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Examiners' Report
June 2015

IAL Physics WPH05 01

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Introduction

The assessment structure of WPH05 mirrors that of other units in the specification. It consists of 10 multiple choice questions, a number of short answer questions and some longer, less structured questions. As an A2 assessment unit, synoptic elements are incorporated into this paper. There is overlap with circular motion and exponential variation in Unit 4, as well as overlap with some of the AS content from Units 1 and 2.

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 11(b)-(c), 12(b)-(c), 13(a)(ii), 14(a)(b), 15(b), 16(c), 17(a)(iii), 17(b) and 18(c)(ii) 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. Some very good responses were seen for such questions, with accurate solutions which were clearly set out. Occasionally in calculation questions the final mark was lost due to a power of 10 error. In general, candidates were able to give correct units for quantities that they calculated. Most candidates understood the convention that in the "show that" questions 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 were examples of candidates disadvantaging themselves by not actually answering the question, or by not expressing themselves using suitably precise language. This was particularly the case in extended answer questions such as 11(b), 14(b), 17(b)(ii) and 18(c)(ii) where candidates sometimes had knowledge of the topic, but could not express it accurately and succinctly.

Some candidates have problems in appreciating the magnitudes of calculated values, as in 17(a)(ii). Similarly, scientific terminology was used imprecisely and incorrectly in a number of responses seen on this paper. In 14(b) there was confusion demonstrated between atoms, molecules, and nuclei. At A2 level it is to be expected that, where candidates use such terms, they do so with accuracy.

Some candidates did not spend enough time reading the question before they started to write their answer. In question 14(b) many candidates gave a description of the fusion process as it applies to a man-made reactor, rather than targeting their response towards fusion in a star.

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

The response to the multiple choice questions was generally good with 7 of the questions having 60% or more correct answers and none with less than 50% correct answers. In order of highest percentage correct they were: Q7 (86%), Q9 (70%), Q8 (69%), Q6 (65%), Q2 (64%), Q1 (62%), Q4 (61%), Q9 (57%), Q10 & Q5 (56%).

Question 11 (a)

Surprisingly, quite a few candidates got this wrong. The most common error was to use a proton number of +1 instead of −1 for the beta particle. Another common mistake was to get the 0 and -1 the wrong way round.

Question 11 (b)

Candidates often failed to gain marks because they couldn't find the right language to differentiate between the penetrating powers and ionising ability for the two types of radiation.

Some candidates stated that gamma radiation had no ionising ability, and many candidates didn't mention ionisation at all. However it was common for 1 mark to be awarded for a comparison of beta and gamma radiation.

A small number of candidates were totally confused and tried to discuss the ionising power of the nickel nucleus. Similarly a number of candidates made (correct) references to alpha radiation, which was not a part of the question.

(b) State, with a reason, the penetrating powers of each of the two types of radiation emitted by the cobalt-60.

(2)

Penetrating power of beta radiation is lower than the penetrating power of gamma radiation, because beta ~~rad~~ particles have more ionising power than gamma ~~particles~~ rays

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Examiner Comments

This response scored 1 mark. The candidate gives a comparison between beta and gamma radiation, but the individual penetrating powers are not stated.

ResultsPlus
Examiner Tip

Be specific and use technical physics terms wherever possible.

(b) State, with a reason, the penetrating powers of each of the two types of radiation emitted by the cobalt-60.

(2)

Beta particles can penetrate to few metres in air and can be blocked by few cm of ~~lead~~ aluminium

Gamma rays penetrate to longer distance in air and penetrate through ~~alum~~ ~~most~~ many mediums, blocked by few metres of lead.

ResultsPlus

Examiner Comments

This response does not score any marks. Although the candidate refers to the penetrating power of each type of radiation, the ranges given are inaccurate. There is no reference to ionising power at all.

(b) State, with a reason, the penetrating powers of each of the two types of radiation emitted by the cobalt-60.

(2)

Gamma rays do not ~~its~~ ionise much (poor ionising power) so loses less energy so has a high penetrating power. (infinite)

Beta particles are moderately ionising, so loses some energy due to ionisation to the other particles, so has a moderate penetrating power. (about 1m – 10m in air)

ResultsPlus

Examiner Comments

Despite suggesting that the penetrating power of gamma radiation is infinite, this response is worth 2 marks.

Question 11 (c)

Most answers were given in terms of ionising cells or mutating DNA, but in too many responses the risk was related simply to ‘cells’ and so it was not clear whether they were talking about cancer cells or healthy cells.

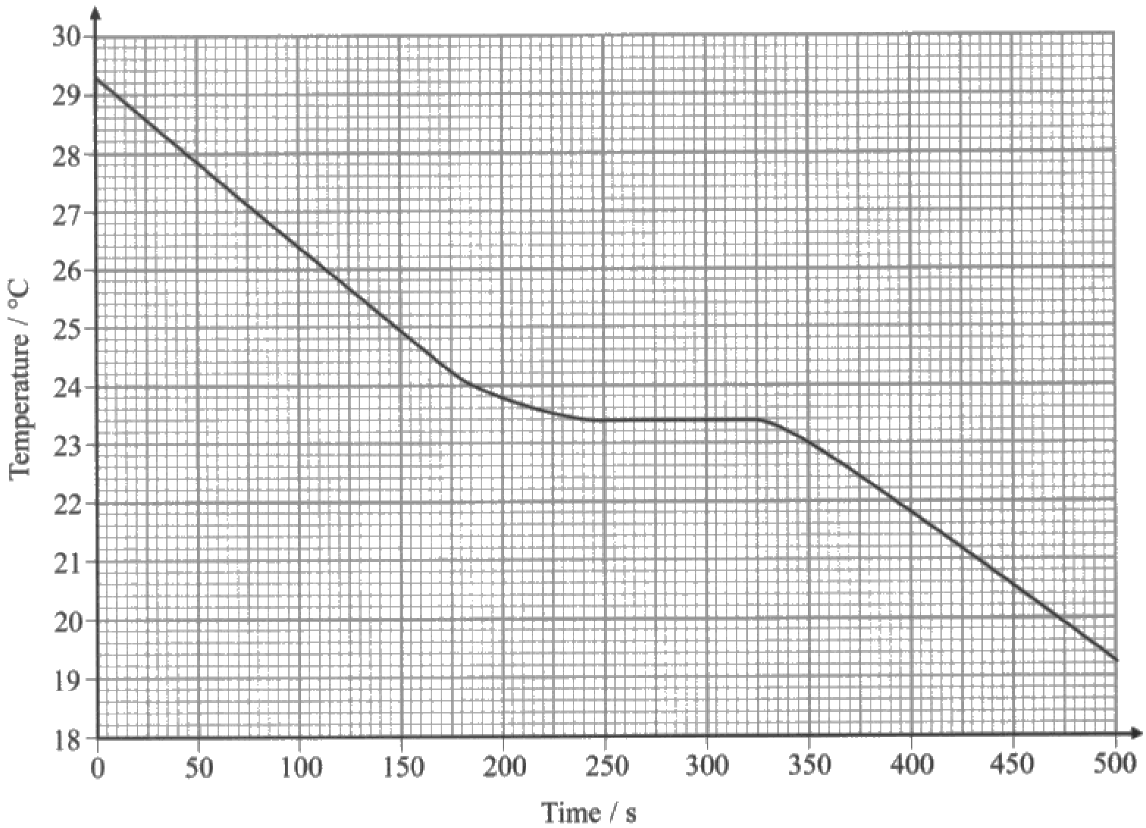
Question 12 (a)

Almost all candidates made a good attempt at this question, although some didn't use the correct section of the graph, considering a temperature decrease over too large a range of time (i.e beyond the linear part of the curve).

Some of those who used the correct part of the graph sometimes used such a small section that their answer was out of the acceptable range. Only a small number of candidates extrapolated the straight line section of the graph so that they could calculate a more accurate value for the gradient. A small number of candidates did not know which section to use and so they carried out the calculation twice, averaging the result from the two slopes. Some converted the temperature difference in °C into K for no obvious reason.

12 A student investigated the properties of chocolate. He heated 0.75 kg of chocolate until it was a few degrees above its melting point. He then used a temperature sensor connected to a datalogger to monitor the temperature of the chocolate as it cooled in cold surroundings.

The rate at which thermal energy was transferred from the chocolate to the surroundings was approximately constant over the temperature range shown in the graph below.



(a) Use the graph to show that the rate at which thermal energy was transferred from the liquid chocolate was about 50 W.

specific heat capacity of liquid chocolate = 2500 J kg^{-1} K^{-1}

(3)

$E = mc\Delta T$

$= 0.75 \times 2500 \times (29.3 - 24.2)$

$= 9562.5$ J

$P = \frac{W}{t} = \frac{9562.5}{175}$

$= 54.6$ W

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Examiner Comments

This is a good answer, scoring all 3 marks.

Question 12 (b)

Candidates knew that the temperature was constant and that the chocolate was changing state but it was rare to find a response that linked this with the fact that energy was still being transferred from the chocolate. Candidates frequently answered the question 'describe' rather than 'explain' the shape of the graph.

A good number who did think about energy transfer often suggested that energy was supplied to the chocolate and linked the absorption of energy with bond formation or an increase in potential energy. Perhaps some candidates were more familiar with heating a substance than letting it cool, as a good number seemed to think that the chocolate was melting at this point.

(b) Explain the shape of the graph between 250 s and 330 s.

(2)

The temperature is ~~conta~~ constant in this region

No energy was transfered in ~~this~~ during part

ResultsPlus
Examiner Comments

This a response scoring zero, typical of those candidates who thought that there was no energy transfer if the temperature stayed constant.

(b) Explain the shape of the graph between 250 s and 330 s.

(2)

The chocolate at this point is becoming solid. The energy transferred ~~given out~~ by the chocolate molecules to the surroundings is removed from their potential energies. Their kinetic energy which is proportional to their temperature doesn't change, hence temperature is constant. So energy is transferred ~~emitted~~ to ~~reduce~~ ~~increase~~ decrease the potential energies of the molecules, so that they will solidify, by coming even closer together at fixed positions

ResultsPlus
Examiner Comments

This is a response worthy of both marks, as the candidate clearly understands the processes that are occurring.

ResultsPlus
Examiner Tip

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

Question 12 (c)

Candidates had a poor understanding of specific heat capacity and often had not realised that the chocolate was cooling and solidifying in this question. Many scandidates were able to identify that the temperature difference between the chocolate and surroundings was less, but not all could describe the effect of this on the rate of energy transfer.

Many candidates could only state that the temperature difference with the surroundings had reduced, but some candidates thought that this was because the cooling chocolate had raised the temperature of the surroundings. Some talked about "thermal equilibrium" without mentioning the link between the temperature of the chocolate and that of the surroundings.

Those who thought about specific heat capacity were just as likely to say that it was less for the solid.

(c) During the last 100 s of cooling the temperature fell at a lower rate than during the first 100 s of cooling.

Suggest why this is the case.

decrease slowly.

→ move slower, **(2)**

Solid chocolate has higher specific heat capacity than liquid chocolate. Therefore, more energy is released for the temperature of solid chocolate to fall by 1 K. As the rate of thermal energy trasfer is constant, the temperature falls slower. ~~hence~~

(Total for Question 12 = 7 marks)

energy gain → break bond

energy loss → formed bond.

ResultsPlus
Examiner Comments

The candidate has interpreted the graph correctly and made both points from the first marking scheme, hence scoring 2 marks.

(c) During the last 100 s of cooling the temperature fell at a lower rate than during the first 100 s of cooling.

Suggest why this is the case.

(2)

The temperature difference of the chocolate and the surroundings in the last 100s is less than that of the fast 100s hence energy is dissipated to the surrounds from the chocolate at the last 100s at a ~~lower~~ lower rate thus temperature also fell at a lower rate.

(Total for Question 12 = 7 marks)

ResultsPlus

Examiner Comments

The response includes both points from the alternative marking scheme, and so is worth 2 marks. The idea of rate of energy transfer is clearly expressed.

Question 13 (a) (i)

This was generally well answered, although a common mistake was not to specify the nucleus, or to say 'when a nucleus will decay'. Marks were also lost through the use of atoms, particles, nuclides instead of nucleus.

Question 13 (a) (ii)

It was very rare to see 'average' or 'mean'. Most candidates seemed not to have upgraded their understanding of half-life since GCSE. A small number constructed their answer around a decay in the mass of the sample.

Question 13(b) (i)

This was well answered. Occasionally candidates lost one mark because they only quoted their answer to 2 significant figures when they should have used 3 or more.

(b) A sample containing 7.30×10^{19} atoms of technetium-99m is prepared for use in a medical application.

(i) Show that the activity of the sample when it is prepared is about 2.3×10^{15} Bq.

(3)

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

$= \frac{\ln 2}{2.16 \times 10^4}$

$= 3.21 \times 10^{-5}\ s^{-1}$

$\therefore A = -\lambda N$

$= -3.21 \times 10^{-5} \times 7.30 \times 10^{19}$

$= -2.3 \times 10^{15}$ Bq

$A = 2.3 \times 10^{15}$ Bq.

ResultsPlus
Examiner Comments

Although the calculations are clearly outlined, the final answer is only given to 2 significant figures, hence this response only gains 2 marks.

ResultsPlus
Examiner Tip

In a "show that" question your final answer must be given to at least one more significant figure than the value given in the question.

Question 13 (b) (ii)

The majority of candidates scored 2 marks. However, for some candidates there was confusion between λ and half-life as well as between N and A (= dN/dt), with many using N_o for A_o.

Despite being given 1 day in seconds in the question, too many candidates attempted their own conversion, often unsuccessfully. Some candidates forgot to write down the correct unit (Bq or s^{-1}) with their answer.

(ii) Calculate the activity of the sample 1 day after the sample was prepared.

1 day = 86 400 s

(2)

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

$A = 2.34 \times 10^{15} e^{-3.21 \times 10^{-5}(86400)}$

$A = 2.34 \times 10^{15} \times 0.0624$

Activity of sample after 1 day = 1.46×10^{14} Bq

ResultsPlus

Examiner Comments

Using the exponential decay equation, the candidate obtains the correct answer and scores full marks.

(ii) Calculate the activity of the sample 1 day after the sample was prepared.

1 day = 86 400 s

(2)

$2.34 \times 10^{15} \xrightarrow{21600s} 1.17 \times 10^{15} \xrightarrow{21600s} 5.85 \times 10^{14} \xrightarrow{21600s} 2.93 \times 10^{14} \xrightarrow{21600s}$

1.46×10^{14}

Activity of sample after 1 day = 1.46×10^{14} Bq

ResultsPlus

Examiner Comments

The candidate has realised that 1 day is exactly 4 half-lives and so they have obtained the correct final answer without using the exponential equation. This method still scores full marks.

(ii) Calculate the activity of the sample 1 day after the sample was prepared.

1 day = 86 400 s

(2)

~~$2.34 \times 10^{15} = Ae^{-3.21 \times 10^{-5} \times 86400}$~~ $A = 2.34 \times 10^{15} e^{-3.21 \times 10^{-5} \times 86400}$

$\Rightarrow A = 1.46 \times 10^{14}$

Activity of sample after 1 day = 1.46×10^{14}

ResultsPlus

Examiner Comments

In this response the final answer is correct, but the units have been omitted. Hence this scores just 1 mark.

ResultsPlus

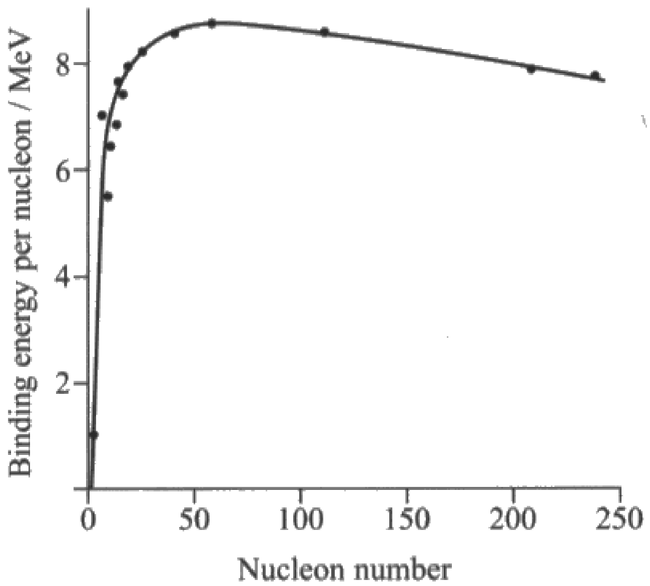
Examiner Tip

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

Question 14 (a) (i)

This was poorly answered, with most students just stating it was the energy that holds the nucleus together. Many answers gave the impression that energy would be required to form the nucleus. Some simply referred to mass defect or were unable to use both the terms nucleus & nucleons correctly.

14 The graph shows how the binding energy per nucleon varies with nucleon number for a range of nuclides.



(a) (i) State what is meant by the binding energy of a nucleus.

(1)

The minimum energy required to break a nucleus into it's constituent nucleons.

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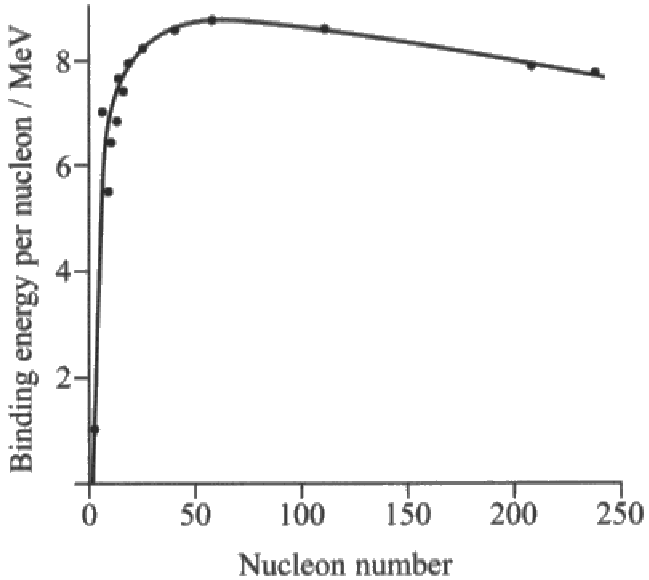
Examiner Comments

This is a good response and gets the mark.

14 The graph shows how the binding energy per nucleon varies with nucleon number for a range of nuclides.



(a) (i) State what is meant by the binding energy of a nucleus.

(1)

Energy needed to hold the nucleus together

ResultsPlus
Examiner Comments

This is a fairly common response that has completely the wrong idea about binding energy. Energy is confused with force, and there is the suggestion that energy has to be provided for the nucleus to form. Responses such as this scored zero marks.

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Examiner Tip

Learn the definitions of standard terms that occur in the specification.

Question 14 (a) (ii)

This question was poorly answered with most students misunderstanding the point of the question. In those answers where binding energy was discussed it often wasn't linked to a release in energy, nor was there a reference to per nucleon.

Typical common responses that in no sense address the question were 'Light nuclei have lower binding energy so need less energy to form' and 'Light nuclei combine to become more stable because they have higher binding energy'. Only the better answers referred accurately to binding energy per nucleon. Candidates rarely stated explicitly that B.E. per nucleon needs to increase in order to release energy but simply reiterated the stem of the question.

Quite often candidates saw the word fusion and gave an answer which was unrelated to the question.

(ii) Explain why nuclear fusion is only viable as an energy source if light nuclei are used.

(2)

when 2 light nuclei join together or fuse together to produce a much heavier one, the heavier nucleus has a higher binding energy per nucleon and so energy is released since the mass of the heavy nucleus is less than the mass of the 2 light nuclei. Fusion beyond iron isn't thermodynamically feasible since the binding energy per nucleon decreases ∴ you would have to put in energy to fuse elements beyond iron.

ResultsPlus
Examiner Comments

This is a response worthy of both marks, as the candidate clearly understands the processes that are occurring.

(ii) Explain why nuclear fusion is only viable as an energy source if light nuclei are used.

(2)

Beyond iron-56 the binding energy per nucleon decreases. So, energy is required for the ~~a~~ nuclei to fuse.

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Examiner Comments

This response almost says enough for 2 marks. The first marking point is made, but there is not quite enough for the second marking point to be awarded. The candidate needed to specify what they meant by "beyond iron-56", as it's not clear if this is the limit for the nuclei fusing, or for the fused nucleus.

Question 14 (b)

In general the answers seen tend to indicate that this process is not well understood. Most answers had parts of several of the marking points but they could not pull together the complete argument to score.

Students had clearly learned responses for MP1 & 3 but they often failed to score marks. For MP1 this was usually for failing to mention nuclei (a significant number referred to molecules) or kinetic energy, for MP3 it was usually the lack of sufficiency in the answer that lost them the marks. Few referred to MP2. There were many jumbled attempts at MP4 but few were accurate enough.

In general students confused / mixed the terms pressure and density, so the use of pressure in place of density was common eg 'there must be high pressures to create sufficient rate of collision'.

Some candidates were clearly confused with a fusion reactor, and referred to high magnetic fields required and collisions with the walls of the container reducing temperature and energy.

*(b) Outline the conditions necessary for viable fusion to occur and explain why the interiors of stars are ideal for this.

(4)

• ~~Hig Exter Extremely high temperatures and deni high density is req~~ • Extremely high temperatures needed so that reacting positive nuclei have enough Kinetic energy to overcome repulsive forces and come closer together for fusion to occur.

• High density ~~&~~ of the reacting material is required ~~as~~ so that the collision rate is sufficient to maintain the fusion reaction.

• Star interiors have ~~very~~ extremely high temperatures as gravitational collapse caused gravitational potential energy to be converted to Kinetic energy.

• Since the core ~~is o~~ has a ~~very~~ small volume and lots of masses, so the density is very high which can ~~maintain the coll~~ provide sufficient collision rate to maintain the fusion reaction.

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Examiner Comments

This is a good example of a response worth full marks. Note how the candidate has sketched a list of things to include below their answer.

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Examiner Tip

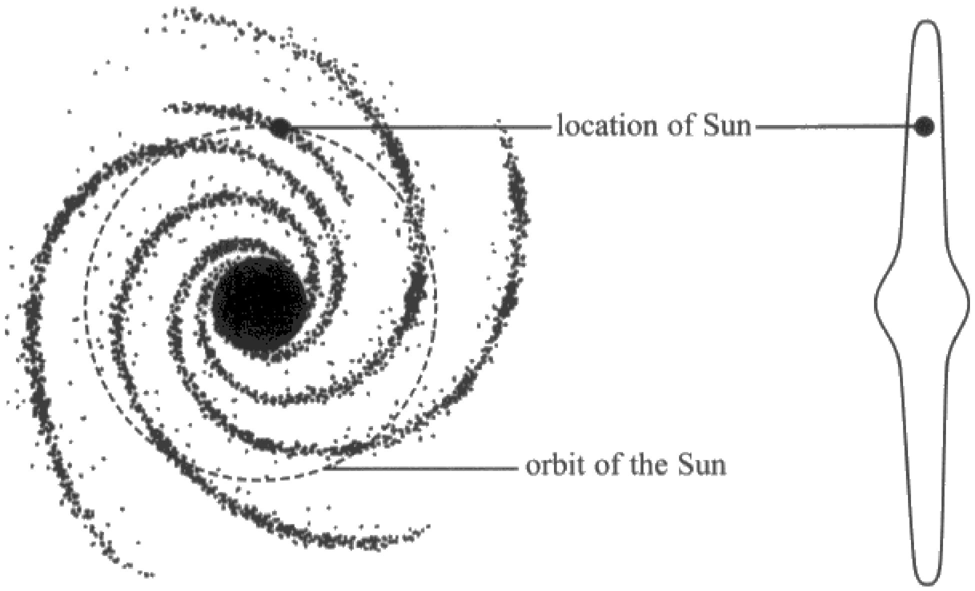
Plan your answer to a question like this before you start to write, and ensure that you always use appropriate specialist terminology when giving descriptive answers.

Question 15 (a)

Many good answers to this question were seen. The most common reason for not getting the correct answer was not to square the velocity, although some candidates made a power of ten error because they did not change kms^{-1} to ms^{-1}.

15 The Sun is a typical star in our galaxy, the Milky Way. It is 2.5×10^{20} m from the centre of the galaxy. The Sun orbits the centre of the galaxy at a speed of 220 km s^{-1}.

The diagrams below represent the Milky Way. The central black area represents a very high density of stars, known as the nucleus of the galaxy. The total mass of stars within the orbit of the Sun may be treated as a point mass at the centre of the galaxy.



Face-on view   Side-on view

(a) Calculate the mass of the Milky Way within the orbit of the Sun.

(3)

$$F = \frac{Gm_1m_2}{r^2} = \frac{m_1V^2}{r}$$

$$\frac{Gm_2}{r} = V^2$$

$$\frac{6.67\times10^{-11}\times m_2}{2.5\times10^{20}} = (220\times10^3)^2$$

$$m_2 = 1.81\times10^{41}\ kg$$

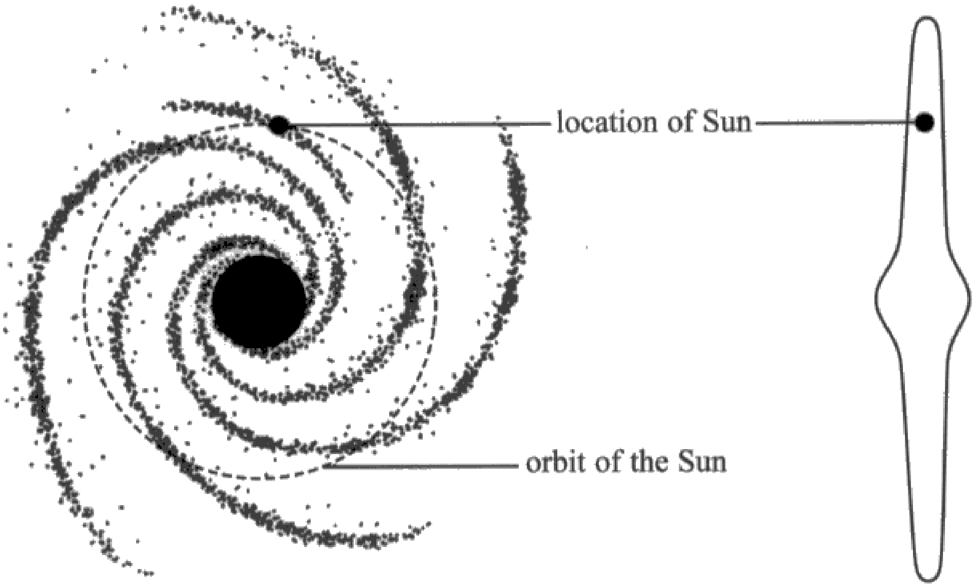
Mass = 1.81×10^{41} kg

ResultsPlus
Examiner Comments

This is a good response and scores 3 marks.

15 The Sun is a typical star in our galaxy, the Milky Way. It is 2.5×10^{20} m from the centre of the galaxy. The Sun orbits the centre of the galaxy at a speed of 220 km s^{-1}.

The diagrams below represent the Milky Way. The central black area represents a very high density of stars, known as the nucleus of the galaxy. The total mass of stars within the orbit of the Sun may be treated as a point mass at the centre of the galaxy.



Face-on view

Side-on view

(a) Calculate the mass of the Milky Way within the orbit of the Sun.

(3)

$$\frac{GM_1M_2}{r^2} = \frac{M_2 v^2}{r}$$

$$\frac{GM_1}{r^2} = \frac{v^2}{r} \qquad M = \frac{220^2 \times 2.5\times10^{20}}{6.67\times10^{-11}}$$

$$v^2 r^2 = GM_1 r \qquad M_{galaxy} = 1.81\times10^{35} \text{ Kg}$$

Mass = 1.81×10^{35} Kg

$$\frac{v^2 r^2}{Gr} = \frac{v^2 r}{G} = M_1$$

ResultsPlus
Examiner Comments

This would have been a good response, but it only scores 2 marks as the candidate has not converted the speed into SI units.

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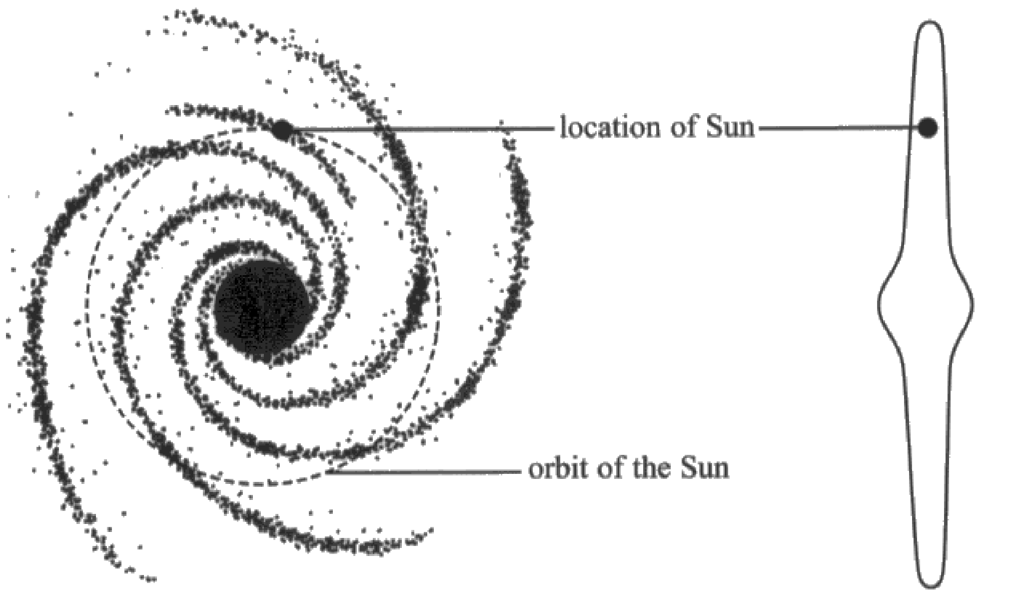
Examiner Tip

Check carefully for SI units when substituting into equations.

15 The Sun is a typical star in our galaxy, the Milky Way. It is 2.5×10^{20} m from the centre of the galaxy. The Sun orbits the centre of the galaxy at a speed of 220 km s^{-1}.

The diagrams below represent the Milky Way. The central black area represents a very high density of stars, known as the nucleus of the galaxy. The total mass of stars within the orbit of the Sun may be treated as a point mass at the centre of the galaxy.



Face-on view | Side-on view

(a) Calculate the mass of the Milky Way within the orbit of the Sun.

(3)

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

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

$GM = v^2 r$

$M = \frac{v^2 r}{G} = \frac{220 \times 10^3 \times (2.5 \times 10^{20})}{(6.67 \times 10^{-11})}$

Mass = 8.25×10^{35} kg

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Examiner Comments

Although the candidate has written the equation correctly, they have not squared the velocity when they have substituted.

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Examiner Tip

Check carefully for indices when substituting into equations.

Question 15 (b) (i)

Those who tried to follow on from the previous question by referring to $v^2 = GM/r$ failed to address what happens to *M*. It was rare for a candidate to make the point that the Mass of the Milky Way stays constant. Some did score both marks, usually by saying that *GM* is a constant.

In scheme 1 some candidates were confused into thinking that *M* was the mass of the Sun and not the mass of the Milky Way nucleus. In scheme 2 candidates got the equation and said that *F* decreased and *r* decreased, but not that the decrease in *F* was greater. The idea common to both schemes relating to a quantity's change being smaller / larger than another corresponding change proved to be too difficult for most candidates.

(b) (i) The vast majority of stars in the Milky Way are observed to be within the nucleus of the galaxy.

$r\uparrow$ $\quad F = \frac{mv^2}{r}$ $\quad g = mv^2$

Explain why it might be expected that stars similar to the Sun, but further away from the centre of the galaxy, would orbit at a lower speed than the Sun.

(2)

$F = \frac{mv^2}{r} = \frac{GMm}{r^2}$ $\therefore v^2 = \frac{GM}{r}$ where G and M (mass) are constant, hence $v^2 \propto \frac{1}{r}$. ~~Since~~ Hence the similar stars to the Sun have a greater radius they have a lower ~~sp~~ speed than the Sun.

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Examiner Comments

This is a response worthy of both marks, as the candidate clearly understands the factors that are important.

(b) (i) The vast majority of stars in the Milky Way are observed to be within the nucleus of the galaxy.

Explain why it might be expected that stars similar to the Sun, but further away from the centre of the galaxy, would orbit at a lower speed than the Sun.

(2)

Ans:- ~~$V = \frac{2\pi r}{T}$~~ $V^2 = \frac{GM}{r}$, From the equation, it can be seen that, as the radius increases, the speed ~~⇒ As the radius of orbit increases,~~ would ~~decr~~ decrease.

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Examiner Comments

The candidate has referred to a useful equation, but they have not said anything about the mass. Therefore this response only gets credit for the first marking point.

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Examiner Tip

When drawing conclusions ensure that you take all relevant factors into account.

Question 15 (b) (ii)

This question returned some creative but usually incorrect answers. There were a lot of irrelevant responses, and a number referring to the expansion of the galaxy. Surprisingly, not many candidates recognised the idea that the mass of the galaxy could be greater than expected. The most common way of obtaining a mark was the mention of dark matter. Those who did mention dark matter often didn't make a link to the mass of the galaxy being greater than expected.

Many candidates failed to understand the question and had possibly never heard of dark matter. A number thought the galaxy and the universe were the same thing. Quite a few candidates latched onto trigger words and wrote down what they knew about Doppler shift or open/closed universe.

(ii) Stars similar to the Sun, but further away from the centre of the galaxy, are actually observed to have orbital speeds that are all approximately the same as the Sun's.

Explain what astronomers can conclude from these observations.

(2)

The mass of Milky Way is greater than calculated value. ~~This give~~ There is dark matter present which doesnot emit light ~~but~~ but has a gravitational attraction with other astronomical object in the galaxy

ResultsPlus
Examiner Comments

This is a response worthy of both marks, as the candidate clearly understands the significance of the data provided.

(ii) Stars similar to the Sun, but further away from the centre of the galaxy, are actually observed to have orbital speeds that are all approximately the same as the Sun's.

Explain what astronomers can conclude from these observations.

(2)

There must be more mass in the Milky Way than is apparent. This hidden mass attracts those stars and gives them the centripetal acceleration required to spin at similar orbital speeds.

ResultsPlus
Examiner Comments

This is a response which scores 1 mark, as the candidate refers to "hidden mass" rather than the technical term, "dark matter".

ResultsPlus
Examiner Tip

Know and use technical words correctly.

(ii) Stars similar to the Sun, but further away from the centre of the galaxy, are actually observed to have orbital speeds that are all approximately the same as the Sun's.

Explain what astronomers can conclude from these observations.

(2)

There must be matter that we cannot observe using ~~visible~~ EM radiation in the universe ie. dark matter. Or that the Milky way is contracting. Or that the universe is expanding and distant stars are travelling faster away from us.

ResultsPlus
Examiner Comments

This response makes the point that there must be matter in the galaxy that cannot be observed (dark matter), but then goes on to give a number of irrelevant alternatives.

ResultsPlus
Examiner Tip

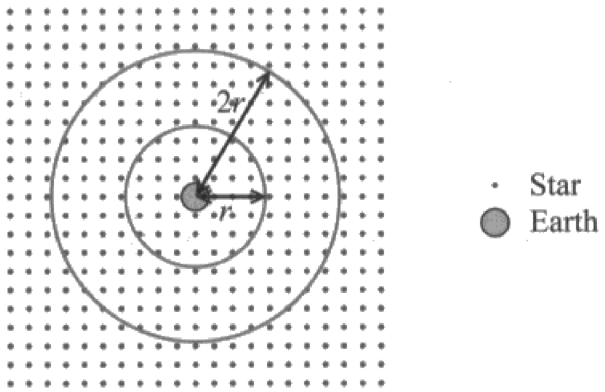
Planning your response will help you to write your answer out logically and with no omissions and a minimum of repetition.

Question 16 (a)

Candidates found it very hard to describe concisely what is going on. Those who appreciated the fourfold increase in number of stars were usually able to gain both marks. Most appreciated the inverse square nature of the change in flux, but only the best candidates answered the question with clarity. Those who approached it algebraically usually scored better than those who tried to explain their reasoning.

16 In the early 19th century, Heinrich Olbers asked the question, "Why is the night sky dark?" He reasoned that in an infinite universe light from very distant stars should make the whole of the visible sky bright.

To see how much distant stars contribute to light reaching the Earth, the universe can be modelled as a uniform distribution of identical stars. If this universe is divided into a series of thin concentric 'shells' centred on Earth, there will be a certain number of stars on each shell.



The diagram shows two shells of equal thickness at distances r and $2r$ from the centre of the Earth.
There are four times as many stars on the shell at $2r$ than on the shell at r.

(a) Explain why the total radiation flux received at the Earth from the stars on each shell is the same.

(2)

$F = L/4\pi d^2$ if there are 4x the numer of stars theres 4x the Luminocity $\therefore$ $F = 4L/4\pi(2d)^2$

$= 4L/4\pi 4d^2$ cancel out 4π $\Rightarrow$ $= 4L/4d$ $\therefore$ $F = L/d^2$

$\therefore$ the ~~ratio of~~ flux is the same in each ring.

ResultsPlus

Examiner Comments

This response presents a logical argument using algebra, and so is worth 2 marks.

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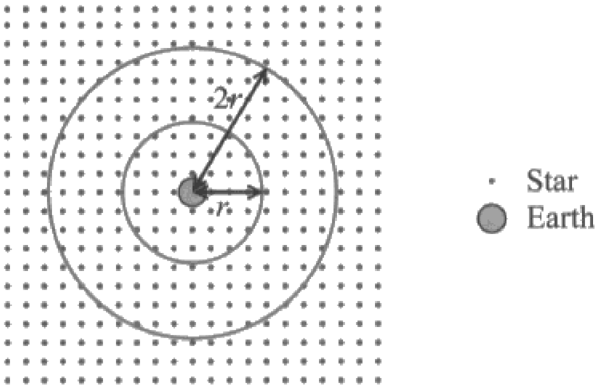


The diagram shows two shells of equal thickness at distances r and $2r$ from the centre of the Earth.
There are four times as many stars on the shell at $2r$ than on the shell at r.

(a) Explain why the total radiation flux received at the Earth from the stars on each shell is the same.

(2)

$F \propto \frac{1}{d^2}$, therefore, even though the stars at a distance of 2r from earth are further away, there are four times as many on that shell ~~than~~ ~~a~~ than on the shell at r.

ResultsPlus
Examiner Comments

This response only scored 1 mark, as the argument is incomplete. Although there is a reference to the inverse square law, the candidate doesn't state that at 2r the brightness of each star decreases to a quarter of the value at a distance r.

Question 16 (b) (i)

Many calculate the power correctly but a number were confused about what to put into the formula for the area. Some candidates used the $4\pi r^2$ form of the equation with $r = 1$.

(b) One explanation proposed for why the night sky is not bright was that there is too much dust in space for distant stars to be seen. However, such dust would absorb radiation and heat up.

(i) Space is estimated to be at a temperature of 2.7 K. Use this value to calculate the radiant power emitted per m² of a body at this temperature.

(2)

$\frac{L}{A} = \sigma T^4$

$= 5.67 \times 10^{-8} \times 2.7^4$

Radiant power emitted per m² = 3.01×10^{-6} W m^{-2}

ResultsPlus
Examiner Comments

This response scores full marks.

Question 16 (b) (ii)

The calculation was usually done correctly with the occasional missing unit. The shape of the graph was more challenging. Although the graphs were often poor, the λ_{max} value was usually marked correctly. Some candidates lost MP3 because they failed to convert from m to mm for the wavelength scale on the x-axis. A number of graphs seen were symmetrical, and some of the peaks were not labelled at all.

Question 16 (b) (iii)

This was generally answered in terms of 'higher and to the left'. A few only referred to the change in λ_{max}, and a minority discussed what would happen if the temperature was decreased.

Question 16 (c)

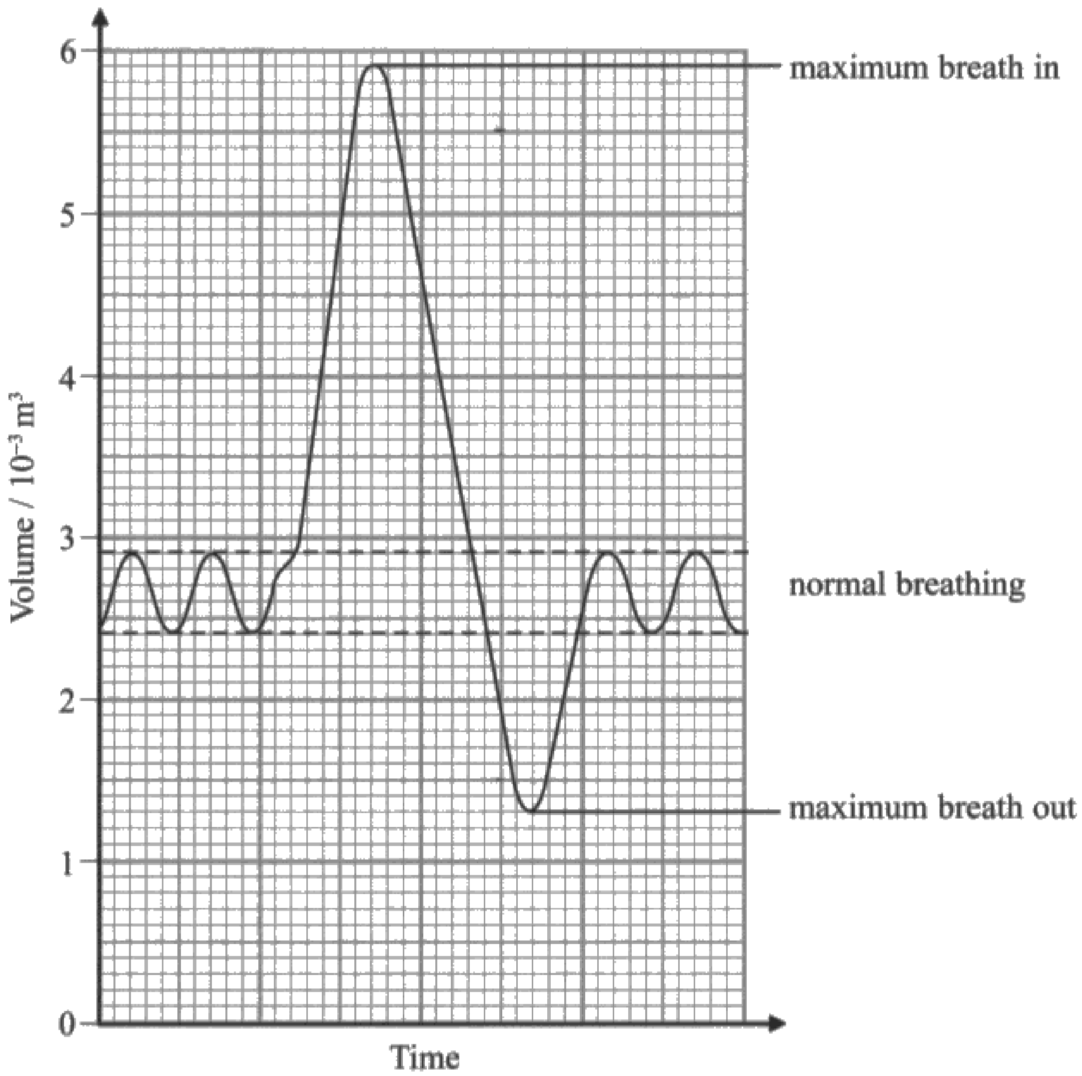
Many candidates appreciated the time problem, but lots of other reasons were given such as: the Universe is expanding and stars are moving too far away, the stars' luminosities are too small, stars are changing into supernovae, black holes, dark matter etc.

Question 17 (a) (i)

Most candidates knew that they needed to use $pV = NkT$ and correctly converted the temperature into kelvin, but not all could read the volumes correctly from the graph. Some candidates missed the 10^{-3} on the volume axis, and others failed to convert 37 □C to 310K.

17 A spirometer is a device used in medical tests to investigate breathing. The spirometer measures the volume of air entering and leaving the lungs.

A patient is asked to breathe normally, take a maximum breath in and a maximum breath out, then breathe normally again. The results are shown on the graph.



(a) Whilst in the lungs the air was at a temperature of 37.0 °C and a pressure of 1.02×10^5 Pa.

(i) Show that the number of air molecules expelled from the lungs between the maximum breath in and the maximum breath out is about 1×10^{23}.

(3)

$pV = NkT$

$(1.02 \times 10^5) \times (4.6 \times 10^{-3}) = N \times (1.38 \times 10^{-23}) \times (37 + 273)$

$469.2 = N \times 4.278 \times 10^{-21}$

$\therefore N = \frac{469.2}{4.278 \times 10^{-21}}$

$N = 1.09 \times 10^{23}$

ResultsPlus

Examiner Comments

This response is well set out and leads to a correct answer, hence it scores full marks.

17 A spirometer is a device used in medical tests to investigate breathing. The spirometer measures the volume of air entering and leaving the lungs.

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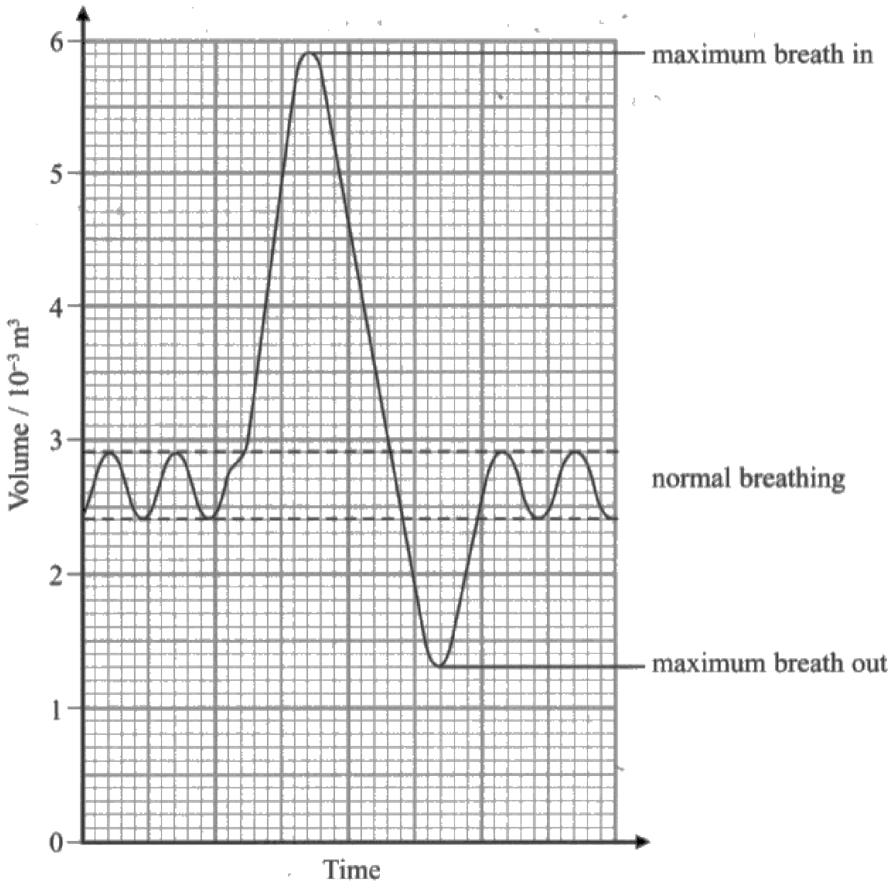


(a) Whilst in the lungs the air was at a temperature of 37.0 °C and a pressure of 1.02×10^5 Pa.

(i) Show that the number of air molecules expelled from the lungs between the maximum breath in and the maximum breath out is about 1×10^{23}.

(3)

$PV =$ ~~nRT~~ NKT

$\Rightarrow (1.02\times10^{5})(5.9\times10^{-3} - 1.3\times10^{-3}) =$ ~~n~~ $N \times$ ~~(8.31)~~ $(1.38\times10^{-23}) \times (37)$

~~$\Rightarrow n = 1\times10^{23}$ (shown)~~

$\Rightarrow (1.02\times10^{5})(4.6\times10^{-3}) = N \times 5.1\times10^{-22}$

$\Rightarrow 469.2 = N\times(5.1\times10^{-22})$

$N = 1\times10^{23}$ (shown)

ResultsPlus
Examiner Comments

The solution is correct, but only gets 2 marks as the final answer is only given to 1 significant figure.

ResultsPlus
Examiner Tip

In a "show that" question your final answer must be given to at least one more significant figure than the value given in the question.

Question 17 (a) (ii)

The majority of candidates scored 1 mark for use of $3kT/2$ but many then failed to multiply by N. A considerable number used a wrong value for k. Occasionally candidates lost MP2 because they neglected to put any units in their final answer.

(ii) Calculate the total kinetic energy of the air molecules expelled from the lungs between the maximum breath in and the maximum breath out.

(2)

Kinetic energy $= \frac{3}{2} kT$

$= \frac{3}{2} \times (1.38 \times 10^{-23}) \times (273 + 37)$

$= 6.42 \times 10^{-21}$ J

Total Kinetic Energy $= 6.42 \times 10^{-21} \times 1.1 \times 10^{23}$

Total kinetic energy of air molecules = 706.2 J

ResultsPlus

Examiner Comments

A fully correct solution, scoring full marks.

(ii) Calculate the total kinetic energy of the air molecules expelled from the lungs between the maximum breath in and the maximum breath out.

(2)

$\frac{1}{2} m \langle c \rangle^2 = \frac{3}{2} kT$

$= \frac{3}{2} (1.38 \times 10^{-23}) \text{JK}^{-1} \times 310 \text{ K}$

$= 6.417 \times 10^{-21}$ J

Total kinetic energy of air molecules = 6.417×10^{-21} J

ResultsPlus

Examiner Comments

This response scores just 1 mark, as the candidate has not calculated the total energy. The small value of the energy should have been an indication to the candidate that the calculation was incomplete.

ResultsPlus

Examiner Tip

Read through your answers to ensure that what you have written makes sense. In calculations check that the final answer seems reasonable.

Question 17(a) (iii)

Many just said that air is an ideal gas and so the internal energy is the kinetic energy of the molecules. Some who had the right idea failed to score the second mark by saying that the potential energy of the molecules is negligible.

Question 17 (b) (i)

Most responses scored the first mark. A good number of candidates had the right idea about the explanation but failed to refer to the *mean* or *average* kinetic energy.

(b) Air is a mixture of mainly nitrogen and oxygen. Oxygen molecules are more massive than nitrogen molecules. Nitrogen accounts for about 80% of the molecules in a given sample of air.

(i) Compare the mean square speed of the oxygen molecules to the mean square speed of the nitrogen molecules in a sample of air.

(2)

Since both are at the same temperature, their average kinetic energy will be same. But oxygen are more massive, so the mean square speed of oxygen molecules will be lower than the mean square speed of nitrogen molecules.

ResultsPlus

Examiner Comments

This is a good response worth 2 marks.

(b) Air is a mixture of mainly nitrogen and oxygen. Oxygen molecules are more massive than nitrogen molecules. Nitrogen accounts for about 80% of the molecules in a given sample of air.

(i) Compare the mean square speed of the oxygen molecules to the mean square speed of the nitrogen molecules in a sample of air.

(2)

The mean square speed of ~~oxygen~~ nitrogen molecules is greater than the mean square speed of oxygen molecules as they have the same K.E and nitrogen molecules are lighter than oxygen molecules.

ResultsPlus

Examiner Comments

This response is only worth 1 mark as it fails to specify that it is the average molecular kinetic energy that is the same for each gas. Although not penalised here, note that the terms heavy/light refer to weight rather than mass.

Question 17(b) (ii)

The equal volume and temperature mark was rarely seen. Some candidates gave the equation or the proportionality for MP2. Candidates often seemed to get themselves tied up in knots with forces, collision rates and pressure giving lengthy explanations that never quite get far enough to answer the question. Those answers that started with $pV = NkT$ were likely to go on to score 2 marks.

*(ii) The pressure exerted by the air in a sample is partly due to the oxygen molecules and partly due to the nitrogen molecules.

Explain why the nitrogen molecules would account for 80% of the pressure exerted by the air.

(3)

The pressure is produced when molecules collide with the wall of container and other molecules. More molecules produce larger pressure. 80% of the molecules in a given sample of air are nitrogen molecules, so nitrogen molecules contribute to 80% of the total collisions.

ResultsPlus

Examiner Comments

This response is fairly typical of those in which the candidate attempted to consider the collisions of molecules with the container walls. The complication with this approach is that the momentum exchange per collision and collision rate of the molecules both need to be considered for a complete argument. This response said enough for 1 mark to be awarded.

ResultsPlus

Examiner Tip

When drawing conclusions ensure that you take all relevant factors into account.

*(ii) The pressure exerted by the air in a sample is partly due to the oxygen molecules and partly due to the nitrogen molecules.

Explain why the nitrogen molecules would account for 80% of the pressure exerted by the air.

(3)

PV = NkT. Since volume occupied by the both gases is same at constant temperature P ∝ N. Nitrogen accounts for 80% of the molecules in the sample hence pressure exerted by nitrogen is also 80%.

ResultsPlus

Examiner Comments

This response starts with an appropriate equation and goes on to produce a complete argument for full marks.

ResultsPlus

Examiner Tip

Always base your explanations on physical principles. An equation is often a good starting point.

Question 18 (a)

This did not present any problems for candidates. Occasionally candidates lost one mark because they only quoted their answer to 2 significant figures when they should have used 3 or more. Similarly, a small number of candidates lost marks by using g = 10 m s^{-2}.

Question 18 (b) (i)

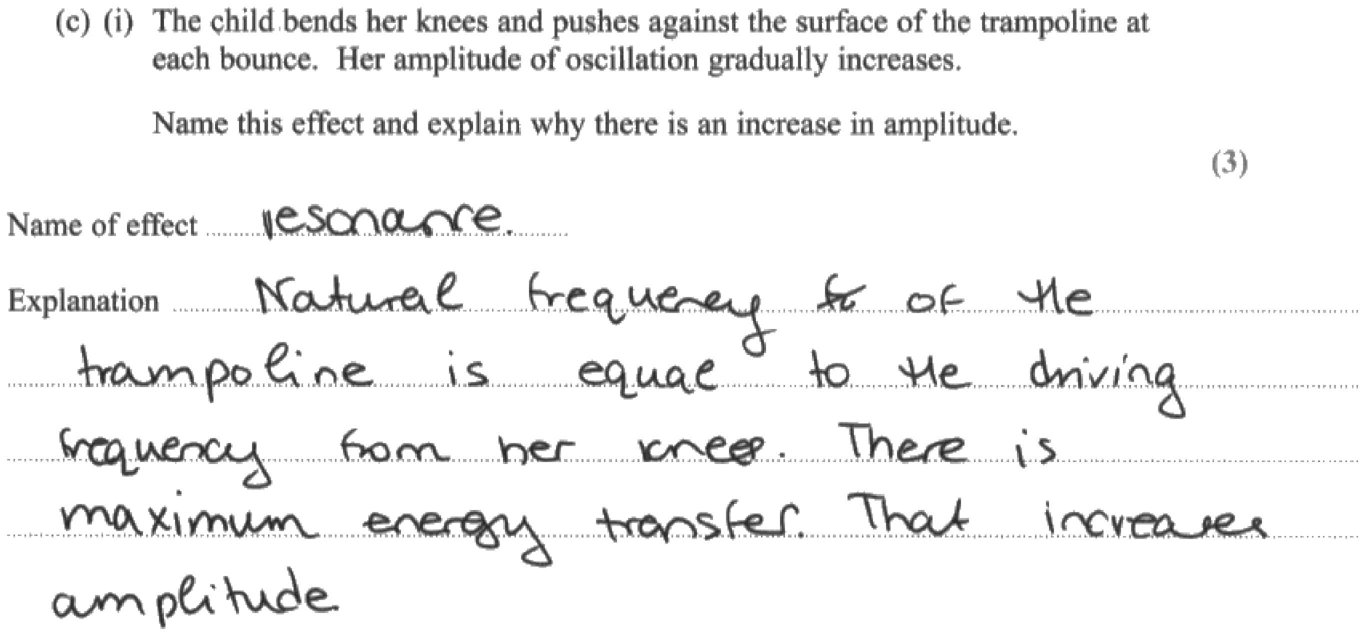
Lots of correct answers to this question were seen. A significant proportion of candidates relied on their memory of possibly relevant formulae without understanding what these formulae expressed. For example, a common method was by using the expression T = 2π√(m/k). However, there were some candidates who attempted to use the inappropriate equation for a simple pendulum, T = 2π Ö (L/g).

Question 18 (b) (ii)

This question was generally well answered. However, a number of unsuccessful attempts were seen to use conservation of energy, or even equations of motion.

Question 18 (c) (i)

Having identified the effect as resonance too many candidates proceeded to give a generic but incomplete definition rather than attempting to explain this particular effect. It was unusual to see a response that mentioned energy transfer. Some candidates wrongly talked about the trampoline causing the child to oscillate at the child's natural frequency!



(c) (i) The child bends her knees and pushes against the surface of the trampoline at each bounce. Her amplitude of oscillation gradually increases.

Name this effect and explain why there is an increase in amplitude.

(3)

Name of effect resonance.

Explanation Natural frequency ~~fo~~ of the trampoline is equae to the driving frequency from her knee. There is maximum energy transfer. That increases amplitude

ResultsPlus
Examiner Comments

This response gives enough detail for all 3 marks.

(c) (i) The child bends her knees and pushes against the surface of the trampoline at each bounce. Her amplitude of oscillation gradually increases.

Name this effect and explain why there is an increase in amplitude.

(3)

Name of effect Resonance

Explanation When the applied frequency is similar of or equal to the natural frequency, the amplitude is maximum.

ResultsPlus
Examiner Comments

This response scores just 1 mark, for the identification of resonance as the effect. The rest of the answer is quite vague in terms of what is forcing and what is being forced into oscillation. There is no reference to an energy transfer, instead the candidate repeats the statement given in the question that the amplitude is large.

ResultsPlus
Examiner Tip

Learn the definitions of standard terms that occur in the specification.

Question 18 (c) (ii)

In general this was not answered very well. Most candidates could quote the criteria required for SHM but didn't necessarily address the points for MP2 and MP3. Only a few candidates realised that once the girl is no longer in contact with the trampoline she only has g or weight acting on her (and that it is constant).

*(ii) As her amplitude of oscillation increases she starts to lose contact with the surface of the trampoline.

Explain why the motion can no longer be described as simple harmonic.

(3)

For simple harmonic motion (SHM), the restoring force F has to be proportional ~~F~~ to the displacement x from the equilibrium position and act in the opposite direction, i.e. $F = -kx$, where k is the positive force constant. When the child loses contact with the trampoline surface, the only force acting on her is her constant weight $W = mg$, which is thus not proportional to the displacement from the equilibrium position (W remains constant as x changes). So, the essential condition for SHM is no longer ~~fulfi~~ fulfilled.

ResultsPlus
Examiner Comments

This is a good response, scoring all 3 marks. The candidate has given a condition of SHM and explained why the girl does not meet this condition.

Paper Summary

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

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

Grade Boundaries

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

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

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