Examiners' Report
June 2013

GCSE Physics 5PH3H 01

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June 2013

Publications Code UG036899

Introduction

This was the first examination of the third unit of the new specification. The unit was divided into five topics and all five topics were tested in the examination.

The topics were:

- radiation in treatment and medicine
- X-rays and ECGs
- production, uses and risks of ionising radiation from radioactive sources
- motion of particles
- kinetic theory and gases
- It was intended that the examination paper would allow every candidate to show what they knew, understood and were able to do. To achieve this, each question increased in difficulty as the question progressed.

Within the question paper, a variety of question types were included, such as objective questions, short answer questions worth one or two marks each and longer questions worth three or four marks each. The two six mark questions were used to test quality of written communication (QWC).

It was encouraging to note the positive way in which the vast majority of candidates approached the paper.

Successful candidates were:

- well grounded in the fundamental knowledge required
- willing to think, use their knowledge to solve new problems and apply their knowledge to unfamiliar situations
- able to analyse and interpret data in graphical form
- able to tackle calculations methodically and show the stages in their working
- able to construct their explanations in a logical order, using the marks at the side of the questions as a guide.

Less successful candidates:

- had gaps in their knowledge
- found difficulty in applying their knowledge to new situations
- found difficulty in analysing and interpreting data in graphical form
- did not do well in calculations involving changing the subject of an equation or standard form
- did not think through their answers before writing.

The quality of written communication was generally appropriate to the level of response.

When it was not, the mark within that level was reduced, if possible.

This report will provide exemplification of candidates' work, together with tips and/or comments, for a selection of questions. The exemplification will come mainly from questions which required more complex responses from candidates.

Question 1(b)(i)

The marks here were for collisions between the air molecules and the walls of the container. As expected, the vast majority of candidates scored both marks here.

(i) The air molecules in the cylinder move randomly.
Describe how these air molecules exert a pressure on the cylinder.

(2)

The air molecules collide with the ~~container~~ cylinder and create a force on the cylinder. This is the pressure

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Examiner Comments

This does not talk about the walls of the cylinder but the meaning is clear, especially with the mention of the force.

Question 1(b)(ii)

This was a calculation about a gas expanding at constant temperature. The majority of candidates scored both marks.

(ii) The cylinder contains air at a pressure of 21 000 kPa.

The volume of air in the cylinder is 15.0 litres.
When the valve on the cylinder is opened, the air expands until its pressure is 100 kPa.
The temperature of the air does not change.

Show that the new volume of air is about 3 200 litres.

(2)

$$\frac{P_1 \times V_1}{T} = \frac{P_2 \times V_2}{T}$$

21000 kpa × 15 l = 100 kpa × V_2

$$\frac{21000 \text{ kpa} \times 15}{100 \text{ kpa}} = V_2$$

V_2 = 3150 litres

ANS close to 3200 l.

ResultsPlus
Examiner Comments

A well set out response, finishing with the statement that 3150 is close to 3200.

ResultsPlus
Examiner Tip

Treat 'Show that...' questions like ordinary calculations. They are usually used to make sure that a correct value is used in the next part of the question.

Question 1(b)(iii)

This was a more challenging calculation, involving realising the volume was constant and then rearranging the equation. Even so, more than half the candidates were able to score all 3 marks.

(iii) The cylinder is filled with air in a hot country and then taken to a cold country.

The temperature in the hot country is 305 K.
The temperature in the cold country is 278 K.
The pressure in the cylinder in the hot country is 21 000 kPa.

Calculate the pressure in the cylinder in the cold country.

(3)

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

$$\frac{21,000}{305} = \frac{P_2}{278}$$

$$\frac{21,000}{305} \times 278 = 19140 \cdot 98361$$

pressure in the cylinder in the cold country = 19140·98361 kPa

(Total for Question 1 = 8 marks)

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Examiner Comments

Good, clear substitution in and rearrangement of the equation, clearly recognising that the volume does not change. Very easy to follow and reduces the chances of making a mistake in the calculation. 3 marks awarded.

ResultsPlus
Examiner Tip

There are too many figures quoted in the answer here. It is good to remember that the number of significant figures in the answer should be the same as in the question. In this case, that is 3 significant figures.

Question 2(a)(iii)

Almost a third of candidates could demonstrate their understanding of the term thermionic emission with a similar number being able to score 1 of the 2 marks available.

Question 2(a)(iv)

Most candidates were able to suggest a reason for the vacuum in an X-ray tube.

Question 2(b)

This very challenging calculation involved rearranging a complex equation and using standard form. It was rare to see full marks for this question.

One of the most common errors was to confuse the upper case V for voltage with the lower case v for velocity.

(b) The potential difference between the filament and metal target in an X-ray tube is 40 kV.
The charge on an electron is 1.6×10^{-19} C and its mass is 9.1×10^{-31} kg.

Calculate the speed of an electron as it reaches the target.

(3)

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

$= \frac{9.1 \times 10^{-31} kg \times v^2}{2} = 1.6 \times 10^{-19} C \times 40000 V$

$= 4.55 \times 10^{-31} kg \times v^2 = 6.4 \times 10^{-15}$

$\therefore v^2 = \frac{6.4 \times 10^{-15}}{4.55 \times 10^{-31}}$

$\therefore v \simeq 118597890.7$ m/s

$v \sim 119,000,000$ m/s

speed of electron = 119 000 000 m/s

(Total for Question 2 = 8 marks)

ResultsPlus
Examiner Comments

This response shows the equation, substitution and rearrangement clearly and methodically, a good routine to adopt. The velocity is evaluated correctly. 3 marks were awarded.

ResultsPlus
Examiner Tip

Even though a list of equations is given at the front of the paper, it is a good idea to learn the equations to become familiar with them and not have to think what the symbols mean. This would have been particularly useful in this case, meaning that there would be less chance of confusing V and v.

(b) The potential difference between the filament and metal target in an X-ray tube is 40 kV.
The charge on an electron is 1.6×10^{-19} C and its mass is 9.1×10^{-31} kg.

Calculate the speed of an electron as it reaches the target.

(3)

$1.6 \times 10^{-19} \times 40000 = 6.4 \times 10^{-15} = KE$

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

$v^2 = \frac{KE}{\frac{1}{2}m}$

$v^2 = \frac{6.4 \times 10^{-15}}{\frac{1}{2} \times 9.1 \times 10^{-31}}$

$v^2 = 1.4 \times 10^{16}$

$v = 1.2 \times 10^{8}$

speed of electron = 1.2×10^{8} m/s

(Total for Question 2 = 8 marks)

ResultsPlus
Examiner Comments

A perfect response, even the number of significant figures is correct.

Question 3(a)(ii)

Examiners were looking for responses to mention relative ionising ability or mass.

(ii) Suggest why a beta particle will travel further in air than an alpha particle.

(2)

A beta particle is ~~less is~~ less ionising than alpha particles and are therefore ~~to~~ more penetrating because it doesn't lose energy as quickly as alpha particles. ~~that ionise atoms more easily~~

ResultsPlus
Examiner Comments

This scores both marks for saying that beta particles are less ionising than alpha particles.

Question 3(c)(i)

Responses in terms of a proton decaying into a neutron or quarks changing flavour were acceptable. Some candidates who tried both explanations contradicted themselves so lost some, if not all the marks.

(c) Some unstable nuclei decay by emitting β^- radiation.

(i) Describe the process of β^- emission.

(3)

in β emission ~~an~~ a down quark in a neutron becomes an up quark ~~and an electron~~, the neutron changes to a proton and an electron is emmited.

ResultsPlus
Examiner Comments

Both strands are correct here and the beta minus particle identified as an electron.

Question 3(c)(ii)

Here candidates had to explain that the mass number did not change but the atomic number increased by 1.

(ii) Explain what happens to the mass number and the atomic number of a nucleus when β^- emission occurs.

(3)

The mass number will stay the same because there are the same number of neutrons and protons in total. But the atomic number will increase by one because there is one more proton than before.

(Total for Question 3 = 10 marks)

Atomic = proton (+1)

mass = both. (same)

ResultsPlus

Examiner Comments

An acceptable response for all 3 marks.

Question 4(a)(iii)

Full marks could be gained for stating two of these three ideas:

- momentum is conserved
- kinetic energy is not conserved
- some kinetic energy is dissipated as thermal energy.

(iii) The collision between the bullet and the wooden block is an inelastic collision.

State what is meant by an **inelastic collision**.

(2)

a collision where momentum is conserved, but kinetic energy is lost as heat, sound etc.

ResultsPlus

Examiner Comments

This has all three ideas.

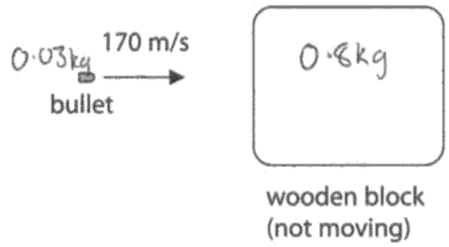
Question 4(a)(i),(ii)

(i) The equation for momentum is not given at the front of the paper so this is a 'Show that' question to enable candidates who do not score the first mark to proceed with the question.

(ii) This requires the conservation of momentum and the first mark can be gained for stating this. Those who did not go on to score all 3 marks usually omitted to include the mass of the bullet in their calculation.

Collisions

4 (a) The diagram shows a bullet moving towards a wooden block.



(i) The bullet is moving with a velocity of 170 m/s.
The mass of the bullet is 0.030 kg.

Show that the momentum of the bullet is about 5.0 kg m/s.

(1)

170 x 0·03

= 5.1 kgm/s

(ii) The bullet collides with the wooden block and sticks in it.
The bullet and the wooden block move off together.
The mass of the wooden block is 0.80 kg.

Calculate the velocity of the wooden block and bullet immediately after the collision.

(3)

Momentum before = momentum after

170 x 0·03 = 5·1kgm/s
+
0·8 x 0 = 0 kgm/s

0·03 + 0·8 = 0·83

0·83 x V = 5·1

5·1 / 0·83 = V   V = 6.14

velocity = 6.14 m/s

Question 4(b)(i)

ResultsPlus

Examiner Comments

Even though the layout is a bit jumbled, 'momentum before = momentum after' is clearly visible and the working is correct and leads to the correct answer.

A very challenging application question, requiring candidates to realise that momentum must be conserved and use the idea that momentum is a vector.

(b) An electron and a positron collide and annihilate each other.
Two photons are produced.

(i) Explain why two photons must be produced, rather than just one.

(2)

Momentum needs to be conserved. When an electron and proton collide they are travelling opposite direction at the same speed and their momentum overall is zero. By producing two photons that travel opposite directions it makes sure momentum stays at zero and is conserved.

ResultsPlus
Examiner Comments
This is a well structured explanation, worth both marks.

Question 4(b)(ii)

(ii) Calculate the minimum total energy of the photons produced when an electron and positron collide.

Use the equation

$$E = mc^2$$

mass of an electron = 9.1×10^{-31} kg
speed of light = 3.0×10^8 m/s

(2)

$2 \times 9.1 \times 10^{-31} = 1.82 \times 10^{-30}$

$1.82 \times 10^{-30} \times (3 \times 10^8)^2 = 1.638 \times 10^{-13}$

energy = 1.638×10^{-13} J

(Total for Question 4 = 10 marks)

ResultsPlus
Examiner Comments
Methodical, clear and realised there were 2 particles of equal mass involved. This scores both marks.

Question 5(a)(ii)

This involved analysing and using some quite complex data about the inverse square law and rearranging an equation. The most common error was to use the wrong value for the area.

Question 5(b)(i)

This required candidates to estimate a value on the y-axis from a family of curves. Most were able to do this successfully.

Question 5(b)(ii)

Candidates had to explain their choice of frequency of ultrasound for scanning organs deep inside the body.

(ii) Explain which of these frequencies of ultrasound can be used to scan organs deep inside the body.

(2)

the 2MHz because it penetrates furthest so can travel furthest through soft tissue, into the body. It also has the highest intensity at 4·5 than the others so the least amount has been absorbed so will produce best image of inside body.

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Examiner Comments

This is a good explanation which does more than just repeat the question.

Question 5(c)

A comparison was required here between the uses of electromagnetic radiation in two different diagnostic devices. One of these, an endoscope, was given but there was a free choice for the second. The best responses identified the second device and both radiations involved and went into some detail about the use of each device. Responses which involved radiation other than electromagnetic failed to score.

*(c) Medical physicists have developed endoscopes and many other devices to help doctors diagnose medical problems.

Compare the use of electromagnetic radiation in endoscopes and in one other diagnostic device.

(6)

Endoscopes use visible light, ~~carried~~ totally internally reflected by a bundle of optical fibres to carry light into the body. A different tube carries the light back to an eyepiece or a screen. The electromagnetic radiation used in endoscopes is not ionising and has no harmful effects on cells. It enables doctors to see real-life images of the inside of the body, eg diagnosing stomach problems. However, CAT scanners use electromagnetic radiation of a higher frequency – X-rays. The patient lies on a movable table and an X ray tube is rotated around them and detected by detectors on the opposite side of the tube. This helps create images of the inside of the body, as 'slices' ~~taken by~~ are used to compile a 3D image. CAT scans are used to detect hard as well as soft tissue eg cancers. However useful the ~~CA~~ X-rays are, they are ionising and cause damage to healthy cells.

(Total for Question 5 = 12 marks)

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Examiner Comments

The candidate has identified visible light as the radiation used in endoscopes and as X-Rays in CAT scanners. There is then some good detail about the use and risks in each case.

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Examiner Tip

It is good practice to do as this candidate did and underline the key words before answering the question. It would have been better in this case if the word 'compare' had also been underlined as this is the command word of the question.

Question 6(a)(i)

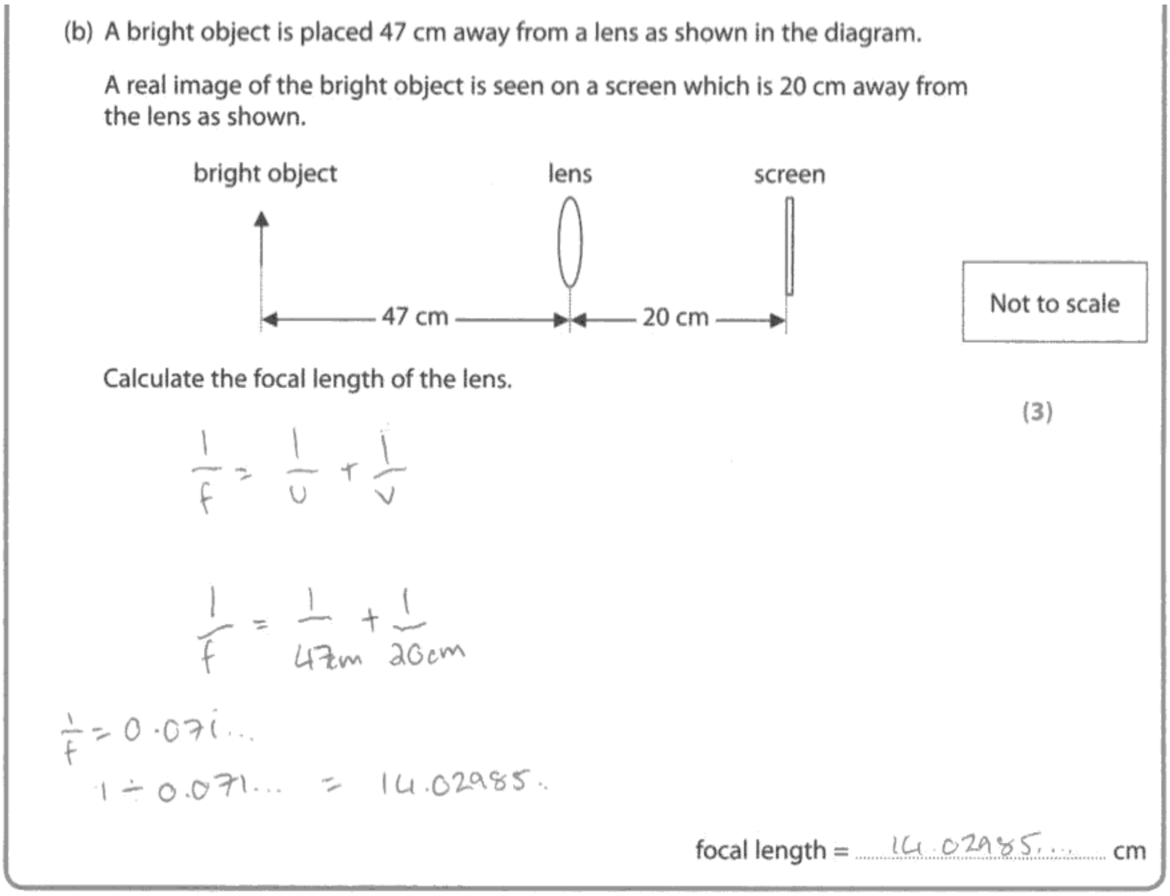
It was pleasing to see that the vast majority of candidates were able to correctly label the iris on a diagram of the human eye.

Question 6(a)(ii)

Most candidates were able to name two parts of the eye involved in focussing with only a very few being unable to score at least one of the marks.

Question 6(b)

It was good to see that well over half the candidates were able to score some marks in using the lens equation, with many of them scoring all 3. It was disappointing to see that some candidates did not even score the 1 mark available for substituting the values for the object and image distances into the equation.



(b) A bright object is placed 47 cm away from a lens as shown in the diagram.

A real image of the bright object is seen on a screen which is 20 cm away from the lens as shown.

Calculate the focal length of the lens.

(3)

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

$\frac{1}{f} = \frac{1}{47cm} + \frac{1}{20cm}$

$\frac{1}{f} = 0.071...$

$1 \div 0.071... = 14.02985...$

focal length = 14.02985... cm

ResultsPlus
Examiner Comments

All the steps are set out clearly here, making the work easy to follow and reducing the chances of making a mistake.

ResultsPlus
Examiner Tip

There are too many figures quoted in the answer here. It is good to remember that the number of significant figures in the answer should be the same as in the question.

Question 6(c)

This was a straightforward question in which candidates' understanding of some defects of vision and their correction was tested. The best responses were well structured, logical explanations involving the causes and effects, and a correction for one of them. Responses which were not presented in a structured way often became confused or even contradictory.

There were a lot of excellent responses to this question.

*(c) Long sight and short sight are two defects of vision.

Explain how long sight and short sight are different from normal sight and how one of these defects can be corrected.

(6)

In normal sight, the eye can focus easily on both near and far objects. However, long sighted and short sighted people have trouble doing this. In long-sight, people find it hard to focus on objects near to them. This can be either because their eyeball is too short so the image is formed behind the retina or because their lens or cornea is too thin/weak. Short-sight is when people find it hard to focus on objects far away. This can happen because their eyeball is too long so the image is formed in front of the retina or because their cornea or lens is too thick/powerful. Long sight can be corrected using converging or convex lenses which converge (bend rays closer together) so the image is formed on the retina.

(Total for Question 6 = 12 marks)

TOTAL FOR PAPER = 60 MARKS

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Examiner Comments

This discusses what each defect is with optical detail and how long sight is corrected.

Paper Summary

In order to improve their performance candidates should:

- make sure that they have a sound knowledge of the fundamental ideas in all five topics
- get used to the idea of applying their knowledge to new situations by attempting questions in support materials or previous examination papers
- show their working at each stage of a calculation
- use the marks at the side of a question as a guide to the form and content of their answer
- learn the equations to make it less likely that they will confuse the symbols, as in question 2b.

Grade Boundaries

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

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