RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **A2 H559**

Advanced Subsidiary GCE **AS H159**

Examiners' Reports

January 2011

HX59/R/11J

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Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

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EXAMINERS' REPORTS

Chief Examiner's Report

The candidates who took Advancing Physics AS and A2 units in January fall into two groups – those who are taking a unit for the first time (predominantly G491 and G494) and those who are retaking units (predominantly G492 and G495). In particular, the cohort for G495 included a proportion of candidates who had left their place of A level study and therefore did not necessarily have the benefit of careful preparation of the Advanced Notice Paper. It is unsurprising, therefore, to find that the mean mark for this paper is considerably lower than the June sitting. The other papers show a broadly similar performance to previous sessions. The G491 and G494 mean marks have risen in comparison to January 2010. This is encouraging. There is still some evidence of candidates being rushed in G491 but this is being addressed by the senior examining team who realise that the first paper seen by the candidates does need to reflect the specification requirements whilst being sufficiently accessible to the inexperienced cohort.

All four papers gave candidates opportunities to write about basic physics and it was noticeable that this remains the area in which candidates exhibit weakness. Centres can help candidates improve their explanatory responses by giving them the opportunity to practise this area in class. For example, a few minutes question-and-answer at the end of a lesson can help candidates put ideas into words, with perhaps the better responses used as exemplars or as part of written notes. However, the majority of the candidates were well prepared for the examinations and Centres had clearly followed the specification in spirit and in the letter. As ever, the best responses were a joy to mark.

G491 Physics in Action

This was a largely accessible paper with most questions being successfully attempted by a large proportion of candidates. Most candidates showed evidence of having read the whole paper and reached the end, even if some were pushed a little for time to complete some parts. There were some well attempted calculation questions which was encouraging; but overall there was a disappointing lack of rigour in written explanations and a reluctance to write more than a few words by many candidates. The mean mark was just below half the paper marks, the spread and differentiation of candidates was also successful.

Section A

1) A simple introduction question on units knowledge was well answered by most candidates. The most common error was to put the inverse answer Ω instead of S in part (c).

2) This concerned a potential divider circuit.

   a) Most candidates understood the ± 5% resistor tolerance.

   b) Only the better candidates were able to recall and successfully apply a potential divider calculation to predict the smallest possible output p.d. So marks tended to be 0 or 2/2, although either quoting a correct divider equation or finding the circuit current were possible part marks. Many weak candidates could not visualise the correct resistance combination of (95 + 105) Ω and got the total resistance incorrect.

3) This question presented a frequency spectrum of radio signals. Many weaker candidates did not appreciate that the x-axis represented frequency, and interpreted it as distance, hence confusing bandwidth with wavelength on the diagram.

4) This question was about the partial polarisation of light reflected from a water surface. Candidates had to describe how they could use a polarising filter to verify stated aspects of the phenomenon. In general the descriptions were poor, weaker candidates just describing the Fig. 4.1. Most marks were awarded for rotate filter and observe the change of intensity ideas. Fewer candidates spoke of varying the angle of reflection *r* as requested.

5) This question presented a calibration graph for a wind speed sensor with uncertainty bars represented.

   a) The most common error in estimating the ± % error was to get double the correct answer ie to quote the range as a %. Half the candidates got this correct at between ± 2% to 3%.

   b) Well over half the candidates correctly stated that the uncertainties grew with wind speed / % uncertainties remained constant. Weaker candidates just explained what error bars show in general.

   c) In stating how the sensor output varies with wind speed: many quoted direct proportionality missing the "turn on" speed for the sensor; or terminology let them down "output decreases" was confused with "increases at a decreased rate". Many discussions of uncertainties continued from 5(b) and were not credited here.

6) This question was about the information content in a company logo.

a) About half the candidates correctly selected 1 bit / pixel so gained 144 bits. Many candidates incorrectly gave 288 bits – perhaps thinking of 2 options per pixel.

b) Many ecf marks given for correct 8 bits / byte calculations so that well over half of candidates got this mark.

c) For the number of possible alternative logos – many candidates were reluctant to calculate 2^{bits} which does generate the enormous answer of 2.2×10^{43}. Common errors were: $\log_2$(bits), or 2^{bytes} or 144^2. But about a third of candidates got the correct value.

7) This question was about two spectacle lenses of different curvatures and refractive indices, which had the same optical power and density. It was not well answered. Many candidates write so briefly, and clearly do not expect to link two concepts in one sentence for one mark at this stage.

a) Many candidates had the idea of less material / volume contributing to the thin lens lower weight, but did not mention the equal density. Others gave an answer approaching that required for 7(b) talking about the power of the lens or how much it altered the curvature of the wavefronts.

b) Many candidates just rewrote the question. Very few referred to the consequence of the higher refractive index, and did not make the link to lens shape / curvature. A common error was to say that the lenses have the same focal length, therefore they have the same power.

Section B

8) This question was about the elastic behaviour of metal wires.

a) i) Candidates were asked to draw a graph **B** of force vs extension for a wire of twice the length of the original **A**. Two thirds managed to draw a line of half the gradient. There were many different errors: usually the line was just too low; sometimes drawn on top of the original graph **A**; sometimes at a steeper gradient than **A**; sometimes a graph in the correct position but unlabelled.

ii) To draw the line **C** for a wire of double the original diameter, was beyond most candidates. The most common error was to draw a graph twice as steep, forgetting that the x-area is quadrupled and the gradient should have been x 4 the original.

b) i) As evidence of elastic behaviour from the graph, candidates should have mentioned the proportionality. Following Hooke's law was accepted, and about a third of candidates got this mark. The most common errors were just saying linear, or line has not started to curve yet.

ii) This involved a Young modulus calculation combining data from the graph with more numerical data from the question. It was much better answered than Young Modulus calculations in previous sessions with most candidates securing 2 or 3/3 marks. Those scoring 2/3 were mainly due to power of ten errors on the extension, missing mm from the graph data.

c) Here candidates were asked to describe metallic bonding and explain elastic behaviour in metals using these ideas. It proved a discriminating question. Many marks were lost due to descriptions of **plastic** behaviour (with which the candidates may be more familiar), and these were restricted to 2/4 max. Many marks were given for correct mention of a sea of delocalised electrons and lattice of positive ions, or their representation on a labelled diagram. Writing coherently and at some length remains a problem for most candidates at this level and less than a tenth secured the Quality of Written Communication mark available here.

9) This question was about uses of piezoelectric sensors in microphones and in a STM (Scanning Tunnelling Microscope).

a) Candidates had to read the amplitude of a microphone signal (22 mV) given on a graph. Over half got this correct. The common incorrect answers were 44 mV (confused with peak to peak signal), and 21 mV (misreading the vertical value of a graph square).

b) Here candidates had to calculate the signal frequency from the time period of the waveform on the graph. There were many power of ten errors on milliseconds. Weaker candidates tried to use the wave equation and floundered.

c) This was a 'show that' question for the strain in the piezo-crystal, from a given pressure stress and Young modulus. It was pleasingly well answered considering the rather novel context of the question.

d) From a microscopic scaled image of a STM tip, candidates were asked to estimate the image resolution. About a quarter managed this, but there were many gross errors giving enormous values for resolution in tens or hundreds of m which was disappointing. There is still confusion with resolution being the number of pixels per metre rather than the correct metres per pixel.

e) i) Candidates were given a piezo-electric coefficient and asked to calculate the extension of a crystal at a certain voltage. Over a third of candidates scored the marks here, again pleasing for a novel context. Some candidates saw the *V* in the strain equation as a unit rather than a quantity and failed to multiply the coefficient by the 900 V applied. Few calculated the strain first and then the extension, so it was hard to award part method marks if their final answer was incorrect.

ii) Most candidates who got a distance in (e)(i) managed a mark here by ecf for the number of atomic diameters moved by the tip of the crystal. A few did not understand the pm (pico-metre) multiplier for 10^{-12} ,although it is on the data sheet.

10) This question was about a plasma TV screen.

a) Describing what is meant by an ionised gas was poorly answered. Many candidates had charged gas / gas with positive or negative ions, but few identified atoms / molecules losing electrons to become positive ions.

b) This involved calculating the wavelength of the uv radiation emitted inside the plasma pixel. Three quarters of candidates managed this well. Most errors were due to incorrect rearrangement of the wave equation $c = f\lambda$.

c) Again this was well answered with most candidates correctly calculating the energy gained by an electron in passing through a p.d. of 240 V. There were some power of ten errors that scored 1/2 marks.

d) i) Candidates were given a graph of plasma current vs applied p.d. for one pixel showing hysteresis. Candidates had to read from the graph the voltage that starts ionisation as p.d. increases and the voltage at which ionisation stops as p.d. decreases. This was well done and about two thirds managed this which was pleasing.

ii) Candidates were asked to use the data to estimate the operating power of the TV screen with all pixels running. There were many power of ten errors on μA. Many also used 0.3 μA as the operating current rather than reading the current from the graph at 0.26 μA. Nevertheless over half of the candidates gained marks here.

11) This question compared the use of a variable resistor as a series resistor and as a potential divider to control the brightness of a lamp.

a) Given an I vs V graph for a resistor and a filament lamp, candidates were asked to calculate the value of the resistor.

i) Most got this correct at 9.6 Ω. Incorrect answers were often 12, having misread the graph.

ii) Candidates here had to reason which graph was for the filament lamp. Many descriptions were too weak eg because it starts to curve or takes a while to warm up, rather than noting that the resistance increased as current or p.d. increased. Temperature rise was not accepted as it is not apparent from the graph.

b) i) Only about a third of candidates could explain how the series variable resistor controlled the power to the lamp. However, there was not enough detail in many answers to get both marks.

ii) Candidates had to read appropriate values from the graph to complete a data table for current and power in the lamp. Sadly very few candidates were able to demonstrate understanding of this simple circuit. Most marks were given for power in lamp at minimum resistance ecf from an incorrect current x 12 V.

c) About a quarter of candidates did not reach or attempt this part about the benefit of using the variable resistor as a potential divider. Answers given were mostly too brief and vague eg voltage will be the same or safer or more accurate. Only a few candidates appreciated the full control of the lamp power from zero to maximum by using the potential divider circuit.

G492 Understanding Processes, Experimentation and Data Handling

General Comments

The entry for this paper, all resit candidates, was smaller than in January 2010, suggesting that there were fewer needing to resit. The examination proved more difficult than January 2010, but this may have been due to a weaker cohort of candidates this time. 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.

Comments on Individual Questions

Section A

Proved harder than usual, with good candidates scoring about 15/20.

1) was intended to be an easy start to the paper, but few had both parts correct.

2) also proved very taxing, with very few getting all three correct: many did not wish to use the same letter twice.

3) was answered well by most.

4) most could do the calculation in (a), and it was pleasing to see relatively few power-of-10 errors; (b) was more demanding.

5) part (a) was correctly done by nearly all, and in part (b) most identified destructive interference as the phenomenon.

6) few were able to express themselves clearly enough to get both marks. Many picked up the idea that the distance in a laboratory was perforce rather small, but few explained the consequence of the short travel time in making measurements.

7) was done correctly by most, who correctly assigned a negative sign to the acceleration of gravity.

Section B

As usual, this section was demanding. 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.

8) Some candidates found the 'snapshots' of the standing wave hard to visualise, but most could label nodes and antinodes and explain in (a)(ii) why the wavelength was 1600 m. The calculation in (a)(iii) was usually correct, but many did not explain why the period was 96 s. Most gained some credit in (b), but many did not recognise that harmonics could be generated in a standing wave system, and that they needed to link period with frequency and with wavelength.

In (c) there were some good answers, but many just wrote 'It's a bigger lake' without justification, so did not get the mark. (It was a bigger lake, also much shallower — Lake Erie. The question was based on seiches in a small Scottish loch.)

9) Part (a) was well answered by most, although some omitted to add the 1.2 s in (a)(iii). Most obtained two marks in (b) for showing a gradual decoration when the parachute opens, with the trace asymptotic to 6 m s-1. (c)(i) was a harder part, and many answered 'Longer time gives a smaller force' without explaining why in terms of deceleration or momentum change; some talked about 'spreading the force over a larger area'. Most candidates did (ii) completely correctly.

10) Part (a) was done well, and (b)(i) and (ii) were also well understood, even if the explanations were not always clear.(b)(iii) was more difficult, and many tried to reverse-engineer the solution into an argument, which was rarely successful. Successful candidates here drew a labelled diagram of the path difference between adjacent sections of the slit. Substitution into the given equation in (c) was done well.

11) This question was the hardest on the paper, and few candidates showed an understanding of the components of a force. Part (a)(i) was poorly explained, and in part (ii) few candidates could use the answer to (a)(i) correctly, and were clearly just trying to juggle the data given to get an answer near 90 N. A very common approach was to calculate 140 N × sin(36°).Part (b)(i) was correctly done by almost all, but answers to (b)(ii) were often superficial. Talking about energy loss (which gained one mark) was commonly done, and many mentioned either the angle θ increasing or the tension *T* dropping, but then failed to develop the idea.

Section C

Many candidates had prepared well for this section but, as always, some did not show that they had worked through the advance notice material adequately. This section proved the hardest on the paper: in June 2010, section A was the easiest and B the hardest, but this time sections B and C swapped places.

12) In (a), most calculated v^2 for all the data rather than just the maximum and minimum, and the poor layout of answers meant than examiners had to root around to see what marks had been achieved.

In (b) many got one mark for stating that the percentage uncertainty in h was small, or for saying that the range bars would have been too small to be useful, but few connected both points: the question did state 'Suggest and explain' which should have pointed them in that direction.

In (c), the outlier was sometimes not mentioned even though it was not included in graph. A few used the origin and quite a number read the scale wrong. Even among candidates who gained 4/4 in this question, it was surprising how small a triangle was chosen to determine the gradient – many used the absolute minimum that the mark scheme allowed.

Part (d) discriminated well, with better candidates explaining (instead of just stating) why the energy loss hypothesis must be wrong in (i), and how h may have been systematically measured too small in (ii).

13) Candidates who understood percentage or fractional uncertainty did well in this question. In (a), very, very few candidates did more than just calculate 0.01m/1.0 / and state that it was small. Only the best found the hypotenuse of the triangle to calculate the sine, or went via the tangent. In (b)(i), most candidates lost marks by stating excessive significant figures. Answers to (b)(ii), (iii) and (iv) were generally correct, although many did not realise 'Justify your answer' in (i) meant 'Do some calculations'. In (c), some candidates tried to explain why it would be difficult to see the fringes, instead of comparing the changes in percentage uncertainty.

14) Part (a) was frequently correct, but candidates often benefited from the fact that an answer of 5.8 mm had to have been done correctly, gaining both marks, as their working and layout was often muddled. (Exactly the same held for 1270 N in 9(c)(ii))

(b)(i) was usually done quite well, but it was surprising that more did not get 3/3 here, as there was an almost identical calculation in the pre-release document; many found the scale hard to read.

In part (c), most gained one or two marks out of three, often for just quoting 'get rid of outliers' (often referred to as anomalies). At AS, a more thoughtful response is expected than would have been appropriate at GCSE. In (d), most gained one mark, usually for realising that Brahe need to calibrate his equipment.

G494 Rise and Fall of the Clockwork Universe

General Comments

The mean mark for this paper was significantly higher than this time last year, suggesting that candidates were better prepared for it. The marks earned ranged from 58 to 4 out of 60. There was no evidence from the scripts that candidates were under any time pressure. The only questions with significant omission rates were the two stretch-and-challenge ones.

It was noticeable that weak candidates fare best where a question asks them to do just one thing. It was noticeable that they found questions which required them to do more than one thing (such as describe and explain) much harder. It might be an idea for centres to train their candidates to read a question again after they have written their response as a final check before moving on to the next question.

The advancing physics course places emphasis on the use of graphs to convey information, so it is likely that, as was the case for this paper, its exams will have assigned a significant proportion of the marks for sketching and interpreting graphs. Since candidates universally find these questions harder than calculations, it might pay centres to give their candidates more practice at acquiring these skills.

It is distressing to find candidates at A2 who lose marks through rounding the answers to their calculations incorrectly. This is especially the case with multi-step calculations, where candidates round too early. Centres need to encourage their candidates to use all the significant figures all the way through and only round (using the correct rules) to two or three sig. figs. at the end.

Comments on Individual Questions:

Section A

The majority of candidates were able to correctly identify the units required for Q1. As expected, many weak candidates used m^2s^{-2} for root mean square speed. Very few candidates recognised the correct method of determining gravitational from a field-distance graph for Q2. However, it was good to find that the majority of candidates were able to select the correct fundamental equations in Q3 to assemble the discharge rate equation for a capacitor. Some were confused by the minus sign in the last stage, slipping it in at the last line without any justification. Q4 was well answered by most candidates, although only a minority realised that for (b) they had to calculate the mass of a single particle before calculating the mean square speed. Most blithely substituted the mass of the whole gas or the molar mass, suggesting a lack of thought about the meaning of the symbols used in the equation. The vast majority of candidates knew that red-shift produced a change of wavelength and that this implied the recession of galaxies, but a significant minority failed to mention that a big bang involves more than just stuff moving away from a single point, it requires all the stuff to start off at that point some time in the past. As ever, weak candidates talk of the big bang as an explosion, flinging galaxies out into space, rather than referring to the expansion of space itself. Surprisingly, only the strongest candidates were able to identify the correct graph for Q6. Since this graph is central to the ideas behind the Boltzmann factor, this is disappointing. However, the vast majority were able to calculate a value for a Boltzmann factor in Q7, and it was good to find that many candidates could correctly identify both reasons why a change of state takes place despite such a small value for the Boltzmann factor. The graph of Q8 proved problematic for many candidates, with too many not thinking carefully enough about the phase of their curve; the displacement must increase with time where the velocity is positive. Q9 was about charging and discharging a capacitor.

Nearly all candidates were able to calculate the energy stored by the capacitor, but only about half worked out that halving the discharging resistor would double the average heating power.

Section B

10) Too many candidates forgot that force is a vector, so omitted to mention that the force from the suspension acts so as to return it to its equilibrium position. Weak candidates lost marks by quoting algebra instead of words, without defining the terms. The calculation of resonant frequency proved to be an excellent discriminator. Only the strongest candidates were able to deal with a two step calculation involving a square root! Similarly, weak candidates often failed to recognise that resonance would take place as the driving frequency was increased from a low value, often resorting to bogus equations to explain why the amplitude had to decrease as the frequency increased. The last part of the question was poorly answered. Too many candidates failed to go into enough detail about the behaviour of gases, many assumed that the gas would act as a damper, and many failed to mention the effect on the resonant frequency.

11) This question was about an orbit in a planet's gravitational field. Very few candidates took enough care over their graphs for the first part, forfeiting marks in the process. So curves that blatantly ignored energy conservation before the rockets were fired lost a mark, as did those that did not have constant GPE or KE once in orbit. Only a minority of candidates ensured that their curves had the rockets being fired at point D and not before. The calculation of exhaust gas velocity discriminated well, with weak candidates clearly confused by the quantity of information. However, it was good to find that very few tried to use energy conservation instead of momentum conservation to find their answer. Similarly, too many weak candidates did not know the rule for centripetal force (although it is in the data book). The final calculation provided no challenge for many candidates.

12) The first stretch-and-challenge question proved, as intended, to be only accessible to the strongest candidates. After an easy start (a straightforward calculation involving the ideal gas equation), candidates had to use $E = kT$ to calculate a power. Since this equation is not in the data book, most candidates are not in a position to get started on this question. However, the last part of the question was well answered by many candidates. It was good to see that many were able to provide a good logical argument with enough detail about the behaviour of particles in gases to earn the majority of the marks.

13) The last question of the paper was about relativity. As ever, only a minority of candidates were able to give a complete definition of decay constant, although the vast majority could calculate it successfully from the half-life. The next part of the question required candidates to combine half-life, speed and time to calculate a distance. A majority of candidates could do this, earning full marks, but a significant minority could not get started at all. The graph discriminated well, with weak candidates losing marks through careless sketching of their curve (often becoming horizontal at the end) or failing to make it pass through the correct points. The last part was the second stretch-and-challenge question. It was good to find that the majority of candidates had a go, but only a minority used the data provided to calculate a value of γ, preferring instead to make up their own value for v and substituting it into the equation provided.

G495 Field and Particle Pictures

General Comments

This was the first January sitting of the new G495 paper. Fewer than 150 candidates took the paper and the lower mean compared to June 2010 (55% compared to 61%) reflects the large proportion of resit candidates, some of whom were clearly insufficiently prepared for the Advance Notice questions. These candidates may well be resitting the paper as external candidates and therefore do not have the support of centres behind them. Although this cohort may not reflect the Summer entry there are lessons that can be learned from the candidates' performance. Once again many candidates performed poorly on descriptive questions. Centres may well want to consider this as they prepare this year's Year 13 candidates for the Summer examination – particularly the Advance Notice element. It is also clear that candidates do not always consider that a question with the command 'discuss' or 'explain' can include calculations in the answer. This is an area that can be worked on in class using this January's paper as an example.

Comments on Individual Questions:

Section A

As usual, this section consisted of short questions that tested knowledge of simple concepts and basic arithmetical techniques. Few questions gave problems. However, question 4, requiring candidates to recognise a shaded area of a graph as the potential difference between two points was not well answered. Many confused potential difference with energy difference and a significant proportion ignored the labelled points on the x-axis. This showed a lack of care rather than a lack of understanding.

Section B

All the questions in this section included accessible calculations which were answered accurately by the majority of the candidates. As ever, descriptive questions and open-ended tasks proved more challenging. These questions will provide useful practice and discussion points in class.

Question 10 was about Rutherford scattering. This was answered well by many, with a good understanding of the probabilistic nature of the scattering demonstrated. There was evidence of clumsiness in converting 5 MeV into joules – many candidates assumed the value was 5 eV. The most difficult part of the question involved an estimate of the density of the gold nucleus in which only the very best candidates showed an understanding of the cube relationship between radius and volume.

Question 11 proved a little more taxing. It concerned the use of iodine-131 in medicine. Candidates were required to calculate an initial activity given the mass of iodine and the decay constant. this proved surprisingly difficult. The most challenging part of the question asked for a dose in gray given the average energy per decay. Candidates were not prepared for dose calculations and only the better candidates could give possible reasons why their estimate was a maximum value.

Question 12 was about electrons accelerated to high speeds in a uniform electric field. It opened with a multiple choice question showing three possible graphs of the electron acceleration vs distance from the cathode. Choosing the correct graph proved a discriminating task. Candidates were on surer footing when calculating the gamma factor for the accelerated electron. However, the final part of the question was challenging for the majority. The question required candidates to comment on whether or not relativistic effects were important when an electron is accelerated to 60 keV. It was disappointing that only a minority of the candidates calculated a gamma factor and then used the value in their arguments.

Question 13 concerned a simple a.c. generator. The first part required candidates to obtain the frequency of the induced emf using a p.d. vs. time graph. This caused more difficulties than expected, with many candidates ignoring the axis label of 'time/ms' and assuming that the time period was shown in seconds rather than milliseconds. The calculation in the second part of the question was generally well-performed but a proportion of the responses failed to get all three marks because the calculation was not carefully set out and so failed to explain the situation under consideration. Part (c) was also challenging. Only a few candidates realised that the largest value of the cosine function is unity and attempted to substitute time values into the equation. This was acceptable if accurately performed but common failings included choosing an incorrect time value and using calculators in degree mode rather than radian. Not all candidates recognised the relationship between flux and flux density.

Section C

The Advance Notice section of the paper was broadly similar in difficulty and style to Section C in June 2010. However, the standard of responses was rather lower than the previous session, with many candidates finding the longer calculations and descriptive sections taxing. This may well be due to the nature of the cohort.

Question 15 concerned temperature control. Candidates lost marks in part (b) owing to lack of clarity in explanations. Part (c)(ii) required a calculation of temperature rise and proved more discriminating than expected. The final part of the question was a simple ratio of pressure and temperature of a gas at constant volume. It was disappointing to see that only a small minority of the responses used kelvin temperature and gained full marks in a relatively straightforward calculation.

Question 16(a) required candidates to explain the term 'exponential relationship' and show that a graph of pressure vs. altitude was exponential in nature. This part of the question was worth five marks. The better candidates performed well but many confused exponential relationships with inverse relationships. Explanations were often based around 'half life' calculations, seemingly ignoring the quantities given on the axes. This will be a useful question to use for preparation of future candidates as it does not require a careful study of the Advance Notice article to complete and will give candidates useful practice in preparing relatively long explanatory answers.

Question 17 was another explanatory question, this time based around composite materials. This was much more accessible with a good proportion of the candidates gaining full marks.

Question 18 was about the energy of micrometeoroids and possible damage that they can cause. The first two calculations were accessible to most candidates but the calculation of the depth of penetration of the micrometeoroid was poorly performed with many candidates ignoring the fact that the micrometeoroid vaporises a hemisphere rather than a sphere.

Question 19 focused on the solar wind. Although the opening calculations were accessible, candidates found the last part of the question, concerning health risks, much more challenging.

The last question on the paper, on momentum, was accessible and generally well performed by the better candidates. It was encouraging to see that nearly all candidates completed the paper.

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

14 – 19 Qualifications (General)
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

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