RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **A2 H559**

Advanced Subsidiary GCE **AS H159**

OCR Report to Centres

January 2012

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Oxford Cambridge and RSA Examinations

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.

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OCR REPORT TO CENTRES

Overview

The four papers taken in this January session have shown the best candidates performing to very high standards. It would appear that Centres are becoming familiar with the revised course and are generally preparing their candidates carefully for the examinations. This is particularly noticeable in G491. The examiners have worked hard to make this paper accessible for the Year 12 January candidates by making the language as clear and simple as possible. The mean mark on this paper was 35.4 out of 60 in this session which compares very favourably with 26.7 out of 60 for the previous January sitting. The principal examiner notes that, commencing in the June 2012 series, Section B will consist of three questions rather than four. It is hoped that this will further increase the accessibility of the paper as a whole.

The majority of those sitting G492 were resit candidates. The paper was more accessible than in January 2011, raising the mean mark.

G494, Rise and Fall of the Clockwork Universe, showed a similar distribution of marks to previous sessions. Once again, it is clear that Centres are working hard to bring the candidates up to the level needed for a January paper.

The number of candidates sitting G495 is very small and includes individuals no longer in full time education. This is reflected in the responses to Section C, based on the Advance Notice Paper, which in some cases show very little evidence of preparation before the examination. The individual reports below include many useful comments. As ever, good candidates can let themselves down through imprecise wording or incomplete argument. However, there is much to praise about the work of the best candidates in all the papers.

G491 Physics in Action

The vast majority of candidates appeared to cope well with most questions, managing attempts at nearly all parts. Much effort has been made to write questions which are quicker for candidates to answer by cutting down the amount of reading involved and presenting data in a variety of ways. To help further with this from the June 2012 series there will only be three questions in section B. There was little evidence of any shortage of time as only a small number missed the last few questions; also there were no dead marks which no candidates could obtain. A few left out selectively the harder parts of early questions and Q9 and Q10 in section B. These factors lead to a mean mark which was well over half the paper total, with a satisfactory spread. The quality of presentation of candidates' answers seemed to be an improvement on previous series.

Section A

Q1a. This involved selecting units from a list for pressure and conductance; this was a highly accessible opening question as hoped. Part b discriminated better by asking for equivalent units from the list for J s^{-1} and J C^{-1}. The answers W and V were sometimes quoted the wrong way round, and a few candidates wrote down the quantities power and voltage rather than selecting the equivalent units from the list as instructed.

Q2 was a straightforward question on analogue to digital signal conversion. In part a most candidates realised the bandwidth was the range of frequencies present in the original signal. In part b to identify the sampling frequency, the most common error was to double the bandwidth rather than the maximum frequency present in the signal. In part c the correct relationship to show that 7 bits per sample was sufficient: $2^7 = 128$ was usually shown and the question was well answered by most candidates. Part d did afford more differentiation in asking for the rate of information transfer, a significant minority used 128 rather than 7 bits per sample to multiply by the sampling frequency. Here ecf was allowed on an incorrect sampling frequency.

Q3 This was a straightforward question on image processing, recognising noise removal, sharpening or contrast enhancement in a before / after image pair of one of Saturn's smaller moons. In part b linking named image processes to possible explanations of how they are achieved was well done.

Q4 This was a successful question on a relatively hard topic, internal resistance and emf and terminal p.d. In part a candidates had to select two correct statements about emf. Most correctly picked B and E, and almost all had at least one correct, B. D was the favourite incorrect response, probably because it included the word "force" as in electromotive "force" for emf. In part bi candidates had to find the p.d. across the external resistor R. Often done most directly by ($V = \varepsilon - I r$); though other methods were sometimes used successfully, for example finding the total resistance by 3/0.45 then subtracting 0.38 Ω (effectively doing part b first) then multiplying by the current. Part bii was also often correct but a significant proportion of candidates get the total circuit resistance from (V / I = 3/0.45) without then subtracting 0.38 Ω for internal resistance.

Q5 This showed wavefronts from a distant star being focussed by a lens. In part a candidates had to place an X at the image position, a number were placed on the axis well to the right of the figure, and some lost the mark as they didn't place the cross carefully enough. In part b candidates had to simply state that the lens adds curvature to the wavefronts for the mark. There were quite a few good explanations of how the lens works by slowing light down without actually mentioning curvature, but these did not answer the question and gained no credit.

Q6 Involved calculating the speed of light in diamond from its refractive index. Most candidates could transpose the equation from the formulae sheet and complete the calculation. A few of the weaker candidates multiplied c by 2.4 ending with a superluminal speed that didn't ring alarm bells for them, and a few more were caught out by rounding error (1.25 back to 1.2) x 10^8 m s^{-1}.

Q7 This was about identifying the source of greatest uncertainty in a calculated resistivity. About half the candidates correctly identified the diameter of the wire D as supplying the greatest % uncertainty. Many referred only to D being squared in the formula which was not enough to earn the second mark. Many good candidates calculated percentage uncertainty (± 4%) to explain their answer, although this was not required for the second mark.

Section B

Q8 This concerned the physics of the cables in a large scale lifting crane.
In part a candidates had to name and explain a property of steel other than strength important in this application. Good clear answers were at a premium. A surprising number of candidates wrongly thought that high tensile steel cables are made by cold drawing a block of steel, hence requiring ductility or malleability. Just under a half correctly discussed the high stiffness (Young Modulus) or toughness of the steel; a few weaker ones could not then explain a correct property sufficiently well. Well-reasoned answers about sufficient flexibility for cables to bend around pulleys were also accepted. Those that decided to talk about strength (ruled out by question root) lost both marks.

In part b candidates had to calculate a cable cross-sectional area from tension and stress. Nearly 90% achieved this with only a few weaker candidates making power of ten or mis-transposition of equation errors.

In part c candidates had to show that the strain in a given cable was about 0.05%. The method was usually correct but some candidates failed to gain full marks as they did not give a second SF to their show that calculation. The other common error was power of ten confusing the absolute and % strains. Candidates then had to calculate the extension on a long cable (original length x strain). The most common error was to use % strain rather than absolute strain, and score only one of the two marks.

Part d yielded some very weak and confused answers, to the question why the maximum stress in such a cable is kept below about 1/3 of the yield stress. Simple statements were more likely to get the easy "safety margin" marking point, but many tried to give an explanation of yielding (often in terms of breaking rather than plastic deformation) rather than addressing the safety factor. Other candidates presumed that the cable lost its elasticity above the 1/3 value and so made contradictory statements.

Q9 This was about a thermistor in a potential divider sensor circuit.

Part ai was designed as an easy mark to explain why the circuit given is called a potential divider. About half got the mark for describing two resistors in series / sharing out the total p.d. ; so this provided more differentiation than anticipated.

Part aii was for three hard marks to explain the action of the sensor to temperature variation. Better candidates usually earned credit but fully-reasoned clear answers were not common. Many spent several sentences repeating parts or all the root of the question for no reward. A surprising number got off on completely the wrong foot, for example the thermistor resistance increasing (despite being told it decreases with rising temperature). Others thought the total resistance must stay constant so had the fixed resistor increasing in value; or the current staying constant; or the reduced thermistor resistance allowing more voltage to flow to the fixed resistor... There were rather a lot of concepts to keep in the mind at once, and candidates did need to be clear which p.d. or resistance they were talking about, so few gained the QWC mark here. Most “middling” candidates picked up one mark for V thermistor falls so V fixed rises (implication of constant circuit p.d.), or gained 2/3 marks for a partial explanation with no physics errors and good spelling and grammar.

In part bi nearly three-quarters of candidates realised from the graph that sensitivity was decreasing (with increasing temperature). A small number had the sensitivity increasing, presumably muddled with the p.d. increasing.

Part bii was very weakly answered by the majority of candidates . Surprisingly few, of even the better candidates, could work out the local gradient of the graph for the sensitivity. Even those who stated sensitivity was the gradient (earning 1/3) many actually calculated V/T rather than $\Delta V/\Delta T$, or calculated the average gradient over the first 70°C rather than gradient based on a tangent or sensible small triangle around 70°C. This skill is worth developing early in the course. Part 9biii concerning a potential divider calculation scared many weaker candidates. Most found the 3.7 V output for 70°C from the graph for 1/3 marks but then often ascribed it to the thermistor rather than the fixed resistor to calculate an incorrect resistance value around 500 Ω. Some tackled this part by the divider equation, others worked it from p.d. ratio = resistance ratio. It was good to see the top 20% of candidates scoring 3/3 on this tricky calculation.

Q10 concerned the precision of a hawkeye type camera position-measuring system, and candidates found it challenging (4/9 marks available were targeted at Higher level marks, so this is not surprising).

In part ai candidates were asked to calculate the magnification of the lens from object and image heights. The equation v / u has to be recalled and a half got this. Inverse magnification was a common incorrect answer, but many strange numbers were produced. Candidates seemed reluctant or unfamiliar to deal with a magnification of less than 1 for the reduced image, and some may have panicked?

In part aii most tried to use the lens equation to find the power $1/f$ of the lens. Just under half arrived at the correct answer of 18.3 D. Of the rest, the commonest issue was incorrect sign for u leading to incorrect answer of 18.1D; some candidates mixed up u (object distance) and v (image distance). A few candidates earned 1/2 for transposing the lens equation correctly. Many candidates substituted v for f in $P = 1/f$ which is a reasonable approximation, but the mark scheme insisted approximations had to be declared to gain credit. This could have been done by using the ≈ symbol or by stating that the object distance >> focal length of the lens. This level of sophistication was sadly not observed.

In part aiii candidates had to show that the size of the image was about 0.4 mm on the camera CCD. This was the first part question with a high omit rate, around 1/5 gave up on this part. However, the facility was high at well over 1/2 with good differentiation. Many who had got the inverse magnification in ai at 182 realised that the image was smaller than the object and sensibly divided the ball diameter by 182 now and full marks were awarded ecf with benefit of the doubt.

Part bi asked for the number of pixels across the image of the ball. Many, many candidates erroneously calculated 70 pixels mm^{-1} x 67mm to get 4690 pixels apparently not realising it would be the 0.4 mm image of the ball (occupying about 28 pixels) that would be on the CCD. Part bii asked for the distance the ball had to move sideways for its image to move across by one pixel. Again, most struggled to appreciate the significance of the numbers obtained in early sections, the most common error was to find the pixel width 1 mm/70 and give 1.4×10^{-5} m as the answer, without applying the magnification ratio to find the real ball displacement (about 2.6 mm).

Part c was not attempted by just over 1/3 of candidates. Of those few who produced an acceptable maximum distance value for the balls movement, many sadly omitted the unit and could not articulate an explanation. The idea that hawkeye should have an “uncertainty shadow ring” around the ball position was appreciated by about 1/5 of the candidates of whom about a half could express the idea.

Q11 was an easier question to finish on comparing material properties of plastics and ceramics for halogen lamp supports.

Part a was well answered by most, calculating the current drawn by a lamp and its conductance. A few answers were quoted as 2A (1SF) and were penalised. The commonest error was use of an incorrect power equation. Ecf was applied to the conductance calculation from the current value.

Part b was a 3 mark explanation of the electrical conductance of metals with QWC. Over half of the candidates earned 2/3 for mentioning delocalised electrons. About a third of the candidates progressed further to write well about charge carriers or their very high density in metals to secure the third mark.

In part ci most candidates correctly responded that plastics and ceramics have no (or very few) free electrons, to explain their insulation. A few gave the trivial answer that ceramics and plastics are good insulators because they do not conduct, which gained no credit.

Part cii asked for an explanation of why ceramics are preferred for halogen lamp fittings. Over half the candidates produced an acceptable answer related to the problem of heating and possible melting of plastic.

In the final question ciii just under half gave correct answers in terms of toughness of plastics or the brittleness of ceramics. Weaker candidates thought plastics were better insulators than ceramics or were preferable because they are cheaper or easier to mould, which gained no credit.

G492 Understanding Processes/Experimentation and Data Handling

General Comments

The entry for this paper, all resit candidates, was similar to January 2011. The examination proved easier than January 2011, although there was no evidence that the cohort of candidates was stronger. All 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.

Candidates continue to handicap themselves by a lack of organisation in laying out their work: in 14(b) and (c)(ii) it was often hard to trace the order in which the arguments were being developed. Many continue to show great insensitivity to the appropriate way to display numerical answers. Excessive significant figures were often seen – although penalised in only two instances, in 12(a)(i) and 14(c)(iii) – and in 10(b)(ii) the commonest answers were 10361067.5 and 10.4×10^{6} m s^{-1}, both clearly copied directly from calculator displays. Only the very best candidates reported this speed as 1.0×10^{7} m s^{-1}.

Section A

Proved accessible, with good candidates scoring 17+/20.

Q.1 was done well, with most getting at least 2/3 marks.

Q.2 proved more difficult, with very few correctly identifying more than 2 of the four graphs.

Q.3 was answered well by most, although a number ticked three boxes, thereby limiting themselves to a maximum of 1 mark.

In **Q.4**, most could do the calculation in (a), but in (b) many chose (quite legitimately) to use $v^2 = u^2 + 2as$ and lost marks by not ensuring that *a* and *s* had opposite signs.

Q.5 was well done.

In **Q.6**, most could do the calculations, but few stated the assumption needed in part (b). Some lost marks by incorrect rounding in part (a).

In **Q.7** nearly all recognised that they needed to find the area under the graph, even if they went awry on the subsequent calculations. A few ignored the graph totally and calculated the distance $s = ½(u + v)t$ or equivalent.

Section B

As usual, this section was more demanding, with the contexts in the first two questions more straightforward than the last two. Candidates showed good mathematical fluency, but did not always lay out their work clearly. Explaining themselves in continuous prose is also a skill that many lack. In most questions in this section candidates gained high marks on the earlier parts, but found the latter parts more demanding.

Q.8 (Standing waves on guitar strings)

Parts (a) and (b) were well done
In (c) (i) the calculations were well done by those candidates being able to rearrange equations.
Many in (c)(ii) tried to answer without reference to the two equations and did not get the mark.
The explanation of standing waves in (d) was generally done well.

Q.9 (Performance of a small car))

Part (a) was well answered by most, although a surprising number assumed that the force needed to increase in (a)(ii). Some did not gain the second mark by omitting to give the expected difference in the outcome of the 0 – 60 mph test, namely that the time would increase.
Part (b) was tackled well, with over three-quarters of the candidates getting full marks in (b)(iii).
However, answers to (b)(iv) were mostly too vague and general to gain credit.

Q.10 (Electron diffraction)

This topic area is demanding, and this question proved the hardest on the paper. Parts (a) and (b)(i) were done well, but thereafter marks were rare. The three-mark question on the effect on the pattern of increasing the electron energy was done well by very few, with only about 10% gaining 3/3 (unlike the much easier question 8(d), where 28% gained 3/3). A number ignored the equation given in the stem of the question, and attempted to use $E = hf$ in their explanation. In (c), the admittedly difficult phasor representation when applied to a single electron proved hard for most, although many gained some credit by writing down everything they could remember about phasors.

In (d), a few successfully attempted to use the diffraction grating equation with light to show that an impossible condition [and angle of arcsin(6000)] ensued, but most seemed to have a mental model of electrons squeezing through the gaps between atoms. Very rarely did examiners see a clear treatment in terms of diffraction of waves of different wavelengths by a gap.

Q.11 (Vector nature of velocity and acceleration)

Most candidates could answer part (a) well, although some lost a mark for ignoring the minus sign in (a)(ii).
Part (b) was often done well, although some had no clue about plotting the coordinates and finding their vector sum. Some candidates chose quite eccentric scales in doing their plotting: 3.5 small squares = 0.1 m s^{-2} was seen (it gained full credit). It was sometimes difficult to deduce the direction of the acceleration from what the candidate had written: a labelled angle on the diagram was accepted, as was a bearing from north (even though this hardly applied).
In part (c), only a minority of candidates were able to demonstrate that they knew the definition of work, and fewer showed that they could apply it in this example.

Section C

Most candidates had prepared well for this section which was between sections A and B in difficulty, as intended. As always, some did not show that they had worked through the advance notice material adequately: a very small number of candidates confused the quantity *s* with the unit s in the table in 13(a)(i), where one would hope that some prior analysis of the table in the advance notice material would have allowed those candidates to clarify that difference.

Q.12 (Dot plots)

In (a), most could calculate the mean and spread well, but a number did not then deduce correctly that 1.6 s was a potential outlier. In (a)(iii), calculation of the speed of sound from the data often produced, as in GCSE, an answer of half the correct size.

Most could suggest an uncertainty or error in (b), almost always the reaction time of the students. The commonest improvements suggested in (c) were either to increase the distance from the students to the reflecting wall, reducing the percentage uncertainly due to reaction time, or to replace the human aspects with sound sensing and data logging.

Q.13 (Measuring *g* by freefall)

Most candidates correctly completed the table, plotted the points and drew good best-fit straight lines, although a few did appear to think that the use of a straight-edge was unnecessary. There were many good justifications for expecting the graph to go through the origin, most commonly substituting t = 0 s in the equation, but also modelling $s = ut + ½at^2$ on $y = c + mx$, followed by stating that u = 0 m s^{-1} so c must = 0, was often seen also.

In (c), only the best candidates correctly realised that either the measured value of *t* must be too large, or the measured value of *s* must be too small and gave a possible cause. The consequence of this systematic error on the graph, in part (d), was rarely explained well.

Q.14 (Can we measure the size of atoms?)

Part (a) was usually done completely correctly.

Part (c)(i) was invariably done well, and nearly all candidates were able to calculate the thickness *t* of the oil layer in (c)(ii), although quite a few then did not divide this by 12 to get the atomic diameter. Part (c)(iii), which was intended to be harder, was done completely correctly by 21% of the candidates, with many losing one mark only for a significant figure penalty (one of only two such instances on the paper). Those who deduced that a 20% uncertainty in *r* would result in a 3 × 20% = 60% uncertainty in r^3, and hence in *t*, gained full credit.

A number attempted to combine percentage uncertainties for *x* and *R*, which is not only contrary to the instructions in the question, it is also not the method encouraged by the course; any use of ΔR was treated as neutral by the examiners, and ignored. Candidates who attempted to include a 2 × 5% factor for the variability in *R* with the 60% factor for the variability in r, resulting in an answer of 70%, were not penalised, and so gained full marks, even though the method is not sound, assuming as it does negative correlation between Δr and ΔR, whereas these variables are likely to show no correlation at all.

G494 Rise and Fall of the Clockwork Universe

General Comments

The distribution of marks earned for this paper was similar to that of previous seasons, with some candidates earning nearly all of the marks. The two stretch-and-challenge questions worked as expected, with only the strongest candidates able to earn marks for them. It was good to see that even the weakest candidates felt able to answer the vast majority of the questions - they nearly always provided an answer, even if it was to a question of their own invention!

Some of the questions involve calculations, often involving the use of more than one equation from the data sheet. Weak candidates are unable to do this, suggesting a lack of practice at calculations of this complexity. Clear layout of algebra when combining equations is still a problem for many candidates, making it difficult for their examiner to decide if they deserve the marks or not.

Many candidates could clearly do with more practice at writing free response explanations of phenomena. Too often, they stop halfway through the argument, or fail to make it clear exactly which part of the model they are talking about - they need to be taught to avoid the use of the terms *it* and *they*.

Section A

1 This question on units was the traditional start to the paper. Nearly all of the candidates correctly identified the unit for momentum, but the unit for kinetic energy proved to be more troublesome; many weak candidates could not translate the formula into base units.

2 Although the majority of candidates were able to say something sensible about changes to the gas outside the bag, few bothered to explain how the gas inside the bag allowed it to expand.

3 It was good to find that the majority of candidates could correctly sketch the graph for the velocity of an object in SHM. Many candidates drew a waveform which looked like a full-wave rectified waveform for the kinetic energy. Although this is incorrect, it was credited with a mark.

4 It was good to find that only a small minority of candidates were unable to correctly indicate the direction of the force on a satellite in orbit. Explaining why that force did not do any work on the satellite proved to be more challenging; too many candidates failed to provide a clear enough answer to earn the mark.

5 This calculation with the Ideal Gas Equation proved straightforward for the majority of candidates. Weak candidates often got lost in their manipulation of the equation.

6 Nearly all candidates earned both marks for this question.

7 Although many candidates correctly identified the variation in relative velocity as the cause of the red shift, many failed to earn the second mark by correlating the red shift to the change of velocity. Many weak candidates incorrectly assumed that the different distance of different parts of the galaxy was responsible for the difference in red shift.

8 Nearly all candidates earned all of the marks for this calculation of the thermal energy released.

9 It was good to find that the vast majority of candidates were able to correctly calculate the mass of gas in this two-step calculation.

Section B

10 A surprising number of weak candidates were unable to write down the correct expression for the velocity of the satellite. As expected, only strong candidates earned full marks for their derivation of the equation for the radius of the orbit; weak candidate often tried to unsuccessfully work back from the answer or failed to show enough working to convince their examiner. However, nearly all candidates had no trouble in calculating the radius of the orbit, despite the need to take a cube root of a fraction. As always, weak candidates fell into the trap of calculating gravitational potential instead of gravitational potential energy. Candidates who obtained the correct answer by invoking the equation *GPE = mgh* earned no marks. Too many candidates lost a mark by forgetting the negative sign for the GPE. Many weak candidates confused kinetic energy with total energy.

11 It was good to find that the vast majority of candidates were able to correctly place the meters in the circuit and calculate the conductance of the thermistor. As ever, weak candidates found it difficult to earn marks for their use of the Boltzmann factor to explain the properties of a thermistor. Some thought that the ratio ε/kT was the Boltzmann factor, and many lost marks by discussing the Boltzmann factor in general rather than applying it to the model described in the question. The final calculation was the first stretch-and-challenge question; as expected, it proved to be difficult for all but the strongest candidates. Most candidates failed to realise the two-step nature of the problem, clearly failing to understand the nature of the constant G_0.

12 A large minority of candidates were confused by the first part of the question, discussing the motion of the spacecraft **at** t = 5 yr instead of **before** t = 5 yr. Only strong candidates could explain why the world-line of light was always at 45°, although nearly all weak candidates thought they knew the answer, often involving the laws of reflection. However, the majority of candidates correctly drew the world-lines for the pulse. Too many candidates failed to use data from the graph and show all their working when showing that the pulse reached the spacecraft at time 5 yr when it was 4 yr away. Quite a few did not bother with data at all, just giving a general explanation - this approach earned only half of the marks. Many weak candidates gave unconvincing calculations for the speed of the spacecraft, with not enough detail to show that they hadn't simply worked backwards from the answer provided. It was good to find that the majority of candidates could successfully calculate the time dilation factor, although answers presented as fractions or incorrectly rounded earned no marks. Few candidates realised that time would pass more slowly in the spacecraft than on Earth.

13 Nearly all candidates could calculate the energy of a single molecule - a considerable improvement on previous seasons for a calculation involving a rule which is not in the data sheet! Calculation of the speed of the molecule proved difficult for many candidates, most of whom assumed that the molar mass was the mass of a single molecule. Although weak candidates didn't know where to start, strong candidates had no difficulty in identifying the two equations to be combined to find the answer. Although the majority of candidates were unable to describe a random walk without recourse to the word random, most were able to use kinetic theory to explain it satisfactorily. The final part was another stretch-and-challenge question; as expected, only the strongest candidates could explain why the number of collisions would be proportional to the elapsed time before using algebra to prove the required equation.

G495 Field and Particle Pictures

General Comments

This paper was taken by about 140 candidates of whom the great majority were resit candidates. Given the small size of the cohort the mean and standard deviation can be greatly affected by individual performances. Nevertheless, the mean for the paper of 53 % (standard deviation 15.3) compares well with the previous January sitting. The marks of the candidates varied from 16/100 to 84/100. As usual, middle –ranking candidates scored well on the calculation questions but performed less impressively on longer written sections. There was evidence of candidates being ill-prepared for the Advance Notice section of the paper and this probably reflects the nature of the cohort. Although the Section C comments given below are very paper-specific it is hoped that the more general comments on Section A and B questions may prove useful to colleagues whether or not their candidates sat the examination in January.

Comments on Individual Questions

Section A

This section proved accessible to the majority of the candidates. It contained many straightforward questions alongside some that proved more challenging. In question (1) most candidates managed to spot the unit for the tesla but looking for two equivalents to the volt proved more difficult, with J s^{-1} being a popular alternative. Question 2 was reasonably well answered by most but the occasional candidate's work was so confused and lacking structure that the examiner had to do a great deal of searching to find a way through a simple proof. Questions 3,4 and 5 were all straightforward. The responses to question 6 show that candidates may need a little more practice in drawing such trajectories and reminding to take care and use a ruler where sensible. The most common error was to continue the curved path beyond the screen. Question 8 was largely a matter of recall of the difference between flux and flux density, nevertheless, some came unstuck. The rest of the questions were unproblematic.

Question 10: This question was about a simple d.c. motor and, unusually for a section B question, required no calculations. Drawing a flux line was an easy task for the majority of the cohort but explaining the turning of the rotor in terms of the shape of the flux line proved more difficult, although it is a picture that is used often in the course and similar questions have been asked before. Part (b) of the question concerned the materials used for the motor. Unfortunately, many candidates used the term 'permeance of iron' rather than 'permeability of iron' and failed to reach the marking points. The answers to the part concerning laminating the iron were generally encouraging. Nearly all candidates suggested that reducing eddy currents was the purpose of the laminations and many correctly described the interaction between the eddy currents and the flux. Part (c) proved more difficult, as expected. This produced a lot of muddled responses and few candidates managed to picture an emf induced opposing the current in the coil. This is a more challenging area of the course and it is possible that some of the candidates had avoided it during their revision.

Question 11: This question was about the electric field near a positively-charged sphere. The first parts of the question were unproblematic . Part (c) proved more discriminating. In (c) (i) candidates were asked to describe how a graph of potential versus distance can be used to show that the potential is inversely proportional to the distance from the sphere. Few candidates clearly described taking pairs of points and showing that $Vr = k$. Although credit was given for more complicated but correct methods this did not affect the accessibility of the question suggesting that perhaps candidates need more practice in manipulating graphical data. The difficulties continued in (c)(ii) where candidates where expected to show clearly how they used data from the graph to calculate field strength at a r = 0.0008 m. Only the better candidates drew the correct tangent and completed the calculation. Markers saw a lot of evidence of haphazard lines drawn on graphs or points taken with little understanding. Please note that using E = V/r is arithmetically correct for this situation but should not be confused with E = V/d (the equation for a uniform field). The latter method did not score marks.

Part (d) proved far too difficult for the vast majority. They missed the idea of charge flow across the spheres leading to a greater separation between the charge centres. The vacuum created by this lack of understanding was filled by many spurious ideas, the most common being that the spheres were further apart than the question stated.

Question 12: This question was about the decay of potassium-40 in the body. Part (a) was easy recall and most candidates managed to gain the mark. It was most encouraging that the majority of the responses to part (b) were correct – the 'scaffolding' in the answer space clearly helped this time around and it may be that this method can be used to help candidates gain confidence in the calculation in the classroom. Disappointingly, few candidates realised that the neutrino took away most of the surplus energy in the decay and many fell back on the old stalwart of 'heat'.

Part (c) considered the decay of potassium in the body and focused on the concepts of activity, dose and risk. The 'show that' question for the activity was standard and proved reasonably accessible. However, it is clear that this cohort of candidates was less confident about dose and risk. Common errors included multiplying the energy absorbed by the mass to find the dose and confusions between 3% and the factor 3.

Question 13: The final question of section B was about the cyclotron. This question had a long initial stem to set up the picture but it appears that this did not affect the candidates. Most gained the majority of the available marks in part (a) although not all made it clear that the B field was responsible for the force on the particles. Part (b) proved trivial. Part (c), a calculation of the radius of a proton in the magnetic field was largely straightforward although some candidates got carried away on their calculators and performed the calculation $r = \sqrt{\frac{2mE}{Bq}}$ rather than the correct $r = \frac{\sqrt{2mE}}{Bq}$.

At this stage in the paper this suggests lack of attention to detail rather than running out of time.

Part (d) required calculations of gamma factors. There is a clear misunderstanding of the gamma factor amongst the candidates of this cohort. Many did not realise that expression 'total energy' in the numerator means 'rest energy + kinetic energy'. This misunderstanding did not allow them to make a lot of progress through the question and may be an area that needs more work with future candidates.

Section C

These questions were based on the Advance Notice Article 'Floating an Idea or Two'.
When these papers are sat at the end of Year 13 many candidates have the benefit of practice questions produced by their teachers and colleagues. It was clear that this was not the case with the majority of the candidates sitting the paper in this session and the difference in quality of some responses highlights how useful the preparation can be to Year 13 June candidates.

Question 14 was a nice starter to the section but part (c), implicitly using the ideal gas equation, proved difficult for some. The most frequent error was to ignore the temperature variation and imagine that pV was constant.

Question 15 showed the lack of preparation of many candidates who chose properties that do not go with materials but with specimens. Many mentioned ‘flexibility’ or ‘lightness’, others incorrectly used ‘elastic’ to mean low stiffness. Others trawled for more imaginative properties like ‘waterproof’ or ‘temperature resistant’ – there were not deemed markworthy. 15 (b) showed a confusion between diameter and radius in calculating circumference. Parts (c), (d) and (e) were about the forces on the balloon. Weaker candidates ignored the weight of the balloon when calculating acceleration and were surprisingly prepared to assert that 39.4 m s^{-1} was about 30 m s^{-1}. Part (e) was well answered but only a few candidates took any notice of the pencil icon and ensured that their explanation was carefully ordered and clear.

Question 16 was based on work done in the Imaging chapter right at the beginning of the AS course. This was another area where lack of preparation of resit candidates led to errors that one would not expect from June entrants. The most common error was to miss the point that 256 intensity levels requires 8 bit sampling.

Question 17 was about cosmic rays and relativity. Parts (a) and (b) (i) were reasonably accessible and caused few difficulties but part (b) (ii) requiring a calculation of the gamma factor to establish the half life of mesons in the laboratory proved very difficult – as expected. It was encouraging to see the best candidates scoring well here.

Question 18 was about the cosmic microwave background. Not all the candidates reached this stage of the paper but those that did managed the first two parts reasonably well. Part (c), which related temperature fluctuations of the early universe to its subsequent evolution was reasonably well-answered but few responses managed sufficient clarity to gain the third mark, dependent in part on QWC.

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