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Examiners' Report
June 2015

GCSE Physics 5PH3H 01

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Introduction

This examination aims to allow candidates to demonstrate that they can accurately recall concepts and phenomena in physics and can communicate their understanding using both qualitative and quantitative models. The specification uses physical principles and links these to medical applications.

The assessment is through multiple choice questions, short answers, extended writing, calculations and analysis. Candidates need to be able to apply mathematical skills, express their ideas clearly and concisely and interpret scientific data which is presented in a variety of ways.

The work produced for the examination showed that many candidates are confident in their use of mathematical models and were able to explain complex phenomena with clarity and insight. Many candidates were able to demonstrate their understanding of the main features of the shape of an electro-cardiogram trace but only a few used the quantitative data on the diagram to determine the heart rate. Although many candidates knew about hospital cyclotrons and research particle accelerators and were able to describe the workings of both, a comparison which was concise and included similarities and differences was rarely produced. Candidates are also familiar with the idea that momentum, charge and mass-energy are conserved during electron –proton annihilation but many are unable to explain this.

Candidates need to be aware of the link between the units of a quantity and the equation used to determine that quantity as this helps understanding. Most candidates could relate kinetic energy of particles to the temperature of the gas but the relevance of the temperature being measured in Kelvin was not apparent. Candidates should also expect to provide a quantitative answer when a question includes numerical values.

It is important that candidates are able to interpret diagrams. Few candidates were able to indicate the focal length and the position of the image produced by marking these on a ray diagram for a concave lens. However, many candidates demonstrated their ability to correctly calculate the image distance for this type of lens.

Most candidates made use of the formulae sheet at the front of the examination paper and were able to quote equations correctly. Although full marks are given to correct answers to calculations, with or without working, it was pleasing to see that most candidates quoted the equation and transposed or substituted into the equation. This allowed them to gain marks even if the final answer was not correct. It is often the inability to correctly input standard form into calculators which produces power of ten errors in answers. Correct use of calculators, correct rounding of answers and an appreciation of significant figures are skills which need to be developed.

Question 1 (c)

To complete the nuclear equation it was essential to know the mass number and atomic number assigned to the beta minus particle. Many candidates were able to give zero for the mass number for beta minus and get fourteen by for the mass number for nitrogen by equating this with the mass number for carbon. The most common error was to use 'one' instead of 'minus one' for the atomic number for the beta minus and then, by equating with the atomic number of six for carbon, giving the atomic number for nitrogen as five.

Candidates need to be able to assign the correct mass number and atomic number to particles such as beta plus, beta minus (electron),proton and neutron.

(c) Carbon-14 decays by emitting a β^- particle to form an isotope of nitrogen.

Complete the nuclear equation for this decay by filling in the boxes.

(2)

$$^{14}_{6}C \rightarrow \,^{13}_{5}N + \,^{1}_{1}\beta^-$$

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Examiner Comments

The answer shows incorrect values of mass number and atomic number assigned to beta plus and although the atomic numbers and mass numbers equate no marks are awarded.

Nuclear equation correctly completed.

(c) Carbon-14 decays by emitting a β^- particle to form an isotope of nitrogen.

Complete the nuclear equation for this decay by filling in the boxes.

(2)

$$^{14}_{6}C \rightarrow \,^{14}_{7}N + \,^{0}_{-1}\beta^-$$

ResultsPlus
Examiner Comments

The top or bottom line of values correctly completed gains one mark

ResultsPlus
Examiner Tip

Start by putting in the values for the beta minus particle, that should be known and then work out, by equating the mass number line and then the atomic number line, the correct values for Nitrogen,

Question 1 (d)

Candidates need to know that three quarks are contained in protons and neutrons and give the correct combination of up and down quarks.

The candidate needs to know the number of quarks contained in a proton and if they are 'up' or 'down'.

(d) Protons and neutrons both contain quarks.

Describe the arrangement of quarks in a proton.

(2)

In a proton there are a total of 3 quarks which go in order of down, down, and up quark.

ResultsPlus
Examiner Comments

Knowing that the proton contained three quarks or some up and down quarks was sufficient to gain one mark. Knowing the correct configuration of quarks gained the second mark. This answer gets one mark for identifying that the proton contains three quarks but wrongly names them as down, down, up.

ResultsPlus
Examiner Tip

Learn the correct configuration of quarks in protons and neutrons.

Protons;- up, up,down.

Neutrons:-down, down, up.

NB. Electrons do not contain quarks.

This answer gave the correct configuration of quarks.

(d) Protons and neutrons both contain quarks.

Describe the arrangement of quarks in a proton.

(2)

Quarks arrangement in a proton is uud, up up down.

ResultsPlus
Examiner Comments

The abbreviation uud would have been accepted for the second mark without up, up, down being written in full.

Any attempt to use charges in this answer was ignored.

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Examiner Tip

Configuration of quarks has to be learned.

Question 1 (e)

Full marks can be gained for this question without any knowledge of quarks although many candidates did gain the first mark by referring to a quark changing from up to down in addition to or instead of giving that a proton changed to a neutron. The second mark was then given for the knowledge that a positron was emitted when the change occurred.

If the question is answered in terms of how the atomic number and mass number are affected then both marks can be obtained.

Only gains one mark for the emission of a positron.

(e) Explain what happens to a nucleus during β⁺ decay.

(2)

A nucleus will emit ~~an~~ ~~a~~ a positron which will be ionising. This is to make ~~to~~ the nucleus more stable

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Examiner Comments

The emission of a beta plus particle, which has been correctly called a positron, has been confused with the emission of a gamma ray to stabilise the nucleus.

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Examiner Tip

When nuclei emit charged particles it should be recognised that the particles in the nucleus have changed.

When nuclei emit charged particles it should be recognised that the particles in the nucleus have changed.

(e) Explain what happens to a nucleus during β⁺ decay.

(2)

the nucleus emits a positron and an neutron turns into an proton

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Examiner Comments

Gains a mark for knowing that a positron is emitted.

The candidate then makes the contradictory statement that a positively charged particle is emitted but the nucleus gains a positive charge by a neutron becoming a proton.

ResultsPlus
Examiner Tip

Consider carefully the charges that particles have and if the charges have been lost or gained.

The statement is sufficient for two marks.

(e) Explain what happens to a nucleus during β^+ decay.

(2)

A proton ~~atom~~ changes into a neutron and positron.

ResultsPlus
Examiner Comments

Although there is no mention of positron emission this answer gives the change that occurs in the nucleus.

ResultsPlus
Examiner Tip

Learn the relative masses and charges of all the nuclear particles.

This answer contains two possible approaches to gaining full marks.

(e) Explain what happens to a nucleus during β^+ decay.

(2)

During β^+ decay, the nucleus emits a positron and a proton turns into a ~~[illegible]~~ neutron, and so the proton number decreases by one, but the mass remain the same.

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Examiner Comments

'during beta plus decay the nucleus emits a positron and a proton turns into a neutron' is sufficient for two marks.

However, 'the proton number decreases by one but the mass number remains the same' on its own would also be sufficient for two marks.

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Examiner Tip

The process can be explained in several different ways but having given one explanation go on to the next question.

Question 2 (a) (i)

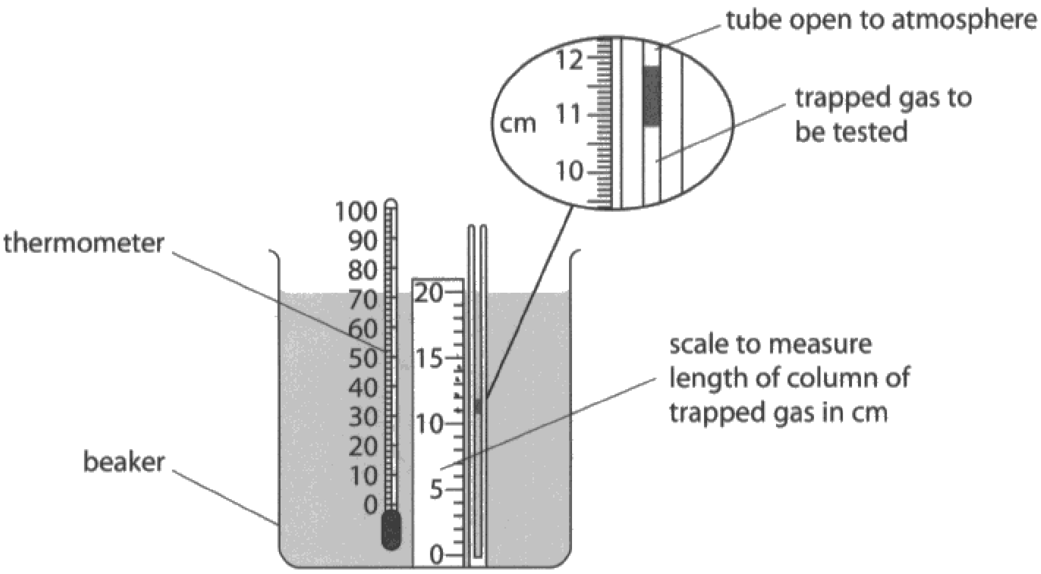
It was necessary to read the entire stem of this question and the labels on the diagram, particularly for candidates that had not seen the apparatus before.

The labels must be read carefully for the required measurement to be taken.

Gas laws

2 A student investigates how the volume of a gas changes when its temperature increases.

The diagram shows the equipment used and the length of the trapped gas at 25 °C.



(a) (i) Use the scale to estimate the length of the column of trapped gas.

(1)

length of column of trapped gas = ...12...... cm

ResultsPlus
Examiner Comments

Many candidates read to the wrong end of the block in the tube or did not read the magnified scale with sufficient accuracy. The value of each division on the scale must be found.

ResultsPlus
Examiner Tip

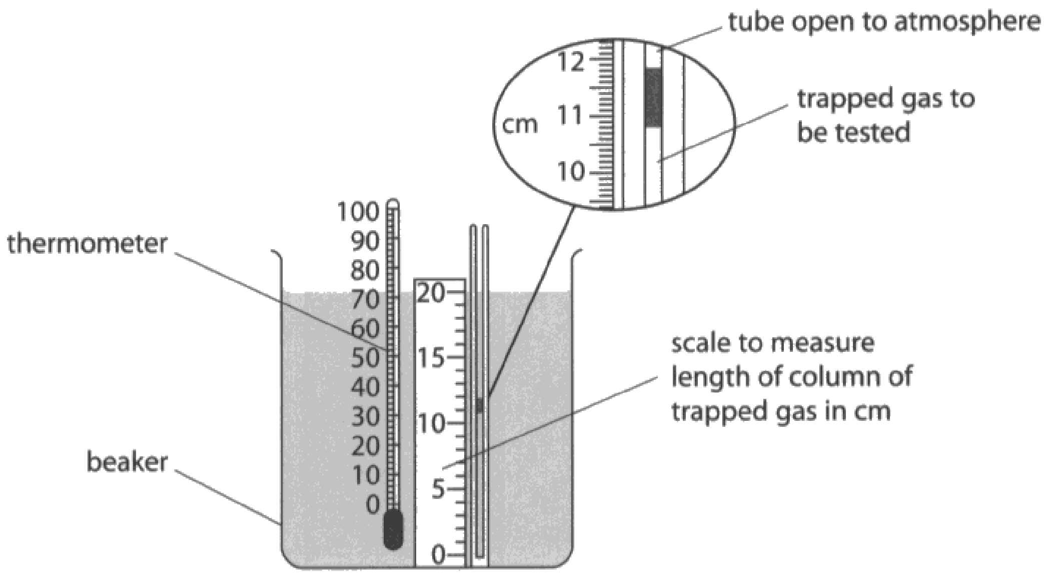
Use a ruler across from the block to the scale to accurately determine the length of the column.

Correctly estimated the length of column of trapped air.

Gas laws

2 A student investigates how the volume of a gas changes when its temperature increases.

The diagram shows the equipment used and the length of the trapped gas at 25 °C.



(a) (i) Use the scale to estimate the length of the column of trapped gas.

(1)

length of column of trapped gas = 10.8 cm

ResultsPlus
Examiner Comments

Correctly identified which part of the scale to use and determined the value of each division correctly.

ResultsPlus
Examiner Tip

Draw a horizontal line to read off the scale.

Question 2 (a) (iii)

Candidates were given the volume of trapped air at 50°C and were required to calculate the volume at 100°C. The need to convert degrees Celsius to Kelvin was missed by many candidates and although the equation is on the formulae page and needs no transposition many candidates found it necessary to calculate V_2 and therefore had to complete an unnecessary transformation.

The answer obtained two marks out of three. Degree Celsius temperatures have not been converted to Kelvin.

(iii) The gas is heated to 50 °C.

The volume of the trapped gas at 50 °C is 2.31×10^{-2} cm³.

Calculate the volume of the trapped gas at 100 °C.

(3)

$$V_1 = \frac{V_2 T_1}{T_2}$$

$$2.31 \times 10^{-2} = \frac{V_2\, 50}{100}$$

$$V_2 = 0.0462$$

volume of the trapped gas = 0.0462 cm³

ResultsPlus
Examiner Comments

There is no need to substitute in the equation so that it has to be rearranged to calculate the volume.

ResultsPlus
Examiner Tip

Remember the gas laws equations can only be applied for temperatures measured in Kelvin.

This candidate converted temperature to Kelvin but still transformed the equation rather than just finding V_1.

(iii) The gas is heated to 50 °C. V T

The volume of the trapped gas at 50 °C is 2.31×10^{-2} cm³.

323 K

Calculate the volume of the trapped gas at 100 °C.

(3)

$V_1 T_2 = V_2 T_1$

50°C = 323 K

100°c = 373 K

$2.31 \times 10^{-2} \times 373 = V_2 \times 323$

$\frac{2.31 \times 10^{-2} \times 373}{323} = V_2$

0.027

volume of the trapped gas = 0.027 cm³

ResultsPlus

Examiner Comments

The power of ten is correct and so is the rounding however for this calculation three marks were awarded for both 0.027 and 0.026.

ResultsPlus

Examiner Tip

Make sure when values are given in standard form they can be correctly entered into the calculator.

Correct substitution into an equation that needs re-arranging and the rearrangement is incorrect. Gains one mark.

(iii) The gas is heated to 50 °C.

The volume of the trapped gas at 50 °C is 2.31×10^{-2} cm³.

Calculate the volume of the trapped gas at 100 °C.

(3)

$$V_1 = \frac{V_2 T_1}{T_2}$$

$$2.31 \times 10^{-2} = \frac{V_2\ 50\,^\circ C}{100\,^\circ C}$$

$$\frac{50\,^\circ C}{2.31 \times 10^{-2} \times 100\,^\circ C} = V_2$$

$$= 21.64502165\ cm^3$$

volume of the trapped gas = 21.6 cm³

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Examiner Comments

It would be better to give V_2 the value 2.31×10^{-2} cm³ T_2 50°C and T_1 100° C then the equation does not have to be rearranged.

ResultsPlus

Examiner Tip

Only rearrange equations when it is necessary.

Gains one mark for the conversion of degrees Celsius to Kelvin.

(iii) The gas is heated to 50 °C.

The volume of the trapped gas at 50 °C is 2.31×10^{-2} cm³.

Calculate the volume of the trapped gas at 100 °C.

(3)

$V_1 = \frac{V_2 T_1}{T_2}$

50 + 273 = 323 K

100 + 273 = 373 K

$\left(\frac{2.31 \times 10^{-2} \times 50}{100} = 0.01155 \right)$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\frac{5.6 \times 10^{-4}}{50} = \frac{2.31 \times 10^{-2}}{100}$

$1.12 \times 10^{-5} = 2.31 . 10^{-4}$

volume of the trapped gas = 2.31×10^{-4} cm³

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Examiner Comments

The correct conversion of temperature to Kelvin in given but not used in the attempted calculation. This gains one mark.

ResultsPlus

Examiner Tip

Keep each pair of temperature and volume with the same subscript.

Question 2 (b)

Most candidates were able to state that as the temperature of a gas increased then the average kinetic energy of the particles of gas also increased and some gave the relationship as directly proportional but only a few stated that this relationship was only true when the temperature was measured in Kelvin.

This response gained three marks just for the first two lines.

(b) Describe how the average kinetic energy of the particles of the gas changes as the temperature of the gas changes.

(3)

Kinetic energy is proportional to temperature in kelvin.
As the temperature increases the kinetic energy also increases.

ResultsPlus
Examiner Comments

Whilst 'directly proportional' is preferred 'proportional' was sufficient to gain the second mark.

ResultsPlus
Examiner Tip

This is given in the specification as recall and as such should be learnt.

This response was given two marks.

(b) Describe how the average kinetic energy of the particles of the gas changes as the temperature of the gas changes.

(3)

When the temperature doubles, the kinetic energy doubles. They are directly proportional. Therefore, if the temperature halves, so does the kinetic energy.

ResultsPlus
Examiner Comments

The statement 'as temperature doubles the kinetic energy doubles' was sufficient to show direct proportionality without that being added. However, there is no mention of Kelvin for the third mark.

ResultsPlus
Examiner Tip

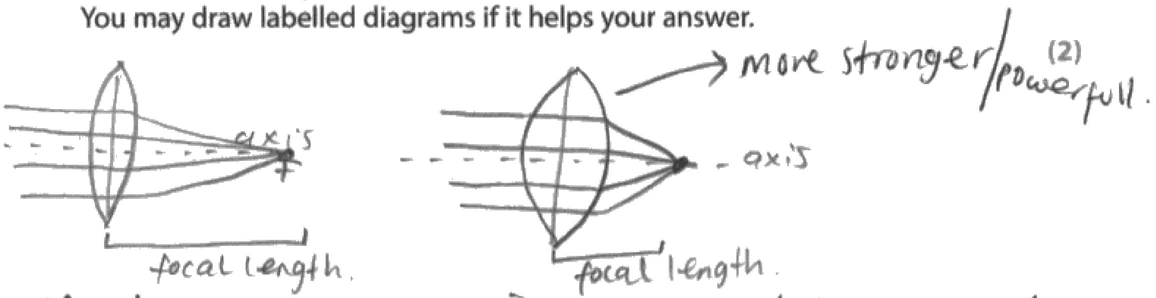
Kelvin is the most important temperature scale when changes in pressure, volume and kinetic energy of particles in a gas are being considered.

Question 3 (a) (ii)

Most candidates were able to give an effect of changing the shape of a lens and link this correctly to the power of the lens. This was quite often shown by the use of a diagram.

This answer uses both a written explanation and a diagram.

(ii) Describe how the power of a lens is related to its shape.
You may draw labelled diagrams if it helps your answer.



If the shape of the lens is more curved there will be a higher power. This is because the focal length will be shorter because the rays of light will converg much stronger.

ResultsPlus
Examiner Comments

Stating that the more powerful lens will have surfaces that are more curved would get the first marking point. Including that this increases the power of the less gave the second marking point.

ResultsPlus
Examiner Tip

Use diagrams to clarify explanations.

Candidates lost marks when they did not refer to power in their answer but tried to compare convex and concave lenses.

(ii) Describe how the power of a lens is related to its shape.
You may draw labelled diagrams if it helps your answer.
(2)

Concave lenses helps people who are short sighted as it magnifies objects that are further away because of their shape. Convex lenses help people who are ~~th~~ long sighted as they magnify objects that

ResultsPlus

Examiner Comments

Although some of the information given in the answer is correct it is not relevant to the question asked.

ResultsPlus

Examiner Tip

Note what is asked in the question and keep answers relevant to that.

This answer was awarded one mark.

(ii) Describe how the power of a lens is related to its shape.
You may draw labelled diagrams if it helps your answer.

(2)

As the thickness of the lens increases, the rays of light are refracted more ~~and the image the longer~~ changing the ~~st~~ size of the image.

ResultsPlus
Examiner Comments

An effect of increasing the thickness of the lens is given but this is not related to the power of the lens.

ResultsPlus
Examiner Tip

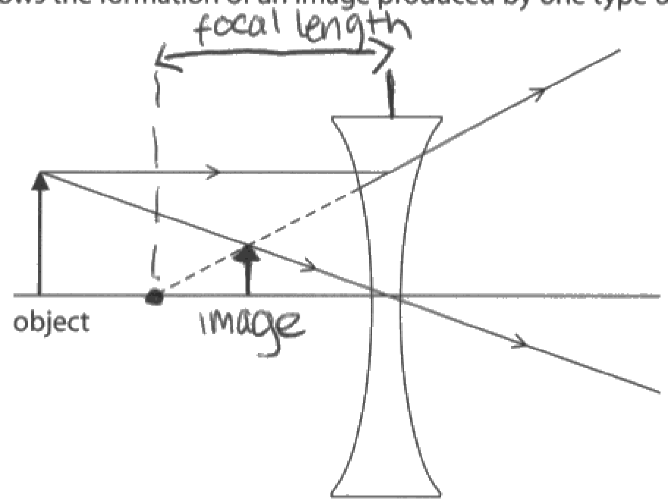
Make sure that you do describe the quantities that the question refers to, in this case 'power' and the 'shape of the lens'.

Question 3 (b) (i-ii)

Very few candidates were able to accurately show on the diagram the correct position of the virtual image or indicate the focal length of the concave lens.

The answer is awarded two marks. The diagram has the correct position for the virtual image and the focal length.

(b) The diagram shows the formation of an image produced by one type of lens.



(i) On the diagram, draw and label the image produced.

(1)

(ii) On the diagram, show and label the focal length of the lens.

(1)

ResultsPlus
Examiner Comments

The diagram has the correct position for the virtual image taking it from where the rays cross to the principal axis and also indicates with the arrow that the image is erect. The focal length is shown as the distance from the centre of the lens to the point from which the diverging ray appears to come.

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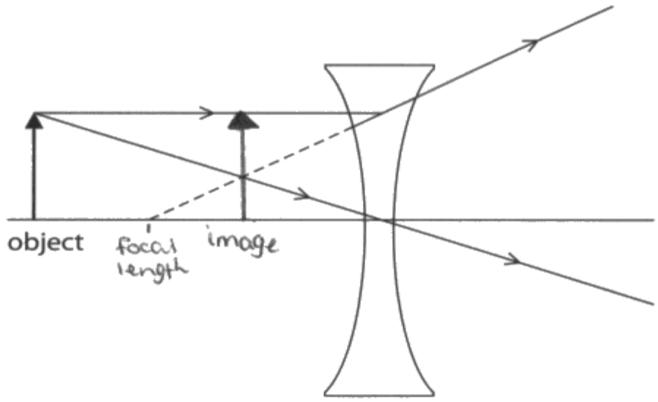
Examiner Tip

Practise completing ray diagrams for both convex and concave lenses.

No marks awarded.

(b) The diagram shows the formation of an image produced by one type of lens.



(i) On the diagram, draw and label the image produced.

(1)

(ii) On the diagram, show and label the focal length of the lens.

(1)

ResultsPlus
Examiner Comments

The image is erect and comes from the principle axis but extends beyond the two rays crossing.

The focus of the lens has been labelled the focal length.

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Examiner Tip

The focal length is a distance and not to be confused with the focus which is a point.

Question 3 (b) (iii)

The majority of candidates knew that the concave lens was used to correct short sightedness (myopia).

Question 3 (b) (iv)

Most candidates started off by quoting the lens equation and were able to substitute correctly into the l equation but transforming the equation with a negative value for focal length proved more difficult.

If the transformation was completed correctly then most candidates could obtain the answer -5.03 cm using their calculators. The inversion was then completed by some candidates.

Setting out the work so that the steps can be followed rather than attempting to do more than one operation at a time generally proved to be the more successful approach.

This response gains one mark.

(iv) This lens has a focal length of –0.33 m.
An object is 0.50 m in front of the lens.

Calculate the distance of the image from the lens.

(4)

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{-0.33} = \frac{1}{0.50} + \frac{1}{v}$$

$$\frac{1}{-0.33} \Big/ \frac{1}{0.50} = -\frac{50}{33} = -1.515151 5$$

distance of image from lens = –1.5 m

ResultsPlus
Examiner Comments

Correct substitution then an error in transposition.

ResultsPlus
Examiner Tip

Learn to apply the basic mathematical rules for transposition to all equations.

(iv) This lens has a focal length of –0.33 m.
An object is 0.50 m in front of the lens.

Calculate the distance of the image from the lens.

(4)

$$\frac{1}{-0.33} = \frac{1}{0.5} + \frac{1}{v}$$

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

length object image

$1 \div -0.33 = -3.03$

$1 \div 0.5 = 2$

$2 - -3.03 = 5.03$

distance of image from lens = 5.03 m

ResultsPlus
Examiner Comments

The substitution is correct but because the equation has not been written down line by line the 1/v has been lost and there is no final inversion. Also the negative sign has been lost between -2 -(-3.03) and 5.03. The minus sign needs to be in place to have three marks awarded.

ResultsPlus
Examiner Tip

Keep the whole equation and work through it line by line so that the quantity that has to be determined is apparent.

(iv) This lens has a focal length of –0.33 m.
An object is 0.50 m in front of the lens.

Calculate the distance of the image from the lens.

(4)

$\frac{1}{\delta} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{-0.33} = \frac{1}{0.5} + \frac{1}{v}$

$\frac{1}{0.5} - \frac{1}{-0.33} = \frac{1}{5.\dot{0}\dot{3}}$

$\frac{1}{\frac{1}{-0.33} - \frac{1}{0.5}} = 0.2\text{m}$

$\frac{1}{5.\dot{0}\dot{3}} = 0.2$

distance of image from lens = 0.2 m

ResultsPlus
Examiner Comments

The calculation until the last evaluation where the minus sign is lost. However, as the question requires a distance to be found, a negative or positive value for the answer 0.2m is given full marks.

ResultsPlus
Examiner Tip

Write calculations so that the steps that you have used can be followed.

(iv) This lens has a focal length of –0.33 m.
An object is 0.50 m in front of the lens.

Calculate the distance of the image from the lens.

(4)

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{-0.33} = \frac{1}{0.5} + \frac{1}{v}$$

$$\frac{1}{-0.33} - \frac{1}{0.5} = \frac{1}{v}$$

$$\frac{1}{1/_{-0.33} - 1/_{0.5}} = v$$

$$V = \frac{-33}{166}$$

$$V = -0.198795$$

distance of image from lens = -0.2 m

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Examiner Comments

The equation is written, values substituted, the equation is transformed to find 1/v and the inverted to determine v.

The value of v still has the negative sign as it is a virtual image that is produced by the lens.

The value is calculated to a number of decimal places and then correctly rounded to -0.2 m.

Question 4 (a) (ii)

Candidates needed to know the properties of alpha radiation and then apply this to the treatment of cancers. When considering the half-life this should be related to the time necessary for effective treatment or that the pellets do not have to be removed.

This response score two marks.

(ii) Pellets which contain radium-223 can be put inside the body to treat cancers.

Radium-223 has a half-life of 11.4 days and emits alpha radiation.

Explain why radium-223 is suitable for use inside the body to treat cancers.

(3)

Because alpha radiation is strongly ionising so it will severely damage the tumour, yet it can not move very far ~~so~~ and is not very penetrative so it wont ~~[illegible]~~ harm many other cells as it cant move far. It also has a relitavely short half life so you wont be radioactive for long.

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Examiner Comments

The alpha radiation is described as 'strongly ionising' which gets one mark and also as 'not very penetrating', this gets a second mark.

Although the alpha radiation is described as 'will severely damage the tumar' just damage is not sufficient for the third mark, destroys tumours or mutates cells is required.

No mark is awarded for the reasoning behind the short half life as it did not relate to the treatment.

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Examiner Tip

Learn the properties that each type of radiation and how these can effect human tissue.

This response scores three marks.

(ii) Pellets which contain radium-223 can be put inside the body to treat cancers.

Radium-223 has a half-life of 11.4 days and emits alpha radiation.

Explain why radium-223 is suitable for use inside the body to treat cancers.

(3)

Because it emits alpha radiation, it means that the radiation won't penetrate into the body past the cancers and therefore there will be minimal damage to the healthy cells while the cancer cells will be killed off due to alpha radiation being strongly ionising.

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Examiner Comments

This response makes no mention of half life but gets marks for:

- strongly ionising
- won't penetrate into the body past the cancers.
- cancer cells will be killed off.

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Examiner Tip

Apply the properties of alpha radiation to the situation given in the question.

Question 4 (b)

The majority of candidates understood how the use of radiotherapy for palliative care could be helpful to patients and were able to describe some positive outcomes of this type of treatment.

This response scores two marks.

(b) Radiotherapy is often used for palliative care when cancers are incurable.

Explain how using radiotherapy in this way is helpful to patients.

(2)

Slows down the cancers growth to give patients more time to live. Reduces suffering the cancer may cause giving a better quality of life.

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Examiner Comments

The candidate explains that the radiotherapy 'slows down the cancer's growth' and then gives a reason that this is of benefit to the patient.

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Examiner Tip

Learn the meaning of the term 'palliative care'

Question 4 (c) (i)

Some candidates did not appreciate that the CT scan is made up of a series of Xray images (slices) that are combined to produce a 3D image and that it is the time that this process takes that gives a higher dose of radiation to the patient. The greater intensity of the radiation from the CT scan was rarely mentioned.

This response scores one mark.

(i) Explain why a CT scan of the chest gives a much higher dose of radiation than a chest X-ray.

(2)

This is because a CT scan is many x-rays creating a 3D image of the chest not just one x-ray. So many x-rays produced a lot more radiation than one.

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Examiner Comments

The mark is awarded for the candidate knowing that the CT scan is many X-rats creating a 3D image.

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Examiner Tip

When two marks are available remember to make two points.

This example scores two marks.

(i) Explain why a CT scan of the chest gives a much higher dose of radiation than a chest X-ray.

(2)

the process of a CT scan is longer than an XRay giving a more intense dose of radiation.

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Examiner Comments

The response states that the CT scan takes longer for the first marking point. The second mark is awarded for 'giving a more intense dose of radiation. A concise answer which gets full marks.

Question 4 (c) (ii)

Candidates found it difficult to justify the use of large doses of radiation in terms of the benefits outweighing the risks but most could gain one mark by giving an advantage of using a medical procedure that involved giving patients a large dose of radiation.

This response scored two marks.

(ii) Justify the use of medical procedures which give patients large doses of radiation.

(2)

Medical procedures involving radiation ~~is~~ have to be evaluated to calculate whether the benefits outweigh the risks. Despite the patient being exposed to radiation, this radiation can ~~some~~ help to ~~detect~~ diagnose / treat something a lot more dangerous, e.g. cancer.

(Total for Question 4 = 10 marks)

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Examiner Comments

The candidate justifies the use as the benefit out weighing the risks and gives a possible advantage of the patient receiving the treatment.

ResultsPlus
Examiner Tip

Learn that the 'benefits outweighing the risks' is a justification for using medical procedures which could cause harm to patients.

Question 5 (a) (i)

Most candidates knew that the momentum of the gamma rays produced from electron-positron annihilation was zero.

Question 5 (a) (ii)

Not all candidates identified the correct equation to use for this calculation, there was quite frequent use of the equation for kinetic energy instead of $E=mc^2$. The question not only tested the candidates understanding of mass-energy conversion but also their ability to calculate using powers of 10 and to round answers correctly. Although the number of significant figures was not used as a marking point candidates should be encouraged to give answers to the same number of significant figures given in the question.

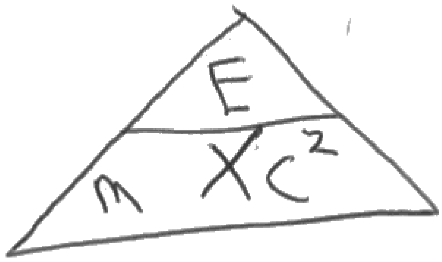
This example scored three marks.

(ii) The total energy of the two gamma rays produced is 1.6×10^{-13} J.

Calculate the total mass of the positron and electron before annihilation.
The velocity of light is 3.0×10^{8} m/s.

(3)

$E = m \times c^2$



$E \div c^2 = m$

$\frac{(1.6 \times 10^{-13})}{((3.0 \times 10^{8})^2)}$

$1.777777778 \times 10^{-30}$

total mass of positron and electron = $1.777777778 \times 10^{-30}$ kg

ResultsPlus
Examiner Comments

Although this response gets three marks as the answer is eventually correctly rounded, the use of such a large number of decimal places suggests a lack of understanding of their significance.

ResultsPlus
Examiner Tip

All the values used in the question are to two significant figures and candidates should be encouraged to provide the answer to the same number of significant figures.

This example scores one mark.

(ii) The total energy of the two gamma rays produced is 1.6×10^{-13} J.

Calculate the total mass of the positron and electron before annihilation.
The velocity of light is 3.0×10^{8} m/s.

(3)

$E = mc^2$

$m = E \div c^2$

$m = 1.6 \times 10^{-13} \div 3 \times 10^{8}$

$m = 5.333333333 \times 10^{-6}$ or $5.\dot{3} \times 10^{-6}$

total mass of positron and electron = $5.\dot{3} \times 10^{-6}$ kg

ResultsPlus
Examiner Comments

The candidate has chosen the correct equation and transformed in correctly getting one mark. However, there is no mark for substitution as the candidate has forgotten to show the velocity of light squared. This would not be considered if the answer was correct, but once the answer is incorrect substitution and transformation are looked at to see what marks can be awarded.

ResultsPlus
Examiner Tip

Take care to substitute correctly.

This response scores full marks.

(ii) The total energy of the two gamma rays produced is 1.6×10^{-13} J.

Calculate the total mass of the positron and electron before annihilation.
The velocity of light is 3.0×10^{8} m/s.

(3)

$E = mc^2$

$1.6 \times 10^{-13} = mass \times (3 \times 10^{8})^2$

$\frac{1.6 \times 10^{-13}}{(3 \times 10^{8})^2} = mass$

~~1.26×10~~ $\frac{1.6 \times 10^{-13}}{9 \times 10^{16}} = mass$

$mass = 1.\dot{7} \times 10^{-30}$

total mass of positron and electron = $1.\dot{7} \times 10^{-30}$ kg

ResultsPlus

Examiner Comments

The answer is correct as it shows 1.7 recurring $\times 10^{-30}$ kg although it could have been rounded to 1.8 $\times 10^{-30}$ kg.

ResultsPlus

Examiner Tip

The working is shown with the whole equation being written on each line, equal signs beneath each other and only change being made in each line making it much more likely that the correct answer will be obtained and if the answer is not correct only one mark would be lost.

This response scores two marks.

(ii) The total energy of the two gamma rays produced is 1.6×10^{-13} J.

Calculate the total mass of the positron and electron before annihilation.
The velocity of light is 3.0×10^{8} m/s.

(3)

$E = mc^2$

Energy = mass × (speed of light)^2

mass = $\frac{\text{Energy}}{(\text{speed of light})^2}$

mass = $\frac{1.6 \times 10^{-13}\ \text{J}}{(3.0 \times 10^{8}\ \text{m/s})^2}$ = 5.3×10^{-22}

total mass of positron and electron = 5.3×10^{-22} kg

ResultsPlus

Examiner Comments

Correct substitution and transposition gets two marks. The answer is incorrect because the velocity of light was not squared.

ResultsPlus

Examiner Tip

Make sure that all the facilities available on the calculator can be used properly.

No marks are scored for this example.

(ii) The total energy of the two gamma rays produced is 1.6×10^{-13} J.

Calculate the total mass of the positron and electron before annihilation.
The velocity of light is 3.0×10^{8} m/s.

(3)

$KE = \frac{1}{2}mv^2$

$\frac{KE}{0.5v^2} = m$

$\frac{1.6 \times 10^{-13}}{0.5 \times (3 \times 10^8)^2} = 3.6 \times 10^{-30}$

Ans x 2 $= 7.1 \times 10^{-30}$

total mass of positron and electron = 3.6×10^{-30} kg

ResultsPlus

Examiner Comments

The candidate has selected the wrong equation and even if the equation had not been included the addition of 0,5 would show this.

ResultsPlus

Examiner Tip

Make sure that the equation you choose to use fits the application for which it is being used.

Question 5 (a) (iii)

Many candidates know that momentum, mass-energy and charge are conserved in electron-positron annihilation but explaining how charge was conserved proved to more difficult. Candidates generally realised that the equal and opposite charges on electron and positron would cancel out but often concluded that this combined zero charge showed that charge was conserved rather than considering that the two gamma rays produced had zero charge and that the same charge before and after the annihilation meant that charge was conserved.

This response scores two marks.

(iii) Explain how charge is conserved in a positron-electron annihilation.

(2)

The charge before the annihilation was zero since the positron had (+1) a positive charge, whilst the electron had an equal but opposite negative charge, of -1, and after the annihilation the overall charge was still zero since gamma rays don't have a charge.

ResultsPlus
Examiner Comments

The candidate explains that the total charge before the annihilation is zero and that the total charge afterwards is also zero as the gamma rays do have charge.

ResultsPlus
Examiner Tip

Learn that for a quantity is conserved it must be the same before and after an event.

This response does not score a mark.

(iii) Explain how charge is conserved in a positron-electron annihilation.

(2)

Charge is conserved because gamma rays travelling in opposite directions are produced.

ResultsPlus

Examiner Comments

The candidate has confused conservation of charge with conservation of momentum but then only considered what is happening after the event.

ResultsPlus

Examiner Tip

To explain conservation of any quantity its value before and after an event must be considered.

This response scores one mark.

(iii) Explain how charge is conserved in a positron-electron annihilation.

(2)

The total charge of +1 - 1 = 0 (positron = +1, electron = -1)

ResultsPlus

Examiner Comments

The candidate has given that the total charge before the annihilation is zero but has not compared this with the charge after the collision.

ResultsPlus

Examiner Tip

Consider before and after an event to explain conservation.

Question 5 (b)

Candidates could provide a description of how hospital accelerators work or the design of particle accelerators used in international research but in many cases did not make a comparison. The comparison should include a concise explanation of similarities and differences and not be a detailed description of the workings of one or the other device.

This response is Level 1 and gains two marks.

*(b) Compare the design and use of particle accelerators used in international scientific research with particle accelerators used in hospitals.

(6)

Particle accelerators in hospitals are used to find/eradicate problems in the body, whereas the scientific research accelerators (E.G. the LHC) are used to accelerate particles into each other, to either make a new particle, or find ones that ~~are~~ were only theorized to exist. (Such as the Higgs-Boson).

ResultsPlus
Examiner Comments

The general misconception that hospital accelerators are used to treat patients rather than used to produce the isotopes with short half lives which are used to treat patients was apparent in the first few lines of this answer. Therefore the response does not contain any correct similarities or differences.

The correct statements that research accelerators such as the Large Hadron Collider are used to 'accelerate particles into each other' and 'find ones...... such as the Higgs -Boson' is sufficient for level 1.

ResultsPlus
Examiner Tip

Note the command word for the question, in this case 'compare' and then consider similarities and differences.

This response is level 2 and gains 4 marks.

*(b) Compare the design and use of particle accelerators used in international scientific research with particle accelerators used in hospitals.

(6)

Particle accelerators in scientific research are much larger and more powerful, allowing the particle to accelerate a lot faster before collision. This is used to show the existence of quarks. Particle accelerators in hospitals are much smaller and cheaper as they only need a fast enough particle to create unstable isotopes for treatments

ResultsPlus
Examiner Comments

This answer gives differences.

Scientific research accelerators:

- much larger
- particles are accelerated much faster
- used to show the existence of quarks.

Hospital accelerators:

- much smaller
- used to create unstable isotopes.

ResultsPlus
Examiner Tip

Keep the answer concise and make a comparison.

This response is level 3 and is awarded 6 marks.

*(b) Compare the design and use of particle accelerators used in international scientific research with particle accelerators used in hospitals.

(6)

International scientific research use large and complex cyclotrons whereas hospitals use small and simple, cheap particle accelerators. In addition, scientists use cyclotrons to cause collisions to discover new sub-atomic and fundamental particles and hospitals use particle accelerators to create unstable, radioactive isotopes for PET scans. However, both the hospital and scientists use a magnetic field to create a centripetal force that causes charged particles to move in a circular motion and spin outwards.

(Total for Question 5 = 12 marks)

International
More complex and large design
Use is to find subatomic particles

Hosp:
Simple, cheaper
Used to create radioisotopes for PET scans etc.

Both use centripetal force to create circular path using magnetic field

ResultsPlus
Examiner Comments

The response gives both similarities and differences and therefore does make a comparison.

Differences:

- hospital accelerators are smaller and simpler
- hospital accelerators are used to create unstable isotopes
- scientists use cyclotrons to discover new sub-atomic and fundamental particles

Similarities:

- use magnetic fields to create centripetal force
- particles move in a circular motion

ResultsPlus
Examiner Tip

The points to be used in the answer have been planned in the space below the answer line. This keeps the answer concise and relevant.

Question 6 (b) (i)

Most candidates were able to correctly plot the graph points although some did not pay sufficient attention to the scale on the y-axis and plotted all three points incorrectly.

Question 6 (b) (ii)

The curve drawn should be smooth and pass through all the points in this case. Very thick lines, double lines or lines that were distant from plotted points did not score the mark for drawing the curve of best fit.

This response scores 2 for 6bi and 1 for 6bii.

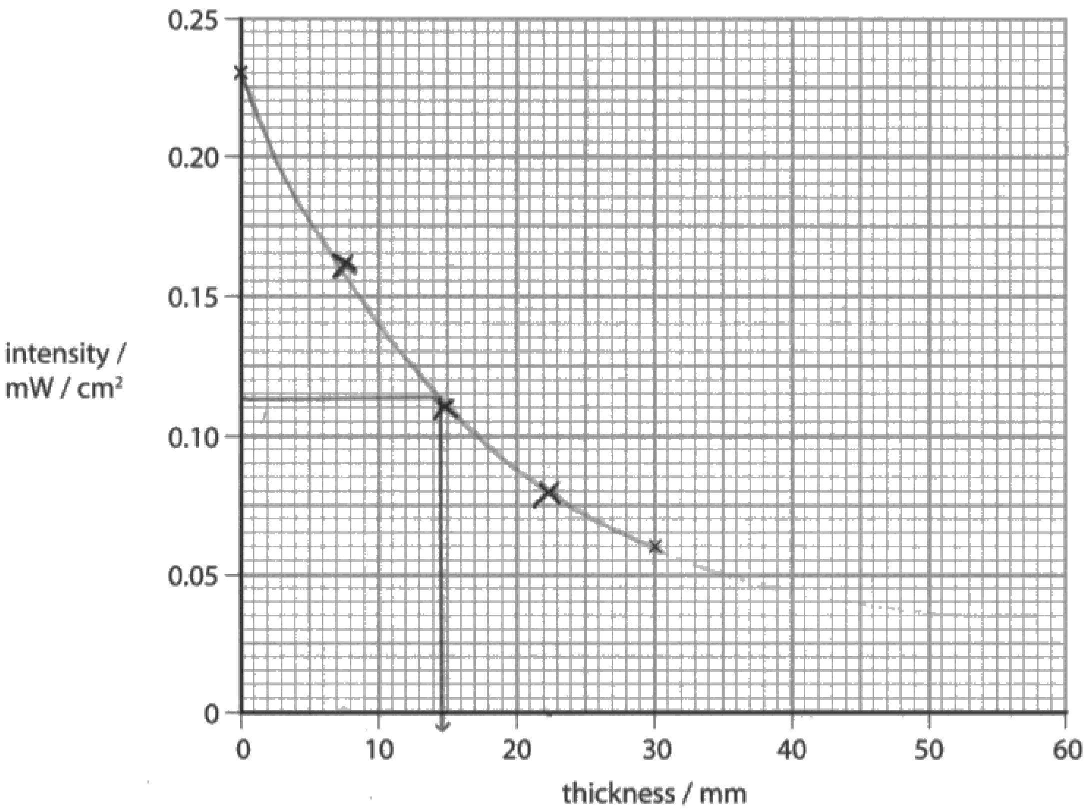
Complete the graph of intensity (*y*-axis) against thickness (*x*-axis).
Two points have been plotted.

(i) Plot the remaining points.

(2)

(ii) Draw a curve of best fit.

(1)



ResultsPlus
Examiner Comments

The points are plotted correctly and the curve of best fit is smooth and passes through all of the points. This graph also shows that the candidate has been able to find the half thickness required for 6biii but has not continued the graph passed the 30 cm thickness and therefore is unlikely to be able to make a sensible estimate of the intensity of the background light as required for the answer to 6biv.

ResultsPlus
Examiner Tip

Take a pencil and an eraser into the examination so that errors on graphs can be removed and the graph redrawn.

This response scored no marks for both 6bi and 6bii.

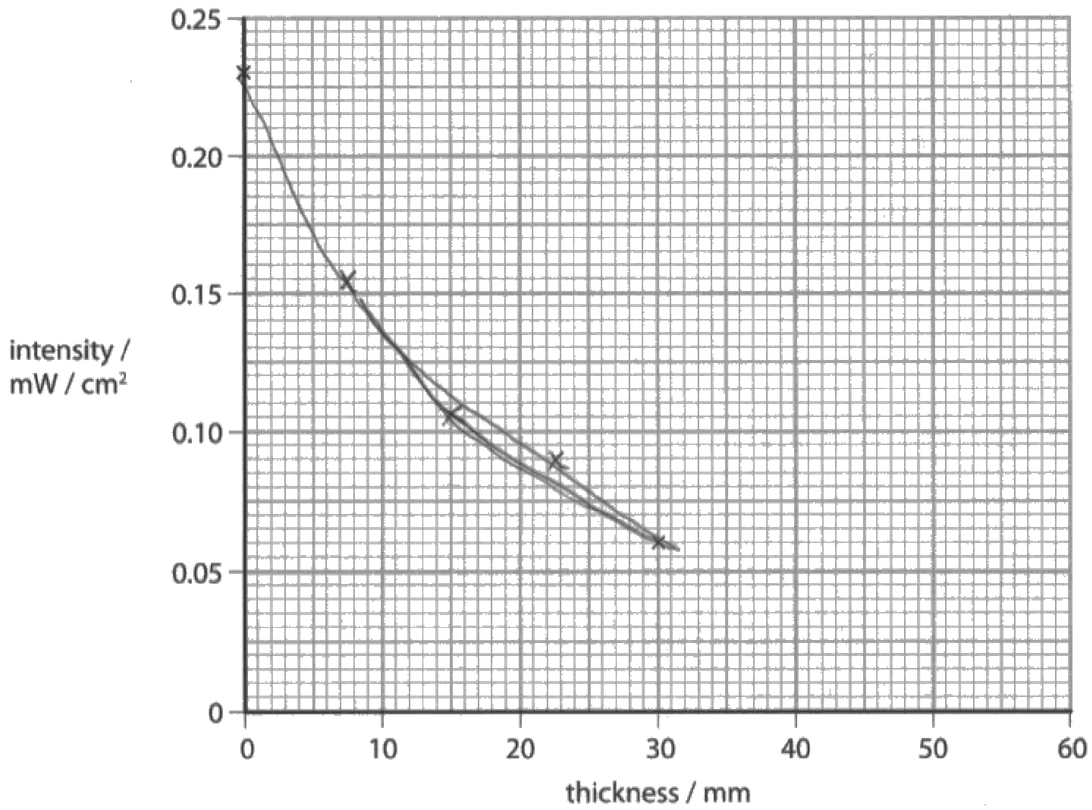
Complete the graph of intensity (*y*-axis) against thickness (*x*-axis).
Two points have been plotted.

(i) Plot the remaining points.

(2)

(ii) Draw a curve of best fit.

(1)



ResultsPlus

Examiner Comments

The three points are wrongly plotted as the candidate has not taken into account that there are two divisions for each 0.01mW/cm^2 on the y axis.

No marks are awarded for 6bii because there is more than one line drawn to show the curve of best fit.

ResultsPlus

Examiner Tip

Make sure the curve that is to be marked is clearly indicated.

This response scored two marks for 6bi and no marks for 6bii.

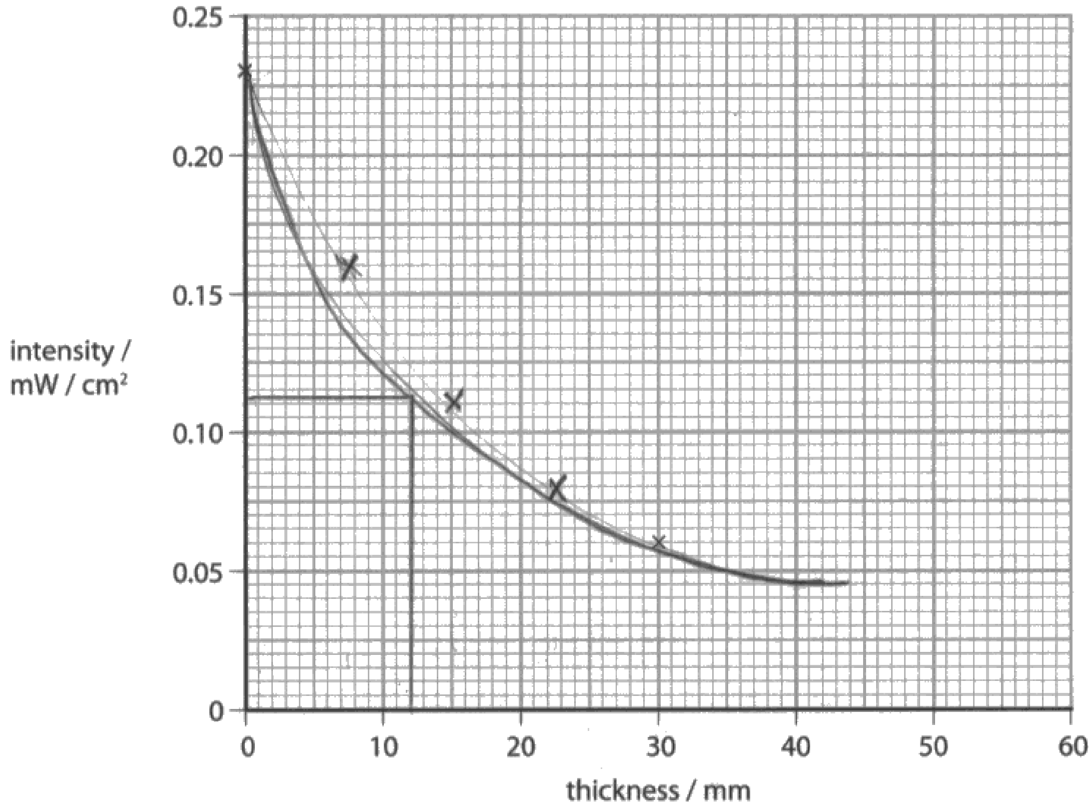
Complete the graph of intensity (*y*-axis) against thickness (*x*-axis).
Two points have been plotted.

(i) Plot the remaining points.

(2)

(ii) Draw a curve of best fit.

(1)



ResultsPlus
Examiner Comments

The points are plotted correctly but the curve drawn is displaced from three points so no mark is awarded for the curve of best fit. This response does show that the lines have been drawn to find the thickness at 50 % of the original intensity but because the curve is inaccurate this value will be outside the values acceptable for 6bii. The curve is continued passed the 30cm thickness and therefore the value of the background intensity could be determined from the graph this would be 0.045mW/cm^2 which would make it within tolerance for the value for the background light intensity.

ResultsPlus
Examiner Tip

Remember to use the features of the graph to answer the question related to it.

Question 6 (b) (iii)

Candidates with correct graphs were usually able to obtain an answer within the tolerance allowed. As half the initial intensity was 0.115mW/cm^2 it was often the scale on the vertical axis which gave rise to incorrect answers.

Question 6 (b) (iv)

Candidates need to extend their graph beyond 30 cm thickness and realise that because the curve did not go to zero that the value of the intensity after about 40cm thickness must be due to the intensity of the background light. Even when candidates had extrapolated the graph the scale had to be read correctly and the most common error was to give answers which were a power of ten too large.

Question 6 (c)

Candidates were generally able to relate the electrocardiogram trace to the way that the heart pumps blood but did not always consider the horizontal and vertical scales or use the quantitative information given.

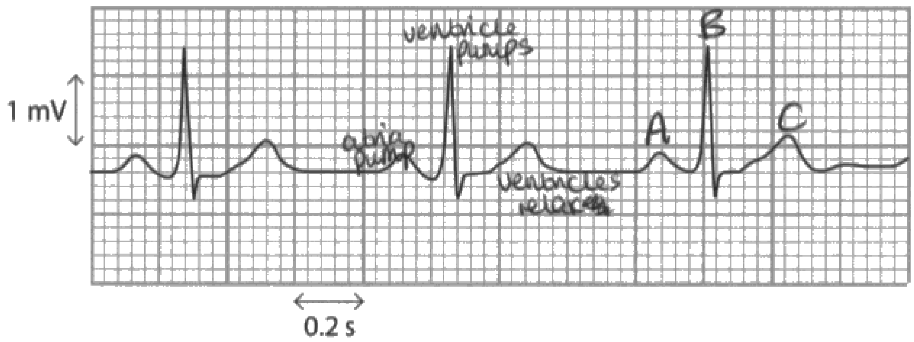
This response is level 2 and gains 4 marks.

*(c) The diagram shows an electrocardiogram (ECG) trace with values given for the horizontal and vertical scales used.

Describe how the characteristic shape of the curve and the distance between peaks relates to the way the heart works.

You may add to the diagram to help with your answer.

(6)



The heart has an elecrical activity of a three-beat pattern. Firstly at point A, the atria pump blood through and the peak is at over 0.2mV than before. Point B is then where the ventricles – the lower chambers of the heart – tighten and pump. Point C is where the ventricles relax. The distance between the peaks is 0.8 seconds which enables you to work out whether the heart is healthy. In this case there will be 150 peaks per minute.

ResultsPlus

Examiner Comments

The candidate knows that the electrocardiogram shows the electrical activity of the heart and although the generally accepted labelling has not been used it is clear from the diagram that the heart action has been correctly described. The value of 0.2s given on the horizontal scale has also been used giving a correct value of 0.8s between heart beats. However there is no indication of how this value has been used to find the heart rate and the heart rate value is not appropriate for this trace. The candidate has given a simple explanation of the signal shape and the distance between peaks and achieves level 2.

ResultsPlus

Examiner Tip

Quantitative information needs to be used correctly to gain the highest level.

This response is level 1 and gains two marks.

*(c) The diagram shows an electrocardiogram (ECG) trace with values given for the horizontal and vertical scales used.

Describe how the characteristic shape of the curve and the distance between peaks relates to the way the heart works.

You may add to the diagram to help with your answer.

(6)

The diagram shows the heart contracting twice then relaxing. It shows us the current of blood ~~blood~~ flow. The distance between peaks relates to the distance between beats. If someone exercises, they get closer as the heart beats faster. The shape of the curve shows us the ~~c~~current of blood flow and the further apart the peaks, the longer the time inbetween contractions.

ResultsPlus
Examiner Comments

The standard labelling for the heart beat has been given on the diagram and there is an attempt to describe the shape of the trace in terms of how the heat works but this is not accurate and is not credited.

The distance between peaks is then related to 'the distance between beats' but this is clarified with 'as they get closer the heart beats faster'. This is sufficient for a level 1 to be awarded as there is a limited explanation of the distance between the peaks.

ResultsPlus
Examiner Tip

Use the information on the diagram, the 1mV label should be a clue to the fact that electrical signal are being measured.

This response is level 3 and was awarded 6 marks.

*(c) The diagram shows an electrocardiogram (ECG) trace with values given for the horizontal and vertical scales used.

Describe how the characteristic shape of the curve and the distance between peaks relates to the way the heart works.

You may add to the diagram to help with your answer.

(6)

The first curve of the ECG, labelled P, shows the electrical signal which stimulates the contraction of the atria, pushing the blood flow into the ventricles. The second part of the curve, labelled QRS on the diagram, shows the contraction of the ventricles and the relaxation of the atria, which ~~~~ pushes the blood flow to the lungs & around the body & allows ~~~~ ~~~~ ~~~~ back the atria ~~~~ to refill with blood. The final part of the curve, labelled T, shows the relaxation of the ventricles. The duration of each heartbeat is around 0.78 seconds, which shows a heartrate of around 76 bpm, which is the average heart rate of a person at rest.

(Total for Question 6 = 12 marks)

ResultsPlus

Examiner Comments

The diagram shows the accepted labelling for an ECG trace and also indicates correctly the time between heart beats.

The description of the action of the heart is accurate and indicating that the largest electrical potential is developed when the ventricles of the heart contract.

The candidate then considers the horizontal scale giving the time between beats correctly and then calculating the heat rate to be 76 beats per minute.

ResultsPlus

Examiner Tip

Use quantitative information when it is given.

Paper Summary

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

- Always show your working for calculations.
- Be able to calculate using standard form.
- Understand when and why units need to be changed or can be left unchanged.
- Use the information provided by diagrams and images to help answer questions.
- Learn the meanings of scientific terms in physics such as conservation.
- Read extended writing questions carefully and take note of the command words.
- Remember questions citing numerical values require quantitative answers.
- Learn the values of atomic number and mass number that are assigned to atomic particles.
- Become familiar with how the position of an image produced by a lens is identified on a ray diagram.
- Plot points on graphs and draw lines or curves of best fit accurately.

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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