d)

In (i) most candidates were familiar with the possible fates of the universe, but very few linked these to the critical density. Instead candidates preferred to use terms such as 'high density', 'low density', thus introducing much ambiguity into their answer. A common error included referring to open/closed/flat universe without mentioning what these terms mean with regard to universe expansion. Similarly, the use of terms such as 'big crunch' with no further explanation was relatively common. In extreme cases candidates did not incorporate average density into their statements at all.

In giving statement 2, it was a pity that some candidates were very much on the right lines, but omitted to state that the universe would continue to expand before it contracts; while in statement 3 some candidates omitted to state the final point in that the universe would stay at that size.

Unfortunately, some remembered some physics but got the 'greater' and 'less than' the wrong way round, suggesting recall rather than understanding.

In (ii) many candidates appreciated that the presence of dark matter was a source of uncertainty, but often failed to explain that it is the uncertainty in the *amount* of it that is crucial.

Alternative 2 in the mark scheme was the most common approach. For MP1, a minority of candidates stated that the amount of dark matter is uncertain, and for MP2 a small minority stated that dark matter has no interaction with electromagnetic radiation. However, it was more common to see references to dark matter being undetectable, which is not quite the same thing.

(d) Hubble's law is seen as one piece of evidence supporting the Big Bang theory of the origin of the universe. In this theory the universe has been expanding ever since it was created 14 billion years ago.

(i) Describe how you would expect the average density of matter in the universe to affect its ultimate fate.

(3)

the average density of matter effects the gravitational pull from the universe. If the average density is less than the critical density the universe is open (will expand forever). If the average density is more than the critical density, the universe is closed (will shrink - the big crunch) and if the average density = critical density, then the universe is flat, (will remain same size forever).

(ii) It is difficult for scientists to estimate the average density of the universe reliably. Explain why.

(2)

~~because the distances of galaxies are have large~~ ~~uncer~~ because there is a lot of dark matter which can't be seen as it doesn't emit electromagnetic radiation which changed the density of the universe as scientists can't account for it.

(Total for Question 16 = 13 marks)

ResultsPlus
Examiner Comments

In the response to (i) there is enough for MP1 and MP2 (although reference to the 'big crunch' is not very descriptive, the idea that the universe will shrink in size is clear). The final statement is not enough for MP3 to be awarded, although it comes close.

Part (ii) gains both marks via route 2 in the mark scheme.

ResultsPlus
Examiner Tip

Ensure that you always use appropriate specialist terminology when giving descriptive answers.

(d) Hubble's law is seen as one piece of evidence supporting the Big Bang theory of the origin of the universe. In this theory the universe has been expanding ever since it was created 14 billion years ago.

(i) Describe how you would expect the average density of matter in the universe to affect its ultimate fate.

(3)

If the average density of the universe is equal then it will stop expanding but won't ~~shrink~~ collapse. if its greater, the universe will expand, stop then collaspe in on itself. If its less, it will be open and keep on expanding forever

(ii) It is difficult for scientists to estimate the average density of the universe reliably. Explain why.

(2)

Because we cannot see nor measure the density of dark matter. Also since the universe is constantly expanding, the volume is impossible to say accurately.

ResultsPlus
Examiner Comments

This response seems to have been written in a hurry, with key words omitted from the description. Part (i) does not gain any marks, although part (ii) has enough for MP2 of route 2 in the mark scheme.

ResultsPlus
Examiner Tip

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

Question 17 (a) (i)

The majority of candidates were familiar the underlying equations, although some introduced an arbitrary minus sign during the derivation, not appreciating that it is present in the equation for the restoring force. When explaining the significance of the minus sign, the main omissions were candidates referring to 'displacement', rather than 'displacement from the equilibrium position'.

Candidates should understand that because displacement does not have to have a central datum point it is incorrect to state that 'force direction is in the opposite direction to displacement'. It is for this reason they must refer to the 'equilibrium' or 'rest' position.

Question 17 (a) (ii)

A large number of candidates were familiar with the underlying equations of SHM, however it was often not clear how they had determined that $w^2 = k/m$.

Some candidates who went wrong tried to fiddle their working to get to the final stated equation.

(a) (i) The trolley is displaced towards one of the supports through a distance x and then released. Show that the initial acceleration of the trolley when it is released is given by $a = -\frac{kx}{m}$ and explain the significance of the minus sign.

(2)

$F = ma \Rightarrow a = \frac{F}{m}$

$F = -kx$.

$\therefore a = \frac{-kx}{m}$

This shows that direction of acceleration is in the opposite direction to force.

(ii) Use the expression in (i) to show that the trolley will oscillate with a time period T given by

$$T = 2\pi\sqrt{\frac{m}{k}}$$

(3)

$T = \frac{1}{f} = \frac{2\pi}{\omega}$

$a = -\omega^2 x = -\frac{kx}{m}$

$\omega = \sqrt{\frac{k}{m}}$

$T = \frac{2\pi}{\sqrt{\frac{k}{m}}} = 2\pi \times \frac{1}{\sqrt{k/m}}$

$T = 2\pi\sqrt{m/k}$

ResultsPlus
Examiner Comments

In (i) there is enough for 1 mark, but the explanation of the significance of the minus sign is not enough for MP2.

In (ii) all 3 marks are clearly present.

ResultsPlus
Examiner Tip

In SHM displacement has to be from the equilibrium point.

Question 17 (b) (i)

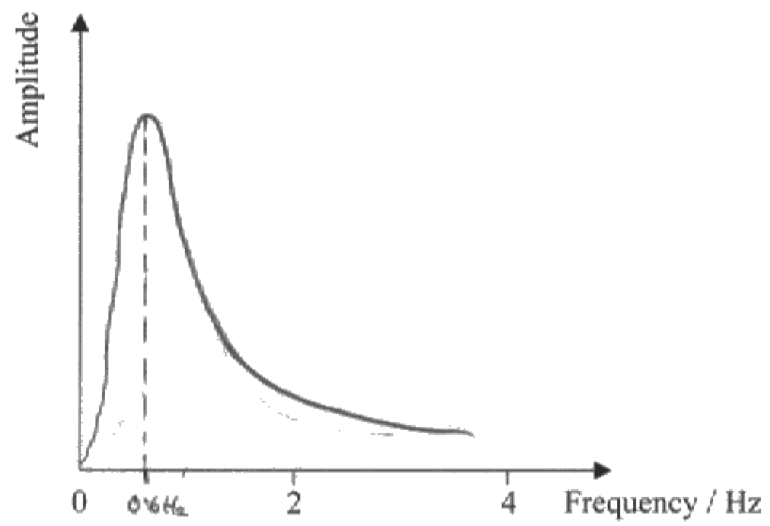
This was well answered, with the vast majority of candidates scoring full marks.

Question 17 (b) (ii)

Most candidates were familiar with the shape of this graph, and a very good number went on to correctly indicate 0.6 Hz as the frequency that the maximum amplitude would occur at. However, very few candidates indicated that the graph would have a sharp peak, with many drawing wide curves in spite of being told to ignore the effects of damping.

(ii) Sketch a graph to show how the amplitude of oscillation of the mass would vary with the frequency of movement of the building. Ignore the effects of damping.

(3)

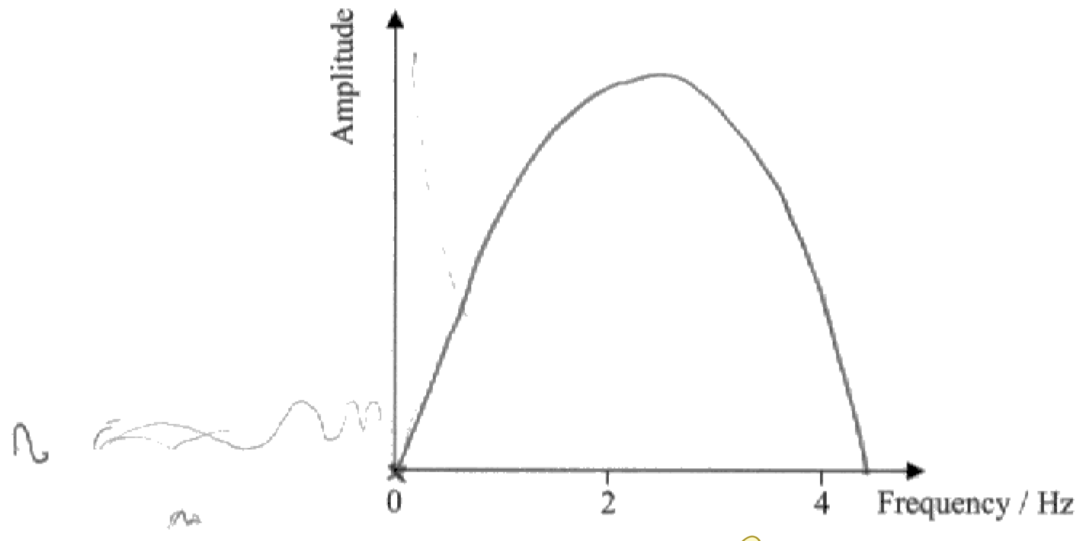


ResultsPlus
Examiner Comments

This is a well-drawn graph with a sharp peak at the correct frequency.

(ii) Sketch a graph to show how the amplitude of oscillation of the mass would vary with the frequency of movement of the building. Ignore the effects of damping.

(3)



ResultsPlus

Examiner Comments

This graph scores no marks. The shape is poor, and the peak does not correspond to 0.6 Hz.

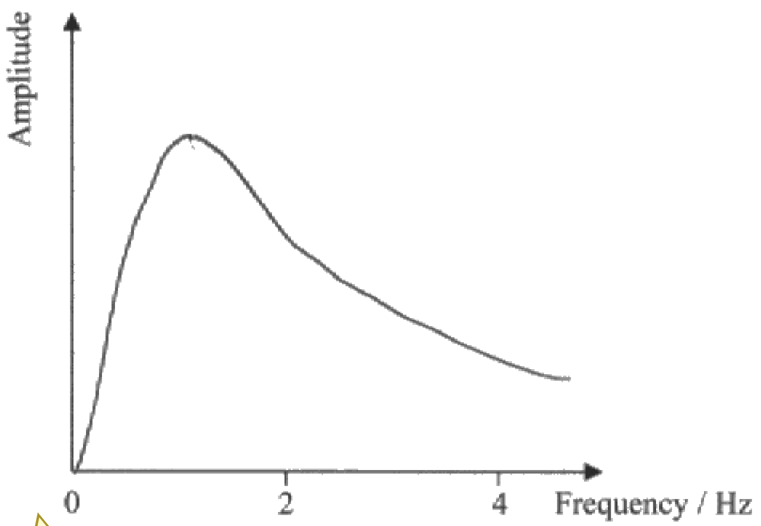
ResultsPlus

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.

(ii) Sketch a graph to show how the amplitude of oscillation of the mass would vary with the frequency of movement of the building. Ignore the effects of damping.

(3)



ResultsPlus

Examiner Comments

This scores 1 mark, as the peak is too broad and it doesn't correspond with 0.6 Hz.

Question 17 (b) (iii)

The vast majority of candidates understood the effects principle of damping on the amplitude of oscillation. Candidates often then went on to discuss this in terms of energy transfer, but often introduced ambiguity into their answers with vague statements (such as 'kinetic energy is transferred' rather than 'kinetic energy is transferred from the system to the surroundings'). Many did not refer to the mass/spring system at all so gave little evidence of understanding of what was happening in the context of the question. A few understood the idea of energy dissipation so got all 3 marks. The more able candidates were able to refer to energy being removed from the system, although most were not sure where the energy was been removed from.

(iii) In order to be effective the mass-spring system needs to be damped.

Explain what is meant by damping in this context and suggest why damping is a desirable feature of the mass-spring system in a tall building.

(3)

Damping is a resistive force exerted upon an oscillation to reduce the amplitude of oscillation. It is a desirable feature for a tall building because it stops it from resonating which would increase the amplitude.

ResultsPlus
Examiner Comments

This response gains MP1 for reduction in amplitude, but there is no reference to energy at all and so no further marks can be awarded.

ResultsPlus
Examiner Tip

Always base your explanations on physical principles.

(iii) In order to be effective the mass-spring system needs to be damped.

Explain what is meant by damping in this context and suggest why damping is a desirable feature of the mass-spring system in a tall building.

(3)

Damping removes energy from a oscillating system and decreases the amplitude of the oscillations and so it's desirable as the mass spring system removes energy from the building effectively due to the similar natural frequency and so the building oscillates less vigorously.

(Total for Question 17 = 14 marks)

ResultsPlus
Examiner Comments

There is enough here for MP1 and MP2, but it is not clear that energy must be dissipated and so MP3 is not awarded.

Question 18 (a) (i)

Given that candidates were provided with a very clear diagram this was not answered as well as expected. The most common errors were using ^{1}H instead of the isotopes of tritium and deuterium, and an 'inverted equation' with nucleon (mass) numbers written on the bottom line and proton (atomic) numbers on the top line.

Question 18 (a) (ii)

Although this should have been a straightforward calculation there was evidence of a lot of poor arithmetic. This included incorrect subtractions and only working out one side of the equation. A large proportion of candidates did not know what to do with the c^2, and so multiplied the result of their subtraction with it to obtain an impossibly large answer.

Question 18 (a) (iii)

Many candidates correctly identified that momentum was conserved and knew that the smaller mass of the neutron was crucial to the answer. However, many failed to relate this to a relevant equation, and so failed to score more marks.

(iii) Explain why most of the energy released in the fusion of one deuterium nucleus with one tritium nucleus is transferred to kinetic energy of the neutron.

(3)

This is to conserve momentum. As the helium ~~nucleus~~ nucleus has much greater mass (four times the mass of the neutron), so to conserve momentum (and energy) the neutron must have a high velocity ~~[illegible]~~ ($\Sigma p_{initial} = \Sigma p_{final}$). Therefore, as the velocity of the neutron is high, its kinetic energy is high ($E_k \propto v^2$), thus conserving momentum and energy.

ResultsPlus

Examiner Comments

This is a good response and gains all 3 marks.

(iii) Explain why most of the energy released in the fusion of one deuterium nucleus with one tritium nucleus is transferred to kinetic energy of the neutron.

(3)

The momentum before must be equal to the momentum after-wards, total momentum must be conserved. Therefore the energy that is released is transferred to the kinetic energy of the neutron because it has the smallest mass and so will need a greater speed to concerve the momentum.

ResultsPlus
Examiner Comments

This says enough to gain MP1 and MP2, but omits a reference to kinetic energy depending upon velocity squared and so misses out on MP3.

ResultsPlus
Examiner Tip

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

(iii) Explain why most of the energy released in the fusion of one deuterium nucleus with one tritium nucleus is transferred to kinetic energy of the neutron.

(3)

- Neutron is lighter than helium.
- As total momentum must be conserved, the neutron moves faster.
- It must therefore have greater kinetic energy.

ResultsPlus
Examiner Comments

This response illustrates a fairly typical way in which MP2 and MP3 can be lost.

Question 18 (b)

A very well answered question. Most candidates were able to use the equation $t_{½}$ = ln2/l to determine the decay constant, and most then went on to use the exponential relationship for decay to gain 1 mark. Some candidates incorrectly determined a value of N/N_0 of about 0.9, hence missing out on the mark for the final answer. Many candidates gave themselves extra work by converting to seconds and then back again. This sometimes introduced calculation errors into the solution.

Question 18 (c)

This question was not answered well, with most of the answers seemingly prepared from previous papers. An award of full marks was very unusual for this question. Whilst most candidates were familiar with the process of nuclear fusion they were often unfamiliar with it outside the context of stellar nucleosynthesis, and thus often were not awarded marks due to a lack of relevant detail.

Some candidates provided a stock answer relating to a fission reactor and many failed to see that a chain reaction was not possible in a fusion reactor. Only the more able candidates talked about containment.

When marks were awarded it was usually for 'very high temperature' and 'strong magnetic fields'.

*(c) The article states that "it would be inherently very safe, and would not produce any significant radioactive waste."

Comment on this statement and outline the technical difficulties of producing a practical nuclear fusion reactor.

(5)

The amount of radioactive waste produced would be quite small compared to the amount of energy that is made. In order for fusion to occur the reaction will need very high temprature pressure and density. The ~~ver~~ high temprature helps the nuclei to ~~ver~~ over come the large electrostatic repulsions. the density & pressure helps to maintain a high collision rate. The main techincal difficulties include confinement issues. ~~&~~ Heat would be lost when ~~the~~ it in contanct with the container and the process would also need very strong magnetic fields which are hard to produce.

(Total for Question 18 = 15 marks)

ResultsPlus
Examiner Comments

The 2 marks awarded for this response are for MP3 and MP4. There is a reference to heat being lost if the plasma were to touch the container walls, although the key result (that temperature would fall) is not mentioned. References to the need for a high collision rate and overcoming the large electrostatic forces between nuclei repeat marking points from previous mark schemes for different questions, and do not relate to the context given here.

ResultsPlus
Examiner Tip

Try to relate questions to theory relevant to the context.

*(c) The article states that "it would be inherently very safe, and would not produce any significant radioactive waste."

Comment on this statement and outline the technical difficulties of producing a practical nuclear fusion reactor.

(5)

- No significant radioactive waste would be produced, only the Helium and neutrons.
- Would be safe as there is no possibility of meltdown through a chain reaction as fusion is a controlled process.

Nuclear fusion reactor requires extremely high temperatures and pressures to function, containing this whilst harvesting the energy is extremely difficult due to materials not being able to withstand these temperatures & pressures

(Total for Question 18 = 15 marks)

ResultsPlus
Examiner Comments

This response says enough for the first 3 marking points, although the issue of containment is not explored in sufficient detail for any further marks to be awarded.

Paper Summary

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

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

Grade Boundaries

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

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

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