GCE

Physics A

Advanced GCE **7883**

Advanced Subsidiary GCE **3883**

Report on the Units

January 2008

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Oxford Cambridge and RSA Examinations

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GCE Physics A (7883)

Advanced Subsidiary GCE Physics (3883)

REPORTS ON THE UNITS

2821 Forces and Motion

General Comments

The general impression of the Examiners who marked the paper for this module was that the level of difficulty of the questions was appropriate for the candidates for whom it was intended. The paper consisted of a wide range of questions covering a large proportion of the Specification. The candidates produced a very wide range of responses and the majority of questions provided good differentiation. There was an almost complete range of marks but very few scored less than 10 or more than 50. This suggests that the paper contained sufficient material to test the most able candidate. There were a significant number of candidates with less than 20 but the number of candidates scoring more than 50 was less than in previous years.

Some of the clearly better candidates lost marks needlessly with careless mistakes in simpler parts of questions. Those candidates with less than 20 were often unable to give acceptable definitions, used inappropriate formulae in their calculations and gave low-level responses in their explanations. Basic understanding and recall was absent and suggested that these candidates had not encountered much of the content of the course. The weaker candidates scored poorly in parts of questions where explanations were required. In 'show that' situations they were also prone to omit the statement of the formula for a calculation and therefore were more in danger of losing marks if later work was unclear. Many errors were the result of untidy presentation of work. There were many scripts showing a high level of competence, especially with the numerical work. The mean mark for candidates in this session was 31.8, which was 0.7 marks lower than the mean mark obtained in the January session in 2007.

All the questions except question 4 provided the opportunity for the weaker candidates to score some marks, and each question had at least one part in which the more able candidates were able to show their understanding of the subject. The responses differed widely depending on the Centre. There were many centres whose candidates had clearly been very well prepared but equally there were a number of centres where the candidates had a very poor understanding of the concepts involved. The lack of precision, poor use of English, basic errors in calculations and the failure to read the question carefully reduced the marks of many candidates of the full range of abilities. The parts of questions that required descriptive work and the precise statement of a definition were poor generally. However, the majority of candidates were able to give good answers to some parts of every question. The most able candidates scored highly in all the questions on the paper.

The length of the paper was considered to be about correct, with the vast majority of the candidates finishing the paper in the required time. There were however, a number of examples of blank sections in question 6 to suggest that some candidates had insufficient time to complete the paper. The standard of written communication was generally adequate with many candidates scoring at least one of the marks available for written communication. Marks were lost by a significant number of candidates who failed to spell many of the key words correctly, write in sentences or failed to describe the experiment in a logical and organised order, as indicated by the headings in the question.

Comments on Individual Questions

1 **(a)** **(i)** The majority of candidates were able to select the relevant information and rearrange the appropriate equation to obtain the answer for the time taken for the plate to fall. The weaker candidates often did not write down the appropriate equation and hence failed to gain any credit.

(ii) There were many correct solutions to this straight forward calculation. Errors were made in calculating the final velocity instead of the average velocity or in rounding to two or three significant figures incorrectly.

(b) **(i)** The good candidates had little problem with this part but the weaker candidates were unable to cope with the rearrangement of the equation or started with an initial velocity of zero.

(ii) The majority of candidates were able to suggest air resistance as a factor but few described the effect on the value of the acceleration. Very few candidates gave two reasons for the difference in values for the acceleration as required in the question. Weaker candidates often described the difference as due to the plate reaching terminal velocity. Poor descriptions that scored no marks were to suggest that the plate slowed down or the acceleration slowed due to air resistance.

2 The weaker candidates often scored the majority of their marks on this question.

(a) **(i)** The majority of candidates scored both marks. The main error made was incorrectly reading the time from the graph.

(ii) The candidates who started their analysis with the distance is the area under the graph often went on to show a correct solution. The weaker answers showed very poor presentation with various numbers and incorrect equations written across the page eventually arriving at the value required.

(iii) The equations for kinetic and potential energy were well known. The main error was to fail to square the velocity when completing the calculation for kinetic energy.

(iv) The majority of average to good candidates found little difficulty with this calculation for the potential energy. Some of the weaker candidates equated the kinetic energy with the gain in potential energy or used a height of 5 m rather than the 190 m given.

(v) Some candidates do not associate 'rate' with time and divided by the distance travelled. The unit was generally given correctly by the average candidate and above.

(b) **(i)** There were many reasons for mark deductions in this part. Mistakes included the wrong manipulation of the formula, use of mass rather than force, failure to convert kPa to Pa and insufficient significant figures in the final answer.

(ii) This part differentiated well at the top end of the ability range. A minority of candidates realised that there was a difference between the two sections of acceleration. Those that did describe correctly to two different effects on the pressure often did not give an acceptable explanation. The idea of the direction of the resultant force in relation to acceleration was not well known. There were minority of candidates who misunderstood the graph and discussed the problem as if the lift was going up at first and then later coming back down.

3 The answers to this question were very Centre dependent.

(a) Many, even the high scoring candidates, quoted the definition of moment of a force rather than the principle of moments. Also weaker answers that failed to score were those that did not include the word 'sum' in their statement.

(b) **(i)** Part (b) proved a good discriminator. There was a general improvement in the calculation involving moments and many good candidates obtained the correct answer. The weaker candidates calculated the moments due to the weights acting on the beam and equated this moment to the force at B or they missed out one of the weights in their moment calculation.

(ii) Generally this part was well answered but marks were often lost due to some of the explanations being poorly expressed. Many weaker candidates tried to explain the answer in terms of the moments rather than the forces acting to give a resultant of zero and hence equilibrium.

(iii) The question asked for the effect on the forces at A and B but many tried to give reasons for the changes. Hence the majority only scored one mark for A decreasing and B increasing. The weaker candidates tried to give explanations in terms of moments and also had the forces changing in an incorrect manner.

4 This question differentiated the average from the good candidates.

(a) Many of the good candidates scored full marks for this section. There were marks available for correct resolving of the forces or a correct vector triangle and a number of average candidates gained these although they made mistakes in the final analysis. Those that resolved horizontally and vertically had great difficulty solving the equations. The right angled vector triangle when drawn correctly helped many candidates to a quick solution. However, a number of candidates produced triangles with the wrong angles or divided the weight equally between the tensions in the two ropes. The reversed answers were often seen as a result of incorrect resolving or incorrect transposing from the diagram to the triangle. Those who resolved in the directions of the two ropes found the solution very straight forward.

(b) This part tested the very good candidates and a significant minority were able to give non-equilibrium as the reason for the method not being suitable. However, very few then went on to give an acceptable explanation of the situation in terms of the forces acting.

5 The answers to this question were very centre dependent. It was obvious that some centres had not described or demonstrated this experiment.

(a) The diagrams varied from the meticulous, with full labelling to the unacceptable and completely unworkable arrangements. Many did not clamp the wire or had no pulley or used a stand and clamp with the wire vertical. The marker if present at all was often near the clamped end of the wire.

(b) The weaker candidates were unable to state what was to be measured and with what instrument. Only the good candidates explained correctly how the extension would be measured. A mark was obtained by a number of candidates for measuring the diameter in several places but the weaker candidates stated that they would obtain the area. The mass was also obtained or known rather than measured.

(c) The candidates who did not know the experimental determination could obtain marks in this section for correct definitions but to gain full marks they needed to relate the measurements made to the definitions. The better candidates gained full marks by describing the use of a graphical method to obtain the Young modulus from their measurements. There was a good range of marks for this question and it differentiated well. However, many centres had clearly not covered this part of the specification and candidates made up experimental arrangements that were not workable.
The marks for QWC were often not gained because of the general poor spelling, sentence construction and organisation in the candidate's answers.

6 **(a)** Marks were lost in this part for the use of 'time' in the definitions instead of distance. Failure to mention that the car is brought to rest in part (ii) also was a cause of lost marks.

(b) **(i)** The majority scored full marks for this part.

(ii) This was only answered well by the good candidates as expected. The majority only used the braking force in their calculation and did not obtain the answer required. Only the good candidates were able to calculate the component of the car's weight down the slope and hence determine the correct resultant force on the car. Many that tried to find the resultant force omitted 'g' from their analysis and hence tried to resolve the mass of the car rather than its weight down the slope.

(iii) This part caused the average candidate difficulty. The selection of the correct equation proved difficult except for the good candidates but even then manipulation of the equation often led to mistakes. A significant minority added the thinking distance to the calculated braking distance. The question did not ask for the stopping distance and marks were again lost by the candidate not reading the question carefully.

2822 Electrons and Photons

General Comments

The performance of most candidates was very much Centre-dependent. It was clear from candidates' work that many Centres had made good use of past papers to prepare their students. There was some improvement in the quality of analytical work. For some candidates, manipulating equations remains a daunting task. The quality of written work continues to be a cause for concern. Candidates are reminded to think about their answers before committing their ideas to paper. Using relevant technical vocabulary, being clear and precise are important qualities for descriptive work in physics. The Quality of Written Communication (QWC) was assessed in **Q2**. In spite of convoluted answers, the majority of the candidates gained two marks for organising their text and correctly spelling most of the words. Candidates are reminded to write legibly for the long answer questions. Almost all candidates finished the paper in the scheduled one hour.

Comments on Individual Questions

Question One

Most candidates demonstrated a decent knowledge of series circuits in this opening question. The majority of the candidates secured five or more marks for this question.

Most candidates drew a functional circuit diagram in **(a)**, sensibly opted for a diagram drawn freehand and used the correct circuit symbols for all the components. Inevitably, a small number of candidates guessed the symbol for the thermistor.

Almost all candidates used $V = IR$ to determine the potential difference across the resistor in **(b)(i)**. A significantly number of candidates determined the total resistance (280 Ω) of the circuit in **(b)(ii)**. Some candidates used their answer of 0.60 V from **(b)(i)** and the current of 5.0×10^{-3} A to calculate the resistance of the thermistor. Sadly these candidates failed to realise that they were determining the resistance of the resistor and not the thermistor. A pleasing number of candidates either used 0.80 V and the current of 5.0 mA or 120 Ω subtracted from the total circuit resistance of 280 Ω to determine the resistance of the thermistor.

Too many candidates failed to mention either the resistor or the thermistor in **(c)**. Hence a statement such as '*the resistance goes up hence the voltage across it increases'* made very little sense. In order to secure full marks, candidates had to make clear reference to the resistance of the thermistor increasing as the temperature was lowered and also this meant that the p.d. across the resistor decreased. Low-scoring candidates were totally baffled by this question and ended up making contradictory statement such as '*the current decreases because the resistance of the thermistor decreases and so the p.d. across the resistor also decreases*'. Candidates are reminded to think about their physics before writing down their answers.

Question Two

The majority of the candidates found this question accessible, but a significant number of candidates also lost marks because of poor powers of expression.

Most candidates secured one mark for **(a)** by correctly identifying the component with their *I-V* characteristic.

A disturbing number of candidates wrote copiously but failed to mention the fate of the resistance of the component. An important skill in answering question is to carefully scrutinise the opening sentences of a question. Most candidates did well in **(b)(i)** by mentioning that the wire had constant resistance and this was because '*current in the wire was directly proportional to the voltage*'. The answers for the diode in **(b)(ii)** were often convoluted. A disturbing number of candidates thought that the resistance of the diode was somehow affected by temperature. Many candidates wrongly linked zero current with zero resistance of the diode. Only a small number of candidates, from specific Centres, made good use of technical terms such as 'reverse-bias' and 'forward-bias'. Most candidates managed to secure at least one mark in **(b)(iii)** for the filament lamp. Most candidates recognised that the temperature of the filament increased with either current or voltage. Sadly, too many candidates still associate $(\text{gradient})^{-1}$ from a current-voltage graph with the resistance of the component.

Question Three

Candidates struggled with stating general definitions in this question. This question once again demonstrated the poor understanding of internal resistance.

Most candidates made a good start in **(a)** by mentioning that both quantities are measured in volts. Some candidates also secured a mark by stating that both e.m.f. and p.d. are related to '*energy transfer per unit charge*'.

The definition for the volt in **(b)** was universally very disappointing. Only a handful of candidates quoted '$1\text{V} = 1\text{JC}^{-1}$' or '*one volt is equal to 1 joule <u>per</u> coulomb of charge*'. Too many gave the answer as '*a p.d. of 1 volt is when a 1 Ω resistor has a current of 1 A*'.

The definition for the kilowatt-hour showed poor understanding of both energy and power. It was not uncommon to find candidates mentioning '*a power of 1 kW h*' or '*a device of energy output 1 kW*'. A disappointing number of candidates failed to mention that the kilowatt-hour is a unit of energy. In desperation some candidates even misquoted the kilowatt-hour as 1.6×10^{-19} J.

The answers to **(d)(i)** were generally well-structured with most candidates opting for the power equation $P = \dfrac{V^2}{R}$ to determine the p.d. *V* at maximum power. Only a small number of candidates either used an incorrect equation (e.g: $P = V^2R$) or were unable to correctly rearrange the equation to the form $V = \sqrt{PR}$. About a quarter of the candidates realised that **(d)(ii)** had something to do with the internal resistance of the supply. Candidates who made reference to '*lost volts'* in the supply were credited with one mark. Too many candidates thought that the heating of the connecting wires was responsible for terminal p.d. not being the same as the e.m.f. of the supply.

Question Four

This was a high-scoring question with candidates demonstrating decent knowledge of the equation $F = BIL$.

Most candidates drew the correct magnetic field directions between the poles of the magnet in **(a)**. A small number of candidates missed this question. Some candidates wasted their time by drawing elaborate field patterns when only the direction of the magnetic field between the poles was required.

The answers to **(b)** were generally very good. Most candidates did well to determine the current in the wire before using the equation $F = BIL$. The most common error was to quote the final answer for the force to 1 significant figure. Candidates are reminded that their answer must tally with the significant figures provided in the stem of the question. Only a handful of candidates gave the wrong unit for force. The most popular incorrect units were the tesla (T) and the joule (J).

In **(c)**, most candidates gave descriptive answers to this quantitative question. Some candidates wrongly thought that the force experienced by the wire will remain the same because '*the equation $F = BIL$ was independent of the diameter of the wire'*. A few candidates stated that the strength of magnetic field was affected by the diameter of the wire. Only a small number of candidates gained full marks by making clear reference to the resistance of the wire increasing by a factor of four and the force decreasing by a factor of four.

Question Five

This question proved to be accessible to most candidates; many managed to score seven or more marks.

Most candidates made a good start with **(a)** by correctly stating Ohm's law. There were fewer candidates quoting $V = IR$ for this important law.

The majority of candidates struggled with **(b)**. Only a small number of candidates circled the correct answer as '*energy'*. The most frequently quoted wrong answer was e.m.f. Sadly, this was inevitable because e.m.f. features in the statement for Kirchhoff's second law.

For **(c)(i)**, in spite of poor presentation, a significant number of candidates managed to determine the total resistance of the circuit in terms of *R*. A disturbing number of candidates calculated the total resistance to be 3*R* because of poor algebra. Too many scripts had the solution as:

$$\frac{1}{R} = \frac{1}{R} + \frac{1}{2R} = \frac{1}{3R} = 3R\,.$$

Many candidates gained one mark in **(c)(ii)** through the error-carried-forward ruling. Once again, too many candidates showed their algebraic incompetence by writing the current simply as $\frac{V}{R}$.

Most candidates were familiar with the equation $Q = It$ and went on to secure maximum marks for the current in **(d)(i)**. A good number of candidates correctly determined the number of electrons by dividing the charge of 72 C by the elementary charge *e.* Some candidates decided to multiply the charge with 1.6×10^{-19} to get a nonsensical answer of 1.15×10^{-17} electrons. Most candidates correctly determined the current in the 18 Ω resistor in **(d)(iii)**. Most candidates struggled with **(d)(iv)**. Too many candidates found the p.d. across each resistor and then added them all to arrive at 17.3 V for the e.m.f. of the battery. A disturbing number of candidates either decided that the all three resistors were in parallel or determined the e.m.f. of the battery as follows:

$$\text{e.m.f} = 0.48 \times (12 + 18 + 36) = 0.48 \times 66 = 31.7\ \text{V}.$$

Candidates securing full marks for **(d)(iv)** were inevitably those with high-scores leading to grades A/B.

Question Six

This question once again demonstrated the strange ideas harboured by many candidates about the nature of electromagnetic waves.

Almost all candidates correctly stated one of the main properties of electromagnetic waves in **(a)**. The two most popular answers were '*they can travel in a vacuum*' and *'they are transverse waves*'.

Surprisingly, too many candidates were overwhelmed by listing the named radiations in order of increasing wavelength in **(b)**. Candidates particularly struggled with the ordering of infrared and visible.

The ability of most candidates to set out clearly an answer was poor. Candidates are reminded that only precise definitions can score marks. The definition for work function energy in **(c)(i)** lacked clarity. Work function energy is the **minimum** energy required by a surface electron to free itself from the metal. Too many candidates omitted the key word 'minimum' in their statements. A significant number of candidates were baffled by **(c)(ii)**. A disturbing number of candidates quoted zinc as their answer because it appeared as the last item in the table. Those candidates who managed to identify potassium as the correct metal, then failed to provide an adequate explanation for their answer. In order to gain one of the marks, candidates had to mention that the work function energy was directly proportional to the threshold frequency ($\phi = hf_0 \propto f_0$). Once again, the exciting world of quantum physics continues to be enigmatic and unfathomable for most candidates. In **(c)(iii)**, many candidates did not even mention the photon in their description of the photoelectric effect. Only a small number of candidates realised that the photoelectrons were emitted with a range of kinetic energies because they '*made collisions with the metal ions*' or *'they were removed from different depths from the energy well*'. A good number of high-scoring candidates correctly used the Einstein photoelectric equation to show the maximum kinetic energy of the electrons was 3.0×10^{-20} J. A significant number of candidates attempted to determine the energy of the incident photon using the equation $E = h\lambda$. Many candidates did not realise that the work function energy of 3.7 eV had to be converted into joules. A pleasing number of candidates managed to determine the speed of the electrons and hence the de Broglie wavelength. Weaker candidates correctly recalled the de Broglie equation but then made serious errors by writing either

$$\lambda = \frac{h}{mv} = \frac{h}{m \times 3.0 \times 10^{8}}$$

or

$$\lambda = \frac{h}{mv} = \frac{h}{3.0 \times 10^{-20}}.$$

2823/02 & 2826/02 Principal Moderator's Report

General Comments

The entry was low which is normal for this session. There were a number of Centres who failed to adhere to the mark scheme, thus generating major adjustments. It must be emphasised that attendance at INSET could solve some of the problems where marking was beyond the tolerance allowed.

However, the vast majority of the work was of a very high standard and very well marked by the centres.

There is little new to say about a very mature specification and so the comments below are those made at earlier sittings.

Many centres offered detailed annotation and mark schemes, care should be taken that they are in line with the specification's scheme. Only one "Centre Authentication Form" is needed to cover all the candidates entered and most centres had correct paperwork. Centres must try to ensure that the work they present is that of individual candidates and not a collective exercise. The marker does sign that this is the candidate's own work, unfortunately downloaded scripts and direct copying still seem to get authenticated.

The use of the 8 marks for Planning and Analysing should be viewed with great caution, this level should be for the very best possible work and not awarded too easily. If a moderator disagrees with the award of 8 marks for these two areas, the maximum permitted tolerance is already used up; only one further disagreement will cause the centre to be adjusted downwards. If the 8 mark is awarded, please annotate clearly why the marker feels that this is exceptional quality. Please remember that the "A Grade" is, generally, at 80% of the available marks.

I beg to offer much the same general advice as in previous years.
Often the work presented at AS shows a great deal of guidance is being offered by the centres, it must be borne in mind that in order to score heavily, it is the student's work that should be considered and not the teacher's. At A2, the level of guidance offered should be kept to a minimum so that the quality of original work offered by the candidate may be considered.

There are still rather too many experiments that do not comfortably match the mark descriptors. If the investigation does not end up giving a straight-line relationship on a graph, the higher descriptors in analysis are very difficult to obtain.

All the descriptors may be assessed on a single piece of work with one graph; there is no need to do investigations involving comparisons that simply offer a series of repeat observations. A really fine piece of work may well be completed in less than 10 or 12 sides.

The major problem with A2 remains the linking of work back to other areas of the specification (bold type in the mark scheme); this must be done to get above level 3. Candidates should be encouraged to make these cross-links clear in their work and where this is done, an annotation from the marker would be of great assistance. A good grade A can be obtained with less than 12 sides of A4. Some centres are still allowing their candidates to produce in excess of 100 sides, this may stem from the fact that the students are so excited by their tasks that they get carried away, but the time would be better spent revising for the theory papers and not producing more than one graph etc. etc.

Planning

Attention should be paid to the progressive increase in scientific knowledge and understanding as the basis of the mark descriptors. There should be a variety of external sources referred to in the text. The use of "Wikipedia" is increasing; however students rarely do students acknowledge what authority this source has for the statements made. Anyone can add a page so it is difficult to exhibit the same trust that one might give a recognised encyclopaedia or a university source.

A preliminary experiment should be just that not a double run of the main investigation.

An area often missed is the detailed discussion on the choice of equipment to be used (in terms of precision and reliability). This will severely hinder progress to the higher descriptors.

Implementing

All results should be recorded to the degree of precision available from the apparatus eg to 1mm with a metre rule, and they should be consistent. All observations should be repeated and tabulated properly with units. Care should be taken that we are only looking at direct observations in this section and any inconsistencies in derived figures should be assessed at A7a.

Analysing

It is difficult to progress in this section with anything other than the analysis of a straight-line relationship. Very few candidates take the statistical route though these descriptors and the measurement of a gradient or intercept is more usual. The use of small triangles when taking a gradient is to be discouraged due to the large uncertainty that this would introduce. Only one gradient is needed to assess the mark.

Where ICT is used, strict attention should be paid to the significant figure problems that may be introduced and to the correct labelling of axes. The use of software that will not produce a good trend line is to be discouraged, many candidates are still producing simple "dot to dot" lines.

Centres should be careful in the use of significant figures in producing the candidate's final answer. In particular, uncertainties are sometimes quoted to a greater number of significant figures than the actual result. Again, the use of good scientific knowledge and understanding is at the root of these descriptors.

Evaluating

The numerical evaluation of uncertainties is required and then the combination of these uncertainties into the final values to give, where possible, an "x +/- y" result. Uncertainties can rarely be quoted to a high number of significant figures and if left produce rather silly looking answers.

Comparison with a recognised value is of use to assess reliability but is not what this section is about. The difference between the book value and the student's value is not the error. The level of work involved needs only to be similar to that found in the appendix of " Physics 1"

Once the uncertainties of observations or procedures have been looked at, improvements should be suggested to increase the reliability of the investigation. This should really be attempted in some detail rather than the simple addition of a computer without the description of how it might be used and to what level the improvement might be.

2823/03 Practical Examination 1

General Comments

The general standard of the work done by candidates was similar to previous years. Candidates continue to find the analysis of their results using intercept values in question one and the evaluation section in question two the most challenging areas of the paper.

In question 1 many candidates ignored the fact that the ammeter reading was in milliamps. Some Centres needed to modify the range on the apparatus used in question 2. Following the changes candidates were able to gather useful data.

Candidates appeared to complete the paper within the necessary time allocation and most candidates were able to complete both questions one and two without help from the supervisor.

In the recording of calculations, such as the gradient in question 1 and percentage uncertainty in question 2, candidates should be encouraged to show all the values used in their working. This will ensure their answers are clear. In addition for the evaluation of question 2 candidates should be encouraged to include many more relevant points.

Plans are still centre specific. It is important to note that there is credit available for recording the references to relevant material consulted during the formulation of the plan. Centres are reminded that both the candidate on page two and the teacher on the front page should sign the planning sheet. Sadly some candidates were reported for having plans which were too similar.

Comments on Individual Questions

Plan

Candidates were invited to plan a laboratory experiment to investigate how the current in a diode varies with temperature in the range –20 ^{o}C to 150 ^{o}C.

The majority of the plans were of an appropriate length. Points **(a)** to **(g)** on the planning sheet are designed to focus candidates' attention to relevant areas where marks will be awarded. Candidates should be encouraged to give a response to each section with reasoning. Part **(d)** asked for the range and precision of any instruments that would be used and part **(g)** asked for particular features, which would ensure the accuracy and reliability of the results – plans often omitted these parts.

Candidates were expected to draw a workable diagram of the apparatus including a method of measuring current ie an ammeter in series. It was also expected that candidates should draw a correct circuit diagram using appropriate symbols. Candidates needed to take care with the polarity of the supply relative to the diode. It was disappointing to find many poor diagrams, either carelessly drawn or with non-standard symbols.

The majority of candidates were able to explain their procedure clearly. Many correctly suggested the use of a thermocouple to measure temperature. Weaker candidates simply chose a mercury thermometer without showing they had researched that it would be adequate for the range involved. "Digital thermometers" (probes) were cited with no indication of the physical change being utilised. Good candidates did justify their choice.

Good candidates applied knowledge gained from research well. They suggested a suitable method to meet the demand of exposing the diode to the whole temperature range, –20°C to 150°C. The understanding weaker candidates gained from their research were poor. Also it was evident that weaker candidates did not think carefully about the aim of the experiment. Many suggested the use of oil but gave no justification or even suggested water for the whole range, which was clearly inadequate.

Good candidates appreciated the need to allow time for the diode to reach thermal equilibrium before taking readings. Candidates often did not suggest factors that needed to be controlled. In this experiment the obvious factor was the circuit voltage; an additional detail mark could have been scored for a description of the method for achieving this.

Many candidates did not suggest the range and precision of any measuring instruments used. Good candidates appreciated the need to use a milliammeter. Many overlooked the need to include a current limiting resistor. There was one mark available for a relevant safety precaution. Again too often examiners just see a list of standard laboratory safety rules rather than an explanation as to why a safety precaution is required in this particular experiment. There was very little evidence of any preliminary work having been done.

There were three marks available for extra detail examples included:
Use of uninsulated/teflon coated wires inside hot area as plastic melts
Use of thermocouple or justified use of mercury thermometer/valid thermometer
Calculation of range of ammeter /calculation of value for protective resistor
Use of <u>protective</u> /<u>current limiting</u> resistor
Detail of measuring devices outside the method of changing temperature
<u>Method</u> of keeping V constant across the diode
Evidence of preliminary investigation in the laboratory

In the notes for guidance for the plan it is stated that candidates should list clearly the sources that have been used. Two marks were available for evidence of the sources of the researched material. Detailed references should have page or chapter numbers or be internet pages. Two or more detailed references score two marks. Two or more vague references scored one mark.

Most of the more able candidates were able to score two marks for the quality of written communication, which were awarded for the organisation and sentence construction of the Plan.

1 This question asked candidates to investigate how the current in a circuit containing a diode depends on the resistance of the circuit.

Candidates were initially asked to set up the circuit and measure the readings on an ammeter and voltmeter. A few candidates needed help; a maximum of two marks were penalised if help was given. It is very helpful where Supervisors write in detail the actual help given. Candidates were then asked to calculate values of R and $1/I$. The latter caused few problems. Occasionally the wrong formula for resistance was used.

The justification of significant figures was poorly answered. Good candidates successfully related the number of significant figures in $1/R$ to the <u>number of significant figures</u> in V and I. Answers that referred to decimal places and graph plotting did not score. Some candidates referred to the calculated value of R.

Results tables were generally well presented. The majority of candidates labelled the columns with both a quantity and the appropriate unit for I, V and R; however the units for $1/I$ were often wrong or missing. It is expected that there should be a distinguishing mark between the quantity and the unit. It is expected that all raw data should be included in a table of results. All the raw data should be given consistently.

Graphical work was generally done well. Weaker candidates often used less than half of the graph grid for their points or choose awkward scales. Points were usually plotted accurately to the nearest half square. Often miss-plotted points were very obviously wrong; candidates should be encouraged to check points like this as they finish plotting graphs. The majority of candidates drew their line of best fit with a fair balance of points.

It is expected that the gradient should be calculated from points on their best-fit line, which are at least half the length of their line apart. Weaker candidates often lost marks either by using triangles that were too small, by working out $\Delta x/\Delta y$ or taking inaccurate read-offs from the graph. Good candidates clearly indicate the points that they have used and show their calculation. The *y*-intercept was usually correctly read from the *y*-axis. Where candidates could not read off the *y*-intercept, it is expected that they should substitute a point on their line into the equation $y = mx + c$. This substitution should be clearly seen.

In part **(g)** candidates were asked to use the voltmeter to determine E the e.m.f. of the power supply. Again in part **(h)** weak candidates do not follow the question, which tells them to use their answers for determining the gradient and *y*-intercept. Failure to use these values prevented candidates gaining four marks. Good candidates equated the *y*-intercept to $-P$ and the gradient to E-V_D. A large number of candidates ignored the negative sign, which was not acceptable. Due to ignoring the current unit of mA, many P values were out of range.

In **(h)(iii)** good candidates were able to justify whether their experimental value lay in the expected range using the fact that 10% of 220 was 22 ohms. Weaker candidates failed to consider the acceptable upper and lower limits for P. Candidates were expected to give an appropriate conclusion.

2 In this question candidates were required to investigate how the force of attraction between two bar magnets depends on the separation of the bar magnets and then write an evaluation of the procedure.

In part **(b) (ii)** most candidates calculated F correctly. Finding F should have been simple, but some candidates introduced “g”.

In part (c) the determination of the percentage uncertainty was poor probably as x^2 was involved. Many used a correct value for the absolute uncertainty in x but few had the correct ratio due to using x^2. Good candidates correctly determined the percentage uncertainty in x and then multiplied their answer by two to allow for x^2.
The majority of candidates correctly gained a smaller force for the larger height.

In part **(e)** candidates were asked whether their results supported the relationship that F is inversely proportional to x^2 explaining their reasoning clearly. No marks were awarded without reasoning. Weak candidates were either very vague with their reasoning or confused inverse proportionality with direct proportionality. Good candidates calculated a constant of proportionality. It is expected that candidates will then draw a conclusion based on their results.

(f) Weak candidates are still evaluating experiments by describing the procedure they followed. Some candidates wrote very little of substance. Good candidates scored well by describing relevant problems and suggesting specific ways to overcome them. Vague suggestions without explanation did not gain credit. In particular human error without explanation did not score.

Credit worthy problems:
Difficulty /Parallax in measuring x
Magnets wobble/not vertical
Large percentage error in measuring x
Magnets not directly above one another
<u>Magnetic</u> retort stand may affect reading
Two readings of F and x are not enough to verify the suggestion.

Credit worthy solutions:
Use vernier callipers/clamped ruler/marker on top magnet/eye level
Measure x at different places and take average
Increase separation distance/linked to use of stronger magnets
Use (vertical rules as) guide/straight edge/use a plumb line
Use non magnetic retort stand
Use many different distances <u>and</u> plot a graph relating F and x^2.

Two marks were available for spelling, punctuation and grammar in this part. Often weak candidates did not use capital letters at the start of sentences and there were many spelling errors.

2824 Forces, Fields and Energy (Written Examination)

General Comments

Candidates appeared to have ample time to complete all the questions, most writing an answer of suitable length to the last question, even if incorrect. Less than five percent of candidates failed to attempt Q7. Candidates showed significant knowledge of some topics and little of others. The most successfully answered questions by all candidates were Q1, Q4, Q5 and Q6. The question which proved most difficult for many was the circular motion question, Q3, where many candidates of all abilities showed little understanding of this topic. In the thermal physics question the parts requiring knowledge of ideal gases were poorly answered by most. In Q7 most realised which experiments they should describe but only a few had sufficient knowledge to gain many marks. In the questions written in the form ‘show that…’ candidates were poor in showing all the steps in any calculations, normally leaving out the step between a mathematical equation and the rounded answer given in the question. It is vital that candidates show that they have completed this calculation.

Comments on Individual Questions

1 **(a)** With the exception of the few who misread the scale on the graph, candidates were able to find that the height fallen by the ball is 1.6 m.

(b) Far fewer were able to explain that the increase in kinetic energy was decreasing between the points A and B.

(c) Again most achieved an answer of 3.96 m s^{-1} for the terminal velocity. A majority realised that the drag force must equal the weight at terminal velocity and then most of these candidates calculated the energy loss per second of the ball. Weak candidates were unable to do (ii) or (iii).

(d) Most found the speed after the bounce but some used a kinetic energy of 20% rather than 80%. Few appreciated that the two velocity values must be added and not subtracted to calculate the momentum change. There was some confusion over the units of momentum, including mixing notations, eg kg m/s^{-1}.

2 **(a)** Many candidates wrote down suitable definitions which had obviously been learnt with little understanding of the meaning. Marks were easily forfeited through lack of mention of atoms or molecules or the sum of random kinetic energies.

(b) Almost all candidates achieved the correct answer.

(c) In (i) most gained the first mark but then many used degrees C or the difference in temp with 273 added and so did not score any further marks. In part (ii) few gained more than one mark if any. Most kept the temperature in degrees C or assumed that speed was proportional to temperature. Candidates do not appear to know that the kinetic energy is proportional to the absolute temperature for an ideal gas although this has been asked several times over the last few years.

3 **(a)** The majority of the answers to this question showed that few candidates have much understanding of the dynamics of circular motion. A centripetal force was frequently added to the diagram as an extra force; few appreciating that this is the resultant force. Descriptions in part (ii) were often equally confused. Most gained the mark for (iii).

(b) A common approach was to attempt to use the formula $v = r\omega$; find a time t and hence an angle θ. This showed that these candidates had no understanding of the meanings of the symbols they were using. Another common error was to write sin $\theta = v^2/rg$ instead of tan θ.

4 **(a)** The drawing of field lines was extremely varied. In most cases the candidates achieved a reasonable shape to the pattern but often little care was given to make the pattern symmetrical and with lines starting and stopping normally at the surfaces of the sphere and plates.

(b) High marks were scored for part (i). A minority of candidates then tried to attempt (ii) using Coulomb's law rather than $F = QE$

(c) The correct formula was usually given with correct substitution of the data but many then failed to show clearly that a calculation using their figures did result in the given answer In part (ii) a correct method was followed but with a power of ten error caused by confusing the g unit with kg or the extra force being subtracted instead of added.

5 **(a)** Most candidates drew an arrow upwards but many failed to draw it in the middle region of the magnetic field. In (ii) a common error was to use 6 as opposed to 0.06 m for the length.

(b) The frequency was usually found correctly. The most common error was to fail to notice that the scale on the time axis is in milliseconds. In part (ii) a minority of candidates appreciated that each point on the standing wave on the wire oscillated in simple harmonic motion. However explanations were often vague or incomplete.

(c) Most candidates scored the mark for drawing the resonance curve with increased damping through the correct zero frequency amplitude point. However most also thought incorrectly that the curves merged back together at the highest frequency labelled on the x-axis.

6 **(a)** Almost all knew that Z is the proton number and most that N is the neutron number. A common fault was to state that Z is 37 resulting in N being 83. Candidates only lost one mark if they made these two errors.

(b) The definition of activity in (i) was often too vague to gain the mark. It was necessary to refer to the number of nuclei decaying per second and not just the number of decays per second. Part (ii) was usually correct.

(c) c) (i) was usually done correctly although many could not read the value of N from the graph accurately. In part (ii) some successfully took readings from the graph and correctly inserted them into an exponential equation. The third mark was reserved for those who could show that they had evaluated the exponential expression correctly. A common solution gaining only one mark was to approximate the curve to a straight line. Usually the mass of caesium in part (iii) calculated correctly.

7 **(a)** In general this was not done very well. Few details of X-ray techniques were described adequately. Most realised that diffraction effects were only significant when the wavelength of the incident beam was similar to the atomic spacing of the crystal. Most seemed to have come across electron diffraction and so gave some useful descriptions and included details like requiring an evacuated chamber and a fluorescent screen. Many had no idea how the spacing of the pattern on the screen was related to the atomic spacing and considered that they were the same. Candidates are expected to appreciate that the regular crystal structure leads to coherent scattering and hence an interference pattern from which the atomic spacing can be determined.

(b) The number of candidates who could state appropriate diameters for atoms and nuclei was very small. A common answer to this question was to give a qualitative answer in terms of an analogy, for example, between a pea and a football stadium. In this part and to a certain extent in part a) descriptions were given of alpha scattering rather than of electron diffraction. There was a great emphasis on the electron being a charged particle. Similarly many tried to explain the inappropriateness of X rays in terms of lack of charge or mass instead of the magnitude of the wavelength relative to the diameter of the nucleus. There were many references to the gap between nuclei rather than the diameter of the nucleus showing that candidates do not appreciate that the same diffraction pattern is produced by an opaque object as by a hole of the same diameter in a screen.

The quality of presentation and the standard of writing varied considerably, from excellent to very poor. The examiners were pleased to see that most attempted to draw diagrams to illustrate the experiments described. Spelling and punctuation appear to have improved.

2825/01 Cosmology

General Comments

The entry for this session was nearly 170 candidates and the spread of marks was similar to previous years, but there were no instances of very low scores. A number of very good scripts showed high achievement throughout the paper, demonstrating a thorough knowledge across the syllabus, whilst other scripts showed that some candidates could raise their mark significantly by addressing more closely the requirements of the question.

In general, candidates were more confident on those parts of the paper that drew directly on knowledge of the syllabus. Questions that required interpretation or explanation were not so well answered.

Comments on Individual Questions

1 **(a)** The change in shape of Venus was well known and a mark was awarded for the simple statement that Venus had phases. This mark could be gained from a diagram, but a brief label was required. The reason for the phases was explained well by a number of candidates, often with the help of a diagram, but the majority of answers focused upon the apparent change in size of the planet. This argument gained equal credit, but many candidates could not give the simple reason for this change in size, which would also have lead them on to the conclusion that Venus orbits the Sun.

(b) This question proved straightforward for the majority of candidates, who demonstrated a good knowledge of Galileo's observations and their implications for the Solar System as a whole. One of the aims of the syllabus in this section is to demonstrate the interchange between theory and empirical observation and from this point of view it was pleasing that very few references were made to historical social or religious issues, which do not gain credit.

2 **(a)** A good number of candidates were able to conclude that gravity, being an attractive force, would lead to the collapse of a finite Universe. More able candidates went on to explain that an infinite Universe would produce zero resultant force on a star. The most successful answers were often accompanied by a small diagram by way of illustration, but as in the previous question, a short label was necessary.

(b) Whilst weaker candidates often found 2.a difficult, marks in this part were higher. The requirement to explain the change in speed of the planet was an opportunity to use Kepler's 2nd law, but most candidates relied on arguments using the force of gravity, perhaps prompted by the previous question.

(c) **(i)** Those candidates who applied Kepler's 3rd law found this question very straightforward. The majority of candidates chose to combine ideas of circumference, speed, orbital radius and gravitational field strength and it was, perhaps, not surprising that many got into a bit of a tangle.

(ii) This question produced a much wider range of marks than anticipated. Examples showing two equal and opposite forces were in the minority, whilst many examples were similar to electric field lines around isolated charges.

(iii) This question attempted to bring together the ideas of the previous parts by showing how additional perturbations in the orbit of Uranus led to the discovery of the planet Neptune. Candidates in general answered this part well, but there were few examples where a perturbation was interpreted as an unexpected acceleration.

3 **(a)** The apparent magnitude of a star was well known. Candidates were expected to state that it is the brightness observed from Earth.

(b) **(i)** The calculation of the inverse-square was done well by nearly all candidates. Where an arithmetic error was made, the candidates were not penalised a second time later in the question, so long as they were consistent in plotting the points calculated.

(ii) Candidates generally plotted the graph well. The points from the table gave a good straight line through the origin. When errors are made the best straight line through the plotted points should be drawn, ignoring the origin in this case. The accuracy of plotting was expected to be ± half a small square in each direction.

(iii) A number of errors were made calculating the gradient of the graph. Reading from the scale gave rise to errors and it was common for the factor of 10^4 to be omitted. A surprising number of candidates inverted the readings taken from the 1/ distance^2 scale and working out a suitable unit caused some difficulty, many answers containing pc^{-2}.

(c) **(i)** Manipulation of the relation between intensity and distance using logarithms proved too difficult for many candidates, but those with more confidence were able to split up k from d^2 and then simplify further.

(ii) A mark was awarded for any sensible attempt to substitute a relation for lg(I), reserving the second mark for tidying up the expression. This approach to apparent magnitude has not been tested before on the paper and candidates were clearly unsure how to best tackle the problem.

(d) This question on absolute magnitude moved back into more familiar territory and was well answered by the majority of candidates. The most common error was to confuse apparent and absolute magnitude in the relation $m - M = 5\lg(d/10)$.

4 **(a)** H-R diagrams are clearly very well known and nearly all candidates could plot the position of the main sequence stars, red giants, white dwarfs and show the evolution of a star.

(b) **(i)** Many candidates were able to state that lost mass is converted into energy and quote $E = mc^2$. Where an equation is stated out of context, the meaning of all symbols should be given. Some candidates correctly referred to a loss of binding energy per nucleon and received full credit.

(ii) The conversion of electron-volts to joules proved to be the biggest hurdle in this question. Weaker candidates could not do this part of the calculation and of those that understood the calculation a substantial number either forgot the factor of 10^6 in MeV or used 10^3 instead.

5 **(a)** **(i)** Nearly all candidates could state at least one piece of evidence that supports the ‘big bang’ theory, but fewer went on to give details. Those that quoted the cosmic microwave background radiation would often describe its uniform intensity and correctly give its equivalent temperature (3K was accepted) but very few mentioned the very small ripples in the distribution. A reference simply to ‘background radiation’ was insufficient to gain the first mark.

The unusually high ratio of helium to hydrogen was also well known, but candidates found it more difficult to explain that the big bang theory can explain this increase by the fusion of hydrogen in the very high temperatures that prevailed shortly after the big bang itself.

When describing the red-shift in light from distant galaxies, candidates knew that this implied an expanding Universe but often failed to mention that the recessional velocity is proportional to distance and so lost a mark.

(b) **(i)** Most candidates knew that the age of the Universe is given approximately by 1/ *H*. The conversion of units was too much for many, who used seconds for the calculation. Only a small minority of scripts showed the correct value for the Hubble constant in the required units.

(ii) Surprisingly, most candidates across the whole ability range got this question wrong. The Universe cannot be younger than the Earth, so the time is a minimum, making *H* a maximum.

(iii) This question showed a range of answers. Weaker candidates frequently argued circuitously that without knowing the age of the Universe the value of *H* would be uncertain. Another reason regularly cited referred to the difficulty in measuring the critical density and hence finding *H*. This could gain some credit if the candidate went on to explain that the mass of the Universe may be causing the speed of galaxies to decrease. In fact, any sensible reference to the possibility of speeds changing was accepted.

6 **(a)** Most candidates answered this part with little difficulty and only a few forgot to bring in the requirement of an inertial frame of reference.

(b) **(i)** This was answered well by the great majority of candidates. In this kind of question a unit would normally be a part of the answer but in this particular case that requirement was dropped.

(ii) About half of all candidates completed this calculation correctly. Common errors included using the diameter instead of radius; failing to convert *km* to *m*; using πr^2 or finding the period of rotation instead of the frequency. Basic errors of this nature are often easily eliminated when a candidate checks their work.

(iii) The majority of answers to this question stated that too much energy was required to attain the speed of light. Some candidates used the idea of mass increasing with speed and occasionally the Lorentz factor was quoted. Few candidates seemed to realise that at low speeds an increase in energy leads to an increase in speed while at high speeds the same energy rise results in an increase in mass.

Candidates who stated that the centripetal force would exceed the force of attraction between particles in the star received full credit.

(c) This question produced a wide range of responses. Most candidates were able to state that a rocket and light beam were required. Some answers confused the situation with a thought experiment to show time dilation and consequently placed the direction of the beam parallel to that of the rocket. Usually, candidates who knew that the rocket was accelerating also explained how this would cause the path of the light beam to become curved. Only the more able candidates went on to quote the principle of equivalence and use it to justify the effect of a gravitational field upon a beam of light.

Credit was often gained from diagrams, but these had to be labelled in such a manner to make their meaning unambiguous.

Candidates who described an actual experiment could gain some credit if they referred to the principle of equivalence and had a light beam in a strong gravitational field. Descriptions of balls rolling across deformed rubber sheets were not uncommon but could not gain credit unless the analogy was then used to address the question.

(d) Many candidates realised that measurements taken during the solar eclipse lent support to the General Theory of Relativity. Some answers simply concentrated upon how the eclipse occurs while others thought that the deflection of light was caused by the Moon and that this was only apparent during an eclipse.

2825/02 Health Physics

General Comments

The general standard of the work was high. The paper gave a range of marks that seemed to contain fewer low scoring marks. There were gaps in the work of a number of candidates where recall of AS work was required. Candidates should be reminded that the synoptic question at the end of this option contains theory work from the AS Physics course.

Comments on Individual Questions

1 **(a)** **(i)** This moment calculation was often well done. The main difficulty found by candidates was coping with the inclined force *b*. Many candidates gained full credit.

(ii) Most candidates were successful with the mechanical advantage with only a couple of candidates giving an alternative equation.

(b) **(i)** This part was not well answered with may candidates failing to justify their statement describing how the force *b* will change. It was not uncommon for candidates to repeat the information given in the stem of the question.

(ii) Candidates generally were not explicit in their reasoning for the change in the mechanical advantage. If $a = b/c$, then to assess a change in *a,* it is necessary to describe how both *b* and *c* change.

(a)(i) 1116 N **(ii)** 0.72

2 This question generated high marks, scores of 12 and higher being quite common.

(a) **(i)** It was common to see a score of 1 out of 2. Those who successfully bent the light at both the cornea and the lens often failed to make the rays meet before the retina, or vice versa.

(ii) Nearly all candidates suggested the image would appear blurred, wherever the rays met.

(b) **(i)** It was well known that the corrective lens was concave.

(ii) The reasoning supplied frequently displayed a commendable understanding.

(c) The answers to the calculations were well done, with most candidates achieving at least 6 of the 7 marks. Where an error was made, it was usually in the sign of the corrective lens.

(c)(i) 54.29 D **(ii)** 52.63 D **(iii)** -1.67 D

3 Most candidates were able to gain credit here. It was not uncommon to find the minimum intensity to be quoted without a unit. Many candidates were unable to explain the meaning of the term *threshold intensity* and were also unable to explain the meaning of the graph drawn.

4 **(a)** **(i)** Most candidates achieved 2 marks.

(ii) This proved much harder and a score of 2 was rare. The *there-and-back* factor of two was often missed, but apart from this, the placing of the reflected peak on the grid was frequently wrong.

(b) The majority of answers included *foetus scans* and the reason for the choice, but the second use ranged much more widely. Many candidates were vague with their responses giving answers like ' to view babies because it is safer'. Often reference was made to examples of the imaging of soft tissues in various acceptable parts of the body (though occasionally the location was left vague), with the reason being the better contrast compared to X-rays or the practicality of real-time moving images. The question didn't stipulate *medical* imaging, and a few mentioned marine echo-sounding and locating internal cracks in structures.
(a)(i) 6.25×10^{-6} s

5 **(a)** **(i)** Many candidates showed that they could make an acceptable reading from an awkward scale on the graph, and could follow this through to a correct answer in grays.
(ii) Fewer achieved the mark for this ratio.

(b) Candidates were instructed to use the information from part (a) – which few seemed to *understand* – rather than from the graph itself. However reference to either was acceptable.
Many candidates filled up the blank page by repeating their notes on the effects of X-rays rather than answering the question. (A few candidates gave notes on the production of X-rays.) A few referred to the graph, but usually failed to extract its full significance for the question under discussion.
(a)(i) 4.9×10^{-2} J kg^{-1} **(ii)** 0.21

6 **(a)** **(i)** The usual mistake here was to use the diameter rather than the radius in calculating the area with the conversion factor into metres also causing a number of candidates problems.
(ii) About one quarter of candidates were able to suggest a sensible reason for the increased intensity at the retina.

(b) **(i)** This question caused some difficulty with a number of candidates confusing *frequency* with *wavelength*.
(ii) Most candidates omitted the factor of two and a number gave the reciprocal of rate as their answer. Only one quarter suggested a sensible reason for the assumption.

(c) About half of the candidates seemed to understand what is happening when red light reflects from the surface of a red object.

(d) This was well answered. Many responses were again vague with answers such as '*it is cleaner','it is quicker',* neither being clear enough on their own, to gain credit.
(a)(i) 1.02×10^{8} W m^{-2} **(b)(i)** 3.9×10^{-19} J **(ii)** 6.5×10^{18}

7 **(a)** **(i)** This was well answered.
(ii) Most candidates did not get the idea of *rate* and hence very few scored more than one mark.

(b) **(i)** This was well answered.
(ii) Most candidates were able to get to a mass which corresponded to the energy gain.
(iii) Many candidates correctly calculated the mass of carbohydrate corresponding to the thermal energy generated and added it to the mass corresponding to the useful mechanical work done but forgot to add the mass corresponding to the energy required for metabolic activities.

(c) **(i)** There was a notable number of candidates who had forgotten the specific heat capacity formula.

(ii) Only a half of the candidates made the observation that the surrounding air temperature was higher than that of the runner. Many went on to say that the runner could therefore not lose any energy by conduction, convection or radiation. Very few went on to mention the net flow of thermal energy along a temperature gradient (or words to that effect) or discussed the direction of the gradient.

(iii) Many candidates were able to calculate this value even though they were unsuccessful in earlier parts of the question.

(iv) Most were able to get the idea of water intake. A number were unable to get the second mark as their comment did not relate to the need for water, eg to replace the sweat lost, etc., Many attempts at the second reason centred around pacing the runner and taking rests and food breaks.

(a)(i) 15.7 h **(b)(i)** 5.5×10^5 J **(ii)** 32 g **(iii)** 185 g **(c)(i)** 0.0033 K s^{-1}
(iii) 3.4 kg

2825/04 Nuclear and Particle Physics

General Comments

As usual, this paper revealed a wide range of competence levels from the very weak to the very good. Regrettably, many candidates were inadequately prepared for this paper. This option draws on all the core modules, particularly 2824 and therefore to respond appropriately candidates need to be fully conversant with all these other modules. Possibly some candidates had not achieved this.

Presentation of answers also left something to be desired in some cases. Some candidates' handwriting was difficult to read and many numerical answers were poorly set out. As always answers are marked positively ie marks are awarded only if the relevant information can be seen and recognised by the examiner.

There seemed to be some deterioration in the candidates' ability to represent nuclear equations fully and accurately. Of particular concern was their knowledge of neutrinos and their ability to represent beta particles properly. There were also references to 'atoms' and 'molecules' when the candidate should have been dealing with nuclei.

Comments on Individual Questions

1 **(a)** Candidates were presented with a graphical relationship between the strong force and the separation between two neutrons, for a small range of values. The graph was a straight line over this limited range. Candidates were asked for the significance of the point A on the graph at which the line crossed the separation axis. Most realised that this is the equilibrium separation though only a minority were able to state that it is also the separation of two neutrons in a nucleus.

(b) Most candidates were able to calculate the gradient of the graph, though some took no account of the powers of ten, giving an answer of 200 with unspecified units. Candidates were expected to show by means of a minus sign that the graph has a negative gradient.

(c) Most candidates were able to calculate correctly the electrostatic repulsion between two protons, using the usual formula, though a few failed to square the separation.

(d) **(i)** Most correctly stated that for the strong and electrostatic forces to be in equilibrium they need to be equal. However, to score the candidates needed to state also that the two forces act in opposite directions.

(ii) Candidates were told that the equilibrium separation between two protons is at a point B, close to point A. It was expected that they would realise that at this position the strong force would be equal to the electrostatic force already calculated in *(c)* and use this value together with the gradient calculated in *(b)* to calculate the distance of B from the equilibrium position for two neutrons. They should also have stated that because the electrostatic force is repulsive, B is to the right of A on the graph. This was a novel problem for most candidates and as such it proved too difficult for many. A few appeared to be trying to use the equation $y = mx + c$, forgetting that point B is not on the original line. Some stated that point B is to the left of A, probably having previously seen a force-separation graph drawn the other way up. Some candidates, correctly realising that the force calculated in *(c)* was relevant to the problem, omitted to state which force they were referring to. A few referred irrelevantly to the gravitational force which is utterly insignificant.

2 **(a)** Candidates were asked to write nuclear equations to represent the absorption of a neutron by a uranium-238 nucleus and the subsequent two decays of the product. It was disappointing to note that many candidates failed to score these four straightforward marks, usually because they omitted the neutrino or failed to represent the beta particle properly eg by failing to show both the charge and mass number. A few put the beta particle on the left hand side of the equation; others omitted a nuclide symbol.

(b) **(i)** Most candidates were able to deduce the half-life of neptunium-239 eg by measuring the time for the activity to fall from 5.0×10^{12} to 2.5×10^{12} Bq. Some were unable correctly to calculate the half-life in seconds.

(ii) By dividing 0.693 (= In 2.0) by the half-life many were able to calculate the decay constant of neptunium-239 . Some candidates lost credit by failing to show their working. This was required because the question asked them to 'Show that ...' the decay constant is 3.4×10^{-6} s^{-1}.

(iii) Here candidates needed to find from the graph the activity after 2 days, and then, using the equation $A = \lambda N$, calculate the corresponding number of nuclei. Alternatively it was possible to calculate the activity after 2 days. Candidates who failed to score here often found the activity after 2 days and gave this as the answer. A few tried unsuccessfully to use the Avagadro number.

(c) **(i)** Most were able to remember the half-life of plutonium-239 in years.

(ii) Surprisingly few candidates realised that the activity of pluonium-239 would not change perceptibly in 5 days so few scored the mark for drawing a horizontal straight line on the graph. Both upward and downward curves, presumably intended to represent exponential changes appeared on many scripts.

3 **(a)** Most candidates were able to state correctly the mass and charge of an antiproton but a few lost the second mark by giving the charge as 1 C.

(b) Many were able to suggest sensible places where an antiproton might be found such as a particle accelerator or in cosmic rays; 'inside an antimatter atom' was not rewarded.

(c) **(i)** Candidates were expected to state that there would be two photons after a slow proton-antiproton impact, that they would have equal frequencies and be moving in opposite directions. Few said this though some gained credit for a sketch showing two photons moving in opposed directions, usually as part of their answer to *(iii)*.

(ii) Candidates were expected to realise that the total energy of the two photons is the sum of their rest mass and kinetic energies and to convert this energy to joule. By equating this to the photon energy h□ they could calculate the frequency of the photons. Although most candidates were able to score some credit in this part, many lost marks by omitting one of the two parts of the particles' energy or by omitting one of the factors of 2 (due to two particles and two photons). One gained the impression from the accounts of many candidates that they thought that *most* of the energy of the photons is due to their kinetic energy rather than the rest mass of the proton-antiproton pair.

(iii) Here candidates were expected to state, either in words or sketch that the two photons created in this case would no longer travel in opposite directions but would have some forward momentum ie in the direction of the incident particles, so that their tracks would make equal angles of less than 90° with this direction. Also, the frequency of these two photons would be higher than in *(i)*. This was not well answered; many scored only the mark for recognising that the frequency would be higher. Those who did attempt an explanation seemed unaware that the fact that the two particles were travelling in effectively the same direction had implications for the directions in which the product photons would travel; some candidates showed confusion between kinetic energy and momentum.

4 **(a)** Disappointingly, as indicated in the General Comments above, some lost this straightforward mark by carelessness in the representation of the nuclides eg representing the helium nucleus by ${}^{4}_{2}\mathbf{H}$.

(b) This was a calculation of a kind which has been set many times before. Many candidates showed that they were able to find the mass defect and then to convert it, first to kg and then, using the mass-energy equation to energy in joule. Some candidates converted the mass-energies to joule before deducing the mass defect. This was a perfectly valid approach though it resulted in a longer calculation. A minority of candidates remembered that $1.0\ \mathrm{u}$ is equal to 930 MeV and were able to convert the mass defect by this route. Of those who failed to complete this satisfactorily, some multiplied each nuclear mass by the nucleon number before (if at all) trying to find the mass defect. Others converted each nuclear mass to joule before finding a mass-energy defect and simply got lost in the figures. Some failed to realise the importance of the significant figures in the mass values and, by omitting several, arrived at incorrect energy values. In serious cases this was penalised.

(c) Most candidates were able to find the mean neutron kinetic energy by taking 80% of the energy calculated in *(b)*.

(d) Candidates were expected to state that because the neutron has only a quarter as much mass as the helium nucleus, conservation of momentum will result in the neutron exiting the reaction with a speed four times as great and so, since the k.e is proportional to the square of the particle's speed, the effect of the neutron's 4 times smaller mass will be outweighed by the 16 times greater effect its greater speed has upon the overall k.e. Although this area has been examined several times in recent years, many candidates seemed unaware of this aspect of the deuterium-tritium reaction. Many did however gain credit for stating that the remaining energy will be carried by the helium nucleus which is the other product. A few candidates thought that the unbalanced k.e was due to a change in binding energy.

(e) This required, mainly, recall of the method proposed for converting the k.e. of the neutrons from a fusion reactor into heat energy. Many candidates were aware that a lithium 'blanket' is the preferred method. The neutrons are to be absorbed by a lithium nucleus and the products of the reaction which ensues (tritium and helium) will carry away a large quantity of kinetic energy. In order for this k.e. to become heat energy the fast-moving product nuclei must collide randomly with other nuclei so that the k.e. becomes randomised. Many candidates answered a different question: they assumed that they had been asked how the energy from the reaction can be turned into *useful* energy and so discussed the boiling of water to produce steam for turning turbogenerators. Some candidates seemed unaware that the neutrons are absorbed at all and appeared to believe that the energy conversion was simply a matter of neutrons colliding with nuclei (or often 'atoms' or even 'molecules') and merely passing on their k.e. by collision, clearly not appreciating that without the lithium the neutrons would mainly pass straight through the layer and escape, taking their energy with them (and failing to generate the essential tritium). Disappointingly, candidates from a few centres did not appear to have met this energy conversion process at all.

5 **(a)** Most candidates were able correctly to write the symbols for the three nuclei.

(b) As mentioned above, carelessness deprived some candidates of straightforward marks for writing two nuclear equations, usually either by misrepresenting the beta particles or by omitting or representing incorrectly the neutrinos. A few candidates omitted a nuclide symbol or put the beta particle on the *left* of the equation.

(c) Candidates were expected to deduce from the equations of *(b)* that the carbon decay was in effect the deay of a neutron to a proton and beta particle with emission of a neutrino. Likewise it was possible to reduce the oxygen decay to that of a proton to a neutron and positron. It was then necessary to state and substitute the quark composition of the proton and the neutron before simplifying the equations to the decay of a down quark and the decay of an up quark. For full credit all these steps were necessary since the question had asked the candidate to 'Show all the steps ...'. Marks were often lost because some of the steps were omitted, especially those which involved simplification of the quark equation. Some candidates thought that a meson would be emitted in one or both reactions.

(d) Candidates were given a graph of nuclear mass against proton number and asked to mark the positions of the three nuclides on it. Since both the carbon and the oxygen nuclei decay spontaneously to the nitrogen nucleus with an inevitable release of energy, the nitrogen nucleus must have less mass-energy than the other two nuclei and should therefore have been shown to have a lower nuclear mass. The difference is small but candidates were told that the mass scale did not start at zero so it was possible to show the difference clearly. Unfortunately few candidates realised that they were being asked about nuclear *masses* and answered as if they had been asked about nuclear *mass numbers*. Thus it was frequently stated that, since the sum of protons and neutrons was equal in all cases, the three points would lie on a horizontal line on the graph. A few candidates thought that the nitrogen nuclide would have the highest mass because it has a higher binding energy.

6 As usual this extended writing question gave candidates scope to marshal their facts, in this case to describe the process of nuclear fission inside a nuclear power station. Marks awarded covered the full range from zero to 100%. Candidates who scored highly were the ones who directed their responses most carefully to the bullet points in the question. Some candidates who clearly knew a lot about this topic nevertheless scored poorly because they omitted to state facts which they almost certainly knew. Instead, they gave details about moderators, control rods, nuclear waste and other unasked-for areas. Some gave a diagram but this rarely added to their score. Often a diagram is a useful adjunct to a written account but in this case there was nothing in the question to suggest that a diagram would say anything a verbal account could not. Common misconceptions included the use of the word 'decay' rather than 'fission' to describe the process whereby a large nucleus splits into two parts. Many candidates seemed to think that neutrons have to be *fired at* the uranium nuclei, often at odds with their statement that to be absorbed they need to be slowed down by a moderator. Some candidates conducted their discussion in terms of *atoms* rather than nuclei and a few stated that it is the uranium-238 which fissions rather than the 235 isotope.

7 This question, about the physics of energy use in the human body gave candidates of all abilities a chance to display their knowledge and understanding of some general Physics and many candidates were able to shine.

(a) **(i)** Most were able to find the total energy provided by 250 g of food and by dividing this by the power consumed by the body when at rest were then able to arrive at a correct value for the period of rest fuelled by this mass of food. A minority either failed to take the second step or made an error in converting the time in seconds to hours.

(ii) Only a minority were able to state why the temperature of the person's body remains steady during this resting period. They were expected to point out that heat is being lost by the body but that the rate of loss is balanced by an equal rate of heat generation from the body's 'burning' of food. There were many discursive accounts which nevertheless failed to refer to either of these physical phenomena.

(b) **(i)** Most candidates were able to use the expression *mgh* to calculate the potential energy gain of the climber. A few omitted g.

(ii) Most of those who scored for correct answers to *(i)* went on to score here by dividing the energy required by the energy value of the food.

(iii) This part proved more difficult. Many candidates realised that, since the conversion of chemical energy in food to mechanical energy is only 20% efficient, the total mass of food needed to supply this energy is five times as great. However, many candidates omitted the energy needed to sustain the body's normal processes.

(c) Here candidates were expected to apply their understanding of thermal physics to the case of a marathon runner.

(i) Most realised that they only needed to apply the equation $Q = mc\theta$ to find the temperature rise of the body in 1 second. Candidates who did not score had usually failed to remember this equation, or had difficulty in rearranging it.

(ii) This was a slightly more probing question in that it expected candidates to point out that if the outside temperature is higher than body temperature, heat cannot be lost to the surroundings by conduction, convection or radiation because heat can travel only from a body at higher temperature to one at lower temperature. Most candidates stated that the outside temperature is higher, but many failed to go on to make the second, more general point.

(iii) Given that the runner is experiencing bodily heating at a rate of 900W, candidates needed to calculate the total energy expended in 2.5 hours. Dividing this by the latent heat of water gave the mass of water evaporated. Better candidates had no difficulty in scoring full credit; weaker candidates either lacked the basic physical knowledge of energy, power and latent heat, or they made errors in rearranging the equations.

(iv) Most candidates realised that the important precaution is for the athlete to drink plenty of water in order to avoid dehydration. Other precautions eg wearing loose clothing, wearing porous clothing, pouring water over the runner's body, eating enough carbohydrate before of during the race or keeping as far as possible in shade could also score providing a sound physical justification was given.

2826/01 Unifying Concepts in Physics

General Comments

This paper produced marks in the range 5 - 57 with 14.7% of the 300 candidates being unable to score 20 marks out of the maximum of 60. At the top end there were 14.0% who were able to score more than 45 marks. The discrimination shown by the paper was good. There was not a huge bulk of candidates near the mean mark.

The comments made this time last year dealing with the way too many marks are lost unnecessarily have not resulted in any significant overall improvement. The method of working of far too many candidates simply encourages mistakes. When poor technique is coupled with a complete failure to notice when an answer is nonsensical, the effect is catastrophic from the point of view of the candidate. It was, for example, far too common to be told that the mass of a single atom of potassium was 2.3×10^{25} kg. It is as though division or multiplication is a matter of chance rather than common sense. Candidates seem far too reluctant to use any words when answering numerical questions. They write tens of equations and leave the examiner to sort out the correct ones. Or they write tens of statements linked by = signs even when 'equals' is not meant. '=' becomes a statement of 'from what I have done so far it is possible to get'. What is needed is words. This was very clear in the hundred or more answers of 1.5 m^2 to question 2(d)(i). No one ought to get this wrong in a public exam. It is so easy to write, on two lines

120 W is supplied by an area of 1 m^2
80 W is supplied by an area of ⅔ m^2.

That is, first line a clear statement of what is known; second line a deduced answer.
The next paragraph is a copy of a paragraph taken from last year's report. Unfortunately it still applies.
It is a matter of regret that many candidates simply think of physics as a process of stuffing numbers into formulae and using a calculator to produce an answer which therefore must be correct. Long strings of numbers with no explanation in words are a recipe for disaster in many cases.
Sloppiness of working extended into the handwriting of some candidates. There were many occasions when not only did their lack of clarity make it difficult or impossible for the examiner to discern their meaning but also occasions when they confused themselves and consequently lost marks. All the candidates completed the paper in the allotted time.

Comments on Individual Questions

1 Good candidates could get full marks on this question. Weaker candidates often started off badly by writing N/m/m s^{-1} = N s or similar. Answers to (b)(ii) often involved 20 equations being written. V and v and r were frequently indistinguishable. Candidates only lost 1 mark if they did not know the 4/3 factor for the volume of a sphere, but many candidates had a formula for a volume that only contained an r^2 term. The ability to calculate volumes and areas of certain shapes is clearly stated in the mathematical requirements section of the specification. Many error carried forward marks were awarded in (c). Candidates should have been able to answer (d) correctly, even if they had made mistakes with (c). The graphs were frequently drawn too carelessly.
Answers to (e) were mixed. 'Pressure holds clouds up' was a popular approach and so too was 'clouds float because they are much lighter than air'. Rather more bizarre answers seen were 'the charge on a cloud is repelled by the charge on the Earth', 'they are so far away from the Earth that gravity is negligible on them' and ' they are attracted more from the Sun than from the Earth'.

All that the mark scheme required was that there must be an upward force on the water droplets, the air in the area of the cloud must be rising, and therefore the glider can be lifted as well. One candidate knew that there is a force of rotation as well and mentioned Coriolis! Nevertheless, it was not too difficult, thanks to error carried forward rules, for most candidates to score in the range of at least 8 marks on this question.

2 Most candidates were able to score at least 10 marks on this question but again there were many marks wasted through carelessness. Parts (a) and (b) usually caused no difficulty but in part (c) too many candidates did not show the panel to be at right angles to the direction of sunlight and many gave answers to (c)(ii) that applied to the 80 W maximum rather than to the difference between 80 W and 20 W. Part (d) was reasonably well answered but 5000 hours was a very common answer to part (iv). Answers to (e) showed minimum discrimination. 1 mark was usually scored by candidates stating that the pay back time was too long – even if it was only 5000 hours. Few scored the mark required by the mark scheme to say either, that panels such as this, which are being purchased, are useful in out of the way places, or that they provide 'green' electrical energy.

3 This question was answered well by a good proportion of candidates and marks above 9 were common. However, it started badly by very few knowing what the word nuclide meant. Its definition as either a particular atom or nucleus was accepted. Easy marking was applied to the definition of ion. As long as it was given as a charged particle the mark was allowed. Not many candidates stated that it could be one or more extra electrons or one or more fewer electrons than for the neutral atom. As indicated above, powers of 10 caused problems here and the current was often given as 3.0×10^{-27} A. If candidates wrote the answer as 1.6×10^{-19} C x 5.4×10^{7} s^{-1} they would have a built in check of 8.64×10^{-12} C s^{-1} as their answer. There was the usual problem with a mole as 0.039 kg, but candidates only lost 1 out of 8 marks if they used 39, getting the answer 240 m. On the other hand, candidates who quoted a memorised formula incorrectly as $r = Bq/mv$. lost all 4 marks for (c). Radii of values such as 2.4×10^{12} m or 4.2×10^{-17} m were not awarded the fourth mark in (c) even if it did carry through. Most scored at least one mark in (d). Reference to an isotope of potassium was needed for the second mark.

4 This question produced some extraordinary answers. Lots of candidates gave the speed of light as the speed of sound. Despite having worked with wavelength for vibrating strings and air columns. It did not dawn on candidates that it was unlikely that any musical instrument would have a length of a million metres. It was also surprising how many candidates wrote $v = f\lambda$ therefore $\lambda = f/v$. In part (b) too many diagrams did not show wavefronts and neither did they show, or state, that interference can only occur where there is overlap between the two sets of waves. On this straightforward question there were too many candidates scoring only 2 or 3 marks.

5 Most could answer (a) correctly, though over abbreviated answers, such as 'capacitors' 'capacitance' and 'decay' were not credited. Part (b) caused difficulty for weaker candidates who wrote comments such as 'Fig.(a) does not go down fast enough to be exponential' or 'an exponential does not cross any axis so Fig.(b) is the right answer'. The question also showed those candidates who always fiddle graph values to make them lie on a crossing point on the grid. Figures for *y* values on the graph of Fig.(a) of 4, 2 and 1 were frequently stated to be at times of 0.6, 3 and 5 seconds, giving intervals of 2.4 s and 2 s. Reading more accurately, for example at *y* values of 4.8, 2.4 and 1.2 give times of 0, 2.3 and 4.5 seconds. Many candidates did, sensibly, mark the graphs, but often their lines were not vertical. Both Fig.(b) and Fig.(c) are a long way from exponential decays at the right hand side of the graphs. Fig.(b) is in fact an inverse square law and Fig.(c) is the same graph but displaced so that it does cut the *y* axis. In part (c) many stated that the doubling time must replace the halving time, though many just wrote that the graph would go upwards rather than downwards. A surprising number thought that a *y* proportional to x^2 graph was exponential. Biological growth was usually given in answer to (ii), and quite a few gave bank interest as their answer. This was allowed although it is really the total sum of capital + interest that shows exponential growth, provided interest is added continually.

2826/03 Physics Practical

Just over two hundred candidates took the examination this January, and the standard was very much the same as in previous January sessions. There were relatively few weak candidates, and there were no difficulties reported from centres about apparatus. There appeared to be sufficient time to complete the experiments. The planning exercise was generally carried out well, but the evaluation section of question 2 still causes difficulties for many.

Question 1

This was what used to be the standard compound pendulum experiment, using a weighted metre rule. Setting up the experiment caused no problems, with no candidates needing help, or getting it wrong. To get decent results, the timing of oscillations has to be done carefully, with repeats.

Despite the hint in the stem of (b) (ii) that the graph is a curve containing a minimum, about a third of candidates obtained results showing a smooth curve without a minimum, generally sloping upwards. It was very clear that some had altered their data to fit what they thought the result should be. Others of course had probably just not timed accurately enough. The curve should be U-shaped, and it is not quite symmetrical. Two ‘quality’ marks were given for obtaining a minimum.

In the table of results, credit was given for putting all raw readings into the table, ie distance OX and the time for 5 or more oscillations. Most omitted OX, and a surprising number also omitted raw times and just listed the period T. Units were generally good, but the consistency marks were often lost by not putting OX or h to the nearest mm.

Choice of scales and graph plotting was generally good, but there are still too many starting their x and y axes from zero and finishing up with a small graph in the corner of the paper. Candidates were then asked to find the gradient of the curve at h = 25 cm, and this caused several difficulties. Some drew no tangent and lost all three possible marks. The tangent was expected to be at least 10 cm long. Most spotted that the gradient was negative.

Part (d) required substitution of T and h at the minimum into an equation containing g, and rearrangement to calculate a value for g. The algebraic manipulation was very often wrong, earning no credit, although only one mark was lost if the error was arithmetical. The unit was expected to be cm/s^2 if no conversion from cm to m was seen in the working. This conversion was necessary to earn the mark for m/s^2 or N/kg. The answer was expected to be to two or three significant figures.

In part (e) the equation was given in the form y = mx + c, and candidates were asked to pick out y (T^2h), m ($4\pi^2/g$), and x (h^2). This proved to be quite difficult. Part (f) asked for a comparison of the methods for finding g. The answer expected was that the straight line method is more accurate, using all the readings taken, whilst the other method relies on the inaccurate estimate of the position of the minimum on the graph.

Question 2

This question required candidates to use a converging lens to focus the image of a bulb filament on to a screen, and measure object and image distances (u and v). As this is an unfamiliar exercise for most, the supervisor was required to show the completed set-up to the candidates beforehand.

Some accurate readings for *u* and *v* were taken, and when the proportionality constants were calculated to confirm $uv \propto (u + v)$, they proved to be close. There were however still some who failed to calculate these constants and so lost marks. The uncertainty in measuring the image distance *v* is anything from ± 0.5 cm to ±2 cm and yet many quoted the uncertainty of the ruler (± 1 mm). The % uncertainty formula was well known.

From many centres the evaluation was disappointing. The usual marks were allotted to "two sets of readings are not enough; take more sets and plot a graph; of *uv* against *(u + v)* to get a straight line", to give a total of 3 marks. Most candidates omitted this.

More straightforward perhaps was to say that the image is hard to focus, so take several readings and average them (2 marks in total). This was also usually omitted.

Most candidates however did say that it was difficult to measure from the filament inside the bulb (1 mark) and suggested sensible ways of overcoming the difficulty, such as measuring the diameter of the bulb, or setting up some sort of optical bench (a possible 2 marks).

They were asked to comment on the effect of using the stop, which was provided. Most said that the image was clearer and less bright (2 marks) but failed to say that it is actually more difficult to measure *v* because of the larger range for which the image is in focus.

The standard of written communication was generally good.

The Planning Exercise

Candidates were asked to investigate what effect the spacing between the panes of glass in double glazed windows had on sound transmission. This should have involved measuring the reduction in sound amplitude for a range of frequencies and spacings.

Nearly all sketched a suitable set-up. Marks were given for a labelled diagram containing signal generator, loudspeaker, the panes of glass, microphone and oscilloscope. It was considered inadequate to support the glass with just clamp stands; spacers between the glass sheets were expected. Most earned the straightforward mark for describing the method, but not so many compared the output amplitude from the speaker to the amplitude at the microphone.

There were 3 marks available for describing the use of the oscilloscope. Amplitude had to be measured in volts, and the time base axis had to be explained together with the use of frequency = 1/period.

'Detail' marks were for such things as a quiet room or a soundproof box, selecting a sensible choice of gaps, use of vernier callipers to measure the gap, and having the microphone and speaker close to the glass but not touching. Candidates were generally rather vague on what results to expect, but marks were given for reasonable graphical sketches, with labelled axes. Those who provided numerical evidence of preliminary work were also credited.

Nearly all gave several references, usually web-based, and most accounts were of the correct length (500 words) and not too long. In general the quality of plans this year was fairly high.

Grade Thresholds

Advanced GCE Physics A (3883/7883)
January 2008 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
2821	Raw	60	42	37	32	27	23	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	45	40	35	31	27	0
	UMS	90	72	63	54	45	36	0
2823A	Raw	120	97	86	75	65	55	0
	UMS	120	96	84	72	63	54	0
2823B	Raw	120	97	86	75	65	55	0
	UMS	120	96	84	72	63	54	0
2823C	Raw	120	92	83	74	65	56	0
	UMS	120	96	84	72	63	54	0
2824	Raw	90	62	55	48	42	36	0
	UMS	90	72	63	54	45	36	0
2825A	Raw	90	63	57	51	45	40	0
	UMS	90	72	63	54	45	36	0
2825B	Raw	90	65	59	53	48	43	0
	UMS	90	72	63	54	45	36	0
2825C	Raw	90	65	57	50	43	36	0
	UMS	90	72	63	54	45	36	0
2825D	Raw	90	62	55	48	42	36	0
	UMS	90	72	63	54	45	36	0
2825E	Raw	90	64	57	50	44	38	0
	UMS	90	72	63	54	45	36	0
2826A	Raw	120	92	81	70	60	50	0
	UMS	120	96	84	72	63	54	0
2826B	Raw	120	92	81	70	60	50	0
	UMS	120	96	84	72	63	54	0
2826C	Raw	120	89	80	72	64	56	0
	UMS	120	96	84	72	63	54	0

Specification Aggregation Results

Overall threshold marks in UMS (ie after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3883	300	240	210	180	150	120	0
7883	600	480	420	360	300	240	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
3883	13.2	33.0	56.3	78.9	95.1	100	334
7883	12.8	47.4	70.5	87.2	97.4	100	89

For a description of how UMS marks are calculated see:
http://www.ocr.org.uk/learners/ums_results.html

Statistics are correct at the time of publication.

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