GCE

Physics B (Advancing Physics)

Advanced GCE **H559**

Advanced Subsidiary GCE **H159**

OCR Report to Centres

January 2013

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This report on the examination provides information on the performance of candidates which it is hoped will be useful to teachers in their preparation of candidates for future examinations. It is intended to be constructive and informative and to promote better understanding of the specification content, of the operation of the scheme of assessment and of the application of assessment criteria.

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

OCR will not enter into any discussion or correspondence in connection with this report.

CONTENTS

Advanced GCE Physics B (Advancing Physics) (H559)

Advanced Subsidiary GCE Physics B (Advancing Physics) (H159)

OCR REPORT TO CENTRES

Overview

In general candidates appeared to be well prepared for these January papers. Unit G491 is a particular challenge for Year 12 candidates as it comes so early in the course. As this is the last time candidates will be given the opportunity of a January paper, many Centres will have to think carefully about structuring their teaching now that the mid-point examination has been removed.

As always, calculations were generally well performed although each new cohort of candidates needs to be instructed on significant figures, rounding errors and power of ten issues with units, such as mA.

It can be readily seen that papers now contain more extended writing and unstructured questions than in previous years. These are undoubtedly more challenging questions and, perhaps, the form of question that needs to be practised more frequently in class. This is particularly evident in the A2 papers, in which such questions form the majority of the stretch and challenge component. The explanations offered by candidates in the papers are, at the highest level, extremely impressive and show that Centres are giving candidates a chance to discuss and write about the work they study, and through this gain confidence in using technical vocabulary. The best candidates also appear to realise that there is invariably a 'hidden' equation behind a written explanation and use this method to form precise and concise answers. For example, many explanations of inductive effects at this level rely on transposing the equation $\varepsilon = -N\,d\Phi/dt$ into suitable prose. Of course, this is a higher level skill and requires an understanding of the physics that goes beyond mere recall.

The legibility of candidates' handwriting is always a problem although the scanned scripts were usually clear and easy to mark. The quality of diagrams is variable and it is clear that many candidates do not take a ruler into the examination, or, if they do, do not think they need to use it for straight lines.

However, the mean marks on the papers show that the majority of candidates have responded well to the demands of the course and have been taught in such a way that they can use physics, with confidence, in novel situations.

G491 Physics in Action

The paper worked well to differentiate candidates with a mean mark of just over a half and a good spread. Most of the questions were briefly worded, which meant candidates had sufficient time to process the information in the question. There was little evidence of candidates not having time to complete the paper. Hence the ‘No Response’ rate was generally low, but high in questions 4(a) (where candidates seemed unfamiliar with a sound spectrum), 7(b) (a hard unfamiliar calculation on the number of oscillations in an ultrasound pulse) and 10 (iii) (hard marks at the end of the paper). The amount of longer written answers was a challenge to all, but especially the weaker candidates, with over 1/3 of the paper marks allocated to this type of question between questions 8(c) and 10(b). There were significantly fewer SF (Significant Figure) penalties than usual which was pleasing. However, there were more ‘powers of ten’ and ‘rounding’ errors, than previously. Pleasingly, many more candidates had improved their drawing skills, evident by construction lines and use of a measure for the focussing wave fronts on the diagram in 2(b).

Section A

Question 1

An introductory question on units, which was well answered. The most common errors were to select in part **(a)** C s^{-1} for electric charge; in part **(b)** J s^{-1} for potential difference and in part **(c)** As for conductance .

Question 2

For part **(a),** in justifying the very distant object on a lens diagram, many candidates said “waves were parallel”, which was not sufficient for the mark. A few more lost the mark by contradiction saying the incoming waves had "little or no curvature".

In part **(b)** most candidates scored at least 1 mark for drawing waves converging on the focus. Mistakes tended to be for misjudging the wavelength that they drew for their focussing waves. These were either too irregular or did not match the wavelength drawn in air for waves arriving at the lens. On the whole drawing skills are improving which is pleasing, as a good technical diagram can convey so much information and understanding.

Question 3

This question tested graph reading from a stress vs strain graph and calculation of Young modulus.

In part **(a)** most correctly read to ½ small square graph paper division to get 225 MPa, most errors were 220 and a few 230 MPa.

In part **(b)** nearly half the candidates made POT errors: by missing 10^6 for MPa in stress and even more forgot the10^{-2} for strain %. Weak candidates knew what to do but got 2 ‘powers of ten’ errors and scored 0/2. The weakest took values from the breaking point 300MPa and 0.5% which also scored zero.

Question 4

This question on a sound spectrum was not well answered. In part **(a)** many candidates clearly just read the value of the fundamental frequency from the graph, rather than trying to use higher harmonics to get a more precise estimate as requested, these scored 1/2. There were some good strategies but some did not appreciate the task, perhaps not reading the instructions carefully.

Part **(b)** about a quieter spectrum was not well answered. Many said the spectrum would be smaller, without specifying in what respect, or stating that the same frequencies would be present. Many scored 1 mark for clearly stating that the p.d. would be lower.

Question 5

This question concerned quantisation errors during digital sampling and had good differentiation.

In part **(a)** many chose 8000 bit per second rather than 3000, having confused the number of levels with the number of bits needed to distinguish them. But there were three methods of securing the first easy mark.

In part **(b)** far too many candidates gave "increase sampling frequency" to reduce this error rather than increase the number of bits per sample and hence levels. Those that were awarded marks tended to say "more levels" rather than "more bits" but could still gain 1/2 marks.

Question 6

This question was about working out the total resistance of a circuit. In part **(a)** about 1/3 of candidates chose the distracter answers of 300 Ω or 400 Ω. In part **(b)** nearly all candidates could calculate the current drawn from a 12 V battery by the circuit, allowing for ecf from an incorrect resistance in part **(a)**.

Question 7

Part **(a)** involved calculating the frequency of ultrasound from data in a table and required selecting values. Most selected the correct data or formula and scored the first mark, but about ¼ made 'power of ten' errors in the calculation. Several candidates interpreted the wave speed 1500 m s^{-1} as 1500 mm s^{-1}. In part **(b)** candidates were asked to find how many oscillations are in a pulse of given duration. This involved thinking beyond a standard formula and was more discriminating. Better candidates realised:

oscillations per pulse = oscillations per time x time per pulse

and secured the answer 4. Over half ended with very much larger or much smaller answers gained by inappropriate manipulation of the given data.

Section B

Question 8

This question concerned features of a laptop computer communicating with a wireless hub.

Parts **(a)** and **(b)** were well answered simple calculations on the current drawn by the hub and the wavelength of the radio carrier wave. Inversion of the $I = P / V$ formula and 'powers of ten' were the most common errors respectively.

In part **(c)(i)** many forgot to convert bytes to bits for the size of the information in the file before calculating the time to download, but could still gain 1 mark.
There were a number of 'rounding' errors of 53.4 s (for 53.33 s) and 6.6 s (for 6.67 s) which were penalised, and weaker candidates did not grasp that:

time = info / rate of transfer of info.

In part **(c)(ii)** candidates found it hard to suggest why the download time might be greater, many incorrectly wrote of the laptop being out of range. Some scored 1 mark by mentioning a lower bit rate, but could not suggest why. Fewer suggested error checking or the re-sending of information.

In part **(d)** they were asked to explain why the laptop fails to communicate beyond a certain range, in terms of signal and noise. Many candidate misconceptions became apparent about the nature of radio noise. The most common misunderstandings were: that the signal picks up noise accumulatively as it travels (like a snowplough gathering snow), rather than interfering with the local noise in the environment. Many thought the signal strength only started to decrease outside the range of the hub, rather than the signal to noise ratio decreasing with distance from the hub. Many did get a mark for stating that signal decreases in amplitude with distance or for signal degradation, but some were not clear enough in their explanations. The weakest candidates wrote about noise as sound.

Question 9

This question was a materials question about materials used to make and coat drill bits.

In part **(a)(i)** candidates were asked to explain the term polycrystalline structure in metals. About 1/3 of the marks were gained on average. Labelled diagrams showing grains with different orientations / grain boundaries secured 2/2 marks. A surprising number of candidates just wrote about the metallic bond or described perfect metallic crystal structure in general. Some drew diagrams that were not worthy of credit here being more appropriate for part **(a)(ii)** or some were confused with the concept of polycrystalline in polymers, or even spoke about long chains of metal atoms.

In part **(a)(ii)** they were asked to explain ductility and using structural diagrams of pure iron and steel explain why steel is more ductile. Generally this was well answered, most knew a definition for ductility. Many could name the dislocation in the diagram for iron and how it contributes to the slip of atomic planes, but candidates struggled to explain the concept of pinning of dislocation motion by carbon impurity atoms in steel.

Part **(b)(i)** about the advantage of hardness in a drill bit was reasonably well answered, but weak use of English robbed some of credit: eg hardness as 'ease of scratching' or 'could drill more materials' were common.

Part **(b)(ii)** was demanding and rather few QoWC marks were awarded as no comparison of ease of movement of atoms in the steel bit or the diamond coating was given; even when three technical terms had been used correctly. The metallic bond was better described than the covalent bond but there were some irrelevant descriptions of ionic bonding. Candidates should be encouraged to think about the context of the question.

Question 10

This question was about aspects of the operation of a touch sensitive screen.

In part **(a)(i)** most got the mark, but a few wrote about the finger reaching the lower resistive film.

Part **(a)(ii)** asked why the spacer dots were insulators, weaker candidates said it was to avoid shocking the user, or discussed heat transfer, but nearly 2/3 got the mark.

Part **(b)(i)** asked for the meaning of the term semiconductor and was poorly answered: many wrote conducts a bit or conducts better when heated.

In part **(b)(ii)** few could confidently describe doping in their own words: many offered change the temperature or add a metal during manufacture to change the conductivity, or alter the physical size of the conductor which were disappointing.

Part **(b)(iii)** asked for a straightforward resistance calculation; most got the numerical value correct but about half lost the second mark to 'powers of ten' errors, usually for not converting 60mm to 0.06m.

Part **(c)** was differentiating and difficult as anticipated. Few could discuss the potential divider quantitatively or rigorously in **(c)(i)**. Many just referred to changes in slider position, R or V_{out} without indicating the sense of the change. Many repeated reverse arguments: eg as x increases V_{out} increases (gained 1/2 marks) so as x decreases V_{out} decreases.

In part **(c)(ii)(1)** candidates had to show that the sensitivity of the touch screen was 20 mV mm^{-1}. There were very many unit penalties for an incomplete calculation eg 1.2 / 0.06 = 20 without showing that V m^{-1} are equivalent to mV mm^{-1}. In part **2** many found the inverse of the correct position resolution, having divided sensitivity by voltage resolution.

Most candidates made some attempt at the final part **(c)(iii)** , indicating that they had time to complete the paper. However, only more able candidates could see how to effect a solution to find the bits needed to code for the x-position voltage. This involved using ideas from different sections of the specification. Several quoted $\log_2 (V_{TOTAL} / V_{NOISE})$ erroneously, but could gain some credit if they applied it correctly to $\log_2 (V_{TOTAL} / V_{RESOLUTION})$. ie $\log_2$ (alternative voltage levels) = number of bits required. As always full credit could be gained by using the friendlier (to non-mathematicians) form 2^{bits} = number of alternatives (levels in this case).

G492 Understanding Processes/Experimentation and Data Handling

General comments

The entry for this paper, mostly re-sit candidates, was similar to January 2012, as was the performance of candidates. Examiners reported that the level of difficulty of the paper was appropriate. There was no evidence of candidates suffering from shortage of time in this paper. Unlike previous sessions where section B was the most demanding and section A the most accessible, candidates found the demand of the three sections in this paper very similar.

Candidates continue to find descriptive and analytical questions in continuous prose more demanding than simple calculations, which are generally done very well. When faced with 10 + cm of space in which to write a free-response answer they frequently repeat themselves or argue in a circular manner.

Section A

Questions 1 & 2 discriminated more sharply than was expected for the first two questions on the paper, with parts 1(a) and 2(c) proving the most difficult.

In **Question 2** many assumed that each graph was the answer to one part and one part only: this was true here but not stated as such, and is often not the case in this type of question.

Question 3(a) was almost invariably tackled correctly, with most finding the area under the appropriate part of the graph correctly.

In **Question 3(b)** fewer than half the candidates drew a tangent at t = 9 s and gained no marks in that part. Those who did draw a tangent almost always drew a sufficiently large triangle and found the acceleration correctly.
Question 4 was successfully done by virtually all candidates.

Questions 5 and 6, both 'tick the box' objective questions, were successfully done by the majority, with more being successful in Question 6, where they were not told how many boxes to tick, than in Question 5, where they were told to tick one.

In **Question 7**, many candidates did not interpret the diagram as meaning 'four fringe spacings = 3.0 cm' but attempted to estimate from the diagram, which was allowed. In part **(c)**, a surprising number used $/ = d \sin q$ with the wrong distance for d, either 1.5 m or the answer to part **(a)**. Many candidates recalled and used the Young's experiment equation, which was acceptable.

Section B

This section was more demanding, with Question 10 being the most accessible and Question 11 the most demanding. Candidates showed good mathematical fluency, and it was noticeable that working was laid out more clearly than in previous sessions. Explaining themselves in continuous prose is still a skill that many lack: candidates can perform the relevant calculations but do not always incorporate those calculations convincingly in their discussion – this was particularly noticeable in Questions 8(b) and 9(b). In most questions in this section candidates gained high marks on the earlier parts, but found the latter parts more demanding, which was as expected.

Question 8

Part **(a)** was well done, but a number of candidates did not calculate out their answer in **(a)(i)** and lost a mark: writing $\sqrt{\frac{50\text{ m}}{½g}} = 3\text{ s}$ does not show that the answer has been evaluated, while $\sqrt{\frac{50\text{ m}}{½g}} = 3.19\text{ s} » 3\text{ s}$ does. This is true for any question where the candidate is told to show that a variable has a certain value.
In part **(b)**, better candidates suggested sensible fragile supplies, such as medicines, and considered the effects of wind and the extended time of fall. Weaker candidates tried just to explain how parachutes worked and often had forgotten the context of emergency supplies after a disaster.

Question 9

In part **(a)** many had trouble following the description in the rubric which led the candidates to work through a series of logical calculations and as such, rewarded good physics. Less than half got part **(i)** although all attempted and many got 1 mark, with most mistakes stemming from not knowing how many cycles to include. Almost all got part **(ii)**; in part **(iii)** the most common wrong answer attempted to use $P = Fv$ instead of following the structure of the question to divide (i) by (ii).

In part **(b)** most correctly calculated the number of wave generators required and the length of coastline this would involve. Only the more articulate candidates were then able to evaluate their calculated answers in the context of the question with sufficient detail to gain more than 2 out of 4 marks here.

Question 10

This question proved the most straight-forward, and therefore the most accessible, in sections B and C. In parts **(a)(i)** and **(b)(i)**, the few who lost marks did so by not showing that they had correctly evaluated the 'show that' value by showing it to more than two significant figures.
Part **(b)(iii)** was not required knowledge in this unit (it is A2 material), the idea being that candidates should use the values they had calculated and the information in the question to identify appropriate transitions, with the direction not being required in the answer. Many candidates, not knowing of the nature of the hydrogen spectrum, attempted to draw new energy levels above the ground state by the appropriate value, and this was accepted provided that the new levels were labelled and at an appropriate value.

Question 11

Virtually all candidates answered part **(a)** well, but the vector diagram in part **(b)(i)** proved challenging for many and discriminated more effectively than any other part of the paper. Considering that **(b)(ii)** and **(b)(iii)** were thematically linked to **(b)(i)**, looking at its vertical and horizontal components respectively, it was surprising how many made poor or incomprehensible attempts at **(b)(i)** but then successfully calculated answers to the subsequent parts.
In part **(c)**, candidates were almost equally divided between those who could find only the magnitude of the resultant velocity and those who could calculate the angle of its direction and specify it unambiguously: clearly labelled diagrams were acceptable here.

Question 12

Part **(a)** was well answered, but in **(b)(i)** few knew what the term ‘spread’ meant and did not know how to examine **(b)(ii)** for the likelihood of 1.8 mm being properly classified as an outlier. In part **(d)**, many superficially chose to suggest the use of better apparatus, whereas the more successful realised the advantages of using a longer or thinner wire and were able to link the proposed change to the effects on the other variables in the experiment (principally the extension).

Question 13

Relatively few answered part **(a)** correctly, possibly due to not having picked out the key statement in the article; ‘Different conditions require different designs of turbines.’ On the other hand, most candidates were clear and articulate in parts **(b)(i)** and **(ii)** and scored well there.
In part **(c)**, most calculated and plotted the points correctly, and the majority chose to draw a best-fit straight line through the origin, which was acceptable in **(b)(i)**. In describing the relationship shown in **(b)(ii)**, very few picked out the behaviour at low wind speeds but most noted the linear relationship between P and v^3.
In part **(d)**, most were familiar with the approach, although a few still wanted to plot a graph or do an experiment. Some used diameter rather than area, and some lost the last mark by not showing an awareness of the magnitude of the results to draw a valid conclusion, often ruling out any possible relationship by observing that the calculated values of *k* did not agree to 3 significant figures or by rounding to 1 significant figure to force the data to meet their conclusion. The best candidates wrote comments such as ‘The values seem close, but more data would be needed to confirm if the relationship is correct.’

Question 14

Part **(a)** was well answered by middle and higher scoring candidates. Part **(b)** required clear logical setting-out of answers with a significant minority unable to convert hours and minutes to decimal hours in **(ii)**, and many finding the explanation in **(iii)** hard to phrase although the best answers were of a very high standard. In **(c)(i)** a number did not gain the mark for stating that the ship was moving, as uniform motion would not have provided a problem, whereas a number of interesting and imaginative suggestions were seen in **(c)(ii)**. Unfortunately the suggestions of setting different clocks to different time zones, or of bartering a spare clock for provisions, were not credit-worthy, but most realised that it was essential to have a reliable value of GMT for navigation.

G494 Rise and Fall of the Clockwork Universe

General comments

This paper performed similarly to its predecessors. It was good to find that the vast majority of candidates felt able to supply an answer to a question, even though it may not have been directly the question asked by the paper - see the comments on individual questions below. There was no evidence that candidates ran out of time.

As always, candidates of all abilities fared better with their calculations than with their written explanations. Centres need to be aware that the majority of the calculations on this paper will be of the developed type, requiring candidates to make at least two steps without any guidance. Weak candidates are still over-reliant on the data sheet, often selecting incorrect formulae which appear to contain the correct variables.

It was noticeable that many candidates failed to earn marks for their written explanations because they were ignoring the question completely and writing about something else. Centres might usefully encourage their candidates to read a question again after they have finished their response, rather than rushing straight on to the next question.

Section A

This section was slightly longer than it has been in the past, but still contained many short questions ranging over a spread of difficulties.

Question 1 was about units. The vast majority of candidates were able to identify the correct unit for pressure, but only the most able could correctly work out an equivalent unit for kinetic energy.

It was good to find that in **Question 2** almost all of the candidates were able to correctly identify the observations which provide evidence for a Big Bang.

Question 3 required candidates to use data from an activity-time graph to calculate a value for the decay constant of a radioisotope. Many weak candidates tried to use a formula from the data sheet which contained both activity and time ($\Delta N / \Delta t = -\lambda N$) without any success. Some able candidates who used $\ln A = \ln A_0 - \lambda t$ lost a mark by not using enough of the full range of data ie too small a value of *t*. The majority of candidates who read a half-life off the graph managed to earn both marks.

Question 4 proved to be challenging. Although most candidates could identify one correct statement about the charging capacitor (usually the energy calculation), only a minority could identify two. Many candidates do not know that the charges on the two plates are equal in magnitude but opposite in sign.

Question 5 provided candidates with a force-extension graph for a real spring. Although the most able candidates could calculate the energy stored in the spring for part **(a)**, many weak candidates lost one or both marks by calculating *force* x *extension* or neglecting to convert the extension to metres before the calculation. Part **(b)** was poorly answered by most candidates, with the majority failing to mention the graph at all. Answers which involved damping earned the mark only if they included a plausible source of friction, eg air resistance. It was disappointing to find that many candidates are under the impression that the presence of gravity will stop a mass on a spring from performing vertical simple harmonic oscillations, suggesting that they have never been led through this situation properly.

As expected, only a minority of able candidates were able to shade in the correct area of the graph for **Question 6** part **(a)**, although many more were able to identify the correct deduction for part **(b)**.

Question 7 was about ideal gases. The vast majority of candidates obtained full marks for part **(a)**, with very few failing to express the temperature in kelvin before doing the calculation. Although the vast majority of able candidates were able to sketch the correct curve on the pressure-volume graph for part **(b)**, many weak candidates could not.

Similarly, in **Question 8**, the vast majority of all candidates had no difficulty in calculating the correct value of the specific heat capacity for part **(a)**, but only half were able to explain why the presence of the heater and thermometer would affect the answer. Too many candidates answered another question of their own devising eg sources of heat loss, the finite sensitivity of the thermometer, the need to repeat measurements to compensate for random errors.

Question 9 discriminated well. Weak candidates often assumed a gamma factor of 1/3 (perhaps because they could not find a formula in the data sheet?), and could therefore not obtain a real value for the speed of the pions. However, it was good to find that the vast majority of able candidates earned full marks for this question.

Section B

As always, this section contained four longer questions, with each set in a different applied context, often requiring developed calculations and free-response explanations.

Question 10

This question about gravitational fields discriminated well; few candidates earned none or all of the marks, with the majority earning at least half. Few candidates were unable to sketch the field lines around the Earth or calculate its mass from the data provided. However, even able candidates were able to give a coherent explanation for the equality of the Moon's centripetal acceleration with the Earth's gravitational field strength. Too many provided circular arguments, confused field strength with force or used algebra with insufficient definition of terms. The calculation of the Moon's speed discriminated very well, as it involved two steps. Weak candidates often used the value for g given in a previous part instead of calculating its value in the moon's orbit. However, able candidates had little difficulty in obtaining the correct value. The final part required candidates to explain, in detail, how they could use electromagnetic waves to measure the Earth-Moon distance. Although few candidates earned no marks at all, it was disappointing to find that even able candidates omitted to mention that a pulse of waves was needed, implying the use of a continuous beam.

Question 11

This question was about the conversion of water into steam. Although many candidates recognised that the formula quoted in part **(a)(i)** involved the use of the Boltzmann Function, many candidates lost a mark by not including a model of the situation, ie that a few molecules in the water can 'get lucky' when they have collisions with other molecules. Part **(a)(ii)** required candidates to merge a rule involving proportionality with one involving equality, often with limited success. Too many weak candidates wrote down the two starting equations and the final one, without any plausible steps between. Part **(b)** required candidates to explain how the energy of a molecule in the steam changes with time. Too many candidates answered another question of their own devising, namely how does a molecule in the water gain enough energy to enter the steam? Although many candidates managed to earn two marks, only a small minority earned the last mark by stating that the time average of the energy remained constant. It was good to find that the calculation of part **(c)(i)**, involving a novel formula, was correctly done by most candidates. Most candidates failed to sketch the correct graph for part **(c)(ii)**, usually because they neglected to take account of the exponential in the expression for energy density. They may have been over-reliant on their calculators to find the curve, probably failing to keep the range of values of T to a sensible value for the context.

Question 12

This question about the launch of a rocket was poorly answered by the majority of candidates, with few earning more than half marks. Although part **(a)(i)** required candidates to use momentum conservation to explain the upwards acceleration of a rocket, most chose to ignore momentum altogether and used Newton's Third Law instead, earning no marks at all. Although many weak candidates were unable to successfully combine the formulae for momentum and force to do the calculation of part **(a)(ii)**, most moderately able candidates earned both marks. In part **(a)(iii)** many candidates confused the gradient of a speed-time graph with velocity instead of acceleration, omitted to explain why the mass of the rocket decreased with time or simply described the graph shape as an exponential instead of explaining it.

Part **(b)** required candidates to use the kinetic theory of gases to explain the upwards push on a rocket engine. The vast majority of candidates earned no marks at all, usually because they explained how the pressure of a gas depends on its temperature. Many also confused kinetic theory with kinetic energy. It is disappointing that so many candidates ignore the question on the paper and simply produce what appears to be an answer to a question set in a previous session.

Question 13

This question was about an application of simple harmonic motion involving one mass and two opposed springs. It was most unexpected to find that very few candidates were able to write down correct expressions for the tensions in the springs when the mass was displaced from equilibrium, let alone combine them to obtain an equation for its acceleration. This suggests that only a minority of centres show how the equation of motion for the simple harmonic motion of a real system arises from consideration of basic principles. Candidates fared better with part **(b)**, although only an able minority, as expected, remembered to take account of both springs. Although many candidates earned full marks for their graphs of part **(c)**, few sketched curves which were correct in all respects; they could get one feature wrong without losing a mark.

G495 Field and Particle Pictures

The entry for this paper was similar to January 2012 and was extremely small – about 100 entries. Of these the majority were Year 14 candidates re-sitting the paper. On such a small entry it is difficult to make statements about the performance of particular questions or part of questions. Nonetheless, as ever it is clear that some candidates were well prepared for the advance notice section of the paper and this pulled the average mark up. There were also some mistakes that may show a more general misunderstanding amongst candidates. These are the errors that are highlighted below.

Section A

Question 1 involved recall of units. Although this was generally well-answered candidates do confuse flux and field strength and so the question might not have been the easy starter it first appears.

Questions 2, 3, 4 and 5 were correctly answered by nearly all candidates and showed that even the weaker candidates could recall basic facts and methods of calculation.

Question 6 required basic recall or simple calculations and was handled well by the majority of the candidates, although some did not realise that the frequency of the emf in the secondary coil of a transformer is equal to that of the primary coil.

Question 7, which required a definition (or explanation) of the term ‘electric potential’, was not well answered and provided a reminder of the need to ensure that candidates are confident and clear about the terminology that is commonly employed.

Question 8, concerning binding energy, also proved more challenging for those candidates who did not read part **(b)** sufficiently carefully and calculated the total binding energy for 235 rather than 233 nucleons.

Some candidates also dropped a mark in **Question 9** by not clearly using the quality factor in their calculations.

Section B

Question 10

This question was about the acceleration of protons to relativistic energies. The first part, asking candidates to identify an asymptote, was well answered by many although some candidates rushed a little and wrote responses such as ‘asymptote at a velocity of c = 1’. The calculations of the relativistic factor in part **(b)** were handled more confidently than in previous years, although some candidates continue to misinterpret ‘total energy’ in the numerator of the equation for the gamma factor. The manipulation of units in part **(d)(i)** proved to be as tricky as ever for weaker candidates, some of whom decided to use a completely different equation ($F = ILB$) to reach the answer.

Question 11

In part **(a)** the fact that candidates were working towards a given answer certainly helped their cause and the majority reached the expected value and showed clear working. Part **(b)(i)** was more of a challenge. Weak candidates did not make the connection between power and energy released per decay multiplied by decays per second. Although this is not a subtle relationship it proved elusive to the least prepared candidates who also found **(b)(ii)** beyond their understanding. It may be useful to stress that each part of a question can be expected to use common data so that, in this example, data used in part **(b)(i)** may also be required for **(b)(ii)**. Part **(c)** discriminated well and only the best candidates achieved the highest marks by marshalling a coherent and accurate argument. Some explanation of the consequences of the calculated values was seen in the best answers.

Question 12

This question tested work covered in chapter 16. The calculations in **(a)** and **(b)** were accessible to the majority of the candidates. Part **(c)** proved more of a challenge as it required linking calculations to a logical argument. The best candidates gained marks here, having calculated that the expected difference in force would be detectable by the balance and then suggesting that the movement of charge on the balls cause the effective separation of the centres of charge to be larger than a simple calculation would suggest. Weaker candidates produced spurious reasons for this effect.

Question 13

Unsurprisingly, this question on electromagnetic induction in a novel context proved to be the most challenging on the paper. Questions based around the relationship *induced emf* = $-N\,\mathrm{d}F/\mathrm{d}t$ are frequently asked on this paper but candidates always find them troublesome. In this case part **(b)** required a candidate to realise that the magnetic flux was not changing at the instant that the magnet passed through the centre of the coil. This was indeed a testing problem. Part **(c)(i)** proved more accessible and shows that many candidates can use the equation cited above with confidence. However, part **(c)(ii)** showed that they cannot always use the equation as a basis for an explanation of observations. In this part although a good proportion gained some marks only the very best answers scored more than two out of four. This was because explanations were incomplete and muddled. This will be a good question to use in class. The last part of the question was also discriminating with the best responses showing a complete understanding of the physics of the situation. Many candidates realised that the shape of the emf line would be the same as in Fig. 13.3 but drew the line upside down.

Section C

Question 14

Part **(a)** was the most accessible question in this section as it was a series of relatively straightforward calculations. Part **(b)(i)**, a calculation of the Boltzmann factor, was more challenging but still answered confidently by many. Part **(b)(ii)** proved far less accessible. Although the question stated ‘use your answer to **(b)(i)** to explain...’, very few candidates made the connection between a low Boltzmann factor and the requirement for a population inversion. However, many candidates gained marks by clearly explaining what a population inversion is.

Question 15

This short question was designed to be accessible and so it proved, causing few problems.

Question 16

Another short, accessible question.

Question 17

Part **(a)** was a fairly standard question about logarithmic waves and caused few difficulties. Part **(b)** was more demanding but good candidates read the correct data from the graph and reached the expected value.

Question 18

This question was surprisingly poorly answered, perhaps because it was towards the end of a long paper. Marks were dropped in **(a)(i)** because candidates did not stipulate that a higher power laser is required if the *same* energy is to be transferred in a shorter time. Part **(b)** confused some because of the amount of data given in the stem. Those candidates that began the question by writing down the important data clearly gained more of the marks on offer. Candidates that chased at the answer without really thinking about what they were doing merely performed haphazard calculations.

Question 19

The last question tested AS ideas on refractive index. Those candidates that showed a familiarity with the advance notice article performed well on this calculation whereas some answers showed little understanding of the physics, making basic errors such as ignoring the refractive index in the calculation of the time taken for a pulse to travel down a fibre.

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