Oxford Cambridge and RSA

GCE

Physics A

Advanced GCE **H556**

OCR Report to Centres June 2017

Oxford Cambridge and RSA Examinations

About this Examiner Report to Centres

This report on the 2017 Summer assessments aims to highlight:

- areas where students were more successful
- main areas where students may need additional support and some reflection
- points of advice for future examinations

It is intended to be constructive and informative and to promote better understanding of the specification content, of the operation of the scheme of assessment and of the application of assessment criteria.

Reports should be read in conjunction with the published question papers and mark schemes for the examination.

The report also includes:

- An invitation to get involved in Cambridge Assessment's research into **how current reforms are affecting schools and colleges**
- Links to important documents such as **grade boundaries**
- A reminder of our **post-results services** including Enquiries About Results
- **Further support that you can expect from OCR**, such as our Active Results service and CPD programme
- A link to our handy Teacher Guide on **Supporting the move to linear assessment** to support you with the ongoing transition

Understanding how current reforms are affecting schools and colleges

Researchers at Cambridge Assessment[1] are undertaking a research study to better understand how the current reforms to AS and A levels are affecting schools and colleges.

If you are a Head of Department (including deputy and acting Heads), then we would be very grateful if you would take part in this research by completing their survey. If you have already completed the survey this spring/summer then you do not need to complete it again.

The questionnaire will take approximately 15 minutes and all responses will be anonymous.

To take part, please click on this link: https://www.surveymonkey.co.uk/r/KP96LWB

Grade boundaries

Grade boundaries for this, and all other assessments, can be found on Interchange. For more information on the publication of grade boundaries please see the OCR website.

Enquiry About Results

If any of your students' results are not as expected, you may wish to consider one of our Enquiry About Results services. For full information about the options available visit the OCR website. If university places are reliant on the results you are making an enquiry about you may wish to consider the priority 2 service which has an earlier deadline to ensure your enquires are processed in time for university applications.

Supporting the move to linear assessment

This was the first year that students were assessed in a linear structure. To help you navigate the changes and to support you with areas of difficulty, download our helpful Teacher guide: http://www.ocr.org.uk/Images/345911-moving-from-modular-to-linear-science-qualifications-teachers-guide.pdf

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[1] Cambridge Assessment is a not-for-profit non-teaching department of the University of Cambridge, and the parent organisation of OCR, Cambridge International Examinations and Cambridge English Language Assessment.

Further support from OCR

activeresults

Active Results offers a unique perspective on results data and greater opportunities to understand students' performance.

It allows you to:

- Review reports on the **performance of individual candidates**, cohorts of students and whole centres
- **Analyse results** at question and/or topic level
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- Identify areas of the curriculum where students excel or struggle and help **pinpoint strengths and weaknesses** of students and teaching departments.

http://www.ocr.org.uk/administration/support-and-tools/active-results/

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Advanced GCE Physics A (H556)

OCR REPORT TO CENTRES

H556/01 Modelling physics

General Comments:

This examination produced a very wide range of marks, from 4 to 97, with many of the candidates displaying excellent recall of points of physics and good application of that knowledge in both familiar and unfamiliar situations.

This was the first series of the new specification and for many candidates, the first externally examined physics paper since GCSE. Candidates omitted few questions and there was little evidence that the candidates could not complete the paper in the scheduled time.

The multiple-choice questions (MCQs) section was answered competently by most candidates, who either got the answer correct or chose the most likely distractor. This helped to discriminate between the candidates very well. Candidates used the space on the question paper effectively, often to draft out calculations or to eliminate unlikely options.

Generally, candidates answered questions on practical skills quite well. The two Level of Response (LoR) questions focused on experiments suggested by OCR as acceptable Practical Activity Group (PAG) activities and it was evident that most candidates were familiar with both practical activities. Centres and candidates should remember that each suggested PAG activity includes advice about which practical skills may be tested in the examination, such as consideration and combination of uncertainties as well as methods of obtaining high quality data. Further guidance can be obtained in the Practical Skills Handbook, available on the OCR website at http://www.ocr.org.uk/Images/295483-practical-skills-handbook.pdf .

Many candidates made good use of the Data, Formulae and Relationships Booklet. Calculators were used effectively and answers were often quoted to the correct number of significant figures. Candidates are once again reminded that it is poor practice to round off numbers in the middle of long calculations. In ‘show’ questions, it is always a good idea to add as much detail as possible and to be clear about the logical order of the steps from start to finish.

The quality of extended answers other than LoR questions remains variable. It was easy for candidates to contradict themselves, thus negating previous good physics. A quick read-through could be usefully employed by the candidates to spot those contradictions. Candidates can improve their responses by being brief and organised, possibly by acceptable use of bullet points. Named quantities (e.g. period, energy required to reach boiling point) are usually considerably clearer when communicating ideas, even in multiple-step calculations, than symbols (e.g. T, E). Candidates appreciated the meaning of command words, such as describe, explain and show to a very great extent.

It is worth reminding candidates again that their scripts are scanned and then marked by Examiners. It is therefore important that answers are not written outside the space provided for the answers. Where this is not possible, use of the additional pages at the back of the answer booklet is far preferable to using attached sheets.

There were some excellent scripts with clearly laid out physics and well-presented calculations. The comments that follow tend to relate mainly to the opportunities that were missed by the candidates.

Comments on Individual Questions:

Question	Comment
MCQ 1-15	Virtually all questions showed a positive discrimination, except for question **10**. The questions themselves require careful inspection, as crucial information that could lead to the exclusion of many options can be obtained reducing the need for calculation and guessing. Underlining or circling key points may help candidates to converge towards the correct responses. Candidates should ensure that all letters are clearly formed. If there is a need to amend an answer crossing through the incorrect answer and writing the correct answer adjacent to the box will help avoid any potential for misunderstanding by the examiner. Questions **1,6,9,11,12 and 15** proved particularly straightforward and accessible to nearly all candidates. Questions **2 and 3** were slightly more challenging, with questions **5,7,8 and 14** providing opportunities for middle-grade candidates. In question **5**, candidates generally forgot that the practical skills guide recommends that uncertainties are usually given to one significant figure, ruling out option D. Furthermore, the length and width are both given to two significant figures, which means that the area should also be to two significant figures. The correct procedure is to add the percentage uncertainties in the length and width, which gives the percentage uncertainty in the area and hence the absolute uncertainty of 300m. Question **7** required the temperatures to be converted into kelvin before finding the peak wavelength, giving option B rather than option A. Question **8** showed that candidates had generally forgotten that the resultant force does not have to be in the direction of travel, hence all three statements could be correct, giving option D. In question **14,** candidates should consider the equation pV = nRT. If the pressure and volume remain the same, this gives nT as a constant also. If the number of particles decreases to two thirds of the original number, then the temperature in kelvin, and thus the total kinetic energy and hence mean square speed must have increased by a factor of 1.5, giving option C. Questions **4** and **13** were more challenging still. In question **4**, it was expected that candidates would use the idea that $v^2 = u^2 + 2aS$, hence realising that v^2 was directly proportional to the drop height, *h*, giving option A as the correct answer. In question **13**, candidates often forgot that the impulse provided by the hockey stick is in the opposite direction to the momentum of the puck, again giving option A as the correct answer. Question **10** did not discriminate very well at all. The key point is that the emission lines all undergo the same **fractional** wavelength increase, so that the longer wavelengths will have larger absolute increase, as indicated by option B. Option A gives lines which are all the same absolute increase.
16a	This was answered correctly by most candidates; a tiny number did not convert from cm to m correctly.
16b	Unsuccessful candidates tried to employ ‘suvat’ equations, although many candidates realised that the required ratio was also the ratio of the distances travelled in the same time period. Some credit was given for those candidates that assumed constant pressure and 100% efficiency.

16c	The majority of candidates successfully calculated the work done on the car and hence the efficiency of the system.
17a	A large majority included a correct measuring device, such as a thermometer. Significantly fewer described a technique for accurate measurements such as stirring the water or taking the temperature at several points and calculating a mean temperature.
17bi	Approximately half of the candidature made a correct comment regarding resolution or that the smaller intervals on the psi scale made it a sensible choice of scale.
17bii	The vast majority of candidates correctly calculated the pressure in kPa and stated that the absolute uncertainty was 3 kPa. A very small number of responses were rounded inappropriately.
17ci	Most candidates correctly plotted the point with error bars. In this instance during marking Examiners were instructed to ignore the error bars as they were too difficult to view when scanned.
17cii	It was clear that the majority of candidates had either performed this experiment themselves or had otherwise seen it before. The concept of absolute zero was very successfully described and many knew that an extrapolation or calculation involving the equation of a straight line was required to find absolute zero as the x-intercept of the straight line. Common errors included mis-calculating the gradient, inability to rearrange the equation or inappropriate conversion to kelvin. Re-plotting the graph was not required and merely wasted time for little reward.
17d	Many candidates realised that drawing a line of worst fit was sensible. Far fewer were clear that using the line of worst fit to find a new x-intercept, leading to a spread in values for absolute zero was the correct procedure. Many incorrectly suggested finding the difference in gradients, or percentage differences in gradients.
17e	The first mark for this item was intended to be for a straightforward comparison that the repeated experiment yielded a lower value than that from question **17cii**. Many candidates calculated a percentage difference yet did not refer to the direction of difference. Some candidates successfully suggested that the water would always be cooler than the gas and so the thermometer reading would be systematically lower than the true temperature of the gas. Rather fewer discussed that the pressure reading would therefore be higher than it should be for the thermometer reading. Very few candidates linked this idea to the effect on the graph, namely that the points would all be shifted to the left, causing a lower x-intercept or a less steep line of best fit. There were three acceptable experimental approaches to avoid this systematic error. Stirring the water and waiting until the gas and water equilibrated would have reduced the effects of the rapid cooling. A sensible approach employed by some candidates was to take the temperature of the gas directly using a thermometer or temperature inside the flask.
18ai	Examiners were delighted to see that nearly all candidates could successfully calculate the density of the wood block, although some candidates missed that the diameter rather than the radius was provided. A small number neglected to check the formula for the volume of a cylinder, which was provided in the Data, Formulae and Relationships booklet.
18aii	18ai was intended as a guide to the candidates that the wood's density was relevant. Many candidates successfully saw the link between the wood's density and that of the diver, yet fewer realised the consequence of this i.e. that the wood would reach a deepest point in the water and then float back to

	the surface. Predominantly, candidates sought to describe a second physical property in ways beyond the scope of the specification, such as impermeability to water and shape retention.
18b	Examiners were pleased that nearly all candidates successfully employed Newton's equations of motion ideas to arrive at the correct answer. Those that did not either mis-substituted values or forgot to take a square root.
18ci	The forces referred to by name in module 3 of the specification are weight, drag, upthrust. tension, normal contact force and friction. Candidates should be aware that the three relevant forces in this example are upthrust, weight and drag (with friction as an acceptable alternative). A wide range of other options were provided by candidates, such as gravity, buoyancy, lift, pressure, impulse and air resistance, none of which were acceptable.
18cii	Examiners would like to see an improvement in the understanding of the forces acting on objects in motion as this item on resultant forces was not answered well. A large proportion of candidates misunderstood the scenario, believing it to be a terminal velocity problem. This meant that many responses included the notion that the block would speed up and eventually have zero resultant force acting upon it. In this case, that would mean that the block would continue at constant velocity downwards rather than return to the surface. This item prompted the candidates by asking about the resultant force at the lowest point of the motion, which tying in with the ideas in previous parts of the question about density and floatation, should have hinted that the resultant force at the lowest point was upwards. Those candidates that did realise this often contradicted themselves to ensure an upwards resultant at the bottom of the motion. Typically, this was by stating, incorrectly, that the upthrust or the drag increased, at which point only one mark was possible.
18d	Candidates generally had the right idea on this item yet lacked clear enough language to express themselves adequately. Many had some success by referring specifically to data from the graph or the shape of the trendline to support their assertions. Less convincing attempts included those that suggested that there was square root relationship presumably with Newton's equations of motion in mind, without any justification for doing so from the graph. Centres are reminded that situations with changing accelerations are not expected to be solved algebraically at A2 level.
19ai	Most students had considerable success in deriving the required expression.
19aii	A pleasingly large proportion of students remembered that specification point 5.3.1 (f) states that the period of a simple harmonic oscillator is independent of its amplitude. A similarly large proportion referred to damping or action of the drag force but fell slightly short of the idea that the effect of that force is to reduce the energy stored in the pendulum.
19b	While a small number of candidates described the incorrect experiment (such as masses on a spring or circular motion) most candidates made excellent attempts to describe the experiment and the ensuing analysis. References to even the most basic equipment are essential, such as measuring lengths with a ruler and periods of time with a stopwatch or other suitable timer. Candidates that did neither could not score higher than Level 1.

	Level 3 responses included ideas about achieving high quality data, such as use of a fiducial mark, starting the oscillation count (and hence the timer) at the midpoint where the pendulum bob is fastest, stating a suitable small angle of ten degrees or less and how to achieve that consistently with a protractor and by measuring the length of the string from the suspension point to the centre of the bob. By far the preferred method of analysis leading to verification of the relationship was plotting a graph of T^2 against L and expecting the trend to be not only straight but also through the origin with a gradient of $(4\pi^2/g)$. An acceptable alternative was to suggest calculating several values of (T^2/L) and demonstrating that ratio to be constant and equal to $(4\pi^2/g)$. Note that writing 'Plot a graph of T^2/L' is not an acceptable short hand for 'plot T^2 on the y-axis and L on the x-axis.
19ci	A large majority of candidates successfully showed that the pendulum length should be 0.99m for a 'tick' length of 1.0 seconds. Candidates that attempted the reverse argument, by assuming a length of 1 m and then calculating the corresponding length, were usually unable to show the period of the resulting pendulum was 2.01s. Candidates that showed how to arrive at this period gained full credit.
19cii	Many candidates suggested that *g* is less on the Moon than it is on the Earth, gaining one mark of credit. Most candidates suggested that would mean the period of the pendulum would be larger, but did so without justification from the formula in the question or contradicted themselves by stating that would make the pendulum 'run faster'.
20a	Virtually all candidates correctly found the total energy supplied, remembering to convert the time from minutes into seconds.
20b	This was a challenging multi-step calculation that differentiated between the candidates well. A method employed by many high-scoring candidates began with a word equation "Total energy transferred = energy required to heat water to boiling point + energy required to vaporize water". This made it clear to award the mark for substituting into the specific heat capacity equation and clear to the candidate how to find the mass of vaporized water. A minority of candidates forgot to subtract the mass of vaporized water from the initial mass.
21ai	This item provided good discrimination between the candidates. Many responses referred incompletely to the negative charge of the electron being the only factor, whereas the correct explanation is much more to do with the electron requiring energy to leave the atom and the ionization level being defined as the zero point. Some candidates were on the right path when they referred to the equivalent statement for gravitational potential energies.
21aii1	Virtually all candidates correctly evaluated the energy difference to be 2.55 eV. Negative values were condoned but are unlikely to be accepted in future series.
21aii2	Many candidates correctly calculated the wavelength of emitted light, although a minority did not convert the energy into joules or performed the required conversion to nanometres incorrectly.
21bi	Many candidates muddled up emission (lines emitted by a source) and

	omission (as in lines absorbed by a low pressure gas when a continuous spectrum passes through it, as in an absorption spectrum), so could not score the mark. Some focused on the experimental procedure of using a diffraction grating. A third of candidates correctly stated that the electron dropped down to a lower energy state, releasing a photon or the equally acceptable 'EM radiation'
21bii	This item tested knowledge of specification 5.5.2 (g) and PAG 5. It would be advisable for Centres, where possible, to allow candidates to observe the effect of changing the slit separation and the grating-screen separation independently. Approximately a third of students correctly suggested making one of those adjustments, even if they expressed the former as 'increase the number of lines per mm'. Some candidates presented arguments about plotting the graph on a smaller scale or measuring the wavelength in picometres in an attempt to resolve the peaks in the plot, which was a mis-interpretation of the question.
21biii	Examiners were pleased to see this item answered well, with the majority of candidates gaining either two or three marks. Those that did not either mis-read the position of the red-shifted spectral peak, did not recognise that they were looking for the peak wavelength or did not use the 'at rest' wavelength for the denominator of the expression for the change in wavelength.
21biv	Just over half of all candidates realised that the useful property of hydrogen was its relative abundance in stars and hence galaxies.
21c	Some 9% of all candidates declined to answer this item, the highest rate for any item on this paper. The most common correct response linked higher distance with higher recessional velocity and thus higher increase in wavelength. Higher ability candidates explained that the orbiting stars would have different velocities relative to the Earth resulting in a periodic change in wavelength from the central peak. References to blue-shifting were erroneous and contradictory.
22a	The correct answer for this item was a direct reference to specification point 5.1.2 (d) and required the association with the particles of a system. Many more than half of the candidates would have scored this mark had they included this association.
22b	Question **22a** was designed to lead the candidates into thinking about both KE and PE of the particles contained within the paraffin. The stem of the question includes a reference to constant temperature, so credit could only be awarded to linking this idea to that of the molecules' constant average KE, since average KE is directly proportional to absolute temperature. KE not changing was an acceptable alternative wording to constant average KE, but 'KE not increasing' was not. Candidates often picked up a mark for correctly stating that the PE of the molecules increased but would only gain the final mark for stating that the internal energy increased if they had already got the correct ideas for both PE and KE. Examiners commented that some candidates assumed conservation of energy and so if PE went up then KE went down or vice versa. Candidates wasted time and effort by describing what happened either before

	or after melting, which was not required.
23a	The expression for gravitational potential was listed on the Data, Formulae and Relationships in the module 5 section and was hence reproduced well by the candidates. The minus sign was required.
23bi	Examiners were delighted that candidates proved the relationship for escape velocity very clearly indeed with the higher ability candidates correctly suggesting that 'KE + GPE = 0' was the condition for escape, although 'KE lost = GPE gained' would have been a clear way of reconciling any minus sign confusion. A minority of candidates tried, unsuccessfully, to invoke the expression for circular motion inappropriately.
23bii	Approximately four-fifths of all candidates calculated the escape velocity on Pluto correctly. Those that did not score the mark for this item did so because of improper calculator use or, more rarely, because they selected the wrong data from the question.
23biii	Candidates found this last item very challenging indeed, with only exceptional candidates gaining two or three marks. Many candidates suggested that the reason for Mercury's lack of atmosphere was the superior gravitational pull of the Sun, which is wholly incorrect. Others suggested that the solar wind or 'radiation' had burnt off the atmosphere. Rather fewer candidates correctly related Mercury's smaller mean distance to the Sun and its higher temperature or reasoned that Mercury's escape velocity was higher than Pluto's. Only a small minority of candidates recognised that even though Mercury has a higher escape velocity, its higher temperature gave the atmosphere's molecules a higher average speed which would have exceeded Mercury's escape velocity.

H556/02 Exploring physics

General comments

This examination paper produced a good range of marks from 5 to 97, with many of the candidates demonstrating good understanding and application of physics.

Most candidates employed sensible techniques when answering the multiple-choice questions (MCQs). Equations and key ideas were scribbled down on the scripts but the important calculations were done accurately using calculators. Candidates made good use of the space provided on the question paper for their 'thinking'.

The two level of response (LoR) questions showed that candidates had good practical and graphical skills, acquired through the exposure of work undertaken as part of the practical endorsement and PAGs.

Most candidates made good use of the Data, Formulae, and Relationships Booklet. Calculators were used effectively and answers were frequently quoted to the correct number of significant figures. Some candidates were rounding numbers prematurely in long calculations; this is a poor practice and it is best to carry through the calculator values. A few candidates made errors recalling prefixes, notably pico, which was often quoted as 10^{-9}.

The quality of written work was variable. Many candidates effortlessly used scientific vocabulary in their descriptions and explanations. However, some candidates' verboseness led to contradictory statements. It is best to be brief and precise in Physics; the use of bullet points is encouraged whenever necessary. Candidates are reminded that they must define any symbols, such as ϕ for work function energy, in their descriptions. This is not necessary in calculations, where the use of symbols is normal practice.

It is worth reminding candidates that their scripts are scanned and then marked by examiners. It is therefore important that answers are not written outside the space provided.

There were some very good scripts with clearly laid out physics and well-presented calculations. The comments that follow tend to relate mainly to the opportunities that were missed by the candidates.

Comments on Individual Questions

Question	Comments
MCQ **1** to **15**	All questions showed a positive discrimination, and the less able candidates could access the easier questions. The questions in Section A require careful reading and execution. Underlining or circling key information may help. Candidates are reminded not to use highlighter pens for this purpose. There is ample space for jotting down ideas and key equation, but it is best to do calculations on calculators to save time. Questions **1**, **3**,**10** and **14** proved to be particularly straightforward, allowing most of the candidates to demonstrate their knowledge and understanding of physics. At the other end of the scale, Questions **5**, **9**, and **15** proved to be more challenging. • Question **5** was on the superposition of waves and the relationship intensity $\propto$ amplitude^2. The amplitude of the resultant wave is 0.4a and therefore the intensity of resultant wave must be 0.16I. The most popular distractors were **B** and **C**. Less than half of the candidates got the correct answer of **A**. • Question **9** was about doubling the separation between two oppositely charged

	parallel plates. The only correct statement is **D**. Electric field strength is p.d. divided by the distance between the plates. Since both quantities double, the electric field strength, must remain the same. • Question **15** was about refraction and the equation $n\sin\theta$ = constant at the boundary between two materials. The ratio $n_1/n_2 = \sin 80°/\sin 90° = 0.98$; the correct is **B**. The most popular distractor was **C**, which was the inverse of the correct answer.
16(a)	Most candidates made a poor start to Section B by incorrectly stating the principle of superposition. Instead of '*the resultant displacement being the sum of the individual displacements of the waves'*, candidates wrote about the addition of **amplitudes**. Some simply wrote about constructive (or destructive) interference and stationary waves.
16(b)(i)	One mark for this question was reserved for accurately determining the separation *x* between adjacent fringes using at least two fringe separations. About a quarter of the candidates did this and secured maximum marks for calculating the wavelength of blue light. A wide range of 7 mm to 9 mm was allowed for *x.* Most candidates used the correct equation and had no problems with powers of ten. Almost all the answers were written in standard form.
16(b)(ii)	This was generally well answered with most candidates giving correct explanation of why the fringe pattern was more spread out. Many candidates wrote concise answers such as '*the fringe separation increases because red light has longer wavelength and fringe separation* $\propto$ *wavelength*'. The two most common errors were: • Red light has shorter wavelength than blue light. • The pattern had something to do with the refraction of light through the double-slit.
17(a)	Most candidates could not state an unambiguous base quantity. There was no credit for a correctly named quantity accompanied by its S.I. unit, e.g. '*current in ampere'*. Some answers were just wrong; these include *force*, *charge*, *energy* and *kelvin*.
17(b)(i)	Most candidates were familiar with the equations $R = \rho L/A$ and $A = \pi d^2/4$. The modal score here was two marks. Most scripts had well-structured answers and demonstrated excellent algebraic skills. A variety of techniques were employed to determine the total resistance of the two resistors in series.
17(b)(ii)1	Almost all candidates correctly identified the measuring instrument for *L* and *d.* Some answers were spoilt by mentioning both a ruler and a micrometer for measuring the length of the wire.
17(b)(ii)2	This question produced a range of marks and discriminated well. According to the data shown in the table on page 13, the final value for the resistance *R* had to be given to 2 significant figures (SF), but an answer to 3 SF was also allowed. Top-end candidates produced flawless answers and quoted *R* as either $2.3 \pm 0.1\ \Omega$ or $2.34 \pm 0.08\ \Omega$. Some candidates successfully calculated the maximum and the minimum values for *R* and then the absolute uncertainty from half the range. The most common mistakes being made were: • Omitting the factor of 2 when determining the percentage uncertainty in d^2. • Calculating the resistance of either resistor **X** or resistor **Y**. • Inconsistency between *R* and its absolute uncertainty, e.g. $R = 2.3 \pm 0.077\ \Omega$.
17(b)(ii)3	Some candidates realised that the actual value of *R* would be '*larger because d was smaller or* $R \propto 1/d^2$'. On most scripts, it was difficult to follow if the resistance was the **actual** one or the **calculated** one.

18(a)(i)	The success in this question hinged on understanding the effect of two opposing e.m.f.s in a circuit and determining the total resistance of the circuit. About a third of the candidates produced well-structured and reasoned answer leading to the correct current of 0.037 A. Most candidates picked up a mark for determining the total resistance of the two parallel resistors (40 Ω). The total e.m.f. in the circuit is 2.7 V and the total resistance is 73 Ω. Those using a total e.m.f. of 5.7 V ended up with the incorrect current of 0.078 A; two marks were awarded for this answer. A small number of candidates tried to calculate the current using either using 1.5 V or 4.2 V or 33 Ω.
18(a)(ii)	Most of the answers here showed poor understanding of the circuit in Fig. 18.1. Nothing could be awarded for vague answers such as '*current decreases because $I \propto V$*' or '*e.m.f. decreases so current decreases'*. The current decreases as the e.m.f. of the supply approaches 1.5 V, at 1.5 V the current is zero, the direction of the current reverses and its magnitude increases when the e.m.f. of the supply gets below 1.5 V. About a quarter of the candidates gave credible answers.
18(b)	This was a level of response (LoR) question had three ingredients – drawing a viable circuit diagram that would enable the data shown in Fig.18.2 to be reproduced, using the figure to estimate the internal resistance of the cell and finally outlining any limitations of the data displayed in the figure. There is no one perfect model answer for a level of response question. A variety of good answers did score top marks. Most circuit diagrams were correct and well-drawn. There was the occasional mistake with the circuit symbol for a variable resistor; the thermistor symbol was a regular substitute. Most candidates drew a smooth curve on Fig. 18.2 and used this to estimate the internal resistance of the cell. Many also realised that the data points showed no evidence of averaging or error bars and that there were missing data points between 1.0 Ω and 3.0 Ω. Some candidates wanted '*more data points spaced regularly at interval of 0.5 Ω*', which was a sensible suggestion. Some weaker candidates attempted to draw a straight line of best-fit through the data points and then tried to determine the internal resistance from the gradient. There was a good spread of marks amongst the three levels.
19(a)	Many candidates wrote enthusiastically about photoelectric effect and understood the significance of work function energy (or threshold frequency) and the one-to-one interaction between photon and an electron. Some candidates did not mention 'photons' and this limited the marks they could acquire. The role of intensity was less understood. Many candidates thought it was linked to '*the number of photons*' or *'the amount of electrons emitted*'. The important term **rate** of the missing ingredient. Top-end candidates gave eloquent answers, typified by the response: *'intensity of visible light only affects the rate of photons incident on the plate but not the energy of each photon*'. Two common misconceptions were: • Photons were emitted from the negative plate. • Confusing threshold frequency and work function energy.
19(b)	This was a notable success for most of the candidates. Examiners were pleased to see a range of techniques being used to get the correct answer of 1.3×10^{-19} J. Many answers showed excellent structure, effortless conversion of energy from electronvolt to joule and excellent use of the calculator when dealing with powers of ten. Most candidates scored three marks. A small number of candidates left the final answer as 0.81 eV; the only thing missing was the conversion to J.
19(c)	The electrons emitted from the metal plate have a **range** of kinetic energy. The emitted electrons are repelled by the negative electrode **C**. Fewer electrons reach **C** as the p.d. is increased. When the p.d. is about 2.2 V, and the current zero, the most energetic electron are stopped from reaching **C**. This makes the maximum kinetic energy of the

	electrons equal to 2.2 eV or 3.4×10^{-19} J. The question baffled most candidates. Some top-end candidates commented on '*the electrons repelled by **C***' and the maximum kinetic energy of the emitted electrons being 2.2 eV. Such answers were rare. Too many candidates made guesses with answers such as '*the current drops because resistance increases*' and '*temperature increases and hence the current decreases*'.
20(a)	Most candidates drew decent field patterns and showed the correct direction of the electric field. It is difficult to draw curved field lines, but those who were careful and had the field lines perpendicular at both the surface of the sphere and the metal plate were rewarded.
20(b)	This was not well-answered; the modal mark was zero. Definition for electric potential lacked precision and often made no reference to a 'unit **positive** charge' or 'per unit **positive** charge'. At times, other quantities such as electric field strength and gravitational field strength were being defined. This was a missed opportunity – definitions just need to be learnt.
20(c)(i)	By contrast to the last question, the answers here were perfect. Correct values were substituted into the equation for electric potential to show that the charge was that stated in the question. In a 'show' question, always give the final answer to more significant figures than the required answer. It was good to see many scripts with the final answer written as $8.3\underline{\mathbf{4}} \times 10^{-9}$ C.
20(c)(ii)1	This was a good discriminator with high-scoring candidates either using triangle of forces, or resolution of forces, to determine the electric force on the sphere. The value of the force was given so that it could be used to answer the next question.
20(c)(ii)2	More than half of the candidates correctly calculated the electric field strength using the information provided in **(c)(i)** and **(c)(ii)1**. Some candidates used the elementary charge rather than the value from **(c)(i)** to calculate the field strength; this gave an incorrect answer of 7.5×10^{15} N C^{-1}.
21(a)	Most candidates effortlessly used the equation $C = \varepsilon A/d$ to determine the permittivity ε of the insulator between the capacitor plates. Once again, most answers were well-structured and showed good calculator skills. The most common errors were: • Taking the prefix pico (p) to be a factor of 10^{-9}. • Confusing permittivity ε and permittivity of free space ε_0. • Calculating relative permittivity (2.4).
21(b)(i)	The modal score here was two marks, with most scripts showing excellent understanding of capacitors in combination. Many candidates arrived at the final answer of 1500 μF without much calculation. A small number incorrect swapped the equations for series and parallel combinations and arrived at the incorrect answer of 670 μF.
21(b)(ii)	Many candidates correctly calculated the time constant of the circuit and then either determined the p.d. across the capacitors (0.83 V) or the resistor (0.67 V) – the latter being the correct answer. The most common mistake was calculating $e^{-12/15}$ rather than $1.5 \times e^{-12/15}$. Weaker candidates got nowhere by attempting to use $V = IR$ and $Q = VC$.
22(a)	This was the second level of response (LoR) question in the paper. It required evaluation of a graph drawn by a student and the analysis shown in the box on page 24. Most candidates realised that the graph had few data points, the triangle used for

	the gradient was too small and the line drawn totally missed one of the error bars. The analysis shown by the candidate did not include an absolute uncertainty in *B,* which made the statement written by the student lack credibility. Many candidates wrote about drawing doing a line of worst-fit and determining the percentage uncertainty. This was only possible if there were more data points and the error bars for the *F* values reduced by perhaps repeating the measurements. Once again, there was a good spread of marks amongst the three levels.
22(b)(i)	The topic electromagnetic induction always challenges candidates. Successful responses often showed correct use of technical terms such as *magnetic flux* or *flux linkage*. Most candidates scored a mark for correctly stating Faraday's law of electromagnetic induction. Many realised that an alternating current produced an alternating magnetic flux within the iron core and this change in flux produced an e.m.f. at the secondary coil. One of the popular misconceptions was that there was an alternating current (or induced e.m.f.) within the iron-core. A small number of candidates referred to **electro**magnetic field in their descriptions rather than magnetic field.
22(b)(ii)1	This question on current in the primary coil was successfully answered by most candidates. The most favourable method was to calculate the current in the secondary and then the current in the primary coil. The turn-ratio equation and $P = VI$ were effortlessly used to arrive at the correct answer of 0.10 A.
22(b)(ii)2	Full marks were rarely scored but many top-end candidates did manage to score a mark for suggesting that the lamp was lit for a short period of time at the start because '*there was a changing magnetic flux as the current increased from zero to a steady value*'. Too many answers focussed on the requirement of an alternating supply for an induced e.m.f. in the secondary coil and how a battery is not an alternating supply.
23(a)	Most candidates scored two marks and knew a great deal about the strong nuclear force.
23(b)(i)	The modal score here was one mark. The answers were brief with either proton as uud or the neutron as udd. The up ↑and down ↓arrows were allowed as acceptable notation for the up and down quarks respectively.
23(b)(ii)	A variety of answers for the decay equations were accepted with most candidates picking up marks. No credit could be given for showing the decay of a neutron into a proton because of the absence of the quarks. Some of missed opportunities were: • Representing the electron as e^- rather than ${}^{0}_{-1}e$. • Confusing the positron and the electron. • Assuming the decay was $u \rightarrow d$ rather than $d \rightarrow u$.
23(c)	This proved challenging for most candidates with answers lacking clarity. Some candidates secured a mark for suggesting the $\text{mass}_{\text{nucleus}} \propto A$. Only the very top-end candidates managed to show how the density equation and volume $\propto A$ led to the expected conclusion. Too many scripts had vague answers such as '*neutrons and protons are the same, so their density is the same*' and '*protons and neutrons have negligible mass so density is unaffected'*.
24(a)	About half of the candidates scored one or two marks. Some of the answers were concise with just '*1.1 MeV per nucleon because* ${}^{2}_{1}H$ *has two nucleons*' but some were simply incorrect with an attempt to answer the question using $\Delta E = \Delta mc^2$ and the rest masses of the proton and neutron. Weaker candidates misunderstood the terms

	‘binding energy’ and ‘binding energy per nucleon’.
24(b)	Fusion is possible in stars because the higher temperatures ensure that nuclei have large enough kinetic energy for the most energetic ones to get close enough for the attractive strong nuclear force to trigger the reactions. Many candidates did realise that higher temperatures meant greater **kinetic** energy but some answers were spoilt for either stating that **atoms** were fusing or mentioning that ‘*nuclei overcame electrical forces’* without any further explanation. The superficiality of many answers prevented candidates from picking up marks.
24(c)	This was another question that favoured the top-end candidates. The answers from them showed excellent understanding of pair production. A small number of candidates correctly recalled the 1.02 MeV energy required to produce an electron-positron pair. Full credit was given if this led to the correct answer of 1.2×10^{-12} m for the gamma photon. A disappointing number of candidates used 2.2 MeV from **(a)** and the equation $\lambda = hc/E$ to calculate the maximum wavelength. There was no credit for this incorrect approach.
25(a)	Most candidates scored two or more marks for their description of the PET scanner. Most candidates knew that the annihilation of positrons and electrons was central to the scanning technique. A small number of candidates either confused the PET scanning with CAT scanning or assumed that the gamma detectors were monitoring the emission of positrons from the patient.
25(b)	This was not an easy question. It required knowledge and understanding of activity, decay constant and natural logs. It is good to report that most of the candidates produced immaculate answers. The common mistakes made were: • Using either ln(1/3) or ln(0.70) rather than ln(0.30) in the calculations. • Assuming the decay was linear rather than exponential.
25(c)	Almost all candidates gave a plausible suggestion in this last question in the paper. It is good to report that physicists are mindful of the impact of science on society.

H556/03 Unified physics

General comments

This examination paper produced a good range of marks from 0 to 68, with many of the candidates demonstrating good understanding and application of physics.

Most candidates recalled formulae correctly or made use of the Data, Formulae, and Relationships Booklet. Many seemed to be unaware that the mass of an alpha particle is included in the data section. Calculators were used effectively. However it is worth reminding candidates that it is often useful to record intermediate steps within the answer,the candidate then has more chance to gain credit in situations where an error is made. Often not enough attention was paid to the correct number of significant figures for each stage of a calculation. Sometimes numbers were rounded off in the middle of longer calculations; at other times answers were displayed to too many significant figures, these faults are often ignored by the examiner but are bad practice.

The two level of response (LoR) questions are a new feature to this level of examination. About 15% of the candidates failed to attempt one or both of these questions which automatically reduced their possible mark on the paper by 17%. The questions examined the candidates' skills in and interpretation of practical laboratory experiments and demonstrations.

There were some very good scripts with clearly laid out physics and well-presented calculations where candidates used correct scientific vocabulary effectively in their descriptions and explanations. However the quality of written work was variable. The presentation of some papers was poor with handwriting difficult to read. It is worth reminding candidates that their scripts are scanned before being marked. It is therefore important that answers are not written outside the space provided for the answers. There are extra lines at the end of the paper for any overflow. Some presentation of calculations was also poor. Often parts of the calculation were scattered across the page with no thought to logical development.
The comments that follow tend to relate mainly to the opportunities that were missed by the candidates.

Comments on Individual Questions

Question	Comments
1(a)	Most candidates made a good start to the paper writing a correct equation for the nuclear decay.
1(b)	One mark in this question was reserved for converting units from joule into mega electronvolt. This was the only mark awarded to half of the candidates. Few recognised this to be an isolated system, applying the conservation of momentum to solve the problem. Few appeared to realise that the mass of an alpha particle is given in the Data, Formulae, and Relationships Booklet, calculating it instead by summing the masses of neutrons and protons. The most common incorrect approach was to use the formula $E = mc^2$ or to equate the kinetic energies of the thorium nucleus and alpha particle.
1(c)	A significant number had no idea where to start and left the page blank. Of the rest most managed to decide on 8 alpha particles. A minority worked initially with the proton number rather than the nucleon number incorrectly choosing 5. The explanations about the choice of 6 beta particles were often just restricted to equating the numbers correctly rather than giving any description of the transformation of neutrons into

	protons.
2(a)	This was an exercise in writing basic definitions in algebraic form and then using them to derive a given equation. More than half of the candidates managed to gain full marks with less than one third scoring zero. The presentation was sometimes difficult to follow with the inclusion of unnecessary equations and deletions and the substitution of *d* for *a* in the last line.
2(b)	This exercise of choosing a formula, substituting values in correct units and evaluating was done well with about three quarters of the candidates gaining full marks.
2(c)	Most candidates did not refer back to 2(b)(ii), noting that the potential difference across the Hall probe would be very small making the probe an unsuitable instrument for measuring the magnetic flux density, *B*. However almost all were familiar with the experiment where the magnets are mounted on a top pan balance with a fixed wire carrying the current. Only a small number varied the current and plotted a graph to obtain a more accurate value of *B*. Also few appreciated that the edges of the field spread out making the length of wire in the field the least reliable measurement.
3(a)	The whole question produced a full range of marks and discriminated well. About 70% gained more than half marks. In (a) here was some confusion about V_0. Many candidates correctly stated that $\ln(V/V_0) = -t/RC$ but some looked again at the question and wrote ln(*V*/V) instead not realising that V here related to the unit volt. A smaller number correctly stated the expanded form $\ln V = -t/RC + \ln V_0$.
3(b)	Candidates were given several opportunities to score marks by plotting points, drawing the best and worst lines on a graph and then extracting data from the graph. Many failed to draw the worst straight line losing themselves two possible marks. Many forgot the power of 10^{-6} in the unit on the x-axis. The normal requirement that the final value for the capacitance *C* should to be given to 2 significant figures (SF) and the absolute uncertainty to 1 SF (e.g. 230 ± 0.20 μF) was waived. However the absolute uncertainty had to be stated to the same number of decimal places as the calculated value of *C* to gain the mark.
3(c)	About half of the candidates gained full marks here. Some confused 10% and 90% and about a tenth of the candidates did not attempt an answer.
4(a)	This level of response (LoR) question had two strands – planning how to determine the positioning of two resistors inside an unlabelled four terminal box and then verifying the values of their resistances. Some candidates concentrated on determining the labelling of the terminals; others assumed the positions and explained how the resistances could be determined. Many candidates made the task more difficult than necessary. For example it was intended that once terminals **C** and **D** had been identified, **C** could only be lower left and not lower right, and hence the positions of **A** and **B** were also identified. A very common circuit used to determine the resistances placed the supply between **A** and **C** with the given resistor **R** between **B** and **D**, leading to calculations requiring combinations of resistors in series and parallel. Many ignored the limiting resistor **R** and probed the box without it, a few stating that the current between **C** and **D** would be zero with the supply across **CD**. Some answers lacked any circuit diagram and some 15% failed to attempt the question. Weaker candidates were confused as to when the resistors were connected in series or in parallel. Generally, the responses were clearer in terms of planning than identifying. Comments such as *and then you can work out the arrangement of the resistors* were common without showing how this could be done. A small number of candidates introduced a voltmeter and others wanted to position the ammeter ‘inside’ the box.

4(b)	More than half of the candidates knew the correct circuit symbol for an LDR. The most common error was to draw an LED. More candidates used a potential divider approach to solve the problem than calculated the current in the circuit; many gaining full marks. Those who misread the question and reversed the voltages required to switch the lamp on and off were given some credit for their answers.
5(a)(i)	Most candidates correctly labelled the scale on the displacement axis of the sinusoidal graph that they drew. The points where the air particles were moving the fastest were also well known. Fewer labelled *distance* on the x-axis, many incorrectly writing *time*. Only the better candidates marked the correct scale on this axis and very few indicated that there were 1.5 wavelengths between the points **C** and **R**.
5(a)(ii)	Two common mistakes in the first part were to use frequency rather than angular frequency or only to give the answer to one significant figure. Most knew the correct formula to calculate the mean square speed and used the kelvin scale of temperature. However they were unable to calculate the mass of a single air molecule given the molar mass. Another common fault was to give the *mean square speed as* the answer and not the *root mean square speed*.
5(b)	Answers were generally well structured into two sections, one for each experiment. A few candidates thought they could measure the wavelength on the oscilloscope screen. In experiment (a) most understood that the phase difference between the two oscillations at the microphone changed as one speaker was moved away. Explanations often muddled *path* and *phase* difference or referred to *nodes* and *antinodes* detected by the microphone. Some candidates misinterpreted the experiment moving the microphone to detect interference fringes, allowing the double slits formula to be used to find the wavelength. Others thought that Doppler shift was applicable. For experiment (b) many candidates used *maxima* and *minima* in place of *antinodes* and *nodes* although most recognised this to be a *standing* wave situation. Quite a few candidates ignored the instruction about reducing the uncertainty. The best candidates suggested reducing the frequency to reduce the percentage uncertainty in the wavelength measurement.
6(a)	There were some carelessly drawn arrows on the diagram but otherwise this was done well. There were some arrows labelled *centripetal force*.
6(b)	About half of the candidates completed the angle calculation successfully with a slightly smaller number finding the correct extension of the string.
6(c)	About half of the candidates found the time for the ball to fall to the bench. Most then managed to find the horizontal distance from the point of release, but half forgot that the point of reference in the question was the centre of rotation so failing to complete the calculation.
6(d)	About half of the candidates appreciated that the tension in the string increased or that the angle of the string to the vertical increased. Most answers gave the impression that the *centripetal force* was a *real* force rather than its provision being necessary for the ball to follow a circular path

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