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A LEVEL

Examiners' report

PHYSICS A

H556

For first teaching in 2015

H556/03 Autumn 2020 series

Version 1

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

i	Reports for the Autumn 2020 series will provide a broad commentary about candidate performance, with the aim for them to be useful future teaching tools. As an exception for this series they will not contain any questions from the exam paper nor examples of candidate responses.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

A full copy of the exam paper and the mark scheme can be downloaded from OCR.

Paper 3 series overview

Paper 3 assesses all areas of the Physics A GCE, often through examples of real practical and experimental situations. Since this paper is synoptic, candidates need to be able to apply their knowledge and understanding in unfamiliar contexts in order to gain high marks,

To do well in this paper, candidates must be able to:

- perform and layout calculations logically, showing clear working (such as Question 6c)
- produce concise but accurate responses to questions which involve extended writing (such as question 1b)
- craft clearly structured and well-reasoned arguments to the Level of Response Questions (3b and 5d)
- process and interpret data from an experiment to reach conclusions (Question 2).

Candidates had no difficulty in completing the paper in the time allowed. However, there were several scripts where the more difficult questions had been left blank.

Candidates who did well on this paper generally did the following:	***Candidates who did less well on this paper generally did the following:***
• completed both numerical and descriptive questions equally well • sketched and labelled their diagrams clearly • structured their numerical solutions well with clear manipulation of formulae, full and accurate substitution, and a final response given to an appropriate level of accuracy • retained numbers in their calculator for subsequent stages of a calculation rather than rounding at an early stage • constructed full and logically argued responses to the Level of Response questions • showed that they had encountered practical situations regularly throughout their studies and were familiar with data analysis techniques.	• set out their calculations poorly, making it difficult to follow their reasoning • sketched diagrams hurriedly, without using a ruler or labelling relevant angles • rounded their responses at an early step in a calculation rather than at the end. • used imprecise language to describe scientific phenomena (such as polarisation) • transcribed numbers incorrectly from the question stem, or from the Data, Formulae and Relationship booklet • crossed out (often correct) working without providing an alternative response • either did not attempt the Level of Response questions, or gave a response that was too generalised and did not fully address the question.

Comments on individual questions

Question 1ai

Many lower ability candidates did not appreciate the uniform nature of the electric field between the plates and attempted to use Coulomb's Law.

Question 1aii

Most candidates scored a mark for showing the weight and tension forces accurately. Only a small proportion labelled the electric force arrow correctly and drew it as clearly perpendicular to the plates.

	AfL	Do not use the word 'gravity' in place of 'weight'

Question 1aiii

Although most candidates knew the principle of moments, many were unable to apply it correctly in this situation. More practice at this sort of question is recommended.

Question 1b

The purpose of this question was to challenge the candidates to use their knowledge of electric fields in a novel practical situation. The word 'oscillate' confused many candidates, who tried to explain why the ball would perform simple harmonic motion.

Question 2a

Some candidates obtained $Q = EC_0$ by applying the definition of capacitance at A, but then did not realise that charge would be conserved on switching from A to B. Some chose the wrong formula for capacitors in parallel or attempted to use the potential divider equation.

Question 2bi

Some candidates correctly took the reciprocal of both sides of the given equation but were then unable to show a rearrangement into the standard linear form. A common difficulty was an inability to expand the bracket in $\frac{1}{E} \times \frac{(C + C_0)}{C_0}$ to give $\frac{C}{EC_0} + \frac{C_0}{EC_0}$

Question 2bii

Some candidates gave their response to 2 d.p. instead of to 2 s.f. as required.

Question 2biii

Most candidates gained the mark for using a large triangle (spanning more than 1.5 on the x–axis) to determine the gradient of the worst-fit line. Lower ability candidates were unable to gain credit for finding the gradient of their line because they read the scales on the axes incorrectly. Candidates should take a ruler into the examination and be careful about the positioning of the ruler for drawing a worst-fit straight line. A worst-fit line should join opposite extremes of uncertainty limits and pass between all the uncertainty limits. The Practical Skills Handbook is helpful on this topic.

Several candidates performed the unnecessary step of calculating the fractional (or percentage) uncertainty instead of using $\Delta C_0 = \pm |C_{0\ \text{best}} - C_{0\ \text{worst}}|$ directly.

Question 3ai

Most candidates successfully used the formula for Stefan's Law.

Question 3aii

Higher ability candidates successfully used the more elegant ratios method to reach the correct response. Lower ability candidates had more success if they broke their calculation down into smaller steps, such as calculating and writing down T^4 rather than going straight to T. Candidates should be encouraged to consider whether their responses to calculations are reasonable as this will alert them to a possible error. For example, some candidates calculated the temperature of Sirius (which they were told is the brightest star in the night sky) to be less than 1K.

Question 3b

This was one of the two LoR questions. It required understanding of fusion, mass-energy equivalence, the Maxwell-Boltzmann distribution, and the relationship between mean kinetic energy and temperature for particles in an ideal gas.

Responses to the following questions were being sought:

1. Why is the Sun losing mass?
2. Why is an extremely high temperature needed for fusion in stars?
3. Why does fusion occur in the Sun even though its temperature is 1,000 times less than that required by theory?

Two dissimilar responses could score comparable marks if the criteria set out in the answer section of the marking scheme were met. Level 3 responses gave a clear answer to all three of the questions, whereas Level 2 responses generally had clear answers to only two. In Level 1, limited answers to only one or two of the above questions were given.

Question 4a

?	**Misconception**	Experiencing weightlessness is not the same as being in freefall

There was a lack of understanding of the nature of feeling weightless. The sensation of 'weightlessness' is a lack of the physiological sensation of 'weight'. The skeletal and muscular systems are no longer in a state of stress. This sensation is caused by a lack of contact forces as a result of the ISS and the astronaut experiencing the same acceleration.

Common incorrect responses included:

- the astronaut is weightless because he is falling
- there is no resultant force on the astronaut
- gravity is too weak to have any effect on the astronaut
- the ISS orbits in a vacuum where there is no gravity.

Question 4bi

The simplest method here was to use the fact that g is inversely proportional to r^2, so gr^2 = constant. If this was not used, a value for the mass of the Sun had to be calculated, which introduced a further step. Candidates who omitted this calculation and used a memorised value of the Sun's mass instead were unable to gain full marks, because they invariably knew it to 1 s.f. only, whereas 3 were required.

Errors occurred when candidates used the incorrect distance in the formula for g. Common errors included:

- forgetting to square the radius
- using the Earth's radius rather than the orbital radius of the satellite
- calculating $(6.37 \times 10^6 + 4.1 \times 10^5)$ incorrectly.

Question 4c

The success in this question depended on understanding the meaning of the term m in the formula $\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$ given in the Data, Formulae and Relationship booklet. A significant number of candidates took m to be the mass of one mole (the molar mass, M) whereas m is actually the mass of one molecule. Candidates who used the formula $\frac{1}{2}M\overline{c^2} = \frac{3}{2}RT$ were usually more successful because the molar mass had been given in the question stem.

Question 4d

Although this question looked daunting, it was actually quite linear and many candidates who attempted it were able to gain two or three marks even if they did not eventually get to the correct response. Candidates who set out their reasoning and working clearly were more liable to gain these compensatory marks.

Question 5b

The words 'simple harmonic motion' in the text prompted almost all candidates to use the correct formula here.

Question 5c

Allowing a mark for the diode only letting current pass in one direction enabled many candidates to score this mark. There was little mention of alternating current among the responses.

Question 5d

This was the second of the two LoR questions in this paper. It required knowledge of polarisation, superposition and interference. There is no one perfect model response but generally, for Level 3, candidates were required to give clear reasoning for the situations which gave both maximum and minimum readings in both investigations. Such candidates included correct numerical values in their responses (although 'half a wavelength' was acceptable in place of 30cm). Level 2 responses were sometimes incomplete (e.g. giving the maximum position but not the minimum position) or confused (e.g. the maximum and minimum positions were given but were the wrong way around). Level 1 responses came from candidates who misunderstood the physics of one of the situations, or who confused phase difference and path difference, or whose descriptions were generally too vague to gain much credit.

It may be helpful to point out that investigation **2** was not about the formation of a stationary wave; rather, it was about two overlapping coherent waves forming regions of constructive and destructive interference. A common misconception was that the maximum and minima signals were related to antinodes and nodes.

?	**Misconception**	A minimum or zero reading does not occur when two waves are merely out of phase. They must be *completely* out of phase. The best way to describe this is to say that they are **in antiphase**.

Question 6a

The common errors here were:

- not realising that, for the particle to be deflected through a smaller angle, it needed to be travelling further away from N
- not labelling the final angle of 30°
- not adding arrows to show the direction of travel
- drawing a path that continued bending beyond the stated 30° (usually ending up parallel to the original path).

Question 6b

The most common error here was to use incorrect values for the charges on the two ions. Even so, most candidates were able to gain most of the marks with ECF.

Question 6c

This question provided an excellent opportunity for candidates to produce immaculate responses: identify the physics involved, select and write down the correct formula, do the necessary conversion (MeV to J), rearrange the formula, substitute correctly and then write the final response in standard form to a correct number of significant figures. Some of the common errors were:

- forgetting to convert 5.0 MeV into J
- not showing a full substitution of values (which is necessary for a 'show that' question)
- not calculating the response to more than 1 s.f. (which is necessary for a 'show that' question).

Question 6d

This was not an easy question but, even so, a good number of candidates did well. The marks were given for the direction (rather than for the magnitude) of the momentum vectors. Some of the common errors were:

- forgetting to label relevant angles
- not using arrows to show direction
- drawing a vector triangle without any indication of which arrow was meant to be the final momentum.

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